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STRATEGIES FOR

APPLIED RESEARCH MANAGEMENT

A report of the
ad hoc Steering Committee for the
Study of Research Applied to National Needs
of the
Committee on Public Engineering Policy
Assembly of Engineering
National Research Council

National Academy of Sciences
Washington, D.C. 1978

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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OFFICE OF THE CHAIRMAN 202/389-6868

Honorable Richard C. Atkinson
Director
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Dear Dr. Atkinson:

I am pleased to transmit to you the enclosed report entitled Strategies for Applied Research Management. This report represents the effort of the Committee on Public Engineering Policy (COPEP) and its steering committee for the study of the applied research program of the National Science Foundation.

In December 1973, the Foundation requested the National Academy of Engineering (operating as the Assembly of Engineering of the National Research Council since July 1974) to examine the program areas of the Foundation's program on Research Applied to National Needs (RANN). The work was done as the second phase of a study of RANN's program priorities, in compliance with task order 243 of contract NSF-C310.

COPEP has extended its earlier contemplation of RANN's concerns, to embrace the general question: What ways are open to RANN to achieve effective and timely use of its research results? Proceeding, then, from a discussion of identifiable priorities following its first (1972-73) study of RANN, COPEP now identifies and discusses alternative strategies for managing RANN's subprograms.

This report is based on work--case studies and culminating workshop--performed for the most part in 1974-75. Committee deliberations and report preparation occurred in 1975-76. COPEP lost its study director in mid-1976 and ceased all activities in the spring of 1977. These events contributed to the delay in completing this formal account of the effort. The RANN staff, having reviewed the case studies as

they were completed and attended the workshop, has thus had the principal benefit of the activity for some time. We note this fact particularly to alert the reader that, while the key discussion of management strategies is still considered to be valid, the RANN program has changed significantly both in programmatic detail and organizational structure.

The National Research Council appreciated the opportunity to undertake this important study. We hope you will find this report valuable as you continue to shape the progress of the diverse program areas in the Foundation's Applied Research Directorate.

Sincerely,

C.D. Perkins

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FOREWORD

This report culminates a three-year study of the Research Applicable to National Needs (RANN) program of the National Science Foundation (NSF). The study was undertaken by the Subcommittee on Research Applied to National Needs of the Committee on Public Engineering Policy (COPEP) of the Assembly of Engineering, National Research Council. This study on the alternatives for RANN management was a follow-on to an earlier COPEP report on applied research priorities.

COPEP's 1973 report, Priorities for Research Applicable to National Needs, set the stage for the study undertaken for the accompanying report. In that earlier report, COPEP examined the probable modus operandi of RANN--its probable budget, constituencies and performer resources--and came forth with a set of priorities and recommendations for RANN programming. This new report, in harmony with Dr. Eggers' request, is implicitly less evaluative than was the report on priorities. The report prepared by our subcommittee is not a management audit. It is a logically developed array of alternatives and options that emphasize the use phase of the applied research programs of RANN.

During the course of the study, RANN continued the evolution that had been manifest since its beginning. The evolution has been largely organizational and reactive. Since there is no other specific place within this report to address the RANN organizational issues, this foreward will make the point that research, planning, and testing of applied research management and organizational techniques by RANN and its related units of the National Science Foundation are needed. Without finding fault in any specific organizational style practiced by RANN, its visibility permits some innovation in its internal management. This opportunity might require no action more bold than management training and job rotation.

Definition and development of the strategy options discussed in the report evolved from a careful and thorough review of four RANN program areas of the 1975 period: public-sector service delivery, solar heating and cooling, trace contaminants, and automated industrial production. Taken together, these program areas offer a crosscut of public- and private-sector interests: an example from each RANN focal area--energy, environment, and public and private sector productivity; a range of program budgets from about $2 million (automation) to a $17 million allocation (solar heating and cooling); and a self-evident variety of disciplines among the performing teams. These program areas were selected as case examples largely because of this diversity, and also because each offered a means to poll outside RANN for judgments concerning a program element.

Since RANN has shown the courage to attack major national problems, e.g., energy, it is a tempting target for critical evaluation. Such evaluations are premature if they simply address the issue of whether or not RANN has solved the problem or the need. It is far more appropriate to assess the soundness of the strategies and approaches RANN is relying upon, and to offer well reasoned alternatives. The study sought to provide corresponding insights.

To conduct such a study, the full cooperation of RANN was required, and was pledged early by Dr. Eggers, who headed the RANN directorate at the time of the study. Fruitful arrangements for meetings with RANN staff were made by Robert Crawford, Program Manager and Director of Intergovernmental Programs, with the strong support of Richard Green, Deputy Director of RANN. Continuing the spirit shown during COPEP's first-phase study, RANN's division directors and their deputies participated in the identification of source individuals. They also joined their program managers in attending COPEP's workshop, bringing out certain distinctions and clarifying certain ambiguities for COPEP. The preparation of the series of drafts that led to this report was accomplished in large part by L.F.(Barry) Barrington who was the study director during the early part of the study and later became COPEP's staff director. The committee expresses its appreciation to Alan L. Frohman and Edward B. Roberts of the firm of Pugh-Roberts Associates, Inc., who prepared a paper for the committee which is the basis of the Appendix to this report.

Final editorial revisions in response to the recommendations from Academy reviewers, including the preparation of the Introduction and Executive Summary, were accomplished after Dr. Barrington left the Committee to accept an appointment to the staff of the Congressional Office of Technology Assessment.

In all, nearly three years have passed since the initial case study inverviews were conducted. Where possible, we have called to the reader's attention organizational changes that have since taken place. Needless to say, the details of the program (energy, for example, was largely transferred to the Energy Research and Development Administration) have also changed.

