

*Research
Applications*

RESEARCH APPLIED TO NATIONAL NEEDS

In fiscal year 1971, the NSF organized the bulk of its problem-focused research into a single set of program activities administered by a new Research Applications Directorate. Existing programs in Earthquake Engineering, Weather Modification, and Interdisciplinary Research Relevant to Problems of Our Society (IRRPOS) form the nucleus of the program of Research Applied to National Needs (RANN). Also administered by the Research Applications Directorate is the Office of Intergovernmental Science Programs, now entering its third year.

The Foundation has supported problem-oriented research for more than a decade. Programs such as Earthquake Engineering, Weather Modification and others have yielded considerable experience in the

successful management of these efforts. The Foundation is now applying and building on this experience with a significant part of its resources to encourage research targeted on objectives and foreseeable benefits. Through these programs the Foundation seeks to mobilize a portion of the nation's scientific talent and technological capability for resolving important problems of national concern.

RANN is organized into four major program areas. The Division of Environmental Systems and Resources administers programs in the areas of regional environmental systems, environmental aspects of trace contaminants, and weather modification. The Division of Social Systems and Human Resources administers programs in the areas of municipal operations and services, social data and community structure, and methodologies for evaluating social programs. The Division of

Table 6
Research Applications Obligations
Fiscal Year 1971
(Millions of dollars)

	Number of awards	Funds obligated
Research Applied to National Needs	213	\$34.0
Division of Social Systems and Human Resources		
Municipal Systems Operations and Services	7	1.6
Social Data and Community Structure	7	5.4
Evaluation Methodologies for Social Programs	1	.1
Subtotal	15	7.1
Division of Environmental Systems and Resources		
Weather Modification	22	3.4
Trace Contaminants	7	1.5
Regional Environmental Systems	19	4.3
Subtotal	48	9.2
Division of Advanced Technology Applications		
Disaster and Hazard Research	36	3.6
Technology Needs and Opportunities	52	5.3
Urban Technology	8	.7
Energy Resources, Research and Analysis	26	5.1
Subtotal	122	14.7
Office of Exploratory Research and Problem Assessment		
Problem Definition and Assessment	16	1.4
Exploratory Research	12	1.6
Subtotal	28	3.0
Intergovernmental Science Programs	28	.8
Total	241	34.8



Tributary of the Gallatin River, which may be affected by a recreational development to be known as Big Sky. Scientists at Montana State University are performing baseline measurements to measure the degree of impact on the environment. (Photo Montana State University/Max Hunke)

Advanced Technology Applications administers programs in the areas of energy resources research and analysis, urban technology, earthquake engineering, fire research, excavation technology, enzyme technology, industrial processing, and instrumentation technology. The Office of Exploratory Research and Problem Assessment provides support for efforts to define and analyze emerging problem areas and promising research strategies, to assemble and synthesize relevant existing knowledge underlying such problem areas, and to initiate research efforts in new areas which might be the subject of concentrated research efforts. Problem assessment and technology assessment functions are centered in this office. The Office of Intergovernmental Science Programs focuses on the development of improved programs and institutions for making science and technology available for use by States and local governments in solving

problems, including the utilization of results from both RANN and other NSF programs that have important applications to those problems.

ENVIRONMENTAL SYSTEMS AND RESOURCES

The major goals of RANN programs on the environment include an improved understanding of environmental systems for more effective efforts to prevent environmental degradation, wise development of national resources, and accommodation of man's activities to environmental constraints.

The studies currently supported generally fall into three categories: comprehensive investigations of regional environmental systems, analyses of environmental aspects of trace contaminants, and weather modification research.

Regional Environmental Change in Southwestern Montana

An interdisciplinary team of investigators has been organized at Montana State University to examine the nature and magnitude of the environmental, social, and economic consequences of a large-scale, diverse recreational development in southwestern Montana, known as Big Sky. They have gathered baseline data on many variables likely to be influenced and are now beginning to monitor changes. Their results will include such things as changes in water quality due to the introduction of sewage systems and the changes in community service requirements due to rapidly expanding population. These results are intended to provide a basis for conducting environmental impact studies for similar developments in other parts of the country and for land planning efforts on the periphery of Big Sky. Preliminary data from an exploratory study have already proven useful to a number of agencies and organizations such as the U.S. Forest Service and local planning groups.

