NSF Partnerships with Industry and Academe

Report of the NSF
Industrial Programs Coordinating Committee

to the Director
National Science Foundation

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Industrial Programs Coordinating Committee

National Science Foundation

Committee Membership

Lynn Preston, Chair
Engineering Education and Centers, Engineering

Roosevelt Calbert
Human Resource Development, Education and Human Resources
Joyce Hamaty
Office of Legislative and Public Affairs, Office of the Director
Lance Haworth
Materials Research, Mathematical and Physical Sciences
Carter Kimsey
Integrative Biology and Neural Sciences, Biological Science
Bruce Kramer
Design and Manufacturing Systems, Engineering
Nathaniel Pitts
Science and Technology Infrastructure, Office of the Director
Jewel Prendeville
Atmospheric Sciences, Geosciences
Lawrence Rausch
Science Resources Studies, Social, Behavioral, and Economic Sciences
Alexander Schwarzkopf
Engineering Education and Centers, Engineering
Donald Senich
Industrial Innovation Interface, Engineering
Mary Sladek
Graduate Education and Research Development, Education and Human Resources
Thomas Weber
Advanced Scientific Computing, Computer and Information Science and Engineering

The Industrial Programs Coordinating Committee (IPCC) was established by the Director in early 1992 to study programs across NSF that involve industry/university collaboration and to recommend ways for NSF to strengthen that collaboration. The Committee developed a report which contained an examination of the history of NSF's involvement with industry/ university collaboration and recommendations for how NSF can enhance partnerships with industry to strengthen the contribution of fundamental scientific and engineering research and education to the civilian economy. The report also posed some strategic issues for further consideration.

THE CHALLENGE

There is a gap between the creation of new knowledge and technology in universities and its implementation by U.S. industry. This gap is one of several factors which is hampering the ability of U.S. industry to field competitive products and services in a timely fashion. While many of the reasons for the gap lie individually with academe and the industrial sector, a challenge facing NSF is how to foster strategic links between academe and industry that will narrow the gap.

Since the early 1970s, NSF has operated a growing number of university-based research center programs that feature collaboration of various kinds between academic and industrial researchers. More recently, industry/university collaboration has been extended to a few single-investigator programs. However, most of the research supported by NSF remains long-term and generic, generated by fundamental issues in science and engineering.
There are several newer programs whose primary mission is education, and some of these involve substantial industrial input and interaction.

The IPCC examined the scope of these activities and recommends that NSF broaden and strengthen industry/university cooperation across the spectrum of NSF-supported work. The Committee has identified a number of possible mechanisms for doing so and some broader strategic issues for further study.

HISTORY AND CURRENT STATUS OF NSF UNIVERSITY/INDUSTRY PROGRAMS

NSF's experience in stimulating the interaction between industry and academe has shown that direct collaboration between academic and industrial personnel is an effective means for bringing new perspectives and intellectual challenges to academe, expanding the long-term view of industry, and effecting a more speedy deployment of knowledge to industry. An added benefit is the impact of this collaboration on students, who gain a new perspective on research from industry and often become "agents" for knowledge transfer to industry. Industry draws benefit from academic research through other means as well, such as consultants, attendance at professional meetings, their own direct support of

academic research, etc.

The following is a brief summary of the history of NSF's formalized programs involving industry/university interaction. These programs should be distinguished from those that gain financial leverage through funding from industry without requirements or expectations for interaction.

In the early 1970s, two programs were initiated to stimulate this interaction. One was the **Industry/University Cooperative (IUC) Research Projects** program, a centrally managed program, which provided incentive funds to program directors across the Foundation to support projects where industrial and academic researchers worked together. The cross-directorate scope of the IUC Projects program and the incentive funding system were eliminated when it was transferred to the Directorate for Engineering in the early 1980s, and the program faded away. The other innovation in the 1970s was the **Industry/University Cooperative Research Centers** (I/UCRC) Program, which continues today in the Directorate for Engineering and provides "seed" support for some 50 centers to work in close collaboration with industry on research relevant to industrial needs.

