Planning and Policy Studies

Through its science resources and policy studies, the Foundation identifies and analyzes important science policy issues; provides an adequate data and methodology base for sound decisionmaking; and develops science planning and policy study capabilities at various institutions in the United States. The information developed through these activities is used in assessing alternatives, in establishing priorities, and in arriving at recommendations concerning the national science effort. The results of these study activities serve not only the requirements of the National Science Foundation, in its concern with the scientific enterprise, but also serve other Federal agencies, Congressional groups, and non-Federal organizations.

SCIENCE POLICY ISSUES

The study of science policy issues is an essential component of any overview of the science picture in the United States. Insight is needed into the interrelationships between the scientific enterprise and the society it serves; the requirements of the various areas of science and engineering must be understood; and assessments of the impact of changes in the scientific resource base and the impact of current and potential changes due to scientific and technological advances must be available for guidance.

With limited resources to draw on, one of the critical and continuing problems facing science administrators is the question of establishing priorities for the competing areas of science. Through its support of the activities and special studies of the Committee on Science and Public Policy (COSPUP) of the National Academy of Sciences and the counterpart Committee on Public Engineering Policy (COPEP) of the National Academy of Engineering, the Foundation has been obtaining information concerning the current status and projected needs of the major areas of science as an aid to the determination of scientific priorities. Two COSPUP studies initiated at the end of fiscal year 1969 with Foundation support were fully underway in fiscal year 1970. One study concerned the status and needs of astronomy (both ground and space based), the other concerned the picture for physics. These studies represent the first efforts of COSPUP to update previous reviews of scientific disciplines. The new reviews are aimed at establishing not only the current and foreseeable needs and problems of these two disciplines but also at determining their relevance to other areas of science and technology and to society in general. The reviews will also concentrate on the establishment of priorities within these broad fields. Additional updating efforts, for other disciplines, are currently being planned in order to assure that information available keeps pace with rapidly changing scientific and technological developments.

Over the past year, support of the Committee on Public Engineering Policy continued. The committee addressed itself largely to the question of engineering as it relates to social utility. One activity culminated in the publication of a report, *Priorities in Applied Research*, which recommended that applied research be undertaken in the following major areas: the biosphere, techniques for applied social research, materials research, construction, and transportation.

Another important issue upon which attention was focused during the year concerned the effect of changes in Federal funding patterns on academic institutions in the United States. Federal obligations to universities and colleges totaled

$3.5 billion in academic year 1968–69, representing only a 2 percent rise over the previous year and the second consecutive year in which the growth rate was limited to this level. In contrast, the annual growth rate during the 1963–67 period was 24 percent.[1] Firm data have not been available on the effects of the changed funding pattern and the Foundation, with the encouragement of the Office of Science and Technology, initiated a survey to determine quantitatively the actual impact on academic institutions. The first phase of the study was conducted in fiscal year 1969 in about one hundred universities and some seven hundred graduate departments within these universities. Since the results of this survey indicated that 1968–69 constituted the first year of a major transitionary period, a second phase of this study was initiated in 1970 to provide a comparison over more than one time period. Results will be published in fiscal year 1971.

Also studied during this past year was the question of possible future imbalances between the pool of available Ph.D.'s in science and engineering and requirements for their utilization, a topic of particular importance when viewed within the context of a rapidly changing national situation. The National Science Foundation undertook to analyze and project the future relationship between the supply and utilization of science and engineering doctorates. The results of this analysis were made public in a report, *Science and Engineering Doctorate Supply and Utilization, 1968–80*. This and subsequent analyses seem to indicate that, by 1980, 320–350,000 science and engineering doctorates (compared with about 150,000 in 1968) might be available. However, present job markets for doctorates are not nearly as favorable as they have been in past years, though it is not clear in the current fluid situation whether the major present problem is a mismatch between opportunities and aspirations or actually an oversupply of Ph.D.'s. Thus, the 1980 pool of doctorates will depend on the extent to which the present situation will affect graduate school enrollments and thus the future rate of Ph.D. production. With regard to utilization, several projections were made on the basis of varying assumptions. The projected relationship between supply and utilization figures indicates that by 1980, the supply and utilization of science and engineering doctorates is likely to be in equilibrium. However, it would also appear that significant numbers of Ph.D.'s are likely to be engaged in activities which are markedly different from the primary ones practiced by most present doctorates. Examples of these different activities include non-R&D functions in industry and government as well as teaching in 2- and 4-year colleges. Recent evidence shows that the shift is already beginning. Implications of this analysis are that Ph.D. education should offer a variety of different programs including training most suitable for these new activities. It thus appears necessary for universities to examine their graduate programs and to develop new and different curricula for Ph.D.'s who do not intend to enter research careers.

