REPORT TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND DEVELOPMENT COMMITTEE ON SCIENCE AND ASTRONAUTICS HOUSE OF REPRESENTATIVES

Observations Of Various Organizations And Individuals On Certain Aspects Of Federal Support Of Problem-Oriented Research

B-133183

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

MARCH 28, 1972

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-133183

Dear Mr. Chairman:

Pursuant to your request of September 8, 1971, this is our report entitled "Observations of Various Organizations and Individuals on Certain Aspects of Federal Support of Problem-Oriented Research."

We plan to make no further distribution of this report unless copies are specifically requested, and then we shall make distribution only after your agreement has been obtained or public announcement has been made by you concerning the contents of the report.

Sincerely yours,

Comptroller General
of the United States

C1 1R The Honorable John W. Davis, Chairman
Subcommittee on Science, Research
and Development
Committee on Science and Astronautics
House of Representatives

H 03403

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
DOD	Department of Defense
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
NSF	National Science Foundation
RANN	Research Applied to National Needs

COMPTROLLER GENERAL'S REPORT
TO THE SUBCOMMITTEE ON SCIENCE,
RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE
AND ASTRONAUTICS
HOUSE OF REPRESENTATIVES

OBSERVATIONS OF VARIOUS ORGANIZATIONS AND INDIVIDUALS ON CERTAIN ASPECTS OF FEDERAL SUPPORT OF PROBLEM-ORIENTED RESEARCH B-133183

D I G E S T

WHY THE REVIEW WAS MADE

The Chairman, Subcommittee on Science, Research and Development, House Committee on Science and Astronautics, requested the General Accounting Office (GAO) to develop information concerning Federal support of research directed toward social, environmental, and technological problems (problem-oriented research). GAO was asked to give special attention to a National Science Foundation (NSF) program called the Research Applied to National Needs program.

NSF established the Research Applied to National Needs program in fiscal year 1971. It was designed to focus research on selected environmental and social problems and on opportunities for future technological development. NSF's support of problem-oriented research is intended to complement the research capabilities of Federal agencies having special concerns with environmental, social, and technological problems. In fiscal years 1971 and 1972, research support under the NSF program is estimated to total about $90 million.

Federal obligations for research and development (excluding plant investment) were estimated at $15.6 billion for fiscal year 1971. Of this amount, $2.2 billion (14 percent) was for basic research, $3.7 billion (24 percent) was for applied research, and $9.7 billion (62 percent) was for development.

GAO directed its efforts primarily toward obtaining the views of Government and non-Government organizations and individuals as to:

--who should sponsor and perform problem-oriented research;

--the responsibilities of the sponsors and performers; and

--what the roles of NSF and other Government, private, and nonprofit organizations should be in connection with problem-oriented research.

GAO obtained views from 122 such organizations and individuals but did not evaluate the validity of these views.

VIEWS OF VARIOUS ORGANIZATIONS

Those who commented indicated generally the following views.

NSF should sponsor basic research for the purpose of developing new fundamental scientific data and should sponsor research in problem-oriented and other areas not within the province of other Federal agencies.

NSF should serve as a national coordinator for Federal support of research and should support the development of scientific research capabilities.

Federal mission agencies should sponsor problem-oriented research within the areas of their statutory responsibilities because they are more aware of their research needs and opportunities for effective application and thus are better equipped to monitor the research programs and implement the results.

Academic institutions should perform both basic and applied research related to their principal mission of education and should provide technical and consultative support of problem-oriented research projects undertaken by others.

Industry should sponsor and perform problem-oriented research that is profit oriented. It was expected that research sponsored by industry would involve product improvement or developmental work which would evolve into something marketable.

Nonprofit research institutes, in addition to performing research, should

--sponsor research which is of benefit to the general welfare but which is not adequately supported by the public;

--provide advice and technical services;

--concentrate research activities in those areas not covered by the Government or industry; and

--assist the technical community in defining problem areas and, when known, in indicating probable solutions for them.

The consensus of those who commented was that a sponsor should clearly define the problem, select the performer, and monitor and guide the research work. Monitoring the performance of research was considered essential for evaluating progress, for being kept informed on results being achieved, and for determining whether objectives remained valid or whether they should be modified. The primary responsibility indicated for a performer was to conduct the research work in an efficient and effective manner to provide research results as early as possible for use as intended by the sponsor. (See pp. 21 and 51.)

In addition, some organizations and individuals advocated certain changes to the policies and practices for funding Federal research projects to

provide greater stability in program support and to encourage greater industry participation in problem-oriented research. (See pp. 52 to 55.)

Comments of several individuals indicated also that the dissemination of research information through normal channels, such as scientific journals, professional meetings, and news media, was not efficient or effective and that communication between the researcher and the practitioner needed improvement. (See pp. 56 to 61.)

CHAPTER 1

INTRODUCTION

Pursuant to a request from the Chairman, Subcommittee on Science, Research and Development, House Committee on Science and Astronautics, we developed certain information relating to Federal support of problem-oriented research with special attention directed toward the National Science Foundation's program called the Research Applied to National Needs (RANN) program. A copy of the Chairman's letter dated September 8, 1971, is included as appendix I.

The RANN program was established in fiscal year 1971 when NSF consolidated most of its problem-oriented research activities into a single program. The purpose of this consolidation was to enable NSF to focus research more directly on selected environmental and social problems and on opportunities for future technological development in an effort to provide the knowledge necessary to help solve major national problems.

In his letter the Chairman pointed out that NSF was established by the National Science Foundation Act of 1950 (42 U.S.C. 1861) to support only basic research and science education; the rationale for this restriction was that applied research relevant to Federal activities would be supported by mission-oriented agencies.

The Chairman noted that in July 1968 the National Science Foundation Act was amended by Public Law 90-407 (42 U.S.C. 1862) to grant NSF permissive authority to support applied research and that after that time support for applied research in NSF's budget had increased significantly.

The House Committee on Science and Astronautics stated, in its report on NSF's authorization bill for fiscal year 1972, that the Committee, as a general principle, felt that, to maximize the return on investment in research and development for a particular socially desirable area, as many of the specific decisions as possible concerning such investments should be placed in the hands of the actual user of the research results; thus, where feasible, problem-oriented

research should be supported by the appropriate mission agency.

The Committee indicated that its Subcommittee on Science, Research and Development intended to study in more detail NSF plans for supporting problem-oriented research and particularly to contrast policies for funding such research through the RANN program with alternative mechanisms in the mission agencies.

To assist the Subcommittee's inquiry into NSF's problem-oriented research activities, we agreed to obtain the views of selected Government and non-Government officials and organizations concerning the rationale for supporting problem-oriented research, particularly (1) who should sponsor and perform such research and what the responsibilities of the sponsors and performers should be and (2) what the roles of NSF and other Government and non-Government organizations should be in connection with problem-oriented research. We did not evaluate the validity of such views.

In our review we obtained comments from 122 organizations and individuals representing Federal, State, and local governments; academic institutions; industrial firms; and nonprofit research institutes located in Washington, D.C., and 15 States. Pertinent comments from these organizations and individuals are presented in this report.

The following table shows by type of organization, the number requested to comment, and the number of responses received. Responses from individuals are included in the figures for each type of organization. (See app. II for names of organizations contacted.)

Type of organization	Number		
	Contacts	Respondents	Nonrespondents
Federal mission agencies (including Federal laboratories)	24	23	1
Federally funded research and development centers (note a)	7	7	-
State and local governments	12	11	1
Academic instititions	40	39	1
Industrial firms	23	23	-
Nonprofit research institutes	15	15	-
Others (note b)	4	4	-
Total	125	122	3

[a]Federally funded research and development centers (FFRDCs) generally have been established to meet particular research and development needs of Federal agencies and are administered by nonprofit institutions, including universities and colleges, or industrial firms.

[b]These organizations consisted of the National Academy of Sciences, the National Academy of Engineering, the Office of Management and Budget, and the Office of Science and Technology.

CATEGORIES OF RESEARCH

NSF provided us with the following definitions of basic, applied, and problem-oriented research.

"Basic research" is systematic, intensive study which is directed toward fuller scientific knowledge or understanding of the subject and in which the investigator is motivated primarily by the desire to pursue the acquisition of new knowledge, rather than a solution for a defined problem. This type of research involves the creation of new knowledge about fundamental physical, biological, environmental, and social phenomena and about the operation of natural laws.

"Applied research" is systematic, intensive study to reach fuller knowledge or understanding which will assist in achieving a practical purpose, including the development of analytical and experimental techniques that may be applied as tools for this purpose. Applied research first builds upon existing knowledge created by basic research and then creates additional knowledge. It is not performed, however, for the primary purpose of creating further basic information about principles or laws of the natural or social environment. Rather, applied research begins by bringing together existing knowledge in a directed way, which usually has been tested, for a practical purpose or understanding.

"Problem oriented research" is that research motivated by the prior identification of a social, environmental, or technological problem requiring additions to the store of fundamental knowledge before being amenable to solution. The research can be either basic or applied.

FEDERAL PARTICIPATION IN RESEARCH

Statistics compiled by NSF showed that Federal obligations for research and development (excluding plant investment) were estimated at $15.6 billion for fiscal year 1971. Of this amount, $2.2 billion (14 percent) was for basic research, $3.7 billion (24 percent) was for applied research, and $9.7 billion (62 percent) was for development. "Development" has been defined by NSF as the systematic use of the knowledge and understanding gained from research directed toward the production of useful materials, devices, systems, or methods.

Estimates of basic and applied research funds obligated during fiscal year 1971 by the various agencies follow.

Agency	Basic research 1971	Applied research 1971	Total	Percent
	——(000,000 omitted)——			
Department of Defense	$ 251	$1,264	$1,515	25.4
National Aeronautics and Space Administration	741	706	1,447	24.2
Department of Health, Education, and Welfare	376	904	1,280	21.4
Atomic Energy Commission	282	136	418	7.0
NSF	293	55	348	5.8
Other agencies (note a)	284	678	962	16.2
Total	$2,227	$3,743	$5,970	100.0

[a]Other agencies include the Departments of Agriculture, Commerce, the Interior and Transportation.