Both these programs paved the way for NSF's expanded focus on university/industry collaboration in the 1980s, especially through the medium of centers. The **Engineering Research Centers** (ERC) Program, begun in 1985, is designed to support cross-disciplinary teams in research and education important for competitiveness by focusing their efforts on engineering systems. The program requires active collaboration with industry in planning, research, and education with a view to the transfer of knowledge and technology advances for use in industry. There are currently 18 ERCs. The **Science and Technology Centers** (STC) Program, begun in 1987, is designed to couple university-based scientists and engineers for focus on research with a long-term technological horizon and to promote linkages with industry and other sectors. There are currently 25 STCs. Work in both the ERCs and the STCs to varying degrees spans the research and development spectrum from basic and generic research to proof-of-concept experimentation in testbeds, with the preponderance of the latter in the ERCs.

Other center programs also foster industry/university collaboration. Begun in 1984, the four **Supercomputer Centers** have very close links with industry to facilitate the use of supercomputers by industry. These centers stress industrial collaboration in their missions and provide supercomputing resources, training, and user services to industry. Industrial firms are collaborators in the research and training programs of the centers. The **Materials Research Laboratories** started as Interdisciplinary Laboratories under the Advanced Research Projects Agency in the Department of Defense in 1960. In 1972, the responsibility for the laboratories was transferred to NSF and they were renamed Materials Research Laboratories (MRLs). Because of their broad scope and focus on interdisciplinary programs in materials research, the current set of 10 MRLs has proven attractive to industry. Industrial involvement across the MRLs varies according to the relevance of the work to industrial interests. Support for **Minority Research Centers** of Excellence (MRCEs) began in 1987. The eight MRCEs involve industrial personnel in workshops and as mentors to students and industrial internships are provided

for students. The **National Center for Atmospheric Research** (NCAR) was established in 1960 and has developed an active program of research in atmospheric phenomena relevant to aviation technology that receives considerable industrial support. NCAR's mission includes technology transfer to government agencies and industry. The new **State Industry/University Cooperative Research Centers** program, begun in FY 1991, aims to enhance local economic development and focuses even more actively than the traditional I/UCRCs do on technology transfer and knowledge deployment, especially to small firms where many innovations arise and new jobs are created. The program supports 10 centers.

Though the emphasis of the research in these programs varies along the spectrum from basic to proof-of-concept, the research remains long-term, generic, and pre-competitive. While the ERCs, I/UCRCs and the State I/UCRCs require industrial involvement and the remaining programs foster it, certain forms of industrial involvement are common, including:

- industrial participation on advisory boards
- industrial visitors performing research and advising students
- joint research projects

In addition, most of the ERCs and some of the STCs have industrial liaison officers whose responsibility it is to facilitate interaction. All of these mechanisms enhance the process of technology transfer by increasing the contact between industry and academe. Actual experimentation with research-based advances to determine their potential for use in industry is more limited and tends to be concentrated in the I/UCRCs and the ERCs.

Currently, there are a few relatively new initiatives which focus on industry/university collaboration at the **individual investigator award** level. These focus collaborative research on Decision and Risk Management, Management of Technology (a joint initiative between Engineering and Social, Behavioral, and Economic Sciences), Environmentally Benign Chemical Synthesis and Processing (a joint initiative between Mathematical and Physical Sciences and Engineering), and Strategic Manufacturing (a joint initiative between Engineering and the Mantech Program of the Office of the Secretary of Defense). In addition, the **NSF Young Investigator Program** links new faculty with industry, and the Engineering Directorate supports a program, **Faculty Internships in Industry,** to provide stipends for faculty to work on site in industry.