[1] National Science Foundation, *Federal Support to Universities and Colleges and Selected Nonprofit Institutions, Fiscal Year 1969* (NSF 70-27) Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1970.

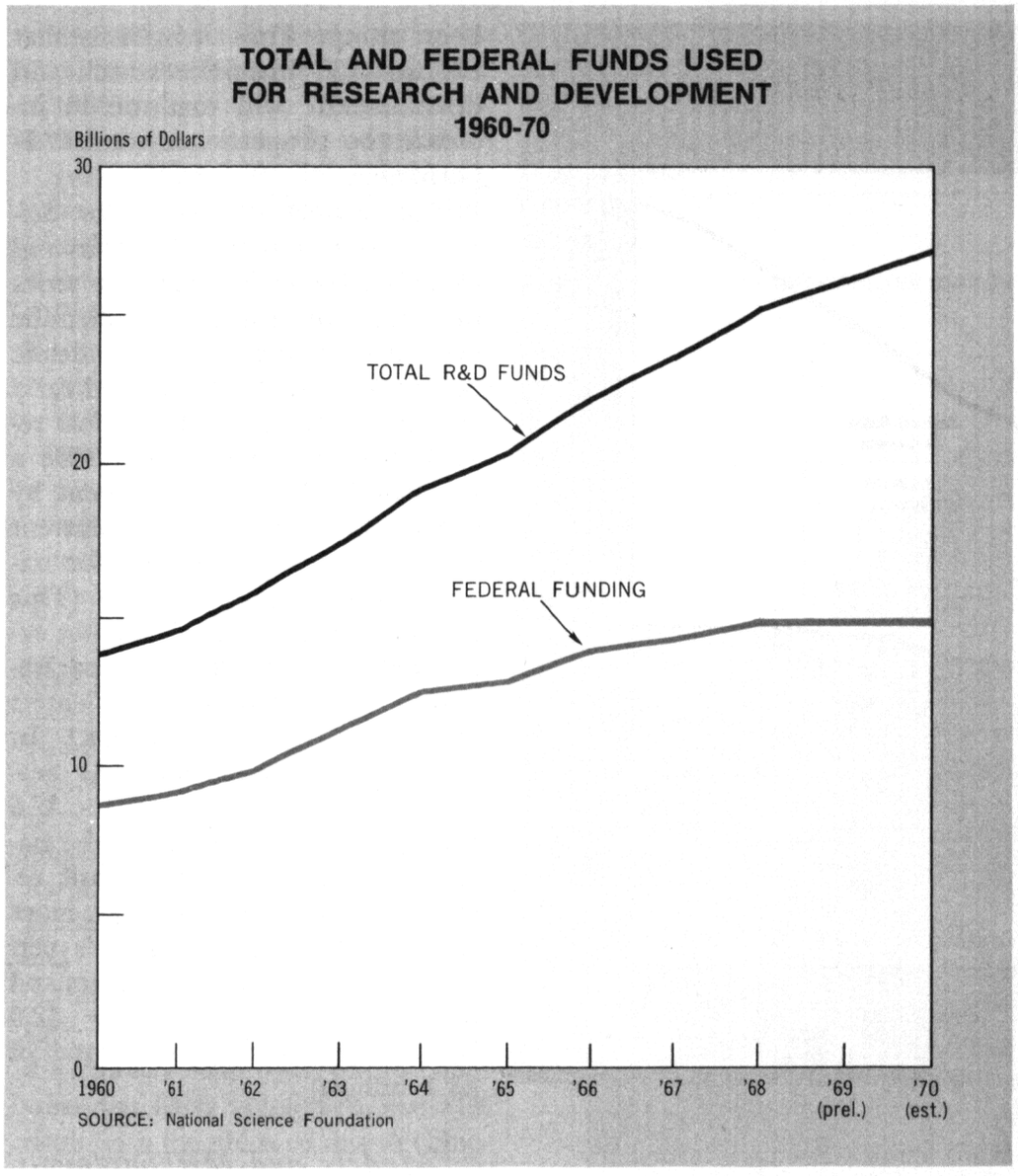
DEVELOPMENT OF BASIC TOOLS FOR SCIENCE PLANNING AND POLICYMAKING

The development of an adequate data and methodology base for the making of science policy decisions is carried out by the Foundation through a broad range of study activities. Included are studies for the collection and analysis of data concerning the nation's scientific resources; the development of concepts and projection and modeling techniques relating to these resources; and the correlation and synthesis of information from many sources on the flow of resources to scientific and technical activities. The more important results of these efforts are highlighted below.

The National Scene

A comprehensive review of total national expenditures for research and development over the period 1953 to 1970 was published in fiscal year 1970 in the NSF report, *National Patterns of R&D Resources*. The data in this publication were obtained through the periodic NSF surveys of all sectors of the economy. They revealed that in 1970 national R&D expenditures, from both Federal and non-Federal sources, reached an estimated record level of $27 billion. This amount is $1 billion higher than the estimated 1969 level and nearly $7 billion more than in 1965. However, the average annual rate of growth during the 1965–70 period was only 5.9 percent compared with a 9.4 percent average for 1958–65. Furthermore, this growth rate over the last 2-year period, 1968–70, has declined to a 3.6 percent level. The major reason for the decline has been a leveling off of R&D support by the Federal Government. Federal expenditures for R&D between 1958 and 1965 grew by 12.3 percent annually but increased by an annual average of only 3.4 percent between 1965 and 1970 and showed no increase at all in the period between 1968–70, remaining constant at about the $15 billion level. (See chart.)

The report on national R&D ex-



penditures also presented information on the full-time equivalent (FTE) number, and sectoral distribution, of scientists and engineers engaged in research and development. During 1968, an estimated 565,000 FTE scientists and engineers were engaged in research and development. Although this was nearly two and one-half times the number employed in R&D activities in 1954, the rate of increase of R&D scientists and engineers has been declining in recent years. Between 1954 and 1961, the annual average rate of growth of R&D scientists and engineers was 8.7 percent. This growth rate fell to 4.1 percent between 1961 and 1968.