Methyl Mercury, A Trace Contaminant

Thomas W. Clarkson at the University of Rochester is concentrating on the biomedical dangers of methyl mercury and related compounds, an environmental problem that received widespread public attention during 1971. Known as a poison since ancient times, mercury has been released, with minimal caution, chiefly into aquatic environments. Despite the growth in numbers of industrial sources and the quantity of mercury processed, the widespread belief that such wastes were very dense and very insoluble had led to what now turns out to be a false sense of security. It is now recognized that some aquatic microorganisms can convert previously in-

soluble deposits of mercury to highly soluble, diffusible and toxic mercury compounds.

As a result, (1) mercury contamination is much more widespread than expected; (2) its concentrations are higher than expected; (3) it is being concentrated still further in the food chains; (4) the toxicity of methyl mercury is many times greater than inorganic mercury itself; and (5) the problem may be irreversible, since few data exist to develop a useful technology to neutralize the mercury already released.

The work at Rochester, a series of coordinated interdisciplinary studies, is concerned with the dynamics of mercury flow through man, including its chemical transformations and the effects it produces. Specific experiments will evaluate conversions of inorganic mercury to the more toxic methyl mercury in microorganisms, the selective action of mercury on the microecology of the intestine, the essential parameters that determine absorption, distribution, and excretion of methyl mercury from the body and its effects on the central nervous system, on the fetus and on the genetic apparatus. Means of reducing absorption and of increasing excretion of mercury will be examined as potential therapeutic and preventive measures. The Food and Drug Administration is cooperating with the National Science Foundation in support of this effort both scientifically and financially.

The National Hail Research Experiment

A major portion of the weather modification program in fiscal year 1971 was directed toward strengthening the effort on the National Hail Research Experiment which is being conducted in northeastern Colorado under the management of the National Center for Atmospheric Research.

A field headquarters has now been established in Grover, Colo.,



Hail causes hundreds of millions of dollars worth of damage to crops and property every year in the United States. This field of corn near Julesburg, Colo., destroyed by a hailstorm in June 1970, illustrates the sort of destruction that hail can inflict on farmers of the Great Plains. (Photo NCAR)

and airborne and ground elements of the field observing network were calibrated and tested in the field in preparation for the first full field operation in the summer of 1972. The objective of the experiment is to develop an understanding of the mechanisms of severe storms which generate damaging-sized hailstones, and then to devise modification techniques which will suppress their formation. A "protected area" of 600 square miles has been extensively instrumented to observe the effects of silver iodide seeding upon hail formation. During the trial phase in 1971, no aircraft-launched rocket seeding devices were deployed due to the need to complete further FAA qualification tests. However, pyrotechnic seeding devices were carried by small aircraft into critical updraft areas of the storms and ignited. A dual wavelength hail detection radar has been constructed jointly by the University of Chicago and the University of Illinois and is now being tested in the vicinity of Urbana, Ill., before

being installed in northeastern Colorado. The radar is expected to be capable of differentiating between the echo received from a liquid water droplet or an ice particle in a cloud. The National Hail Research Experiment will involve the cooperation of seven universities in addition to the participation of five Federal agencies and the Colorado Air National Guard.

SOCIAL SYSTEMS AND HUMAN RESOURCES

The effort to develop an improved understanding of social systems and social data is intended to increase our ability to deal with problems which affect the quality of our society. The research programs on municipal systems, evaluation methodology, and social data and community structure pursue the objective of providing information and analysis of concrete and realistic policy alternatives available to State, local, and Federal officials.

Studies of the Municipal System of New York

One of the problems of the individual in a municipal system who must make policy decisions is the availability of up-to-date information. The Urban Science and Engineering Program of the State University of New York at Stony Brook has a program in which members of its faculty have been working closely with agencies of the New York City government. For instance, they have assisted a city agency in developing cost-effective means of scheduling sanitation crew work loads efficiently and to provide crews for peak collection periods while also giving workers the maximum number of 3-day weekends and equitable work assignments.