A breakdown of estimates of basic and applied research funds for fiscal year 1971 obligated by types of performer follows.

Performer	Basic research Amount (000,000 omitted)	Basic research Percent	Applied research Amount (000,000 omitted)	Applied research Percent	All research Amount (000,000 omitted)	All research Percent
Federal intramural	$ 650	29.2	$1,403	37.0	$2,053	34.3
Universities and colleges	752	33.8	751	20.0	1,503	25.1
Industrial firms (note a)	451	20.3	1,044	28.0	1,495	25.0
FFRDCs administered by universities	280	12.5	140	4.0	420	7.0
Other nonprofit institutions (note a)	71	3.2	262	7.0	333	5.6
Other	23	1.0	143	4.0	166	3.0
Total	$2,227	100.0	$3,743	100.0	$5,970	100.0

[a]Includes FFRDCs administered by these performers.

CHAPTER 2

DESCRIPTION OF RANN PROGRAM

NSF, over the years, has guided basic research toward goals of national importance by creating special programs to focus attention on selected objectives, such as earthquake engineering and weather modification.

In fiscal year 1971 NSF established the RANN program to support research on national problems. Under the RANN program NSF organized the bulk of its problem-focused research into a single set of program activities.

The activities incorporated into the RANN program include weather modification, earthquake engineering, research projects formerly funded under the Interdisciplinary Research Relevant to Problems of Our Society program, and a number of projects previously funded under the Scientific Research Project Support programs. The program for Interdisciplinary Research Relevant to Problems of Our Society, which was the predecessor to RANN, was initiated in fiscal year 1970 to support scientific research on complex societal issues that required the contributions of diverse scientific disciplines. Under the Scientific Research Project Support programs, NSF supports individual research projects in the various scientific disciplines through grants awarded to educational and other institutions.

NSF's brochure entitled "Research Applied to National Needs--Interim Description and Guidelines for Proposal Preparation," states that the emphasis on problem orientation is the key feature which distinguishes the RANN program from the more general research-support programs of NSF.

According to the brochure, activities supported by the RANN program seek to increase our understanding of social and environmental problems and their underlying causes and to identify opportunities and means for applying advanced technology for the benefit of society. The scope of a problem to be investigated may require the combined efforts of physical, biological, engineering, and social scientists, as well as significant contributions from nonscientists.

Whether the research mode is interdisciplinary or is in a specialized field, the key factor--in addition to scientific merit--governing eligibility for support under the RANN program is the potential national impact of the anticipated results and their relevance to a particular national need.

The Deputy Director of NSF stated, during the fiscal year 1972 NSF authorization hearings before the Subcommittee on Science, Research and Development, House Committee on Science and Astronautics, that the role of NSF in problem-oriented research was not to displace or act as a substitute for agencies of the Government that were effectively supporting applied research for their own needs. He stated that NSF's role was to complement the research capabilities of these agencies by addressing the long-range requirements of the Nation viewed from the perspective of all the current national needs.

RANN PROGRAM ELEMENTS

The titles and primary objectives of the RANN program elements are:

Environmental systems and resources--To develop an improved understanding of environmental systems, to develop the knowledge required to permit more effective efforts to prevent environmental degradation, to develop national resources wisely, and to accommodate man's activities to environmental constraints. Initial problem areas include (1) regional environmental systems, (2) environmental aspects of trace contaminants, and (3) weather modification.

Social systems and human resources--To develop an improved understanding of social systems and social data that will help to increase the effectiveness of efforts to deal with major societal problems and to realize more effectively the potential of individual citizens in their various roles and social units. Initial problem areas include (1) municipal systems, operations, and services, (2) social data and community structure, and (3) evaluation methodologies for social programs.

Advanced technology applications--To develop the knowledge base for new or improved technologies to enhance

economic productivity, to exploit the potential contribution to the Nation of advances in science and technology, and to stimulate technological applications that will contribute to the solution of major national problems and thereby improve the quality of life. Initial problem areas include (1) energy resources research and analysis, (2) urban technology, (3) excavation technology, (4) earthquake engineering, (5) fire research, and (6) enzyme technology.

Exploratory research and problem assessment--To develop a better understanding of the research needs related to major national problems and of the potential contribution of science and technology in solving those problems, to initiate research in emerging problem areas, and to develop improved methods for assessing or predicting the impact of new technologies on man and his environment.

According to NSF the following criteria were used in developing the ongoing research efforts of the RANN program and in selecting additional projects.

Importance--Where the significance and urgency of the problem area or the potential consequences for the Nation are great.

Payoff--Where domestic, economic, and social benefits to be realized are significantly higher than the anticipated research and implementation costs or where the potential to strengthen the U.S. position internationally exists.

Leverage--Where science and technology can have a unique and substantial impact on the problem.

Readiness--Where the effort is timely and scientifically ready and where the skilled manpower is available.

Capability--Where Federal, academic, and industrial capabilities exist to mount a successful research program.

Need for Federal action--Where the research is not being conducted by private industry because the immediate incentive is not sufficient or because the market is fragmented.

Unique position of NSF--Where NSF can serve the research needs of the Government most effectively.

The NSF Deputy Assistant Director for Science and Technology told us that determining whether a research project meets the above criteria is strictly judgmental on the part of the project evaluators.

NSF MANAGEMENT OF RANN PROGRAM

The NSF Deputy Assistant Director for Science and Technology advised us that the basic steps for managing the RANN program activities included (1) identifying potential research areas, (2) evaluating preliminary and formal proposals for selection of grantees, and (3) monitoring the research activities. Descriptions of these steps, based on information provided by NSF, are presented below.

Identification of research areas

The RANN program consists of an array of specific programs focused on objectives related to particular national needs and is complemented by a generalized program of exploratory research. In focusing its RANN program support, NSF has identified, in its interim guidelines, a number of problem areas in which proposals for research were desired. The guidelines show the objective of each major program element of the RANN program but do not indicate specific information on the types of research projects being supported within the problem areas.

To provide more information on the RANN program, NSF is developing brochures for each of the major program elements that will provide specific information concerning the objectives and scope of support to be provided within the problem areas. As of January 20, 1972, the brochure for the social systems and human resources element had been published; brochures for the remaining three program elements had not been finalized by NSF.

Proposal evaluation process

NSF's guidelines for proposal preparation establish the requirements for the types of data to be included in proposals from prospective grantees and contractors. The guidelines point out that it is particularly important to identify in the proposal the potential beneficiaries or users of the anticipated research results and to plan for effective information transfer to them. It is essential that the beneficiaries or users be involved in the planning and/or the implementation of the research in all appropriate and practical ways. Research results should be disseminated through normal scientific channels. In addition, proposals

should indicate possibilities for communicating with a larger, nonscientific audience.

Also the guidelines provide that applicants submit preliminary proposals to the RANN program prior to submitting formal proposals. The preliminary proposal is treated as an informal communication between the applicant and the RANN program manager and involves no commitment on the part of either the applicant or NSF.

These proposals are reviewed by the NSF program managers, other NSF staff members, and a limited number of non-NSF individuals for appropriateness to the RANN program. The reviewers' comments and user needs are discussed with the applicant and serve as the basis for development of a formal proposal if the preliminary proposal review indicates that the project would warrant consideration for support under the RANN program.

Formal proposals received by NSF are reviewed by the RANN program manager and other NSF staff members. When a proposal involves a project which relates to the mission of another Federal agency, such agency is requested to evaluate the relevance of the proposed project to its mission. In addition, NSF requests proposal reviews by scientists in the academic and private sector.

Proposals are reviewed in terms of their societal relevance and scientific merit. Proposals also are assessed for their potential contribution to the application of science and technology in dealing with pressing national needs and in the light of the availability of resources to the investigators. To ensure that the resources are available, NSF makes site visits on large proposals which are likely to be accepted for Federal grants. If NSF determines, through the reviews and site visits, that the proposal deserves support, a grant or contract is awarded.

Monitoring research activities

The grants are monitored by NSF program managers who have expertise in the specific areas of the research grants. As of October 22, 1971, there were 26 RANN program managers and 192 active RANN program grants.

The projects are monitored through reference to the management plan which, according to NSF's guidelines for preparation for proposals, is established by the grantee and submitted as a part of the proposal. The plan is to include a schedule of accomplishment milestones expected to be reached at various stages of the research and the estimated expenditures at each milestone. Grantees are required to submit quarterly expenditure reports and final reports on project results, as well as to immediately notify NSF of important findings. NSF has stated that it intends to conduct a semiannual review of the progress and status of each project from the programmatic, administrative, and financial viewpoints.

RELATION OF RANN PROGRAM TO PROGRAMS OF OTHER GOVERNMENT AGENCIES

Many of the RANN program areas have direct relevance to the interest of other Federal agencies. The RANN program is not intended to duplicate research activities already supported by other agencies in the fulfillment of their missions. It is intended that many of the research projects supported under the RANN program will be transferred, in whole or in part, to other Federal agencies as the projects move beyond the research stage toward implementation.

To assist NSF in coordinating its research-support efforts under RANN with those of the other Federal agencies, the Chairman of the Federal Council for Science and Technology established the Committee on RANN Coordination. This Committee is chaired by the Director of the Office of Science and Technology, and the membership consists of representatives from NSF, the Office of Management and Budget, the Office of Science and Technology, and those Federal agencies having mission responsibilities which fall within the scope of the RANN program.

The Committee acts as an intergovernmental advisory group to NSF for the selection of major program areas to be funded under the RANN program and endorses such selection for approval by the Federal Council for Science and Technology. The Committee meets when necessary to review the major programs which have been proposed for the RANN program, to ensure that they are complimentary to the programs of the mission-oriented agencies. The purpose of these reviews also is to consider the priority of the programs in evolving administration policies and national needs and to assist in resolving differences in NSF and other agency programs that may arise from time to time.