NSF's only major experience with direct support to industry to conduct research is through the **Small Business Innovative Research** (SBIR) Program, which originated in NSF in 1976. The NSF program served as a model for the national Congressionally-mandated program, initiated in 1983. This program has an active history of supporting small businesses to carry out research in a broad range of fields. Some 50 percent of the SBIR awards utilize academic talent on a subcontract basis. These awards have generated process and product advances which have been supported through private venture capital and have had considerable market impact.

Education is a mission equal to research in NSF and industry's role in that mission has increased over time to the point where industry is actively involved in a number of new NSF educational initiatives. The **Education and Human Resources Directorate** has the primary responsibility for these initiatives which focus on systemic reform of the science and math curricula in K-12 and the improvement of access to careers in engineering, mathematics, and science for all students, reflecting the diversity of the U.S. population. The active coupling of research and education is a part of the missions of the Engineering Research Centers, the Science and Technology Centers, and the Materials Research Laboratories, which have been enriched by industrial involvement with students in research and in the classroom. Industry provides considerable financial and in-kind support to the four **Engineering Education Coalitions**, cross-university experiments in systemic reform of undergraduate engineering education.

RECOMMENDATIONS AND STRATEGIC ISSUES FOR FURTHER STUDY[1]

The Committee has prepared a set of recommendations and posed a few strategic questions for further consideration by the Director. The Committee believes these can prove fruitful to both academe and industry and speed the creation of national wealth based on the timely application of scientific and engineering knowledge to competitive goods and services.

The opportunities were considered in light of the fact that industry is diverse in its relationship to research, depending on the sector, the size of the firm, and its current focus on research and development. While many large companies maintain active programs to tap into the body of research underway in academe, their representatives voiced a frustration with the ability to make timely and effective use of this information. They acknowledge that the fault lies on both sides. At the same time, some of these large firms are cutting back on expenditures for research and rethinking broad-based grants for academic research that is not directly relevant to industrial concerns. For many small and medium-sized firms, there is an even larger gap in access and ability to make use of research and new technologies. Any programs for enhanced industry/university collaboration should be cognizant of this diversity.

RECOMMENDATIONS

Briefly stated, the recommendations are to:

IMPROVE TWO-WAY FLOW OF KNOWLEDGE BETWEEN ACADEME AND INDUSTRY

- **Establish an Industry/University Collaborative Research Projects Program** to provide support for cooperative projects carried out by universities in

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[1] See the Appendix for a complete discussion of these recommendations and strategic issues.

partnership with industry, focusing on generic (non-product-specific) research. The research can range from fundamental to the proof-of-concept stage but the research would be of mutual interest and carried out jointly with an industrial partner, not just an academic project with industrial leverage. NSF would provide part of the costs for the project and industry the other. The Program should be a Foundation-wide initiative, managed at the division level with the divisions establishing targeted set-asides, at a level appropriate to the level of industrial and academic interest.

- **Promote expanded industry/university and NSF/industry personnel exchanges** through such vehicles as faculty "sabbaticals" in industry, industrial residencies in academe, and student collaborative research with industry. NSF should support professional staff "residencies" in industry and invite industrial personnel to NSF to give seminars and meet for a day with relevant program staff.

- **Improve industrial access to ongoing research** through an on-line data base of ongoing NSF-supported research awards with an intelligent query capability designed with industrial and academic input to be relevant to their respective interests. In addition, industry has voiced the need for an expanded data system of R&D expenses by field of technology, as well as data on employment of scientific and engineering personnel by field of emerging technology to complement the current system based on standardized industrial classifications (SIC) codes and fields of engineering and science.

- **Establish consortia of centers, individual investigators, and their industrial partners working under critical technologies initiatives** to capitalize on complementary research and focus more effectively on industry's needs and technological advances.

INCREASE INDUSTRIAL INVOLVEMENT IN EDUCATION

- **Focus educational programs on industrial collaboration** by linking to existing industry/university cooperation programs to expand student contacts with industry.

- **Reassess industry's role in education** to encourage industry to devote intellectual as well as financial resources to educational reform programs.