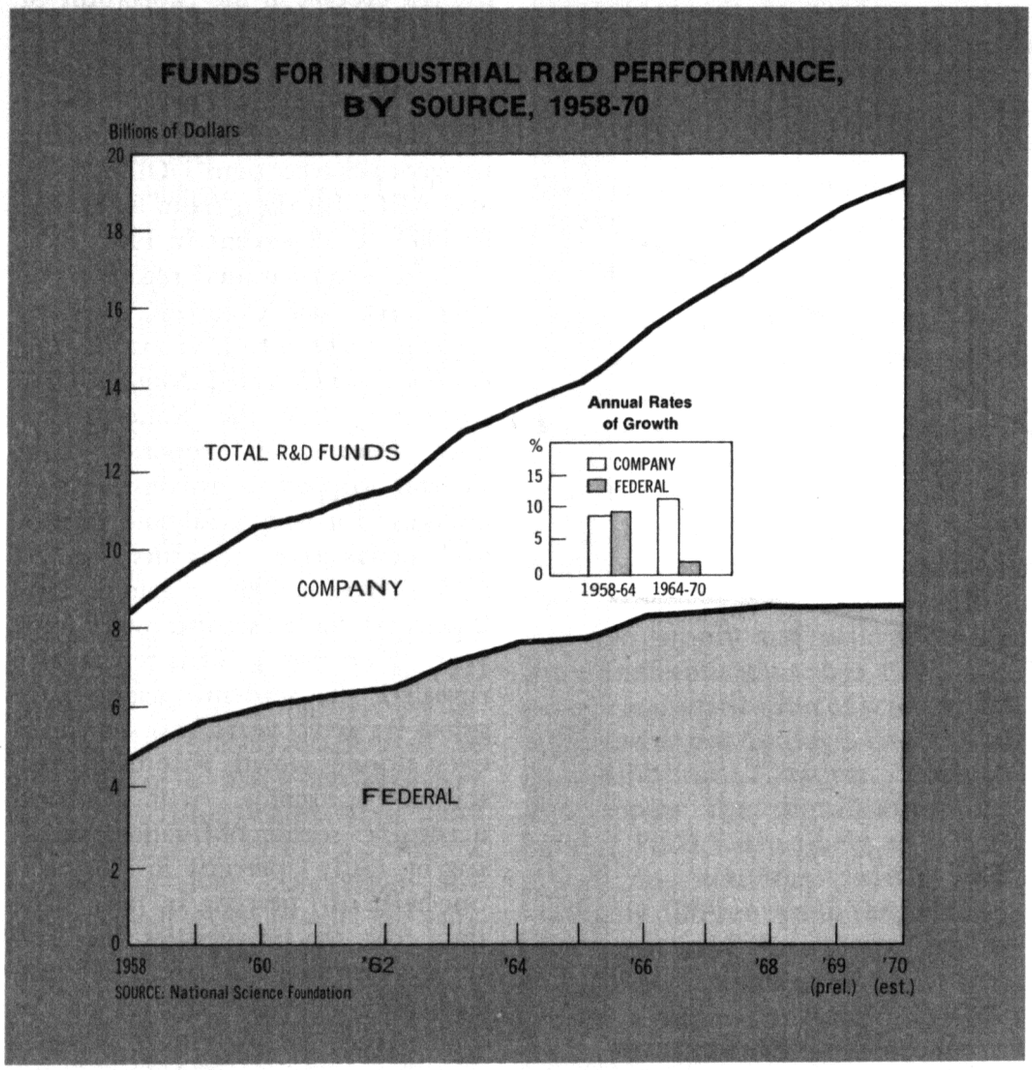
Federal R&D Support

Federal obligations for research and development—as distinct from R&D expenditures discussed above—totaled $15.6 billion in fiscal year 1969 and were expected to total approximately the same amount in both fiscal years 1970 and 1971. (See volume XIX, *Federal Funds for Research, Development, and Other Scientific Activities.* NSF 69-31.) This represents a decline in support from the 1967 R&D obligation total of $16.5 billion—the year of the highest dollar funding of Federal R&D programs. The report on Federal funding also indicates that there has been a significant increase during the last decade in the proportion of federally sponsored R&D activities devoted to areas other than military, space, and atomic energy efforts. The share of total Federal funding in agencies other than DOD, NASA, and AEC has risen from 9 percent in 1960 to 18 percent in 1970.

In its second annual report to the President and Congress, entitled *Federal Support to Universities and Colleges and Selected Nonprofit Institutions, 1969,* the National Science Foundation reported that Federal support to universities and colleges for both academic science and nonscience activities totaled $3.5 billion in 1969, a gain of only 2 percent for the second consecutive year. (See chart.) This report also revealed that academic science programs in recent years have shown an even slower growth rate than nonscience programs, with Federal academic science obligations growing by only 1 percent in 1968 and one-half of 1 percent in 1969. The data for the universities and colleges appearing in this study are gathered under the auspices of the Committee on Academic Science and Engineering (CASE) of the Federal Council for Science and Technology.

In addition to the report to the President and Congress which presents detail for individual institutions, CASE is collecting data on individual federally sponsored university projects covering both funding and manpower associated with the projects. A publication covering this project reporting is expected during fiscal year 1971.