This report, in sum, is the product of interviews, deliberations, reviews, and a workshop--all dedicated to the identification of alternate, workable management strategies for the effective use of RANN research results. COPEP and its RANN subcommittee hope that the report and its description of alternative management approaches will make significant contributions to the strength and value of the RANN program.

Myron Tribus
Chairman
Committee on Public Engineering Policy

INTRODUCTION

The principal mission of the National Science Foundation (NSF) from its inception in 1950 until 1968 was the support of basic or fundamental scientific and engineering research. NSF was prohibited by law from sponsoring applied research. Even in the "mission" agencies of the federal government--other than defense, health, space, and agriculture--rarely supported long-term, problem-oriented, multidisciplinary research. When, in 1968, NSF's charter was amended to permit the sponsorship of applied and problem-oriented research, the Foundation was thrust into new and largely uncharted fields. It assumed a mission and corresponding management assumptions somewhat at variance from its mainstream, historic goals and basic research management philosophy, as characterized by a primary reliance on the peer review of unsolicited proposals from scientists and engineers. The legislative amendment also permitted sponsorship to be extended beyond the universities both to nonprofit and, where appropriate, to profit-making institutions as well.

The broadening of the NSF charter came at a time of lessening international tensions and a consequent redirection of national attention toward an agenda of domestic problems, *e.g.*, violence, urbanization, pollution of the environment, depletion of raw materials, land and energy use, and malfunctioning institutions. None of these issues fits neatly within the jurisdictional compartments of the federal agencies. Society was beset with complicated problems and unmet needs on the one hand and deluged on the other with random information, data, and research. Most seriously unmet were the needed ability and technique to match the problems with research offering possible short- and long-range solutions. Even more deficient were organizational "delivery vehicles" to foster the application of that research.

NSF responded by creating the Interdisciplinary Research Relevant to Problems of Society (IRRPOS) program. In its first study of NSF's applied research program, the Committee on Public Engineering Policy (COPEP) recommended in 1970 that NSF should: (1) support applied research on a problem-oriented basis rather than a disciplinary basis; (2) influence the manner in which applied research is conducted through active encouragement of interdisciplinary research projects; (3) give special attention to applied social science research on social values and goals; and (4) favor research proposals which will develop reliable social and environmental indicators.*

NSF, in essence, accepted these recommendations. IRRPOS was combined in 1971 with other applied research activities to create the Research Applied to National Needs (RANN) program. RANN's objective, simply stated, was to focus scientific and technical research on societal problems of national importance with the objective of contributing to their practical solution.

Over time, RANN evolved a more explicit set of operational objectives: to meet national needs for research in energy resources, environment, and productivity improvement; to communicate solutions as they are found as broadly as possible; and finally, to see that communication leads to application by appropriate users. In addition to responding with appropriate scientific and technological research and development, RANN finds itself necessarily involved in market research and user education.

Virtually alone among federal research programs, RANN, as its name clearly implies, is dedicated to sponsoring the performance of research (i.e., basic as well as applied research) applicable potentially to the full range of domestic problems that the country faces. And, as a program still undergoing evolution, RANN must continue to strive to break out of traditional methods of research, seeking its answers across the boundaries of academic disciplines.

RANN's special purpose is to find ways of doing things better, or to do new and better things, in reaching to satisfy national needs. To do that, RANN has sought ways to tie the scientific and technical capabilities of the country, especially those in the universities, more effectively to industry. In the public sector, RANN has sought to involve all levels of government--federal, state and local--in the research and application of results.

*Committee on Public Engineering Policy, Priorities in Applied Research: An Initial Appraisal. National Academy of Engineering, Washington, D. C., 1970.

COPEP was asked by RANN in 1972 to undertake a broad study and review of national, problem-oriented research priorities, especially as they related to RANN's own developing program. The report based on that study ranked 31 program recommendations, grouped together under 6 problem areas.* More important, perhaps, a number of common themes were suggested in the course of deliberations on the specific recommendations. The conclusion of that report stated:

> Many of the most significant conclusions of this study lie not in the discussion of the overall balance of the research recommended, nor even in the 31 specific areas recommended for programmatic emphasis, but rather in the discussion of two themes, "institutional functioning" and "conservation and patterns of consumption." Here we recommend that the RANN program undertake applied social science research and research into the "demand side" of certain national problems to an extent that would make it virtually unique among mission agencies. These recommendations do not overshadow the need for RANN support of engineering and applied physical science research and, indeed, a coordinated approach to research is deemed imperative; yet these themes contemplate for RANN an approach to problems which had not been widely pursued nor broadly supported before. It is in this way also that this report, while affirming much of the previous work of RANN, recommends some shifting in the emphasis of its overall program.
>
> One particularly important concern was raised throughout the study and should be mentioned here. The unique nature of the RANN mission poses problems related to the very functioning of what we have termed the applied research delivery system. These are the issues of how to organize, manage and utilize applied, problem-oriented, multidisciplinary research in such a way as to achieve the most fruitful relationship between research sponsors and managers, research performers and potential users.

*Committee on Public Engineering Policy, Priorities for Research Applicable to National Needs. National Academy of Engineering, Washington, D. C., 1973.

> Concern has been expressed, for instance, that the nation's capability to undertake and utilize the kind of research recommended herein may be limited, particularly where there is dependence on the use of inter-disciplinary teams and by the alleged insufficiency of social science personnel for work in problem-oriented areas of research. These and many related questions were discussed during this study, but deliberations reinforced COPEP's initial assumption that such problems are so extensive and important as to merit a study of their own. Few conclusions in these respects, therefore, are included in this document; rather attention to these issues, in a planned subsequent study, will be an essential complement to the work of this study.*

This is the complementary report of that "planned, subsequent study." Its objective has been to compare and recommend alternative strategies for managing RANN's applied research delivery system," i.e., the setting of program priorities, the selection of research performers and sites, and, especially, the management of the use of the results of research.