IMPROVE NSF'S OUTREACH TO INDUSTRY AND OTHER SECTORS

- **Focus on a wide-ranging and proactive public relations strategy**, conducting industry/university workshops, expanding the Director's outreach to CEOs and organizations representing business and industry, and encouraging community outreach by universities in cooperation with industry

STRATEGIC ISSUES

Rather than recommend actions on the following strategic issues, the Committee posed them for NSF to consider further because of the challenges they present to the basic mission of NSF.

EXAMINE NSF'S POSITION WITHIN THE R&D SPECTRUM

- What is the appropriate role or range of roles for NSF in support of research along the R&D spectrum from basic to experimental proof-of-concept research exploring possibilities for use?

- Should NSF expand its scope to support deep testbeds necessary to explore a next-generation technology advance?

- Should NSF explore establishing Technology Advancement Institutes where industry and universities meet to continue research experimentation toward development? This may be needed for major systems advances that require large capital investments or for long-term and high-risk ideas that U.S. firms are not exploring.

EXPLORE A ROLE FOR NSF IN THE EDUCATION OF THE TECHNICAL WORKFORCE

- Should NSF take on a responsibility to support technical universities to upgrade the scientific, mathematical, and engineering skills of the workforce? There is a growing need for a technical workforce for industry of people who can function at a highly skilled level, knowledgeable about the fundamentals underlying the processes they control, and able to manage them more effectively to improve productivity.

EXPLORE LEARNING STYLES PREFERENCES IN EDUCATION AND THEIR IMPACT RETENTION OF STUDENTS IN TECHNICAL FIELDS

- NSF should examine whether the U.S. educational system reinforces a preference for verbal skills to the detriment of children who could flourish in schools that were set up to focus on the reasoning skills needed in scientific, mathematical, and engineering fields, with verbal skills as a complementary component of their education.

CONCLUSION OF THE COMMITTEE'S WORK

The Committee presented these recommendations to the Director and the Director's Policy Group for consideration in the development of future plans for the Foundation.

PUBLICATIONS IN PREPARATION BY THE COMMITTEE

The Committee is preparing two publications: (1) a comprehensive description of the major

industry/university collaboration programs with examples of successful collaborations and their outcome plus a directory of centers and laboratories, and (2) a brief brochure depicting successful examples of industry/university collaboration.

Appendix

RECOMMENDATIONS AND ISSUES

The Committee identified three broad topics for near-term action. These are discussed below and recommendations and associated issues are presented. Three strategic issues were raised for further consideration by the Director.

The topics followed by recommendations are:

I. The two-way flow of knowledge between academe and industry
II. Industrial involvement in education
III. NSF's outreach to industry and other sectors

The strategic issues are:

I. NSF's position within the R&D spectrum
II. NSF's position on education of the technical workforce
III. NSF's position on learning styles and education

Topic I. The Two-Way Flow Of Knowledge Between Academe And Industry

Need: NSF supports a large body of research, some of which may provide a foundation for advances in industrial practices, processes, and products. However, except in centers which focus on industry/university collaboration, much of this work remains focused on long-term, generic research generated by fundamental issues in science and engineering and some may need closer association with industry or further proof-of-concept research to explore its full potential for utility.

The Committee made several recommendations that address this need. They are:

A. Establish an Industry/University Collaborative Research Projects Program
B. Promote expanded industry/university and NSF/industry personnel exchanges
C. Improve industrial access to ongoing research
D. Establish consortia of centers, individual investigators, and their industrial partners working on critical technologies initiatives.

A. Establish an Industry/University Collaborative Research Projects Program

Need: Meeting the need for closer collaboration in research between academe and industry requires long-term partnerships between members of each sector. Collaborative partnerships in research will:

- o increase the probability that academic research results will be used by industry
- o enhance the orientation of academic researchers toward the ultimate utility of their work
- o enrich the industrial knowledge base.