At the request of the Federal Council for Science and Technology, the National Science Foundation compiled a *Directory of Federal R&D Installations.* This directory, the first of its kind, was prepared and released for public use in 1970 and provides a comprehensive general reference to R&D



establishments owned and directly controlled by the Federal Government. More than 700 installations are listed in the directory with information provided concerning their location, size, functions, activities, and capabilities. It is anticipated that the directory will be an important mechanism for making more widely known the Federal installations capable of dealing with significant research and technological problems, and that it will also further interagency use of Federal R&D resources.

Non-Federal R&D Support

In contrast to the Federal R&D funding picture, industry has been increasing its financial contribution to R&D at an increasing rate of growth as reported in the NSF publication *Research and Development in Industry, 1968*. In 1968 industrial firms supported 51 percent of their R&D performance with their own funds compared with a decade earlier when companies funded only two-fifths of their R&D activities. In total, industry spent $8.9 billion in 1968 on company-financed research and development, and the Federal Government funded an additional $8.6 billion of industrial research and development. Indications are that the amount of Federal support for industrial research and development has been leveling off since 1968, while the amount of company support has been rising. Thus, it is likely that industrially financed research and development will continue to increase as a proportion of total R&D performance. (See chart.)

The report *Resources for Scientific Activities at Universities and Colleges, 1969,* the latest in a series providing information on scientific activities in the nation's academic institutions, will be published early in fiscal year 1971. This report reveals that in academic year 1968 a total of $7.0 billion was spent by universities and colleges (in current and capital expenditures) for science research and instruction. (This figure does not include funds expended by Federally Financed Research and Development Centers located at these institutions.) In 1968, R&D expenditures at academic institutions amounted to $2.6 billion, only 10 percent of the national total. In terms of basic research dollars spent, however, more than one-half of the nation's performance took place in colleges and universities (approximately $2.0 billion out of a national total of $3.7 billion).

Models and Methodology

In addition to having current, accurate data for planning and policy purposes, it is important to have available suitable models which can assist in putting the data to use. The development and testing of models and methodologies for use in science planning is still in its early stages and the Foundation has continued to encourage and support new exploratory efforts.

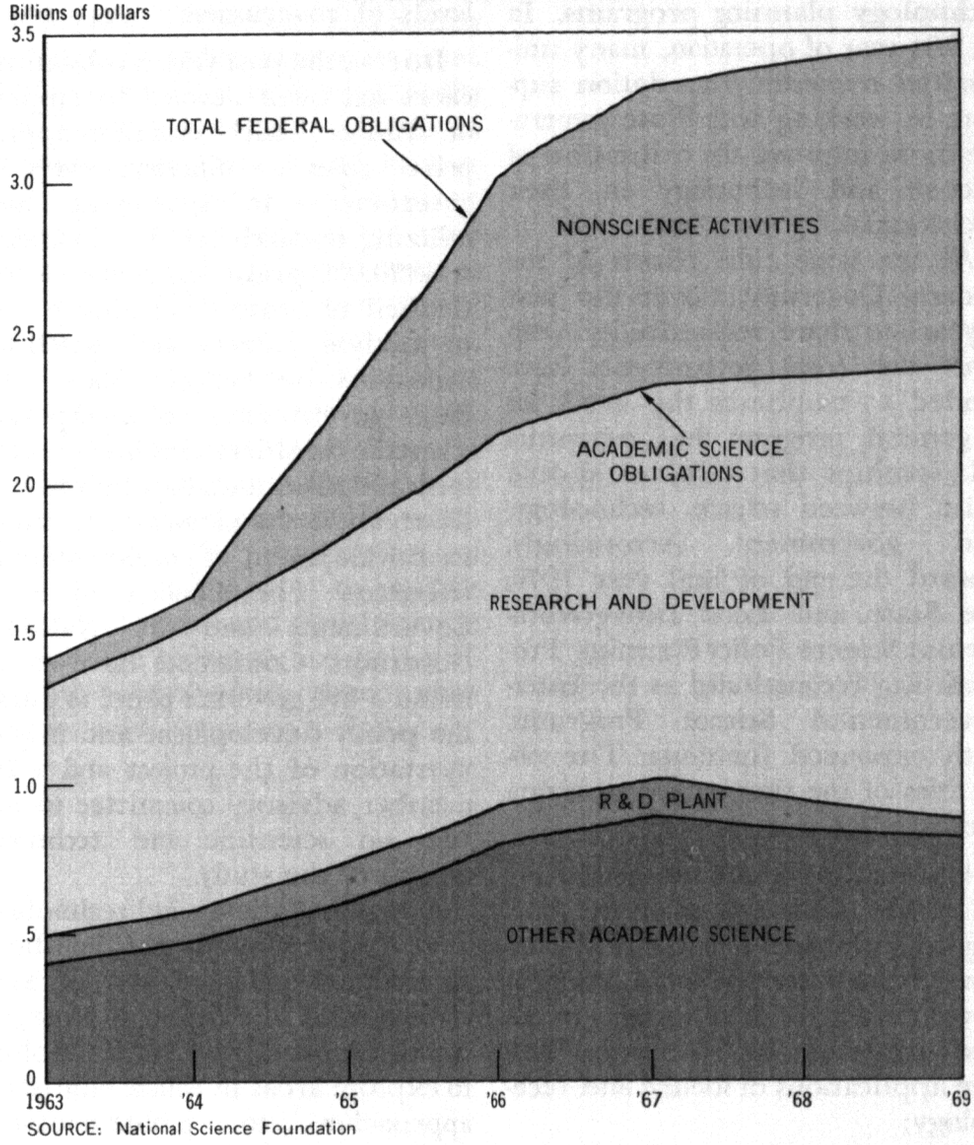
In 1969–70 the Institute for the Future completed a study designed to improve long-range forecasting techniques. New techniques were developed, tested, and applied prospectively and retrospectively to areas of economics, political science, and technology. Specific cases chosen for analysis included:

- the diffusion of hybrid corn in the midwestern United States in the 1930's;
- the dependence of population growth on family planning, health care, mortality, production, etc.;
- the Indian economic Five-Year Plan of 1956;
- future developments in low temperature physics and cryogenics and their interrelationship with certain social changes;
- the social, political, and economic impact of introducing certain technologies into developing countries.

Although the study primarily dealt with the development of methodological techniques, the advice of experts was used to develop the technical framework for consideration of the problem. For example, in the low temperature physics project, physicists were asked to predict the most likely scientific and technological developments occurring over various periods of time. Questions asked of a multidisciplinary team covered not only what was likely to happen, but also dealt with the effects of one development on others. This technique produced matrices which indicate whether one development is likely to increase or decrease another's likelihood. The results strongly indicate that this cross impact method has great potential in a comprehensive approach to forecasting.

NSF has also been contributing to a nationwide effort among academic institutions to design, develop, and implement information systems for their individual use. Conducted by the Western Interstate Commission for Higher Education (WICHIE), the effort involves the development of resource allocation, cost, funding, student flow, and other planning models. In fiscal year 1969 a state-of-the-art seminar was held by WICHIE, supported by the Foundation and the U.S. Office of Education, regarding developments in management information systems and planning models. In fiscal year 1970, again joining with the Office of Education, NSF helped support a WICHIE seminar on the "outputs" of higher education. The conference brought together leaders in higher education research to discuss the identification and quantification of the products of higher education.

FEDERAL OBLIGATIONS TO UNIVERSITIES AND COLLEGES, BY TYPE OF PROGRAM, FISCAL YEARS 1963-69



SOURCE: National Science Foundation

DEVELOPMENT OF SCIENCE PLANNING AND POLICY CAPABILITY

Intergovernmental Science Programs

Fiscal year 1970 saw a significant expansion and reorientation of an NSF activity formerly known as the State and Local Government Science Policy Planning Program. This

program was originated in fiscal year 1969 as an experimental effort to assist State governments in strengthening their science and technology planning programs. In its first year of operation, many universities requested Foundation support in working with State governments to improve the utilization of science and technology in their decisionmaking processes.