*Committee on Public Engineering Policy, Priorities for Research Applicable to National Needs. National Academy of Engineering, Washington, D. C., 1973, p. 100.

EXECUTIVE SUMMARY

COPEP's goal for this study, as described in its proposal, was as challenging as it was broad:

> The study will highlight and illuminate a series of issues relating to the selection, conduct and application of problem-oriented research. The objective of the study is to compare and recommend alternative strategies for dealing with the issues associated with RANN's applied research delivery system. The ultimate product will be a report setting forth alternative and recommended strategies and advice to RANN with respect to these issues for various types of research and user-community situations.

As noted in the Foreword, this study is implicitly less evaluative than was the committee's earlier report on priorities. Its purpose was not to review the selections of priorities or projects by RANN, or of their scientific quality, but rather its management strategies and possible alternatives.* The committee did this primarily through the selection and review of representative case studies.

*For a critical evaluation of NSF's social science research, including the aspects supported by RANN, see National Research Council, Social and Behavioral Science Programs in the National Science Foundation. A report by the Committee on the Social Sciences in the National Science Foundation. National Academy of Sciences, Washington, D.C., 1976.

THE CASE STUDIES

Four case studies illustrating a range of RANN's interests in both the public and private sector provided the principal input for this study. One program within each of four divisions of RANN was chosen for study and analysis. The study was conducted through interviews and discussions with the respective division directors, personnel of other agencies, representatives of participating governmental units, universities and/or industrial firms, and even with representatives of withdrawn unsuccessful bidders. The cases, which focused on the utilization process, were augmented by papers prepared by the committee staff and consultants. The committee members reviewed the case studies individually and deliberated at regular meetings and in a three-day workshop. The four case study areas, detailed in Chapter VI, were:

- The delivery of public (municipal) services to remote areas via telecommunication's technology, e.g., cable TV, teleconferencing, telemedicine.
- The solar heating and cooling of buildings--a program subsequently transferred to the Energy Research and Development Administration (ERDA).
- Trace contaminants in the environment from agricultural, mining, and manufacturing activities.
- Industrial productivity (automation), e.g., computer aided manufacture, modular assembling systems, automatic parts programming, computer-controlled hydraulic ship-frame bending machine, automation of food distribution.

Delivery of Public Services via Telecommunications Technology

Research on delivery of public services via telecommunications technology was an element of the advanced productivity research and technology program area of RANN. This program began in FY 1972 with initial funding of projects involving the application of cable TV, teleconferencing and city government-community feedback devices. The study of a school-community feedback program in San Jose, California, in 1973 showed that economies of scale were possible by the use of telecommunications technology.

In 1973, RANN began two telemedicine projects, at Boston City Hospital and the Dade County, Florida, prison health care system, and awarded eight planning grants in the telecommunications policy area. A number of projects emanated from the 1973 planning, including the continuation of the two national projects.

The committee focused special attention on the Dade County prison health care projects. In the course of this case study, the committee made a number of findings:

1. The emphasis placed by RANN program managers on utilization and dissemination did not appear to dampen the enthusiasm of qualifying organizations to submit proposals. In this case, however, the close interaction with potential participants resulted in a significant reversal of roles, i.e., even though the private firm involved took the iniative, RANN, based on both the relative and specific competencies involved, awarded the grant to the university medical school which, in turn, subcontracted with the company for contract management.

2. In this case study the findings strongly implied that: most work is required to clarify the objectives for utilization and to distinguish between doing research and delivering research results; the area of public service delivery programs presents perhaps the most difficult set of utilization problems confronted by RANN; and, so far, pay offs have been more in the form of information dissemination, largely through conventional publication formats, than in strict utilization.

3. The project, once in the implementation stage, gained community interest and involvement, gives promise of possible replication in the other prison systems and rural settlements lacking physicians where improved communications would be useful, and has generated interest among other commercial firms with similar electronic, microwave gear, and advanced know-how.

Solar Heating and Cooling of Buildings Program

Approximately 25 percent of the nation's energy is consumed for space heating, cooling, and the supply of hot water. RANN sought to establish the full technology base for the widespread availability and use of solar energy systems. A program combining advanced research, sub-system tests, and system proof-of-concept experiments was carried out. The program also included the development, with the National Bureau of Standards, of standardizing testing procedures and the development, through a grant to the American Society of Heating, Refrigerating and Air Conditioning Engineers, of a comprehensive guide to solar energy design data. Projects focusing both on new construction and retrofitting were coordinated with the Departments of Defense (DOD), Agriculture (USDA), and Housing and Urban Development (HUD), the Postal Service, Atomic Energy Commission (AEC), National Aeronautics and Space Administration (NASA), General Services Administration (GSA), and the National Oceanographic and Atmospheric Administration (NOAA). The program was transferred in January 1975 to ERDA.

In addition to program solicitations, one of the bases for planning the solar energy program was several workshops convened by NASA and NSF in 1971 and 1972.* RANN's workshop brought together all sectors within the field--industry, academia, government, and (in the specific case of energy programs) public utilities--to achieve broad participation in deciding potential project activities and priorities. The workshop activities and the preparation of a report with recommendations reflects a general period of gestation that occurs when a major technological undertaking is contemplated by RANN. These workshop activities, which are a characteristic of RANN generally, led to the formation of several project activities and areas related to solar energy use. The solar workshops were convened to examine the state-of-the-art and to identify necessary programs. Subsequently, priorities were set and specific program activities were outlined. This was accomplished by February 1973. During the next six months, several reports and papers for subdivisional activities were prepared and published--ultimately in the form of an NSF/NASA solar energy report.