Carbon Monoxide in St. Louis

A quite different form of information to serve decision-makers is being provided in the St. Louis area. Drawing on the diverse disciplines of sociology, mathematics, hematology, geography, systems engineering, and urban and regional planning, investigators from Southern Illinois University and the medical schools of St. Louis and Washington Universities are collaborating in an effort to develop a carbon monoxide diffusion model to be used in transportation planning. The project also involves the cooperation of the St. Louis chapter of the Red Cross, the St. Louis County Health Department, the Illinois Environmental Protection Agency, and the Department of Public Safety in the collection and provision of data. In addition, members of a black community group, Black Survival, will participate in providing information to inner-city residents about the purposes and results of the project. Major aims are to determine the relationships between carboxyhemoglobin in individuals and various personal, environmental, and vehicular traffic factors, and to develop a pre-

dictive model of expected carboxyhemoglobin levels under changing environmental conditions for use in national and local transportation planning.

The Social Science Research Council and Evaluation Methodology

The need for new methods to come to grips with the rapid pace of social change has led to another set of research activities. One of the more pervasive problems of social programs is the development of satisfactory methods for evaluating their effectiveness. The Social Science Research Council, with the encouragement of the President's Science Advisor and the President's Science Advisory Committee, is continuing its work on the methodology of social experimentation. The council will concentrate on the scientific, managerial, and institutional aspects of carrying out and evaluating experimental studies of social innovations. A core group of senior social scientists with special competence in methodology was assembled by the council for an initial workshop during the summer of 1971 and, during the summer of 1972, will submit a report for publication.

Acquisition of New Data on Social Behavior

New methods are also being developed to help study the impact on man of the environment he builds around him. An interdisciplinary group of architects, planners, and social scientists at Princeton University is studying the effects of buildings and communities on personal behavior, effectiveness, and satisfaction. This project's goal is to define new criteria, concepts, and methods for assessing environmental effects on behavior. Research sites will include both a working and a living habitat and communities consisting of buildings designed by in-

dividual architects as well as by community planners and real estate developers. The researchers expect to develop methods of analyzing and measuring the user's perception of spatial environment, his reactions to it, and the satisfactions he draws from it.

Consideration of both the need for more rigorous methods and the need for more complete information on the quality of life in the nation has led to a broad 3-year grant to the University of Michigan. There the Institute for Social Research (ISR) is measuring and assessing changes in the socioeconomic status, living conditions, and attitudes of the population of the United States. The institute is collecting new data as well as preparing historical data to identify long-term changes. Moreover, with strengthened technical and statistical resources, ISR is improving the quality of the social data they are making available.

Social phenomena are complex, but research can contribute to analyzing and eventually understanding the interaction of the many factors. A team of engineers, physicists, and social scientists at Brown University received an exploratory award for research on which to base an empirical test of an urban dynamics model developed by Jay Forrester. They intend to apply the model to the Providence area, to supply more detailed data than used in Dr. Forrester's initial model, and to demonstrate to policy-makers and decision-makers how the model may be used for dealing with real problems.

ADVANCED TECHNOLOGY APPLICATIONS

This category of RANN projects involves the application of advanced scientific and engineering knowledge to major social, economic, and environmental problems. The objectives of the program are to foster the development, augmentation, and

application of technologies that will aid in the solution of such problems.