Panels have been formed under the Committee to correspond to each of the four major program elements of the RANN program. Each panel consists of the NSF program manager, who serves as panel chairman, and representatives from the Office of Science and Technology and other Federal agencies that are "affected in a significant way" by the research supported under the RANN program. Office of Management and Budget representatives may attend as observers.

The panels are the principal means through which the ongoing interagency coordination is carried out. The panels act as intergovernmental advisory groups to the NSF program managers and constitute the initiation points for interagency fund transfers, personnel interchanges, and transfers of projects and programs from NSF to the other agencies.

NSF has stated that it also coordinates its RANN program with programs of other agencies by providing for joint funding of specific research projects. NSF also anticipates using interagency agreements, task forces, and advisory boards when needed.

The NSF Deputy Assistant Director for Science and Technology advised us that, although there were no formal guidelines for transferring research results to potential users, such transfers were made informally on the basis of mutual agreement among the sponsor, performer, and user of the research.

The chart on the following page represents research efforts under way or planned that, on the basis of information it furnished to the Office of Management and Budget, are considered by NSF to have essentially the same program objectives or to involve research projects which are similar, or parallel, to those of the major RANN programs.

PROGRAM COSTS

NSF support of research relevant to solving societal problems has increased since 1970. Grants totaling approximately $6 million were awarded for such research under NSF's former program for Interdisciplinary Research Relevant to Problems of Our Society in fiscal year 1970. Research support under the RANN program in fiscal year 1971 totaled about $34 million, of which $13 million was for continuing support of projects formerly funded under the interdisciplinary research program and $21 million was for support of projects transferred to the RANN program from other NSF programs.

In fiscal year 1972 NSF was authorized $59 million for its RANN program. The Office of Management and Budget apportioned $56.1 million of the $59 million to NSF; the

OTHER FEDERAL AGENCIES
INVOLVED IN AREAS OF RESEARCH
ALSO SUPPORTED UNDER THE
NSF RANN PROGRAM

RANN EFFORTS	Department of Defense	Department of Housing and Urban Development	Atomic Energy Commission	Department of Agriculture	Department of Transportation	Department of Commerce	Department of the Interior	Department of Health, Education, and Welfare	National Aeronautics and Space Administration	Office of Economic Opportunity	Department of Labor	Environmental Protection Agency	Office of Management and Budget	Department of Justice
ADVANCED TECHNOLOGY APPLICATIONS:														
Energy resources research and analysis	x	x	x	x	x	x	x		x			x		
Earthquake engineering	x	x	x		x	x								
Fire research	x	x	x	x	x	x	x		x					
Enzyme technology			x	x				x						
Urban engineering problems	x	x		x	x	x	x	x						
Applied nuclear technology	x		x					x	x			x		x
Excavation technology	x	x	x		x		x							
ENVIRONMENTAL SYSTEMS AND RESOURCES:														
Weather modification research	x			x	x	x	x		x					
Biome analysis applications	x		x	x		x	x							
Regional environmental systems	x			x		x	x		x			x		
Environmental aspects of trace contaminants			x	x		x	x	x				x		
SOCIAL SYSTEMS AND HUMAN RESOURCES:														
Social indicators research								x					x	
Municipal systems, operations, and services		x			x			x					x	
Social data and community structure research				x		x		x		x	x			
Criminology								x		x	x			x
Evaluation methodologies for social programs			x					x		x	x			
EXPLORATORY RESEARCH AND PROBLEM ASSESSMENT (note a):														
Exploratory research														
Problem technology assessment														

[a]Agencies not identified.

remaining $2.9 million had not been apportioned for obligations. Funds have been allocated by NSF to each RANN program element as follows:

	Amount (millions)
Advanced technology applications	$19.0
Environmental systems and resources	20.0
Social systems and human resources	12.0
Exploratory research and problem assessment	5.1
Total	$56.1

CHAPTER 3

VIEWS ON SPONSORING AND PERFORMING PROBLEM-ORIENTED RESEARCH

We solicited the views of Government and non-Government organizations and individuals regarding the role of NSF, the Federal mission agencies, academic institutions, nonprofit research institutes, and industry in sponsoring and performing problem-oriented research.

The views expressed by those organizations and individuals who offered comments indicated generally that NSF should sponsor basic research for the purpose of developing new fundamental scientific data and should sponsor research in problem-oriented or non-problem-oriented areas not within the province of other Federal agencies. Other views expressed were that NSF should serve as a national coordinator for Federal support of research and should support the development of scientific research capabilities.

It was the general view that the Federal mission agencies should sponsor problem-oriented research within the areas of their statutory responsibilities because, as indicated by certain organizations and individuals, the mission agencies were more fully aware of their research needs and of opportunities for effective application; thus they are better equipped to monitor the research programs and implement the results.

Generally academic institutions were considered appropriate for performing both basic and applied research that related to their principal mission of education and for providing technical and consultative support of problem-oriented research projects undertaken by others.

Industry, according to the organizations and individuals who commented, should sponsor and perform problem-oriented research that is profit oriented. It was expected that research sponsored by industry would involve product improvement or developmental work which would evolve into something marketable.

The roles indicated for nonprofit research institutes were that these institutes, in addition to performing research, should (1) sponsor research which would be of benefit to the general welfare but which would not be adequately supported by the public, (2) provide independent analytical advice and technical services, (3) concentrate their research activities in those areas not covered by the Government or industry, and (4) assist the technical community in defining problem areas and, when known, in indicating probable solutions for them.

Regarding the responsibilities of a sponsor, it was the consensus that a sponsor should clearly define the problem, select the performer, and monitor and guide the research work. Monitoring the performance of research was considered essential for evaluating progress, for being kept informed on results being achieved, and for determining whether objectives remained valid or whether they should be modified.

The indicated primary responsibility of a performer was that it conduct the research work in an efficient and effective manner to provide research results as early as possible for use as intended by the sponsor.

Pertinent comments of Government and non-Government organizations and individuals on the role of NSF, Federal mission agencies, academic institutions, nonprofit research institutes, and industry in sponsoring and performing problem-oriented research follow.

VIEWS OF FEDERAL MISSION AGENCIES

We obtained comments from nine Federal agencies. These agencies advised us that virtually all the research they sponsored or performed was problem oriented and that such research was an essential function of mission agencies in fulfilling their assigned responsibilities. Specific comments of certain of the agencies regarding the role of various organizations in connection with problem-oriented research follow.

Department of Agriculture

The Department of Agriculture stated that it was essential for Federal agencies to sponsor research on problems directly related to their missions and to sponsor development and maintenance of related research and training capabilities in universities and other institutions.

Agriculture noted that industry did, and should, sponsor and conduct problem-oriented research to serve many of its needs. It stated also that other problem-oriented research should be sponsored or conducted by publicly supported agencies because of the uncertainties or the long-range benefits, because the benefits or applications would be derived largely by the general public, or because private organizations lacked the economic capacity or incentives to sponsor the research.

Regarding the role of various organizations, Agriculture stated that:

> "The principal role of NSF is support of fundamental research in broad disciplinary or interdisciplinary areas of need for scientific knowledge. Such research is of interest to society in that it contributes to the foundation for progress in solving societal problems. It thus helps to meet a legitimate national goal. A secondary role of NSF is to support research on broad societal problems that overlap substantially the interests and concerns of more than one Federal agency, that fall between agency missions, or that are sufficiently nebulous as to be 'no-one's' concern. NSF can serve the useful role of focussing

attention on such problems as well as catalyzing interagency communications and cooperation.

"The mission agencies' principal research role is, through directly performing research or by supporting research by others, to evolve solutions to problems related to their missions. Special attention is required for devising solutions to those problems that are in harmony with interests and concerns of the general society as well as their clientele. Such research must have both fundamental and applied elements.

"Public and private academic institutions should be involved in both fundamental and applied research that is generally allied with and supportive of their principal mission of education. Involvements in such research generally sharpens the perspective of the teacher, his Department, College and University, thus enhancing the teaching capability.

"*** [nonprofit research institutes] fall into two categories, those that finance research and those that do research. Those that finance research obviously have latitude to support research of their own special interest. The role of nonprofit research performing entities should be concentrated in the integrative or developmental areas, particularly where they are not the province of government or industry. In particular, these organizations have the opportunity to support research that is of benefit to the general welfare, but is sufficiently risky or politically sensitive as to make public support difficult.

"The industry role is two-fold: Inventive and developmental. It must be profit-oriented, thus potential must exist for the research to evolve something saleable. Industry research should be both fundamental (as in biochemical manipulation) and applied (as in improving the power efficiency of a tractor)."

Atomic Energy Commission

In the view of the Atomic Energy Commission (AEC), research is undertaken by Federal agencies to meet the missions assigned to them by the executive branch or the Congress.

AEC stated that NSF could, and did, play an important role in connection with problem-oriented research and pointed out that:

1. NSF might appropriately decide to support research that was assigned a relatively lower priority by a mission agency due to funding limitations.

2. NSF could assess the total Federal involvement in a research area having potential for providing information to solve problems to determine whether NSF should support such research to fill in gaps or to ensure appropriate attention to the field.

3. NSF might support problem-oriented research projects which stimulate the involvement of new classes of performers, such as universities and laboratories.

4. NSF might support research designed to explore and stimulate the application of advanced technologies, developed for specific missions, to other areas of national concern.

AEC stated that, in such cases as those described above, close collaboration between NSF and the appropriate mission agencies would be necessary to ensure that all parties understand the attention to be given by NSF and that NSF has a clear picture of mission agency requirements and programs.

AEC stated also that:

"Recognizing NSF's prerogative to make its own decisions, it is our view that whenever a mission agency believes that it is adequately supporting a field of problem-oriented research, or where it

believes it has a clear legislative or other mandate to support substantially all the research in a field, NSF should consider only minimal additional support, if any at all."