Recommendation: NSF should establish an Industry/University Collaborative Research Projects Program to provide support for cooperative projects carried out by universities in partnership with industry, focusing on generic (non-product-specific) research. The research can range from fundamental to the proof-of-concept stage but the research would be of mutual interest and carried out jointly with an industrial partner, not just an academic project with industrial leverage. NSF would provide part of the costs for the project and industry the other. The Program should be a Foundation-wide initiative, managed at the division level with the divisions establishing targeted set-asides, at a level appropriate to the level of industrial and academic interest.

The recommended program should:

1. Focus on issues that are generic to a line of problems and not product-specific
2. Provide joint support for collaborative research to the proof-of-concept stage
3. Involve both academic and industrial investigators
4. Involve academic and industrial peer reviewers
5. Involve all sizes of firms.

With regard to administration of the Program:

6. The Director and ADs should establish the program as a Foundation-wide initiative and the divisions should establish target set-asides appropriate to levels of interest
7. Recommendations for awards should be made at the program level
8. The responsibility for stimulating participation and collecting information on outcomes should be in the Director's Office.

B. Promote Expanded Industry/University and NSF/Industry Personnel Exchanges

Need: Time spent crossing over into the other sector is valuable to both industry and academe. Such visits keep industry abreast of the latest developments and bring an industrial perspective to faculty and students. Providing faculty with experience in industry lends relevance to future research, improves the insights they can give to students about practicing science or engineering in industry, and provides industry with access to a person with up-to-date knowledge and a longer-term perspective on research. In addition, NSF staff should have the opportunity to gain experience working in industry and have more frequent access to industrial views.

Recommendations:

1. Support "sabbaticals" for faculty to spend dedicated time in industry, modeled after the experience gained from the current Faculty Internship in Industry initiative in Engineering

2. Support undergraduate and master's students to interact with a firm and work on problem-solving research projects relevant to the firm's needs

3. Support industrial personnel to spend extended time in residence in academe doing research, teaching, and mentoring students

4. Support residencies for NSF professional staff in industry

5. Invite industrial personnel to give seminars at NSF and spend the rest of the day visiting with program staff.

These activities should be cost-shared by industry and NSF, except number 4 which is an NSF responsibility.

C. Improve Industrial Access to Ongoing Research

The Committee identified two elements needed here: an improved on-line data base of NSF research awards and expanded/updated data collection regarding current and emerging fields of technology.

1. On-Line Data Base of Awards

Need: Industry gains access to research by funding it, attending professional conferences, reading publications, or sorting through publications of abstracts. But a more comprehensive and efficient means of access would be desirable. Representatives of industry have voiced the need to have on-line access to abstracts of current NSF-supported research in fields of technology. Both large and small firms have suggested that such a data base would be valuable in their efforts to keep up with the state of the art. The NSF Division of Information Systems (DIS) indicates that the Science and Technology

Information System (STIS) and other wide-area information systems of which NSF is a part, provide this access. However, industry generally may not be aware of this service and the search system may need industrial input to add topics relevant to industrial interests.

Recommendation: DIS and the Office of Legislative and Public Affairs (OLPA) should develop a strategy to inform industry of how to access NSF online systems such as STIS. A study should be made to determine if improvements are needed to provide industry with more effective access. In addition, as future information technologies improve, it would be more useful to have an "intelligent" query capability rather than just keywords search.

2. Support Industry Through Data Collection Efforts

Need: Many of NSF's efforts to compile statistics on national research and development activities follow broad standardized industrial classifications (SIC) and/or disciplines. Industry would find additional value if data could be developed to track current and emerging technology fields. In addition, the NSF codes for categorizing research awards by field of application are out-of-date and often irrelevant to current and emerging technologies.

Recommendations:

a. Develop data that track national efforts in important new technologies, such as data on technical areas of activity, R&D expenditures, technical employment, sales, multi-firm alliances, etc.

b. Revise the fields of application codes on NSF Form 1036 to reflect current and emerging fields of technology.