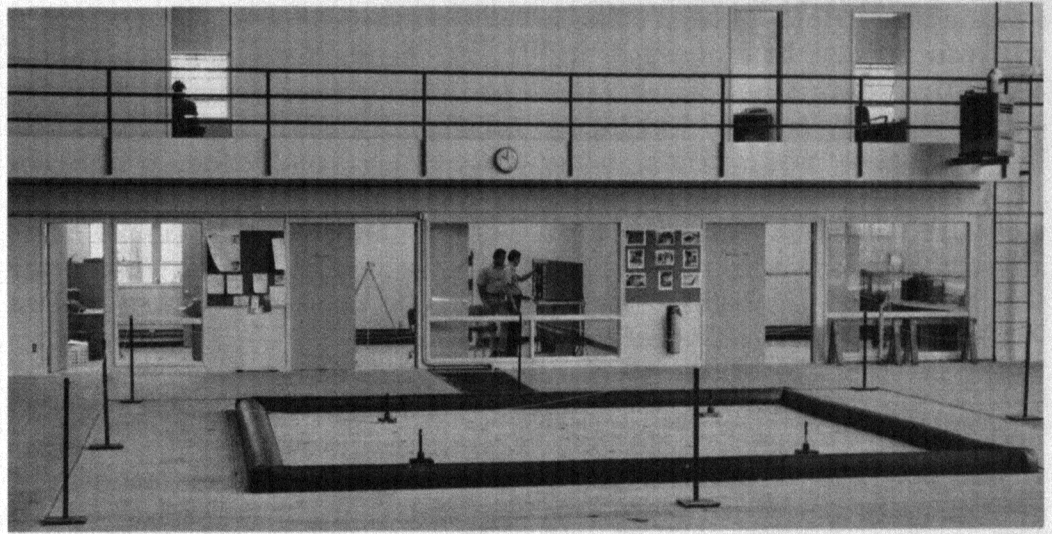
Work currently supported includes elements of programs previously under way elsewhere in the Foundation on research related to fire, energy studies, and earthquake engineering.

Fire Research

An important factor in determining the relative safety of various materials is to test the damage they will do to human skin under fire conditions. So many variables are involved that what is needed is a system that will allow actual experimentation using an analog of human skin. A group at MIT, under the direction of Glenn Williams, has developed just such a simulant of skin for use in measuring the flammability characteristics and burn potential of fabrics. The simulant also serves as a tool to check the reliability of theoretical analyses which are being developed. The MIT project and another grant, for ignition studies, at Georgia Institute of Technology are part of a cooperative effort with the National Bureau of Standards which is directed at the problems associated with establishing standards for fabric flammability. Three trade associations have provided funds for complementary research in two nonacademic institutions—Factory Mutual Research Corporation and Gillette Research Institute.

Earthquake Engineering

The San Fernando earthquake of February 9, 1971, caused damage of nearly a billion dollars to buildings and facilities in the San Fernando Valley and in the Los Angeles metropolitan area. Because of the number of modern structures damaged and because of the unusually complete acceleration measurements obtained, this earthquake is of very great engineering significance and presents unparalleled opportunities



This structure at the University of California, Berkeley, is being used to subject full- or half-scale structures or structural components to the types of motions that actually occur during earthquakes. (Photo University of California, Berkeley)

for research in all aspects of earthquake engineering.

In the past several years, new mathematical tools utilizing large-scale computing equipment have been developed to analyze the effects of earthquakes on engineered structures. To verify these analytic tools, laboratory tests of model and full-scale structures, shaking tests of actual buildings, and studies of strong-motion responses of structures subjected to actual earthquakes have been undertaken. In addition, the magnitudes, frequencies, orientations, and durations of the forces resulting from earthquakes must be better known: There is much information that cannot be reconstructed by simply examining the damage. The San Fernando earthquake yielded 272 strong-motion records; the instruments were mounted on dams, rocks, soils of several different characteristics, building basements, and upper stories. These records are a vital link in the efforts of engineers to develop improved methods of design and analysis.

As a first step in recovering as much information as possible from this event, Caltech is processing and disseminating copies of the strong-motion records to researchers and

engineers in the field. The second step is a series of detailed studies of engineering consequences by six universities (Purdue, Caltech, UCLA, Berkeley, MIT, and Illinois). This collaborative program includes the following basic topics: (1) damage documentation studies—a systematic seismic risk analysis of the performance of modern buildings; (2) structural response to earthquake loading—an analytical and experimental investigation of critical damage observed in certain buildings as a result of this earthquake; and (3) soil-foundation response to earthquake motion—the correlation of known soil motions and structural response.