Department of Defense

The Department of Defense (DOD) stated that problem-oriented research was an essential function of the executive departments of the Federal Government because it made possible improved performance of their missions and promotes new and highly desirable kinds of governmental services for the public. To remove from these mission-oriented departments their responsibilities and capabilities for providing that science and technology base fundamental to their broad responsibilities and goals would, in the opinion of DOD, reduce the effectiveness of those departments in the performance of their missions.

DOD stated also that there was substantial evidence of the validity of the strongly and widely held conviction that science and technology thrive best when closely associated with an awareness of the needs and opportunities for their effective application to recognized problems or goals. In DOD's view, each existing Federal department should develop and nurture that awareness with respect to its mission area and should formulate its research programs in that context.

DOD also pointed out that its relationship to research could be understood only through the distinction between that research needed by a mission-oriented agency and that part of basic research pursued for its intrinsic intellectual qualities.

DOD stated further that:

"*** Basic research sponsored by the National Science Foundation is aimed either at cultural improvement, as an assist to science education, or a long-range investment for the achievement of society's goals. The basic research of DoD directly supports and accelerates applied, developmental and engineering effort. The applied

research of DoD provides the bridge for rapidly moving new and basic ideas into development of weapon systems by providing the necessary technology, component designs, and methodology.

"Each mission-oriented agency should support on a substantial level that basic and applied research which is relevant to its mission. In this manner, the Nation's research programs can be efficiently and naturally focused into areas of probable utility to each of the broad social missions of the government. Furthermore, because of the close coupling between the performer and the potential user, the likelihood of planning for useful application is enhanced ***.

"University research has a characteristic which has been called the 'leading edge' of science and technology, for it has the capability of producing clear new concepts vitally important to national welfare. Each academic institution has an academic mission to perform that socially justifies its existence, and each should treat scientific research as a means to that end rather than as an end in itself ***.

"Those non-profit research institutes having strong leadership can provide a degree of independence both from Government pressures and from commercial market pressures which can make them particularly useful as a source of objective analytical advice and technical services. Their unique management arrangements offer a number of advantages: freedom from traditional hierarchical pattern, a high degree of independence in planning and conducting research, the ability to transmit findings directly to decision makers and policy planners, the ability to attract extremely high competence, greater flexibility in recruitment, assignment, compensation and management of personnel, and simpler administrative and financial controls ***.

"In DoD's view, industry is responsible for the ultimate manufacture of most of DoD's end items *** it should be noted that most industrial managers of research have a great deal of difficulty justifying support of basic research since much of it is just as likely to benefit a competitor as much as itself; and that may, in fact, bear no direct connection to the financial well-being of the company that can be demonstrated to top management ***."

Department of Housing and Urban Development

The Department of Housing and Urban Development (HUD) stated that all research it carried out on the problems of community development and housing was applied and problem oriented in that it had to deal with the "real life laboratory of existing settlements and real environment of housing development."

HUD explained that the objective of its research activity was to obtain an improved understanding of the problems that existed and to apply that improved understanding in programs that were sufficiently large to provide bases for generating change and solution to those problems. Such objectives, according to HUD, must be carried out by mission agencies in the Federal Government, and the major responsibility must be with mission agencies.

HUD also noted that:

"*** there is another goal that is required in research in these housing and community development areas. A notable problem relates to the fact that the capability for analytical and experimental research is thinly distributed thoughout the nation in universities, in research organizations, in industry, in non-profit institutions. There is nowhere the kind of critical mass of capability that has been established in numerous governmental, university, and industrial centers in the physical science and engineering areas. Such a critical mass of capability in the disciplines associated with housing and community development problems must be encouraged.

"Some effort has been carried out at HUD with experiments and development demonstrations on institutional arrangements that can provide such a capability. Much more is needed. The work that has been done by HUD in this area is still problem-oriented research activity. It attempts to relate the discipline capability in universities with real city problems through ties with local government. It is in this area that we believe the National Science Foundation can provide its greatest assistance. Encouragement of problem-oriented research that is directly aimed at establishing centers of capability would certainly be in keeping with the long history of the National Science Foundation and should be encouraged."

Department of the Interior

Pertinent views of various bureaus and offices of the Department of the Interior on the rationale for sponsoring or performing problem-oriented research are summarized below.

Office of Water Resources Research

The Office stated that the most appropriate institutional structure for the support of problem-oriented research would be determined largely by the nature and scope of the problem. The Office considered that, in most cases, the mission-oriented agency was the most efficient organization for administering problem-oriented research directly related to the agency's mission because the mission-oriented agency (1) was most familiar with the problems related to its mission, (2) was adaptable and able to pursue new approaches, priorities, and opportunities as problems and circumstances which created them changed, and (3) had a continuity in program management which contributed to its having a current awareness of all factors bearing on its mission.

The Office believed, as did others, that NSF should remain a general-purpose agency; its primary responsibilities should be in the basic research area, with considerable or major emphasis on non-problem-oriented research. Specific roles indicated for NSF were (1) support of discipline-oriented research, (2) stimulation and support of research in neglected areas of research, and (3) responsibility for ensuring the supply of trained research manpower in the social and physical sciences.

Geological Survey

The Survey expressed the view that under recent legislation NSF had become another mission agency of the Federal Government as far as problem-oriented research was concerned, especially when it entered the realm of applied research, but with the disadvantage of not having a major theme to pursue (such as defense, transportation, housing, natural resources, or health) or the in-house strength in a particular field of scientific or engineering competence

(such as communication electronics, nuclear engineering, earth sciences, metallurgy, or wildlife biology) to bring to bear on the problem. Therefore, in the opinion of the Survey, NSF must rely on the time-consuming processes of assembling outside advisory groups and of obtaining proposals for carrying out the research.

Bureau of Reclamation

The Bureau stated that it believed that the current role of NSF to initiate and sponsor problem-oriented basic and applied research was proper and should continue and that it hoped that NSF, through its new RANN program, would sponsor research programs of the Federal mission agencies.

VIEWS OF STATE AND LOCAL GOVERNMENTS

We obtained comments from 11 officials in State and local government agencies concerning the role of Federal Government and non-Government organizations in sponsoring and performing problem-oriented research. Regarding the role of Federal mission agencies, the predominant view expressed by State and local government officials, which was similar to that expressed also by Federal agencies, was that the mission agencies should support all research related to their missions.

Concerning the responsibilities of other organizations, the views of one State official, which were similar to those expressed by other State and local government officials and by certain Federal agencies, were that:

> "The responsibility of the National Science Foundation for the support of problem-oriented research should be to (1) support those problems which are common to several national agencies of the Federal Government and whose solution would benefit each of them, (2) support those problem-oriented research projects which are urgent but are not being supported by any of the national agencies, (3) initiate problem-oriented research which is long-range and is not being covered by the agency. In these cases, a potential solution should be picked up by the need-agency for further support, thus releasing the NSF funds for other problems."

* * * * *

> "Academic institutions should be responsible to highlight those problems facing our society and to recommend probable solutions. Academic institutions have a responsibility to bring the latest scientific discoveries to bear on existing problems and, if possible, to support some of the research themselves.
>
> "Nonprofit research institutes are responsible to the technical community to assist in defining problems and to disseminate this information,

> particularly those problems whose solution may be achieved through research. If possible, they should carry out exploratory research in order to demonstrate the potential of a solution. Insofar as the research institute is aware of possible solutions or methods of attack on a particular problem and other research activities, they should bring this to the attention of those who have the problem or who are responsible for its solution.
>
> "Industry has the same responsibility as each of the others in defining the research problem and, because of their vast interest, have a responsibility of undertaking research with some of their own funds to solve the problem. The solution to the research problem may provide additional revenue through the sale of equipment, instrumentation or whatever, for that particular group and the potential revenue carries an investment responsibility."

Another responsibility proposed for NSF was that of a national coordinator of a problem-oriented research. One local government official believed that NSF should serve principally as a coordinator of research-support efforts and as an information center to gather, synopsize, catalog, and disseminate the results of research.

A State conservation department official considered NSF to be the logical agency within the Federal Government to encourage, monitor, evaluate, and fund research critical in the national interest. He believed that NSF should be expanded and funded to do a more complete and comprehensive job of establishing, coordinating, and evaluating scientific research. He also stated that NSF should fund all forms of research--theoretical, problem-oriented, basic, and applied research--and that such funds, in addition to being made available to universities and individuals, should be allocated to State agencies capable of conducting research particularly appropriate and oriented to State problems.

A view not typical of those expressed by others was that of one State agency official who said that, although

research was an important activity to the growth and economy of this country, he had grave concern regarding the Government's being heavily involved in the funding of research activities. He believed that the Government should cut back on expenditures for research in all but a few basic research areas that showed great promise.

It is difficult, in his view, for an organization as large as the Federal Government to evaluate properly the products of research. The Government, he said, might write off a bad research expenditure with little adverse economic consequence and often was led to believe that the products of a research effort were effective when actually they were of little value.

He believed also that private industry, using its own monies, should be the main arm for applied and problem-oriented research because a private company would prosper or fall, depending largely upon its ability to finance profitable research efforts; the profit motive usually was the best tool for evaluating the benefits of research efforts.

VIEWS OF ACADEMIC INSTITUTIONS

We obtained from 39 universities or individuals associated with universities their views regarding what the functions of various Government and non-Government organizations should be in sponsoring and performing problem-oriented research. The general view was that problem-oriented research should be sponsored by the Federal Government and by other organizations which were in a position to make use of the information in solving a specific problem.

One university official stated that neither industry nor the academic institutions could, without Federal support, justify the kinds and magnitude of research necessary to meet national needs and that therefore the Federal Government had to be the primary source of support for basic and applied research, including that which was problem oriented. He stated also that the concept of mission orientation in general offered a flexible means of meeting diverse and changing national needs. He expressed the opinion that, since their involvement promoted the early application of knowledge, mission-oriented Federal agencies should provide most of the support for basic and applied research.