Issue: Tracking national efforts in new technologies is not a trivial undertaking. New survey instruments would need to be developed and additional staff would be required to gather such information.

D. Establish Consortia of Centers, Individual Investigators, and their Industrial Partners Working under Critical Technologies Initiatives

Need: While NSF is forming teams of program directors to coordinate the allocation of resources focused on critical technologies, most of the actual research at the investigator level in centers and under individual investigator awards remains uncoordinated. One of industry's main concerns is the plethora of projects underway and relevant to their interests which are often duplicative and uncoordinated. Some of the center programs have begun to link centers through joint projects and some have made a special effort to link individual investigators to the work in the centers through joint projects. However, this effort is under-funded and presently not strategically linked to the critical technology initiatives. Coordinated activities are needed to increase the synergy of various projects related to a thematic or technological focus.

Recommendations:

1. Establish networks/consortia of centers, individual investigators, and key industrial leaders working in critical technology areas

2. Increase support for cross-center collaborative projects linking centers in the context of a thematic or technological focus

3. Expand the support to link individual investigators to centers.

TOPIC II. INTERCONNECTIONS AMONG EDUCATION AND DIVERSITY OF HUMAN RESOURCES INITIATIVES AND INDUSTRY

Improving science, engineering, and mathematics education is a key element in improving the quality of the work force at all levels. Assuring the involvement of a diverse population of students will help the country achieve its highest levels of accomplishment. However, the public sector and academe should not undertake those improvements independent from industry. An integrated effort where industry, academe, and government blend their skills and perspectives will strengthen the long-
term effectiveness of our educational enterprise.
These beliefs prompt the following recommendations.

A. Focus More Educational Programs on Industrial Collaboration

Need: NSF is taking a very active role in focusing the nation on improving education in science, engineering, and mathematics from the K-12 level through graduate school. In addition, most NSF center programs effectively combine their research, education, and industrial collaboration in their missions. The I/UCRC Program and the ERC Program have developed a special collaboration with the Education and Human Resources Directorate (EHR) to support Teacher Enhancement and Young Scholars programs at selected centers. The STCs are focused specifically on this level of education. These efforts capitalize on the industrial involvement in these centers for the benefit of the students and their teachers.

Industry for its part, has been very proactive over the years in bringing the diversity of the American population to the attention of NSF and encouraging our support of activities to involve women and underrepresented minorities in science, engineering, and mathematics. EHR currently obtains industrial advice and involvement in its major efforts to focus precollege education on science and mathematics and its efforts to bring underrepresented minorities into these fields and ensure higher rates of retention. These
EHR efforts include the Minority Research Centers of Excellence, the Comprehensive Regional Centers for Minorities, and the Alliances for Minority Participation.

In light of the demonstrated value of these programs, many of them relatively new, and given the need for greater connection between the academic and industrial sectors, there is a need for more emphasis on deepening the connection between the educational system and the industrial workplace.

Recommendations:

1. Increase the opportunity for industrial involvement in education by using the successful collaboration between the Engineering centers programs and EHR as a model for increasing the industrial focus of education programs, such as the Young Scholars and Teacher Enhancement programs and others

2. Encourage REU site awardees to increase industrial contacts for students as a part of the REU experience

3. Develop a focus for traineeships in educational co-op programs where students spend time working on research in industry

4. Assess the role of industry in major educational initiatives to assure their intellectual as well as financial input.

Topic III. NSF'S OUTREACH TO INDUSTRY AND OTHER SECTORS

Need: The Committee acknowledges that NSF's potential to increase interaction with industry is dependent to a large extent on its public affairs strategy. Underscoring the agency's visibility will increase its influence, lead to new and continuous interaction, and claim the attention of the private sector. Many of NSF's current major initiatives will be enhanced by a better understanding by key groups--business and industry and State Governments among them--whose support is critical to the success of those programs. The following recommendations are geared to improving that understanding.