Prior to the San Fernando earthquake, the National Information Service for Earthquake Engineering (NISEE) was established by concurrent grants to the California Institute of Technology and the University of California, Berkeley. This is a program to collect, organize, and disseminate information. Basic collections are being strengthened and made more accessible to structural engineers, research workers, and building department officials. Catalogs of such material will be issued, and facilities are being established for the rapid reproduction of reference materials so that they can be

supplied at nominal charge. Caltech will concentrate on collecting and evaluating data about earthquake strong motions and on developing instruments to measure them, while Berkeley will be headquarters for computer methods for structural analysis, dynamic tests of soils and structures, and an abstract service for foreign and domestic literature.

Energy Problems

The activities of the energy resources program fall into two general classifications: (1) surveys and analyses of energy resources and research; and (2) support of specific research and development projects that will have direct impact on the energy problems of the nation.

The first classification includes analysis of energy systems and technology to determine their impact on the environment, inventories of energy research, and identification of significant elements of energy economics and policy. One such project undertaken by the National Academy of Engineering seeks to develop a mechanism for supporting the formulation of national energy policies.

The second classification includes research projects on land use, power plant siting and power transmission, solar energy, and thermal energy storage. For instance, one of the great problems for electric power generating systems is the variability of demand for its product and the inability to stockpile it. One of the most obvious aspects of the problem is the summertime "brownout" produced by too-heavy demands on the system by late-afternoon use of air conditioners. Manfred Altman's group at the University of Pennsylvania has presented a technique, using salt hydrates that can "store coolness," that may help alleviate the brownout problem. The salt hydrates, or thermal energy storage material, can be cooled at night, when demand for power is low, and its coolness given up during the heat

of late afternoon when demand is high, thereby helping to iron out the peaks in power demand. The Altman group has come up with a prototype air conditioner which not only evens out power demand, but—even though it must run 24 hours a day—uses 15 percent less power overall to produce the same amount of cooling.

At the California Institute of Technology, the Environmental Quality Laboratory, under the direction of Lester Lees, is mounting a concerted and sustained attack on critical environmental problems affecting modern society. Among their studies are investigations of power utilization and power-plant siting in relation to power needs, economics, and environmental deterioration. EQL's power-plant siting study will investigate the possibilities of dispersing waste heat by remote siting of power plants, or by offshore, under-ocean, or underground siting. Their engineering and economic study will be interpreted in the light of alternate projections of the increase and distribution of human populations in the affected area. Correlated studies by scientists will estimate how different populations would be affected under varying assumptions of energy distribution.

EXPLORATORY RESEARCH AND PROBLEM ASSESSMENT

A critical concern for the overall RANN program is the identification of emerging national problems on which research is most needed and to which research can be effectively applied.

The purpose of exploratory research and problem assessment is to examine the total context of societal problems and to identify the research opportunities which are critical for dealing with them. Research on improved assessment and evaluation methodologies is encouraged,

as is the development of effective organizations and procedures for problem-oriented interdisciplinary research. Innovative institutional groupings and joint arrangements between universities and both non-profit and commercial firms are of particular interest in this latter regard.

Exploratory Research

The Center for Policy Research in New York is examining both the technical features and social "rules" for use of cable television as a mass participatory technology system which would allow citizens to interact with public officials and with each other. An integrated social science-engineering team is undertaking a number of tasks, such as testing the effect of alternative uses of the system in reducing public apathy, alienation, and polarization, and on expanding opportunities for expressing new ideas and minority views. The Center is also investigating the development and testing of random switching, instant polling, and use of telephone exchanges compared to CATV networks and other technological innovations, and comparing of audio-only with audiovisual systems.

Development Sciences, Inc., of East Sandwich, Mass., is exploring alternative pollution abatement techniques by locating recycling plants to convert pollutants into resources in an existing consumer-producer network. It is also looking for opportunities to substitute one process for another to reduce pollution or to enhance reuse potential. It will attempt to identify partners for a shared waste disposal system and a dumping strategy that would either return wastes to a natural ecosystem or isolate them harmlessly. Alternatives for Government policy or industrial applications are being identified through computer scanning of a matrix of industries and chemical processes.