Another university official stated that problem-oriented research should be sponsored by all levels of Government and non-Government organizations that perform research or provide funds for research. He stated also that the extent of financial support by national, State, and local government organizations on any one problem would vary with the nature of the problem and the resources needed to deal effectively with the problem. National support, he said, became more important when the problem was national in scope, when extensive resources were required, or when a single large research facility was the best approach to solving a problem. State governments and academic institutions could perform research more effectively in those situations where proximity to the problem was more important. They are also in a better position to educate the users and to execute the sequences from basic information to practical application.

The view of another university official was that support of problem-oriented research should be provided by the individuals and/or organizations which had identified a problem area or which were most directly in need of results, and should be provided in conjunction with individuals and organizations whose primary expertise and missions were research. He stated that the latter involvement was necessary to ensure that the problems are researchable and that appropriate competence is applied to the problem and to be able to evaluate the validity of results on a scientific basis. Performers of research should be in a position to operate independently and without direct or indirect influence from the sponsoring agencies as to what results must or should be; both conditions are most likely to be met at academic institutions.

Another official believed that the question of which agency should sponsor problem-oriented research needed to be answered in relation to program content. If the emphasis was primarily on basic studies, the appropriate agency was NSF. As the research goals became more concerned with short-run problem solutions readily applicable to societal and environmental problems, the program responsibility should be located more appropriately in agencies having defined service and developmental functions. A role for NSF in the interagency boundary regions would be desirable, but this role would need to be small in relation to the whole of the NSF program if it is not to dilute seriously the central program of NSF.

Several university officials indicated concern over the possibility that NSF's support of problem-oriented research might adversely affect NSF's ability to sponsor basic research. More specific comments in this regard from university officials were that:

> "Basic Research, whether problem oriented or not, is the research that is most difficult to fund because its value is not readily obvious. The National Science Foundation should shy away from Applied Research. To insist that the research it supports be *** [problem-oriented research] will merely dilute the amount of Basic Research that gets done. Without Basic

Research we will run out of problems which can be solved. This is the critical problem and the tendency of Federal Government support to become mission oriented is having a deleterious influence."

"*** the move of NSF into problem-oriented research *** [is] a healthy development, so long as it does not severely impact their ability to support basic research. (Basic research is necessary to provide the scientific underpinnings for tomorrow's problem-oriented work, and NSF is a major source of support for such research in the United States.)

"There are a number of reasons for this view.

"1. *** NSF can provide the initial stimulus for work in areas not currently being pursued by a mission agency.

"2. *** NSF can initiate research which may uncover new concepts, approaches, or methods for evaluating programs in areas which are being pursued by the mission agencies.

"3. *** NSF is in a better position than others to support work which, while having great potential payoff in a particular problem area, has not yet progressed to the point where it can be justified on cost-effectiveness grounds ***.

"4. Since NSF's mandate includes the enhancement of scientific research and education generally, it is concerned with the process by which problem-oriented research can be stimulated and managed in universities and elsewhere. Participation in the support of problem-oriented research may help it to fulfill this role, in part by providing a 'model' for research management which may be adopted by other agencies ***.

"These views are derived in part from the desirability of a pluralistic approach to important

issues requiring highly creative inputs, partly from our belief that among the major government agencies NSF is best equipped to take the risks inherent in supporting some kinds of problem-oriented research, and partly from NSF's proven ability to work with universities in the furtherance of the kind of research objectives that are associated with problem-oriented (as opposed to problem-solving or developmental) research."

"The mission of the National Science Foundation is unique in that it is charged with the responsibility for maintaining the health, vigor, and excellence of American science, and the science education and training structure on which this depends. In doing this, the National Science Foundation keeps the disciplines of science moving forward and lays the foundation upon which technological developments may depend. In my view, it should not ordinarily be the primary supporter of interdisciplinary-problem research. The problems which it should accept can be complex--atmospheric problems, for example--but probably not some of the topics currently being accepted under the RANN *** program which more logically belong to mission-oriented Federal departments and agencies (if they can settle sensibly some inter-agency jurisdictional disputes). The value of the RANN program may be in demonstrating that it is possible to mount interdisciplinary research programs if there is sufficient attention to goals, and some tough-minded direction of the type more usually found in industrial laboratories. Since RANN will largely be built around the academic competence in universities, perhaps the myth that this type of program does not thrive in universities will be dispelled."

The administrative director of one university considered that one of the most important roles NSF should fill was that of becoming the "Federal balance wheel" for scientific research. By this he meant that NSF should identify national needs for science; evaluate its scientific research programs in relation to those undertaken

by other Federal agencies and private research groups; take the initiative in meshing its programs with the research activities of other agencies and with the interests of the scientific community; and, insofar as possible, compensate for disparities in the levels of support for different fields of science.

This same official expressed the view that, as Federal priorities shifted toward fulfilling national needs through problem-oriented research and applications-directed programs, some universities would decline participation as being incompatible with their educational objectives. Most universities, in all likelihood, would make their resources available, although they were fully aware that they must resist slipping into a "service station" role to the detriment of their teaching and research functions and must avoid taking institutional positions that would jeopardize the objectivity with which they approached those domestic problems that generated high levels of tension. He also said that:

> "Many universities will also be willing under appropriate circumstances and on a temporary basis to manage national or local programs for the solution of urban or domestic problems, even where they go beyond the type of demonstration project in which universities have increasingly engaged. In addition, universities are likely to become more involved in providing leadership or participation in coalitions or consortiums of industrial, community, governmental and voluntary associations organized to attack special problems. In general, however, universities should focus on the generation of knowledge and the mapping of policy alternatives, and should not normally play the principal role in the management of action programs."

VIEWS OF INDUSTRIAL ORGANIZATIONS

The views of representatives from the industrial sector were directed principally toward what they believed NSF's role should be in sponsoring problem-oriented research. These views, in most cases, were similar to those previously noted in this report regarding NSF's support of problem-oriented research. Specific comments of certain officials in industrial organizations follow.

One industrial research laboratory manager stated that:

"It would seem that the National Science Foundation could perform an important role of providing support for problem-oriented research in areas where such research is deemed necessary, but no specific agency has been assigned the responsibility of attacking the problem, or there is such an overlap of various agency interests that the NSF could act as an advisor and integrator of various problem-oriented research efforts. Government mission agencies should continue to support problem-oriented research in the areas of their responsibilities; possibly such agencies should place more emphasis on longer-range and more permanent solutions to problems, rather than concentrating almost exclusively on short-range stop-gap solutions. Academic institutions, nonprofit research institutes, and industrial laboratories should be utilized by Government agencies according to their proven capabilities and experience."

In the opinion of a corporate official:

"*** [it is] necessary that NSF expand its support in the area of basic research, particularly since other funding agencies now have a restricted mission or problem orientation. I am particularly concerned that academic scientists continue to have the opportunity to look for fundamental new knowledge in areas of their own choosing. I believe that the good health of our scientific and industrial establishment

depends on a continuing supply of new concepts and basic knowledge that will supply stimulus and ideas to scientists and technologists in applied areas. It is still true that important new knowledge can have very obscure beginnings, and even though non-problem oriented basic research may be inefficient, it is still the only way by which such knowledge can be cultivated."

An official of a consulting firm stated that:

"Within the scope of the definition that problem-oriented research is that which is guided toward goals of importance, it is our opinion that such research should be supported largely by mission-oriented agencies. This point of view is based on the thesis that basic research, applied research and engineering individually flourish most abundantly in an environment which encompasses all three. The synergistic efforts of proximity are real and important.

"*** it is quite appropriate for NSF to continue to sponsor basic research. It is important, however, to recognize that skills and facilities for such basic studies are available not only in universities but in nonprofit and research institutes and in industry. NSF should perhaps recognize these broad sources of research capability and develop adequate grant and contract procedures to utilize all such resources in the most effective way.

"Problem-oriented research, on the other hand, can be most effectively handled by the mission-oriented agencies who in general are better equipped to monitor such programs and to implement the results in a rapid and efficient manner. Nonprofit research institutes and industrial organizations are normally 'performers' of research and generally fill this role well."

The vice president of a research company considered NSF's role to be threefold.

1. Supporting basic research which must necessarily be conducted and ongoing in order to give the problem-oriented research organizations the tools which they needed to carry out their missions.

2. Supporting research to fill gaps which occurred in the problem-oriented research and which, for one reason or another, did not fall under the specific jurisdiction of a given mission agency or for which funds in any given fiscal year were lacking, but where the problem was identified and was intense enough to require a rather rapid solution.

3. Acting as a Federal clearinghouse for bringing together various funding schedules, requirements, and proposal inputs that would be necessary for several Federal agencies to support a combined single effort leading to an overall environmental plan.

VIEWS OF NONPROFIT RESEARCH INSTITUTES

Similar to the views expressed by the other groups, the predominant views expressed by the 15 nonprofit research institutes and individuals associated with the institutes concerning the roles of Government and non-Government organizations in supporting and performing problem-oriented research were that (1) NSF should identify and support long-range research pertinent to societal problems and research not within the statutory authority of a particular mission agency, (2) the Federal mission agencies should support and manage problem-oriented research related to the agencies' particular missions, and (3) industry should support and perform problem-oriented research in its areas of interest and expertise.

One nonprofit research institute stated that:

"Increased support of research by the federal government may be required if appropriate utilization of national technological capabilities is to be realized. Although many agencies of the federal government can and should support such research, an organization like the National Science Foundation, which is capable of spanning many disciplines and areas of interest, should play a leading role. This is particularly important in attempts to apply technology to environmental, urban, and social problems. Although eventual utilization of such research may be at state, regional, or local levels, it will be necessary that a strong Federal support exist; the governmental jurisdictions which will utilize results, have limited resources, and should not carry out much of the research themselves. The federal government has the potential for imaginative encouragement, for monitoring to avoid unnecessary duplications, and for ensuring appropriate applications."