In 1974, RANN's program solicitations relating to research on various aspects of solar heating and cooling drew 450 proposals and resulted in 35 awards. RANN reported

*Included in COPEP's ranking of recommended programs in its Priorities for Research Applicable to National Needs (interim report, 1972) was a very high priority for solar energy.

that there was a relatively low response in FY 1975 by those companies who responded to the 1974 solicitation. This phenomenon may justify further study. Possible explanations include the perceived likelihood of firms ending up as subcontractors to universities, NSF requirements for zero-fee and cost sharing even in high risk problems, propriety rights, and expansion of the firms' own solar research. In contrast to these disadvantages, however, are a number of advantages to companies both small and large, including assurance of nationwide attention to the project, financial support through proof of concept, and improved contacts and relationships both with universities and potential customers.

Solar heating and cooling of buildings reached the proof-of-concept experiment stage in 1974 with the selection of public schoolhouse sites for special projects. Here, utilization objectives were realized within a matter of months even while relying on unsolicited proposals. Another example involved an experimental house in Colorado Springs in which RANN funding was limited to providing instrumentation for monitoring, plus the costs for data analysis and for small-scale investigation into economic, legal, and social acceptance considerations involved in the operation of a solar heating system in a community setting.

Trace Contaminants Program Area

The trace contaminants program is concerned with environmental consequences of mining and manufacturing and from the use and disposal of selected toxic metallic and synthetic organic compounds. The program's early emphasis was on heavy metal and certain complex airborne contaminants. The emphasis then turned to organic contaminants.

The conduct of research in this program area, more than the others, raised many of the knotty institutional problems regarding university arrangements for engaging in interdepartmental, multi-disciplinary research. The cases indicated that where the principal investigator was able to involve various departments and administrative people across the university, both the investigation and rewards were implemented and shared more easily. Some principal investigators, however, reported that RANN requirements would have been easier to fulfill had they been independent of their institutions.

RANN program managers in this area made sure that investigators visit user groups and work with potential users, representatives of the industrial sector, the pollutant-generating organization, the community, and lawmaking groups.

Finally, they used the findings and/or the presence of the investigators in workshops, seminars, symposia and proceedings publications, films, and conferences--all to aid in the dissemination of results. Moreover, the Environmental Protection Agency (EPA), a principal user of such results, used data from RANN's metal contaminant project in its "rule-making" studies.

Industrial Productivity (Automation) Program Area

The principal objective of the automation program area is to develop advanced processing technology to increase industrial productivity through concepts such as new industrial automation technologies. The projects reviewed included the creation of a catalog of ongoing R&D in the industrial automation field, the problem definition for a complete assembly system and study of programming language, applied research and proof-of-concept of a computer-controlled hydraulic bending machine which forms steel beams for ships' ribs, and, finally, a study of possible improvements in the productivity of the food distribution industry.

The program evolved from initial market studies, interactive symposia, expert advice, and, ultimately, unsolicited proposals triggered by public announcements. Grants were awarded pursuant to peer review evaluation.

Since significant utilization of the industrial automation program depends on the direct and thorough familiarity with the technique of small and large shop and plant operators, those individuals interviewed by the committee recognized the need for a strategy to involve the operators in the program in its early stage. (Major firms might provide a facility within their premises to house and support investigators who relocate temporarily from university or nonprofit laboratories for the expected duration of the project.)

The program has tapped only a fraction of the available technical skills in U.S. universities, nonprofit institutions, and industry. However, individuals able to integrate technology, economics, industrial practices, and market appraisals with utilization strategy are in scarce supply. Few professors are acquainted with the latest version of a technology in such a rapidly evolving field. This limitation tends to hold true with respect to the related economics and markets as well. Highly specialized training in the technology and its management appears to be available only within industry. The industrial automation program manager has nevertheless favored giving universities grants to implement projects.

In part, this has been done to expose graduate students to the technologies involved as well as to generate interest among the faculty in developing new courses germane to this field.

University and nonprofit performers benefit from this program primarily because pioneering projects are attractive to students and faculty. The required liaison with industry injects "real world" awareness into groups that may tend to isolate themselves from it; however, costs accrue in enjoying this benefit. However, some institutions (especially universities) face psychological and peer pressure against creating hardware as well as theory. Team leaders reported that peers at some schools disdain both programs that create "hardware" and those who lead them. Some schools have even allowed their shop facilities to atrophy to the point where they cannot construct models. Consideration has been given to partnership arrangements with industry that could circumvent the potential cost of having to tool up for such efforts. The principal investigators believe that this approach may also ensure more rapid and effective utilization of program results.

A growing awareness of means for increasing the strength and value of government/industry joint projects is reflected in the RANN industrial productivity program. Demonstrations and presentations have been made to prospective users of research results. The approaches also suggest attempts to conceptualize and implement alternative strategies that would steadily shift the performance of a program to the user. This requires the program manager's attention to the following issues--some of which are currently addressed:

- Inducing academic performers and institutions to transfer accountability for projects to others as the activity matures and the results become more attractive to the business and financial community.

- Identifying and championing reasonable and proper incentives for the industrial/user sector, such as a form of patent exclusivity.

- Developing understanding by workers and labor unions of the actual impact of a potential automation technology on the work force and working conditions.

- "Brokering" with key RANN/NSF officials, in a carefully constructed case for Executive Office or Congressional consideration of charging front-end research expenses directly to the public so that increased revenues (through taxation of higher corporate incomes) result when private firms use the automation technology.

- Disseminating information to the user community by such means as endowing new journals or strengthening those in existence, and by fostering the preparation of papers for those journals that would command the effective attention of executives in the user sector.