The International Research and

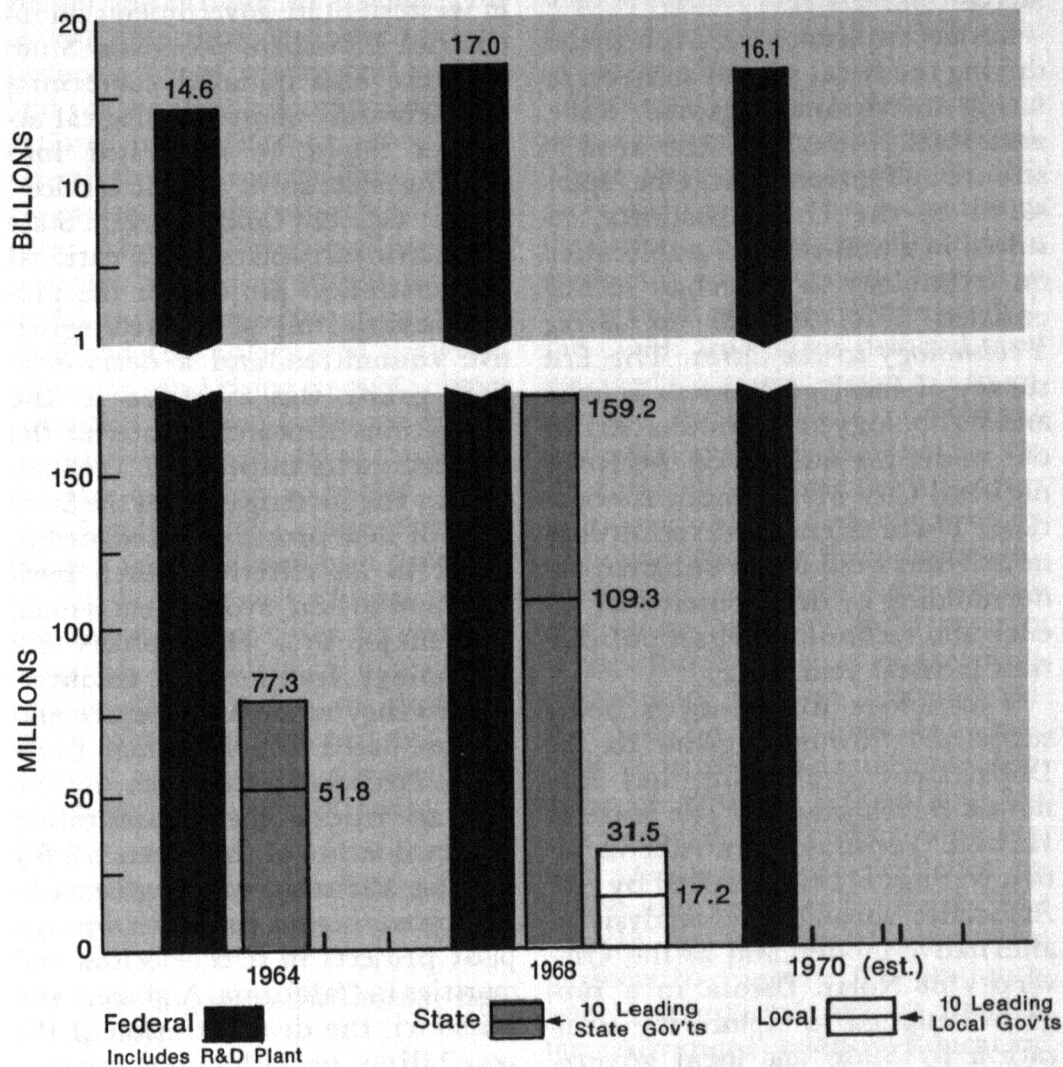
Development Corporation of Washington, D.C., has developed a theoretical model to describe the flows of physical materials and energy throughout the U.S. economy and to and from the environment, taking into account the actual physical and chemical transformations which occur. It is expected that this analytical approach can aid various Government agencies in fulfilling the requirements of the National Environmental Policy Act of 1969, and to assist the Bureau of the Census in structuring the 1972 Census of Manufacturers.