* * * * *

"It is expected that industry will continue to sponsor problem-oriented research, but in areas

of particular interest to product improvement and new areas of operations. Only indirectly can this research be expected to assist in solving current national problems. It can be expected that academic institutions should and will return to an emphasis on teaching and on basic research. It does not seem desirable that they should be the sponsors or even the performers of problem-oriented research. Nonprofit research institutes normally require external funding for their activities, unless they are able to draw on their own endowments or their own resources. Where such resources exist, they can become very effective sponsors, both for in-house activities and for tasks carried out by others."

* * * * *

"Many research activities, even though problem-oriented, will have applications in many fields and across many mission agency responsibilities. Here the National Science Foundation can play a very important role, particularly at the earlier stages of research or experimental development. Some restructuring of NSF and a supplementing of its traditional academic orientation with an applications emphasis may be desirable."

The institute also pointed out that Federal contract research centers could provide technical management services to develop systems and technology to bridge the gap between basic research and successful innovation. These centers, according to the institute, might be able to assist in providing an existing institutional capability, combining many of the advantages of industry and of Government laboratories, and to assist in developing an effective Federal program of research applied to national needs.

The director of another research institute believed that NSF should be funding fundamental research pertinent to long-range societal problems and that, when feasible results were achieved, they should be made available to society as rapidly as possible, probably through a mission agency.

Several officials of another institute also stated that NSF's role should be that of generator of basic information, perhaps 10 to 15 years in advance of applied or problem-oriented research or development. They stated also that NSF should not be involved in applied research which was the province of the various mission agencies.

A director of one institute stated that NSF should support research for which other agencies lacked resources, competence, or objectivity and should provide "seed money" for studies that might have no immediate payoff but that have potential long-range benefit to other agencies that might supply subsequent funding. An assistant executive director of the same institution stated that NSF, with a much broader and less precisely defined mission than most other agencies, was clearly suited for two important roles. He believed, first, that NSF's primary role should be to take a forward view and attack those problems which appeared to be rising in national importance but which were not within the responsibility of any other agency and, secondly, that NSF should continue to support research in the field of other agencies' missions when it believed that a fruitful approach was not otherwise being explored.

A nonprofit research corporation suggested that:

1. NSF should sponsor pilot programs involving new missions or new technologies and exploratory research requiring comprehensive, interdisciplinary studies.

2. Industry and private consultants should perform specialized, directed problem-oriented research, provide technical assistance under contract, and assist in the development and implementation of problem-oriented research programs.

3. Academic institutions and nonprofit research institutes should perform exploratory problem-oriented research, provide interdisciplinary technical support for local governments, and perform evaluation studies for local governments and Federal agencies.

Another nonprofit research institute advised us that:

> "The role of the National Science Foundation should be to support and initiate research in areas where an overview is most needed or where a particular mission-oriented agency is restricted either by function or resources from adequately protecting the public interest in a given matter. Further, the National Science Foundation should solicit support for research by a mission-oriented agency when it appears that the results of such research will significantly further the achievement of the agencies' goals.
>
> "Academic institutions and non-profit research institutes should both be serving a role in problem identification and the construction of the team of individuals to adequately carry out the research. Particular industries may be involved either in the research itself or the support of the research if the aims of the corporation are aligned with it. The limitations of any one industry in terms of its goals should be recognized because of the importance of conducting research which is in the general public interest rather than that of a specific group or industry. For this reason, industrial support should probably come through an independent agency with responsibility only to the public."

A senior research member of a research institute concentrating on medical research stated that:

> "It is perfectly proper for the Government to support Problem-oriented Research, through either *** [National Institutes of Health] or through the National Science Foundation, or through both. Multiple sources of funding are in general a good idea, because they make it less likely that a new constructive idea will be blocked by misunderstandings or emotional difficulties on the part of a single administrative unit. Therefore, from the point of view of productive research, multiple sources of funding are

not redundant, they increase the chance that high-grade innovative projects will actually get funded.

"Most research, even problem-oriented research, in medicine should be performed by universities and other not-for-profit research organizations. This is partly because good medical research is rarely carried out effectively when it is separated very far from the patient and from teaching. Some specific technical problems, involving design of equipment, specific chemical problems, or specific physical problems can be best developed by private contractors."

* * * * *

"*** The role for NSF is to remain essentially separate from other agencies funding research, to use different 'peer' groups to evaluate their projects, and to maintain their own separate viewpoint and analysis of priorities."

A nonprofit research institute director stated that, if NSF continued with programs such as the RANN program, it would have to use institutions which were capable of not only performing research, but also managing it on behalf of NSF. He believed that NSF was not oriented toward management.

He stated also that nonprofit research institutes occupied a unique position somewhere between the academic and industrial research communities. He noted that academic institutions were "free spirits" and excelled at basic research. They were also individualistic in nature and for these reasons generally would be unable to manage problem-oriented research. Traditionally academic institutions have not managed their research, although industrial research laboratories have provided extensive management with little research flexibility. The director believed that nonprofit research institutes provided the program balance of managerial control and research flexibility which was best suited to attacking problems of national significance.

Another nonprofit research institute official stated that:

> "Government's role in support of problem-oriented R&D [research and development] should be when: (a) Technological progress is in the national interest (space programs, energy supply, agriculture, etc.); (b) National security matters are involved; (c) There is broad application of the developing technology for the national welfare; or (d) There is too high a risk to apply diluted industry efforts and capitol [sic] for attainment of a national objective."
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> * * * * *
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> "We view the National Science Foundation as a necessary and important mechanism for insuring growth and superior quality of the Nation's technological base. We agree that NSF should render major support to academic research effort but it should also maintain close liaison with the various mission agencies in the Federal government. In this context we completely concur with the need for NSF's RANN program wherein applied research either of a longer time frame than that normally supported by mission agencies or that lacking funds from such agencies, can be supported by NSF. The RANN program needs to be expanded, particularly in support of innovative energy conversion and waste recycling research areas."

VIEWS OF OTHERS

The Director, Office of Science and Technology, explained that mission-oriented agencies normally instituted programs of problem-oriented research to obtain information needed to accomplish their program objectives. He pointed out, however, that many well-defined problems facing mission agencies did not come primarily under the purview of any one mission agency. Even where there was an agency of primary cognizance, the long-range nature of the required research or inadequate linkage with the university community might make it difficult for the agency to support problem-oriented research. He said that, to support research in such applied or problem-oriented areas, NSF established the RANN program.

The Director stated that increased Federal emphasis on problem-oriented research would provide traditional performers of basic research with opportunities to broaden their horizons and that it might demonstrate the usefulness of traditional basic research in providing the knowledge base needed to solve problems.

Officials of the National Academy of Engineering advised us that the Academy's views concerning Federal support of problem-oriented research were presented in its two reports entitled "Federal Support of Applied Research" and "Priorities in Applied Research, an Initial Appraisal," respectively.

The reports stated that Federal support for applied research currently was limited to programs designed to satisfy short- and medium-range Federal needs. Agencies oriented toward such programs quite naturally concentrated on those applied research activities which appeared to them most immediately relevant and useful to their specific missions. Mission-oriented support of this nature, however, might fail to serve long-run needs when viewed from the broad perspective of all national purposes and goals, some of which might be common to, or fall between, mission-oriented goals.

Thus, according to the reports, there was a gap in Federal support of applied research. This gap arose from

the differences between current applied research support and the more desirable, fuller support discussed above. The reports noted that NSF had filled a significant part of the gap in Federal support of basic research areas but that no single agency had devoted its efforts to filling the gaps in applied research.

The Academy reports suggested that NSF among other things, could (1) stimulate research which fell outside the province of the mission-oriented agencies, (2) help provide the quality and quantity of applied scientific and engineering talent necessary for graduate programs which stress interdisciplinary research, (3) continue to fund original applied research programs only until it was clear that development agencies would fund the applied research at a reasonable level, (4) support applied research on a problem-oriented, rather than a disciplinary, basis, and (5) give special emphasis to research toward the development of a useful social data base.

We obtained the views of the Chairman of the National Academy of Sciences' Committee on Basic Education. He believed that NSF's role should be to sponsor long-term (10 to 20 years) research. It was his opinion that NSF could not serve in the role of a "gap filler" because it was not economically feasible for a small agency like NSF to fill the gaps of the larger mission agencies.

Concerning the roles of the other organizations, the Chairman stated that the mission agencies should support research in conjunction with their missions and that industry should sponsor problem-oriented research to a greater extent, although there was a reluctance on the part of industry to do so.

We interviewed an official of the Economic, Science, and Technology Division, Office of Management and Budget, who told us that he believed that NSF could serve four roles: (1) support problem-oriented research that was broader than the mission agencies' charters, (2) support research in areas that the mission agencies had avoided for one reason or another, (3) support long-range research with the objective of creating new knowledge, and (4) involve and interest the academic community in training people to

participate in interdisciplinary research in such areas as environmental research.

He believed also, as many others did, that mission agencies should support research related to their respective missions and that most of this research would be problem oriented. He thought that industry should, in addition to sponsoring problem-oriented research, assist in planning and monitoring research sponsored by others so that the results from such research might be effectively implemented.

CHAPTER 4

OBSERVATIONS ON CERTAIN ASPECTS OF FEDERALLY SPONSORED RESEARCH

The observations of various organizations and individuals concerning (1) funding of Federal research projects, (2) dissemination of scientific information, and (3) the impact of problem-oriented research on specific Federal and non-Federal organizations are presented below.

FUNDING OF RESEARCH PROJECTS

Some university officials indicated that the lack of stability in financial support was a significant problem in performing problem-oriented research.

One university official advised us that the lack of stability in program support created a "feast or famine" situation which made it difficult to maintain a stable staff of qualified personnel. It also placed severe restraints on the accumulation of expertise which can be retained and transmitted to future work through a stable organizational setting. Consequently he believed that it would be highly desirable for problem-oriented research sponsors to provide support for developing the necessary kind of research capability for effectively working on whatever problems were of high priority and then to provide stable and predictable funding for continued work at some specified level of effort on the problem.

An associate dean of one academic institution stated that the academic institutions were at a disadvantage in performing problem-oriented research because of their disciplinary structures and because of the stability of their staffs. He stated that the academic institutions were unable to "staff up" for particular research efforts unless there were long-term guarantees of research funding.