The foregoing cases, discussed in Chapter VI, provided the basis for the deliberations of the committee. Examination of these cases, as exemplars of the range of RANN's programmatic activities, permitted COPEP to reach some general conclusions and recommend strategies with respect to RANN's overall applied research delivery system. They also allowed the committee to focus on the full range of problem-oriented research--from the selecting of priorities, programs, and performers to program monitoring, review, dissemination, and utilization.

The choice of any alternative applied research management strategy must ultimately depend on the soundness and promise of the utilization plans. In turn, utilization's dominance among the elements of the research delivery system demands that RANN's strategies preserve appropriate roles for priority-setting, program-selection, and choice of performer/performing organization. Finally, alternative strategies also must depend on the availability of development of an adequate data base, as well as on effective communication and dissemination of research results to the user sector and the interested public.

Research program plans typically stress means of expediting the accomplishments of the technical research. "Effective utilization," however, presupposes the utility as well as the soundness of research results. Even so, competing programs with overlapping goals all yield results of acceptable usefulness. Thus, decision makers must choose from among the sets of results those most fitting and affordable. Allowances must be made for outcomes that do not permit the use that was originally intended, i.e., research by-products. Plans should also estimate the proportion of the total program that should be invested in potential non-recoverables before terminating projects.

The need for means to assure the possible use and application in other situations of these by-products demands that attention be given to enlarging the benefits society may receive from the total program.

Comprehensive analyses of any major RANN program area are costly and time-consuming--and some researchers contend they are disruptive since few unobtrusive techniques are available and applicable to evaluate alternative strategies. In suggesting alternative strategies and their susceptibility to constructive analysis, COPEP directly encountered the problem of the scarcity of analyst-evaluators as well as that of the relative lack of confidence potential users show for a newly devised technique or an arcane analytical procedure.

Impact analyses, especially technology assessments, have become increasingly popular and powerful tools for examining effects external to the direct goals of technical activities. In conceiving or suggesting alternative management strategies, COPEP made allowances for the standing need for analyses of the cultural, environmental, and other impacts. As the prospective "user" of alternate management strategies, RANN looked to COPEP for: (1) judgments about the relative facility of extracting impact analyses via alternate strategies, (2) insight into the likelihood that an alternate strategy could create a more-or-less desirable impact, and (3) opinions on the reliability of quantitative comparisons of impacts of alternate strategies.

RANN is often referred to as the Foundation's applied research program, thus evoking the historic basic research-applied research distinction. However, the recommendations and discussion contained in COPEP's earlier report of Phase I established the view that RANN should support any kind of research (with the possible exception of hardware development) which is applicable to the resolution of national needs or problems. This includes the more diffuse goals of seeking information, insights, and new perspectives as alternatives which will provide users, problem solvers, and other researchers with new ways of looking at their problems as distinguished from answers or solutions per se. Rather than seeking knowledge primarily for its intrinsic value, for the edification of researchers and their peers, RANN seeks the prompt transfer of the results to a client or consumer who can or does put them to use to solve or ameliorate a problem.

Accordingly, the committee is persuaded that, in order to provide the requested analysis of issues and alternatives in the "research delivery system" for research applied to national needs, the system should be perceived as involving four reasonably distinct elements, each one of which requires

attention in order to provide RANN with the broadest array of management alternatives. These four elements are: (1) problem identification and selection (priority setting), (2) research program definition (strategies for selecting specific targets within programs), (3) the applied research management and implementation process (selection of performers), and (4) the utilization process (application of results). It is this last element on which the committee has emphasized in this report.

PRIORITY SETTING

Although formal program priority-setting techniques possess strengths and advantages for RANN over informal, reactive practices, this efficacy is limited when RANN is confronted by limited pools of talent and money, or by the press of crisis-type, quick response situations. (Needless to say, priorities are ultimately constrained by the availability and interest of qualified researchers.)

An easy pliancy in priority setting may harm immediate-term plans for well conceived research programs more calmly undertaken--programs which require assurances of continued funding. The committee thus endorses clear objective structures and procedures for priority setting, which would enable RANN to defend resulting priorities against more subjective pressures, should these arise. RANN might also wish to consider different avenues for establishing priorities. For example, with additional funds the RANN staff might be enlarged or reorganized to afford critical masses of several skills and specialities, operating as designated planning and priority-setting entities.

Any strategy or process for priority selection should be responsive to the appearance of an unexpected crisis. It should also possess criteria permitting the accommodation of revolutionary new processes, techniques, or products. This is an element of "technology-push" that has met with disproportionately good success: the unplanned emergence of an unexpectedly superior development as a <u>fait accompli</u>. National prestige or economic factors can draw such developments into the priority mainstream. The operational features of priority setting impose more difficult problems for RANN than do criteria setting or other administrative techniques. RANN management strategies should answer the question: How are priorities set so that the results of RANN research will be effectively used?

Alternative strategies for priority setting include the following (RANN has employed them all in one situation or another):

- Creation of a priority-planning group within RANN, to link goal-setting with planning.
- Use of advisory groups.
- Convening representative leaders of private- and public-sector users.
- Use of a number of consultants possessing expertise in future trends and representing a variety of specialties.

SELECTING APPLIED RESEARCH PROGRAM TARGETS

RANN's responses to priorities are evident in their program areas, which create opportunities for others to help answer national needs. However, the formulation of program plans from priorities does not proceed linearly; indeed the logical appearance of the resultant RANN program belies the complexity of the integrating process that identifies and structures them. Alternate management strategies for effective utilization must take cognizance of the accompanying need for alternate approaches to program selection.

Criteria employed by RANN for selecting among program opportunities included: national importance, cost/benefit payoff, leverage, readiness of technology and skills, capability (for successful research), need for federal action, and the unique position of NSF as the only federal agency whose mission is solely the support of research. Others (e.g., funding requirements, soundness of utilization plans) may be added deemed necessary by RANN or others to fit specific program areas, temporary situations, or project structures. Sensing these possibilities from reviewing the case materials on the four divisional programs, COPEP suggests that RANN should rely upon any of the following:

- Peer group reviews;
- Source-evaluation panels;
- Consultant-advisory panels; and
- Panels comprising RANN personnel, users, and research suppliers.