Problem Assessment

An interdisciplinary team at the University of Oklahoma is performing a technology assessment of offshore oil operations. Projections of the technologies inherent in these operations will be made for 10 to 15 years into the future, and assessments will concern a wide range of consequences—from legal-political to physical-biological. The results will point out and analyze alternatives available to implement policies for offshore oil facility management. The results will also be couched in the context of future national energy needs. Barring unforeseen developments, oil availability will play a large part in satisfying those needs over the next few decades. Past spillages and leakages illustrate the risks and costs inherent in the transportation of oil and in operation of offshore oil facilities. The analysis being undertaken should contribute to needed national and international perspectives on this problem.

Hittman Associates, Inc., of Columbia, Md., is conducting an "Evaluation of the Ecological, Resources and Socioeconomic Impacts of Advanced Automotive Propulsion Systems." The objective is to define and evaluate the major ramifications of the transition from present internal combustion engine technology and practices to any of the potential alternatives. Transitional effects on

RESEARCH AND DEVELOPMENT EXPENDITURES BY FEDERAL, STATE AND LOCAL GOVERNMENTS FISCAL YEARS 1964-1970



materials resources, environmental ecology, energy resource balance, and the socioeconomy will be stressed. A systems analysis approach will enable evaluation of component and total effects of the transitions and comparison with present system baselines. Optimization trends will be identified and assessed as will the policy implications for pertinent areas of the public sector.

INTERGOVERNMENTAL SCIENCE PROGRAMS

The Intergovernmental Science Programs assist State and local governments in strengthening their ca-

pabilities to foster and support the development and use of scientific methods and technologies, and to discover and exploit ways of enhancing the application of scientific methods and technologies by these levels of government as they deal with their critical needs.

The Office of Intergovernmental Science Programs administers its functions in close coordination with the intergovernmental activities of the Federal Council for Science and Technology (FCST), and provides both the chairmanship and the executive secretariat to the FCST's Committee on Intergovernmental Science Relations. Close coordination is also maintained with the National Governors' Council on Science and Technology and with the

Science and Technology Committees of the National Governors' Conference and the National Legislative Conference.

Seven conferences were conducted during the fiscal year on subjects relating to national, regional, State, and local concerns in the area of science and government. One, sponsored by the Urban Institute, resulted in a well-received publication on technology in the urban setting entitled *The Struggle to Bring Technology to the Cities*. The first survey of local government science and technology activities was carried out under the auspices of the International City Management Association. Three science and technology newsletters designed to enhance understanding of developments in science and technology began publication in fiscal year 1971.

Technology forecasting is being supported through a grant to the Department of Planning and Economic Development of the State of Hawaii. Technology transfer in urban settings is being studied by Abt Associates through the analysis of alternative models, and at the University of North Dakota in a program designed to explore the utilization by State and local governments of graduate-level and other research. Technology assessment techniques at the State level are being explored by the National Academy of Public Administration

and the Western Interstate Nuclear Board, which will recommend optimum decision-making procedures in western State governments on industrial Plowshare proposals. Studies were also initiated concerning how scientific and technological activities might be integrated into existing systems of public services.

The Citizens Conference on State Legislatures is planning a national demonstration project for the professional staffing of selected legislative committees and a demonstration grant was awarded to the Operations Research Center at the Massachusetts Institute of Technology for the investigation at the State level of new procedures designed to result in an effective citizen feedback and citizen involvement system.

A major area of emphasis was technology transfer and reconversion as they relate to aerospace and defense-based activities and problems. Projects in this area involve such activities as the demonstration and evaluation of the potentials for placing scientists and engineers in local government positions through pilot projects in selected cities and counties in California, Alabama, and Missouri; the demonstration of the possibilities for technology development available through a State government-based technology exchange; and a study of the role that colleges of engineering should play in their regional environments.