At the same time, efforts of the Federal Government over the past 8 years to share responsibility with State and local governments have tended to emphasize the need for a general program that examines relationships that exist, or should exist, between science, technology, and government. Accordingly, toward the end of fiscal year 1970, the State and Local Intergovernmental Science Policy Planning Program was reconstituted as the Intergovernmental Science Programs, with expanded functions. The objectives of the reorganized program are as follows:

1. To advance the understanding of public issues and problems having scientific and technological content at the State and local levels of government, and to assess needs and opportunities for more effective applications of science and technology;

2. To demonstrate innovative science and technology planning and decisionmaking processes related to State, local, and regional problems;

3. To stimulate selected State and local government experimentation, on a pilot basis, with science and technology systems in the context of their own needs and resources;

4. To encourage adoption of new systems which show promise for enhancing State and local ability to incorporate science and technology into public programs;

5. To improve communication between persons and groups concerned with science and technology at the Federal, State, and local levels of government.

During the past year, a substantial effort has been devoted to support of studies which examine appropriate roles of different levels of government in sponsoring and utilizing research and development. A $320,000 grant was given to the Council of State Governments (1) to analyze current and potential endeavors by Federal, State, and local governments to incorporate scientific considerations into governmental decisions and operations and (2) to assess the national machinery for development of problem-solving resources. The Council of State Governments and the National Governors' Conference have established a five governor panel to guide the policy development and implementation of the project and a 20-member advisory committee to advise on scientific and technical aspects of the study.

A regional science and technology award was given to the Southern Interstate Nuclear Board in association with the States of Georgia, North Carolina, and South Carolina to explore areas in which multistate approaches to problem-solving might be desirable either because of economics of scale or in areas where problems transcend State boundaries. This study, in addition to an earlier study supported at the University of Tennessee, will also examine how individual States might improve their program and policy relationships with the Federal Government.

Another grant was made to the California State Assembly to examine how scientific and technological considerations can be incorporated into the legislative process. In addition, several smaller grants were made to examine different areas of State science and technology policy relating to environmental quality (Louisiana), technological forecasting (Montana), development of new mechanisms for relating academic research outputs to government decisionmaking (Virginia), and Federal-State-local support and utilization of research and development in regulating air pollution (Pennsylvania). A grant to use a new technique of simulation to study Federal-State decisionmaking in regard to allocating governmental resources for science and technology was made to the Institute for the Future.

To improve communication between governmental leaders and the scientific community, a series of four regional (Southern, Eastern, Western, and Midwestern) and one national conference on Science, Technology and State Government were supported in conjunction with other Federal agencies and State organizations.

A survey of scientific and technological advice available to local governments was supported under a joint grant to the New York State Department of Education and the International City Managers Association. This will provide information at the local level to supplement information at the State level that will be obtained under nine State case studies of the science advisory mechanisms to State government supported under earlier NSF grants.

University Science Planning and Policy Program

The University Science Planning and Policy Program is designed to assist in the development of the resources and capabilities of academic institutions for training and research related to science planning and policy activities. The program was established in recognition of a critical need for a better under-

standing of the many complex science policy issues and the lack of adequately trained manpower to deal with these problems.

Institutions currently receiving grants under this program include Harvard University, Massachusetts Institute of Technology, University of Virginia, State University of New York at Albany, Cornell University, the University of Indiana, Stanford University, and the University of California at Berkeley.

These grants help to support teaching, research, and special seminars on such science policy problems as: the use of science in international affairs; scientific and technical manpower; environmental management; technology and the city; nuclear energy, the law and international affairs; the effects of new educational technology; legal and moral implications of modern biology and medicine; the effects of technology on economic growth; and the organization of large-scale technological projects.

The Cornell University Program on Science, Technology and Society has, during the first year of its grant, been successful in involving faculty and students from many disciplines, including the sciences and humanities, in new courses and seminars jointly sponsored with other units of the university, in such areas as Biology and Society, International Flows of Science and Technology, Social Implications of Technology, Law and Environmental Control, and Technology Assessment.

Under recent grants, Harvard will develop a series of case studies which demonstrate the application of analytical techniques to public policy problems; and Stanford will analyze the technical and policy alternatives involved in telecommunications and computer technology.