It was the view of one department chairman at a State college that the bulk of the Federal grant monies went to established researchers at the large research-oriented universities. This, he believed, was a "safe procedure, for obvious reasons," but it did not assist in the

development of capable people and institutions of more modest reputations. He stated that:

> "Much of the engineering research support at the large research universities goes to support graduate students. Typically, these are Ph.D. students who are research oriented, rather than practice oriented. They graduate to enter positions where they are expected to produce proposals for more research. This 'side effect,' of research grants providing support for research students, has always automatically been considered a benefit, however, in view of the supply-demand situation in this country, this point of view should be reconsidered. Perhaps the time has come to divorce, to some extent, research support from student production.
>
> "One way of doing this is to provide research support to professors at non-Ph.D. producing schools. In such instances, the professor himself, rather than graduate students, would be doing the actual work. The research would be accomplished, the professor's existing competence maintained, and his teaching stimulated, without encouraging the production of more researchers in an already-glutted market."

The treasurer of a nonprofit research corporation stated that:

> "To attract and retain high-quality researchers, as well as to allow them to keep abreast of the state of the art in their fields, some funding is necessary for continuing education, professional society activities and personal research. While some of this type of cost is allowable as overhead, grants for scientific study, from agencies such as NSF, can be very helpful in preserving high-quality staffs and thereby promoting high-quality problem-oriented research. Unfortunately, NSF usually requires grantee institutions to contribute funds in the form of cost sharing, and non-profit institutions *** do

not have the resources needed for extensive cost sharing. Relaxation of the cost-sharing principle in special cases could help to preserve high-quality research teams."

It was the opinion of one industry official that industry would like to share in the cost of long-term problem-oriented research if the Government would grant all patent rights to discoveries to private industry on an exclusive basis. He pointed out that England, Europe in general, and Japan were more sophisticated in exploiting the private profitmaking laboratories.

A vice president of a corporate research organization concurred in the suggested change in the Government's patent policy. He stated that:

"*** the patent policy relating to the disposition of basic research carried out with government funds [should] be modified so as to make the terms more favorable to industrial companies willing to develop these research findings. The cost of developing of research to a commercially useful stage is generally far greater than the initial basic research. Nevertheless, once government funding is involved at some stage of research, the protection afforded to a private developer is often insufficient in providing that developer a fair return on his investment, thereby discouraging implementation of potentially useful technology."

The "Statement of Government Patent Policy" was issued by Presidential memorandum dated August 23, 1971, to the heads of executive departments and agencies. The statement provided, in part, that:

"*** the Government shall normally acquire or reserve the right to acquire the principal or exclusive rights throughout the world in and to any inventions made in the course of or under the contract.

"In exceptional circumstances the contractor may acquire greater rights than a nonexclusive license at the time of contracting where the head of the department or agency certifies that such action will best serve the public interest. Greater rights may also be acquired by the contractor after the invention has been identified where the head of the department or agency determines that the acquisition of such greater rights is consistent with the intent of this Section 1(a) and is either a necessary incentive to call forth private risk capital and expense to bring the invention to the point of practical application or that the Government's contribution to the invention is small compared to that of the contractor. Where an identified invention made in the course of or under the contract is not a primary object of the contract, greater rights may also be acquired by the contractor under the criteria of Section 1(c).

"In other situations, where the purpose of the contract is to build upon existing knowledge or technology, to develop information, products, processes, or methods for use by the Government, and the work called for by the contract is in a field of technology in which the contractor has acquired technical competence (demonstrated by factors such as know-how, experience, and patent position) directly related to an area in which the contractor has an established nongovernmental commercial position, the contractor shall normally acquire the principal or exclusive rights throughout the world in and to any resulting inventions."

DISSEMINATION OF RESEARCH RESULTS

Information developed during our review indicated that the mechanism most frequently used to make research results available to potential users was professional or scientific journals. Other means included (1) professional meetings where research results were presented, (2) informal personal contacts between scientists, (3) news media, and (4) personnel transfers between organizations. Several officials from Government and non-Government organizations, however, did not believe that such methods provided the most efficient and effective means for disseminating research results to potential users.

Comments from these officials indicated that a communication gap existed between researchers and practitioners. An official of one nonprofit organization stated that he did not believe that the existing transfer processes were working because there was a lack of communication between the theoreticians and the practitioners.

Also a college department chairman noted that:

> "It is a well-recognized, but rarely-admitted, fact that most engineering research reports and papers are written for other researchers (if in fact they are written for anyone at all) and not for the practitioner. There is a vast gap between the work of the researcher and the needs of the practitioner. The practicing engineer cannot read the technical journals, or, if he has tried, has learned that the information is not useful to him ***.
>
> "*** applied research, to make useful the body of existing knowledge developed from basic research, is virtually unsupported. Some source, and NSF seems a logical one, should be concerned with bringing the fruits of basic research to a point where the practitioner can utilize these results and benefit from them.
>
> "Generally, the people conducting the basic research are not capable, psychologically or technically, to do this. This work must be

done by people more closely aligned with the practicing profession."

A State government agency official, who considered himself to be a user of research results, held the opinion that "far too much money" was being dispensed to academic institutions for basic research; that the results of much of that research was reported in such a way as to be restricted, for practical purposes, to the inner circles of the academic community; and that the relevancy of the research results to existing problems often was indeterminate.

He also pointed out that:

"*** A major problem is that the sheer amount of this research and resulting data is staggering to the practicing engineer or scientist to the point that it is impossible for him to acquaint himself with it, let alone make any evaluation of it in terms of its usefulness.

"This brings me to what I see as a fundamental problem in our technological society, namely, the great chasm between the level of knowledge that presently exists and the level of knowledge that actually finds application in the day-to-day operations of our public and private action agencies. In my view, the greatest service the National Science Foundation could do would be to devise and implement some program that would evaluate, in terms of usefulness, the presently available results of research, both basic and applied, and inflict that knowledge and information on the agencies and personnel that are dealing with everyday problems in our society. I believe such a program could and should be financed at the expense of a portion of what is presently allocated for basic research."

An official of a State agency advised us that potential users of research results were not always aware of research supported by their own organizations. He stated that

potential users of research became aware of research activities when they made distinct and aggressive efforts to do so. He explained that a "distinct and aggressive effort" frequently meant assigning a person the full-time responsibility of being an information source and of acquiring the information.

An official of an industrial organization stated that:

> "*** The responsibilities of supporters and performers should be first and foremost a determination of existing completed problem-oriented research projects. *** we know that a tremendous amount of duplication of effort has occurred in problem oriented research projects in the environmental area. We recommend a compilation and, if possible, a computerized information retrieval system which would catalog all existing problem oriented research projects that have been completed in the environmental field."

One Federal laboratory official stated that:

> "The dissemination of problem-oriented research needs much improvement. Usually one governmental agency has no idea what research is going on in another agency. Unless the research is published in a journal that has wide circulation, it may remain buried for a long time. Some type of abstracting service *** is needed to help make problem-oriented research available to the user. It would also help if each research section of an agency published *** a quarterly summary of research findings, both extra and intramural. In addition, each agency should have programs that try to translate the research results into data that the user can use ***.

Another Federal laboratory official stated that he believed that:

> "*** there is a need for a central clearing house for all data on both completed and ongoing research regardless of whether or not it is problem-oriented,

since there is often an overlap between the two and rigid exclusion of basic research might allow needless duplication. Although the Federal government maintains a running inventory of Federal research (except for classified work) through the Smithsonian *** [Institution] and various minor computerized programs of certain mission-oriented agencies, there is an almost total lack of systemized listing of state, local and private research. This condition needs attention. Currently potential users must rely upon expensive, time consuming literature searches which may often be incomplete because of budgetary limitations. The only other recourse is the personal memory of an individual advisory expert in the field of the user's interest."

IMPACT OF PROBLEM-ORIENTED RESEARCH ON ORGANIZATIONS

Officials of most of the industrial firms and nonprofit research institutes indicated that problem-oriented research had no material effect on their organizations. In two instances State and local government officials indicated that new organizational units had been established to accommodate such research. Officials of certain Federal mission agencies and academic institutions, however, indicated that their involvement in problem-oriented research had had an impact on the structure of their organizations and resources.

DOD explained that the support of problem-oriented research had greatly affected its organizational structure, facilities, and scientific and personnel resources. DOD stated that, because of changes in its research and development activities, the research and development segment of its organization had been changed and refined. As the importance of a defense mission increases, laboratories are established to perform the research and development work pertaining to that mission. As the importance of the mission decreases, the laboratories may be closed and their responsibilities assigned to other laboratories and centers.

The Bureau of Sport Fisheries and Wildlife, Department of the Interior, stated that the performance of problem-oriented research had had an impact on its organizational structure and on the allocation and use of such resources as personnel, equipment, and facilities. The Bureau stated also that in many cases there was a dual use of facilities and equipment and that in some cases there was a sharing of manpower between the research functions and the operating activities. The Bureau believed that this had resulted in increased efficiency.

The director of a Federal research center stated that the impact on the organizational structure of performing problem-oriented research depended on the magnitude of the problem and whether it fitted into the formal charters and organizational elements of the organization. In those cases where it did not properly fit into the organization's usual mold, the practice of the center was to set up special

teams or offices charged with the solution of the particular problem in question. Those groups drew persons from the cross-conventional organizational units in the laboratory, and they typically existed only until satisfactory solutions to the research problems were obtained. When that occurred, the persons then returned to their previous formal organizations. The center had found this to be an effective way of coping with the problem of rapidly changing research objectives that were characteristic of problem-oriented research in contrast to those of discipline-oriented research.

Officials of six academic institutions made the following comments concerning the impact of problem-oriented research on their institutions.