PERFORMER-SELECTION

Success in applied research programs lies not only in their intrinsic qualities, but in the benefits they bring to the user sector on behalf of society as a whole. Unlike basic research, the support of problem-oriented research cannot be justified on the basis of credits for knowledge gained alone. Relying upon a mix of disciplines among research performers, applied research management requires scientific investigation coupled with the insightful leadership of other occupations. To insure that the results of RANN programs are effectively used and applied, RANN should examine and respond to competition among potential performers, performing organizations, and initial users of research results.

Priority issues and selected program areas chosen as targets for responsive action are publicized by RANN, within the community of most likely performers. Current means include seminars, briefings, mailings of program announcements, and insertion of notices in publications such as Commerce Business Daily. The issue of primacy outreach is thus addressed from the perspective of recruiting highly qualified candidates whose participation in RANN project activities is advantageous for the performer, performing group, and society.

OUTREACH AND IDENTIFICATION OF POTENTIAL RESEARCHER

Programs now underway within RANN do not appear to be endangered by lack of any critical research skills. However, successful plans to launch new or expand existing RANN programs will require coupling them to the pools of skills most relevant to the disciplines and crafts necessary for their furtherance. RANN managers should have access to intellectual inventories more trustworthy than the mere claims of those who submit proposals.

The Executive Inventory and similar data banks maintained by the Civil Service Commission exemplify the inventory record that would be serviceable to RANN. Regrettably, no reliable current listing of nongovernment professional people exists that is easily accessible. RANN should consider supporting and/or maintaining and developing a census of individuals whose qualifications are relevant to its future plans.

SELECTION OF RESEARCH INSTITUTIONS

Most of the research performed for RANN programs will be conducted by teams housed in previously established organizations. Although the impact of research strategies on these organizations will be discussed later, their own conventions and traditions influence and limit performers in various ways.

Research institutions--public or private, academic or industrial--offer both resistance to change and leverage opportunities for any proposed set of alternative strategies. In whatever manner they participate in RANN programs, institutions must protect their fundamental interests. Performing organizations are compensated for conducting RANN research by income and the opportunity to play leadership roles in emerging areas of applied research. However, the income does not ordinarily attach to a long-term contract, and RANN's applied research goals may not be consistent with the goals customarily perceived, for example, by science departments in teaching institutions. Alternate strategies might enrich the rewards through such means as contingent long-term awards, assistance in patent exploitation, or endowing applied research journals with greater prestige than derives from their current repute as "trade press."

QUALITY MAINTENANCE IN RESEARCH PROGRAMS

Safeguards should be built into the evaluation procedures, however, to ensure against the disruption of the project itself by the evaluation technique. For example, progress reports are intrusions upon research performers' schedules, and the question of their value to RANN is properly raised. If such reports are of value as documentation only, alternative means of monitoring the advancement of progress might appropriately be substituted or added. RANN should consider increasing its present use of the following procedures for evaluating work in progress:

- Review and evaluation by RANN staff members in a special committee.
- Peer-group evaluations.
- User-group evaluations.
- Outside contractor evaluations.

- Mixed peer group-user evaluations.

- Review by one of the foregoing groups and evaluative monitoring by another group.

Advantages and possible disadvantages of all the listed forms of evaluative review can be foreseen and should naturally be considered by RANN in weighing alternative approaches. Nonetheless, COPEP urges wider employment of user-group evaluations as a means of improving the effectiveness of RANN project outputs.

In addition to the simple evaluation of programs versus goals, RANN, which now arranges for outside review of technical reports, should consider the adequacy of relying on the normal editorial review of papers by principal journals.

RANN's needs for quality maintenance also called for consideration of research by-products in the evaluation of the overall program output. (In this context, "research by-products" include those results of apparent direct value that do not relate to the defined goal, rather than distant effects that are more properly considered within the framework of a technology assessment.) By-product utilization may call for a planned departure in the schema of program activities. Thus RANN may need secondary strategies as alternatives in exploiting the use of by-product results, goods, or services.

Ultimately, RANN should anticipate the termination of projects that encounter intractable technical or social obstacles. RANN's evaluation committee participates in this critical determination. The evaluation committee should be available at an early stage of projects to permit application of evaluation procedures that can evince fundamental signals of failure.

There is much that is unique about the RANN program. Its convergence stems from the breadth of its societal concerns and the multidisciplinary, problem-oriented emphasis of the research it seeks to support. That such a mission requires a degree of management which is unknown, and perhaps undesirable, in the traditional governmental and foundation programs in support of pure research seems self-evident to COPEP. Yet RANN depends no less on the creative accomplishment of the country's best scientists, social scientists, and engineers. RANN must thus adopt a mixed management strategy: it must manage the research, in aid of selectivity of problem areas to be addressed and assuring ultimate application and utilization, without intrusively managing the researchers themselves.

PROMOTING DISSEMINATION AND UTILIZATION OF RESEARCH RESULTS

Theories concerning the dissemination and application of knowledge gained from research abound. Of course, no generic method exists which, if followed routinely, would lead to predictable success. However desirable graphic or schematic illustrations of the progress of results toward utilization may be, such illustrations of a research-delivery system can probably, at best, be only logical displays of the network. Real-world workers must necessarily take note of their nonlinearity.

Each RANN project is required to have a utilization plan developed jointly at the beginning of the research by the RANN program manager and the principal investigator and, to the extent possible, involving the ultimate user or users. Overall utilization plans have been developed for selected programs as well. Present plans call for completing these across-the-board in the future.