Recommendations:

1. Focus on a proactive communication strategy that will cut across all relevant NSF activities. This strategy should include publications, meetings, speaking engagements, workshops, and media coverage that will direct the NSF story to targeted groups

2. Organize workshops, in coordination with industrial associations, that bring universities and industry together to enhance information exchange, seek knowledge and technology transfer opportunities, and plan cooperative community outreach activities

3. Expand the Director's contacts with Chief Executive Officers (CEOs) and other corporate officials, trade groups, industrial organizations, and state policy makers

4. Seek opportunities for NSF's leadership to help industry bridge the gap between the roles of CEOs and vice presidents for research in industry

5. Encourage community outreach activities from universities and research centers to local communities through design competitions, mentoring programs, after-school programs in science and engineering (modeled after the boy and girls scouts), to bring the excitement of science and engineering to students

6. Solicit increased industry cooperation in community outreach and local media activities.

STRATEGIC ISSUES

Rather than recommend actions on the following strategic issues, the Committee posed them for NSF to consider further due to the challenges they present to the basic mission of NSF.

STRATEGIC ISSUE I. NSF'S POSITION WITHIN THE R&D SPECTRUM

NSF should explore its appropriate role or range of **roles in support of research along the R&D spectrum from basic to experimental proof-of-concept** research exploring possibilities for use. The NSF should continue a dialogue with industry, academe, and the Office of Science and Technology Policy to explore the appropriate role for NSF in the full support of research needed to more closely connect the research base of this country with industrial use.

NSF should examine **expanding its scope to support deep testbeds** necessary to explore a next-generation technology advance. This examination should be made in the light of collaboration with other agencies and consortia of firms.

NSF should explore **establishing Technology Advancement Institutes** where industry and universities meet to continue research experimentation toward development. This may be needed for major systems advances that require large capital investments, that are too large an investment for one firm to undertake, or that are especially long-term and high-risk so that one firm is not likely to take the risk to move. This may be an appropriate place for collaboration with the National Institute of Standards and Technology (NIST), recognizing that NSF's likely role is to see that the necessary research is carried out to fully explore and improve an advance before implementation is undertaken.

STRATEGIC ISSUE II. NSF'S POSITION ON EDUCATION OF THE

TECHNICAL WORKFORCE

The Committee urges the ADs to consider a new role for NSF in educating the technical workforce. There is a growing need for a technical workforce for industry of people who can function at a highly skilled level, knowledgeable about the processes they control and able to manage them to improve productivity. This is an issue to consider seriously if we assume that NSF's role is to contribute to the Nation's ability to create wealth through the application of scientific and engineering knowledge at all levels. Many technical universities and community colleges are beginning to assume this role but can benefit from funds to develop appropriate curricula and "pilot-scale" processing/manufacturing lines with which to teach advanced skills. The role of NSF in relationship to the Department of Education in educating the workforce would have to be sorted out.

STRATEGIC ISSUE III. NSF'S POSITION ON LEARNING STYLES AND EDUCATION

NSF should examine whether the U.S. educational system reinforces a preference for verbal skills, to the detriment of children who could flourish in schools that were set up to focus on the reasoning skills needed in scientific, mathematical, and engineering fields, with verbal skills as a complementary component of their education.

There is a growing recognition that children have different innate capabilities and that most children are not uniformly capable across fields. There has long been a recognized difference in performance among children between fields that are dependent upon verbal abilities and those that depend on analytical and spatial reasoning or mechanical abilities. However, our schools are generally dominated by teachers who are more comfortable with verbally-based learning styles, so that students with those proclivities are more likely to succeed scholastically. The other children are thus placed at a disadvantage and many are "lost" before they are able to experience the excitement of science, analytical reasoning, or fields that depend on spatial and mechanical abilities. These are the fields generally most needed by industry.