> "*** the primary impact on the University's organizational structure has been the formation of multidisciplinary centers and institutes ***. Since project and program support does not provide adequately for facilities, during periods of growth there is considerable pressure for facilities support--either renovation of existing space, acquisition of leased space, or construction of new space. During periods of declining support or interrupted support, there is considerable pressure from the units for the University to maintain continuity of the research program or to ameliorate the adverse economic consequences of a reduced or terminated program.
>
> "Primarily, the main problem to the University in conducting research is one of maintaining an appropriate balance between research and teaching, each should support and enhance the other."
>
> "The performance of problem-oriented research has resulted in the establishment of two institutes within the academic department structure of the School to permit better focus on the research programs and better coordination between education and research."

"The emphasis on problem-oriented research that requires large-scale group efforts by faculty from many different fields has resulted in an increased tendency to establish specific centers or programs with a faculty director who is responsible for the overall administration of the project. In many cases, the operation of such large-scale programs requires specialized facilities or equipment, the funds for which are often sought from the funding agency. One perplexing problem that often occurs is the difficulty in obtaining the necessary operating funds for these specialized facilities or equipment after the initial project is discontinued even though the established center or project is still in operation due to other sources of funds."

"Problem-oriented research has significantly affected the organization, resources, and capabilities of U.S. universities, for instance in the field of high-energy physics at selected universities, where major laboratory facilities and staffs have been created. Other examples are the health sciences and schools of medicine and public health. In these and other fields, externally defined goals and programs have provided opportunities for the expansion of resources in particular areas and have correspondingly influenced student enrollments. In many respects, such developments have been beneficial. However, nonbenefiting disciplines frequently view such changes as 'distortions' of the University's natural development and as likely to bring an excess of external influence to bear on University development. In rapidly growing fields (e.g., public health), externally induced expansion, based on external funding, may proceed at a rate faster than the institution can match. There is then the danger that an excess of special-purpose 'soft money' appointments may be made, so that the University becomes highly vulnerable to rapid shifts in Federal policies and appropriations."

"Performance of problem-oriented research has had significant impacts on organization structure and on the allocation of resources.

"Of greatest importance such research results in bringing to the campus equipment and distinctively capable scientists that would otherwise not be attracted. On the negative side, special task forces, centers and institutes often attract capable faculty away from the central interests of departments. Also, successful programs compete for space, equipment and other facilities.

"We view the challenges of competition, shifting interests and change as well as continued adjustments in organization to be healthy and vital to a vigorous *** institution. This competition has substantially increased the quality of research in several areas. The links with the public and the training and contacts afforded staff and students are significant factors in keeping the University in the mainstream of public interest."

"The performance of problem-oriented research has caused many more problems than the basic research more normally associated with a university. Many problem-oriented research projects are conducted under severe time constraints and require immediate allocation of substantial amounts of the university's resources. Sponsoring agencies should consider problem-oriented research with more lenient budget restrictions than are normally provided in research contracts and grants."

COMMITTEE ON SCIENCE AND ASTRONAUTICS
HOUSE OF REPRESENTATIVES
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515

September 8, 1971

The Honorable Elmer B. Staats
Comptroller General of the United States
General Accounting Office
Washington, D. C. 20548

Dear Mr. Staats:

This letter is to request your office to provide assistance to the Committee in performing a review of certain aspects of the National Science Foundation's support of applied research.

NSF was established by the National Science Foundation Act of 1950 to support only basic research and science education. The rationale for this restriction was that applied research relevant to Federal activities would be supported by mission-oriented agencies.

In July 1968 the National Science Foundation Act was amended by Public Law 90-407 to grant NSF permissive authority to support applied research. Since then, support for applied research in NSF's budget has significantly increased. In its request to Congress for fiscal year 1972, NSF included $70 million for applied research, over 10 per cent of NSF's total budget. The NSF Director has testified that applied research may eventually total as much as 20 or 25 per cent of the annual NSF budget.

During fiscal year 1971, NSF consolidated most of its problem-oriented research into the program entitled "Research Applied to National Needs (RANN). RANN supports solicited and unsolicited proposals for problem-oriented research, sometimes in fields already being heavily funded by mission agencies.

The Committee stated in its report on NSF's authorization bill for fiscal year 1972 that:

> "As a general principle, the Committee feels that in order to maximize the return on investment in research and development for a particular socially desirable area, as many of the specific decisions as possible should be placed in the hands of the actual user of the research results. This means that, where feasible, problem oriented research should be supported by the appropriate mission agency.

'This does not mean, however, that the NSF should not play an important role in supporting problem oriented research. It does mean that the Committee desires to look in more detail at NSF plans in this regard, and in particular to contrast policies for funding problem oriented research through RANN with alternative mechanisms in the mission agencies.

"During the coming year the Subcommittee on Science, Research and Development hopes to inquire into these policy issues on a broad basis. It will survey not only the RANN program at NSF and existing mission agency support of problem oriented research, but possible mechanisms through which the NSF and the mission agencies can cooperate in the support of research activities appropriate to both."

In order to assist the Committee's inquiry, we request that your office examine Federal support of problem-oriented research, with special attention to the NSF program "Research Applied to National Needs". In order to establish benchmarks for our inquiry, I would hope that your review would include background and summary data on the sponsors of problem-oriented research (Federal government, industrial corporations, and others) and the organizations which perform that research (universities, not-for-profit laboratories, industrial laboratories, etc.). If feasible, data and ideas concerning the rationale of support for problem-oriented research as well as desirable management procedures should be solicited from officials in the relevant government and non-government organizations. Technology transfer, of course, is also an important aspect of our inquiry and should be addressed in your review.

I realize that this request may be somewhat different from the type which is usually referred to your office. It is, however, an important issue facing the Subcommittee and the Congress today, and I hope you can assist us. I would suggest that your staff work as closely as possible with the staff of the Committee, and that questions which may arise during the course of this study be brought directly to the attention of the Committee staff.

So that the information developed by your office can be useful during the Committee's consideration of the NSF budget request for fiscal year 1973, we would appreciate a draft report on the results of your review in early February 1972, and a final report by March 1, 1972.

Sincerely yours,

John W. Davis

JOHN W. DAVIS
Chairman
Subcommittee on Science,
Research and Development

LIST OF ORGANIZATIONS CONTACTED

ACADEMIC INSTITUTIONS:

- California Institute of Technology
- California, University of
- Carnegie-Mellon University
- Chicago, University of
- Colorado State University
- Colorado, University of
- Denver, University of
- George Washington University
- Harvard University
- Iowa, University of
- Lehigh University
- Massachusetts Institute of Technology
- Michigan, University of
- Missouri, University of
- New Hampshire, University of
- New Mexico, University of
- New York State College of Agriculture
- Northeastern University
- Northwestern University
- Ohio State University
- Oklahoma State University
- Pennsylvania, University of
- Pennsylvania State University
- San Jose State College
- Southern California, University of
- Stanford University
- Utah, University of
- Utah State University
- Wisconsin, University of

INDUSTRIAL CORPORATIONS:

- Arthur D. Little, Inc.
- Auto-Research Laboratories, Inc.
- Avco-Everett Research Laboratory
- Baxter Laboratories, Inc.
- Cook Research Laboratories, Inc.
- E.G. & G.
- Hercules, Inc.
- Illinois Water Treatment Company
- Kaiser Aluminum & Chemical Corporation
- McDonnell Douglas Corporation

INDUSTRIAL CORPORATIONS (continued):
- Metronics Associates, Inc.
- North American Rockwell
- Northrop Corporation
- Raytheon Company
- Standard Oil of Indiana
- Sun Oil Company
- Swift and Company
- The Gates Rubber Company
- Syntex Research
- United States Steel Corporation
- URS Research Company
- Varian Associates
- Westinghouse Electric Corporation

FEDERAL AGENCIES AND LABORATORIES:
- Atomic Energy Commission
- Department of Agriculture:
  - Washington, D.C., headquarters
  - Pacific Southwest Forest and Range Experiment Station
- Department of Commerce:
  - National Oceanic and Atmospheric Administration, Earthquake Mechanism Laboratory
- Department of Defense:
  - Washington, D.C., headquarters
  - Air Force Cambridge Research Laboratories
  - U.S. Army Natick Laboratory
- Department of Housing and Urban Development
- Department of the Interior:
  - Bonneville Power Administration
  - Bureau of Land Management
  - Bureau of Mines
  - Bureau of Mines, Pittsburgh Energy Research Center
  - Bureau of Reclamation
  - Bureau of Sport Fisheries and Wildlife
  - Geological Survey
  - Office of Saline Water
  - Office of Water Resources Research
- Department of Transportation
- Environmental Protection Agency
- National Aeronautics and Space Administration:
  - Washington, D.C., headquarters
  - Ames Research Laboratory
- Office of Management and Budget
- Office of Science and Technology

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS:
- Lawrence Radiation Laboratory
- Lincoln Laboratory
- Oak Ridge National Laboratory
- Research for Better Schools, Inc.
- The Aerospace Corporation
- The MITRE Corporation
- The RAND Corporation

NONPROFIT RESEARCH INSTITUTES:
- Brookings Institute
- Center for Advanced Study in Behavioral Sciences
- Franklin Institute
- Institute for Cancer Research
- Institute of Gas Technology
- Illinois Institute of Technology Research Institute
- John Muir Institute
- Kaiser Foundation Research Institute
- Los Angeles Technical Service Corporation
- Palo Alto Medical Research Foundation
- Stanford Research Institute
- System Development Corporation
- The Hektoen Institute for Medical Research
- The Institute of Medical Sciences

STATE AND LOCAL GOVERNMENTS AND AGENCIES:
- Association of Bay Area Governments (San Francisco area)
- City of Boston, Massachusetts
- City of Los Angeles, California
- Cook County, Illinois
- Massachusetts Bay Transportation Authority
- State of California:
  - Air Resources Board
  - Department of Conservation, Division of Mines and Geology
  - Department of Water Resources
  - State Water Resources Control Board
- State of Colorado, Department of Health

OTHERS:
- National Academy of Engineering
- National Academy of Sciences

U.S. GAO, Wash., D.C.