Each RANN program manager has primary responsibility for ensuring the utilization of research outputs from his grantees. At the same time, networks are being developed to facilitate reception and application of RANN and other R&D results by public sector users.

Some of these networks are in certain ways comparable to the Agricultural Extension Service. The system includes, in part: a big-city technology consortium (all U.S. cities over 500,000 population and 6 urban counties--a total of more than 34 million people); an Urban Technology System (UTS)--27 cities ranging between 50,000 and 500,000 in population size; several multi-city innovation groups; and a federal laboratory consortium.

In sum, the uniqueness of RANN programs derives not only from the breadth of their multidisciplinary, problem-oriented research. It derives also from the special emphasis on utilization and its concern with anticipating those areas of national needs where no other federal research-support agency is significantly at work.

CONCLUSIONS AND RECOMMENDATIONS

This study of the RANN operations has yielded a number of alternative strategies that should be considered to assure effective management and utilization of applied research results. Alternative strategies in five major areas have been identified: priority setting, program and project selection, performer and site selection, project monitoring and control, and utilization.

PRIORITY SETTING

RANN's priority planning functions would be strengthened by a more coordinated attempt to determine precisely what kinds of results research recipients can accommodate. For example, RANN should benefit from the current interest in urban problems, and may propose greater effort on programs aimed at lowering municipal operating costs. Resulting program definitions should, of course, reflect the possible adverse consequences of technology innovation, such as increased unemployment and demands on capital funds.

To broaden its planning effort, RANN has reinstituted an advisory board to recommend new programs.

RANN has developed a number of novel means that offer promise for meeting the needs of state and local governments. The prospects for current RANN programs might profitably be compared against criteria thoughtfully established by a selected user community that could help define new parallel program area. Care should be taken, however, not to raise public expectations too high too soon.

In the course of its planning, RANN should continue to expand its surveys of other agencies' needs, weighing the costs, risks, and benefits of such a survey against the value of a review of surveys conducted by other agencies. Trade-off considerations of this kind help to coordinate institutional needs and to balance issues and priorities for more effective planning.

It should be noted that RANN has been arranging meetings between its management and local government representatives from both the urban consortium and the urban technology system networks to provide direct user input into its fiscal years 1977 and 1978 program planning process.

PROGRAM AND PROJECT SELECTION

In the widest perspective, RANN should re-examine its authority, particularly in relation to the changing economic and political climate, with a view toward possible changes in RANN's role with respect to events and institutional evolution outside its own organization.

In response to observed inertia in the private sector, RANN should explore various kinds of incentives which, if offered to industrial firms, would facilitate utilization. These include seeking authority for extending temporary exclusive license of patents, granting waivers of cost-sharing requirements, or other similar arrangements.

The technical problems of society are not solved by bench scientists alone. RANN should, thus, continue to emphasize that practical solutions require engineers, technologists, applied social scientists, managers, financial institutions, and political bodies. To the greatest extent possible, RANN should continue to foster a diverse mix of skills.

PERFORMER AND SITE SELECTION

Site selection offers RANN an opportunity to respond to the growing trend toward regionalism. RANN might identify and test those programs that provide improved delivery of technology and information to metropolitan areas and improved institutional functions, such as streets and hospitals. The successes of Toronto and greater Seattle should be carefully reviewed as exemplaries. Reflecting on such reviews might increase utilization of the results of productivity research programs aimed at the public sector, especially where regional or local groups can identify with success or failure.

Personnel, cost, and locale have been the most important factors in RANN program successes. These key factors should receive continuing emphasis. Overriding importance should be attached to finding means to induce the participation of investigators who best qualify for specific applied research. In this regard, RANN should consider the opportunity cost involved when researchers whose proposals and skills are not commensurate with those

of the reviewers tie up highly capable researchers in peer reviews and site inspections. Substitution of more objective criteria for the peer review system in certain situations would surely merit a trial.

PROJECT MONITORING AND CONTROL

In general, RANN should devise means to evaluate and reward successful project managers by developing and applying both generic and special criteria for measuring the success and progress of different kinds of programs. While outstanding successes and failures are easy to judge, those programs with intermediate results are not. Consequently, some terms of measurement should be devised that permit recognition and rewards for achievements that are solid if not spectacular--including the attainment of use of intermediate technology.

Evaluators should be aware of the difficulty of judgments on the basis of a single result or of one unique characteristic, and should require demonstrations of how single results bear on the system that is to accommodate them. A case in point could be found in a device that offers the prospect of an improved capability for measuring the level of one specific pollutant, but may not be successful in the marketplace. Competing devices may measure a number of pollutants, but with less accuracy. RANN will have to draw upon the considerable expertise of its principal investigators and potential users to determine whether support for the development of such a single-use, high-accuracy instrument can be justified.

RANN should carefully examine the patent filing policies of foreign governments in its grant program to assure that proper safeguards are established for U.S. intellectual property. Moreover, RANN should consider other opportunities related to domestic technology policy, including, for example, import or export of expertise, coordinated industrial activity, and government-industry partnership.

UTILIZATION

To promote more effective utilization, RANN should examine its rewards system, possibly setting challenge incentives before user personnel. Such inducements, appropriately constructed, might be devised to move research results toward the source of needs, whether in the marketplace or elsewhere.

Along with this effort, RANN should extend its contacts with decision makers in industry and government to better define and respond to their information needs. Relevant factual knowledge should be disseminated as widely as possible to policymaking groups and individuals who are actively considering the use or trial of a RANN result. If the product or service is a "mixed blessing," RANN should continue to advocate thorough evaluations of the suitability of the solutions it brings forth. In the long run, this approach will better serve RANN than would acceding to temptations to promote.

Although RANN works well with government and appointed government executives, interaction is necessary with federal, state, and local bodies. RANN should seek additional ways to inform legislative bodies when a program may, without changes in the law, encounter difficulties. RANN planners should maintain high-level contact with officials to assure that administrative channels are clear within agencies that require RANN's results.

RANN programs should continue to require assessments of technology implementation by the user, instead of the user's surrogate. Independent institutions that may be skeptical of the results, or that have no stake in the solution to a problem, should not be expected to build the case for adoption of RANN results by the actual user.

RANN is a relatively new program with a short and often tumultuous history of funding and support. COPEP strongly emphasizes that RANN's mission is to fund applied research, not to operate programs. Priorities have been subject to the press of public opinion, and RANN has experienced several organizational changes in a short time. As a result, COPEP cautions against expecting too much of the program; RANN is beset with the problem of unreasonable expectations which can cause friction between Congress and NSF, and between the program officers and the grantees.

COPEP finds, nonetheless, that RANN has succeeded rather well in gathering and coupling the skills and resources necessary to assure effective use of program results. Considering RANN's accomplishments during the relatively short time of its existence, progress made during the next five years should close RANN's first decade with examples of successes drawn from a willingness to try adventurous, new approaches to utilization of the results of research.

OBJECTIVES OF THE RANN PROGRAM

HISTORICAL EVOLUTION OF OBJECTIVES

When the National Science Foundation was created in 1950 as a primary vehicle for basic research, it was restricted from supporting any applied research. Mission agencies had long been able to pursue some applied research within their congressionally authorized responsibilities, but their research was usually sharply focused and rarely long-range.

The exceptions to this rule were generally in four areas: agriculture, where the Agricultural Extension Service has successfully exposed individual farmers to advances in agricultural technology and practices; military-defense hardware, where more than a quarter-century of hot and cold war made innovation, change, and improvement imperative; the space program, where a presidentially-decreed national commitment to land a man on the moon within a decade forced the federal government and its contractors into massive research and the immediate application of its results; and, within the medical and health fields, where basic research at the National Institutes of Health had by its very nature, in some cases, relatively immediate clinical applications

But, as noted in an earlier COPEP report: "Beginning in the 60s and accelerating in the 70s, the lessening of international tensions gradually focused attention once again on national domestic needs. Only then did the nation as a whole become fully conscious of what had been happening to it in terms of urbanization, pollution of the environment, depletion of raw materials, usable land and energy resources, and obsolescence of its institutions."*

*Committee on Public Engineering Policy, Priorities for Research Applicable to National Needs, National Academy of Engineering, Washington, D.C., 1973, p.18

By the early 1970's, some agencies of government had intensified their concerns with national needs in areas such as energy, environment, transportation, and housing. However, there was still no single agency of government with a "unified program to serve the broad perspectives of national purposes and goals which spanned mission-agency lines and covered the territory between them."*

U.S. Society was beset with complicated problems and unmet needs on the one hand and deluged with random information data and research on the other. What we needed was the ability and technique to match the problems with research offering possible short- and long-range solutions. Even more deficient were vehicles to foster the application of that research.

Overwhelming societal reasons seem to explain why these deficiencies existed. Within the private sector, research sponsored entirely or primarily by business was necessarily defined by the goals of business--dollars invested in research were almost inevitably and invariably related to making profits within a reasonable time. Research programs whose fulfillment would fall outside this understandable restriction were frequently ignored by private firms.

Within the public sector, other considerations, particularly legislative, resulted in similar limitations. Most legislation has, in fact, been passed to solve immediate, definable problems. Use of the scientific method in problem definition and the consideration of alternate strategies for solutions seemed virtually alien to the conventional wisdom and implied a frame too long for comfort within the normal span of authority of elected officials.

In 1968, Congress gave the National Science Foundation authority to initiate and support scientific research, including applied research, at academic or other nonprofit institutions. That legislation also authorized NSF to support, through other appropriate organizations including profit-making ones, applied scientific research relevant to national problems involving the public interest. In exercising this new authority, NSF is expected to coordinate and correlate its activities with other agencies of the federal government undertaking similar programs in that field.

*Committee on Public Engineering Policy, Priorities for Research Applicable to National Needs, National Academy of Engineering, Washington, D.C. 1973, p.19

That amended charter thrust the National Science Foundation into new and largely uncharted fields. As an early step, the Foundation started the Interdisciplinary Research Relevant to Problems of Society (IRRPOS) Program. The direction IRRPOS took was, in part, the result of a 1970 COPEP report, which made four recommendations: "(1) that the National Science Foundation support applied research on a problem-oriented basis rather than a disciplinary basis; (2) that the National Science Foundation influence the manner in which applied research is conducted through active encouragement of interdisciplinary research projects; (3) that the National Science Foundation give special attention to applied social science research on social values and goals; and (4) that the National Science Foundation favor research proposals which will develop reliable social and environmental indicators."*

Those suggestions were, in essence, accepted by NSF. By the spring of 1971, when IRRPOS had made only its first preliminary steps, it was combined with other applied research activities to create the Research Applied to National Needs (RANN) program. RANN's objective was to focus scientific research on societal problems of national importance with the objective of contributing to their practical solution.

Since its founding, RANN has evolved a more explicit set of operational objectives. These are to: meet national needs for research in energy, environment, and productivity improvement and resources (responsibility for energy has since been assumed by the Department of Energy); communicate solutions to as broad an audience as possible; and see that such communications lead to application by the appropriate users. In addition, therefore, to sponsoring appropriate scientific and technological research and development, RANN should be involved in market research and user education.

Alone among federal research programs, RANN, as its name clearly implies, sponsors research (i.e., basic as well as applied research) that has application to national problems. As a program undergoing evolution, it must break out of traditional methods of research and seek answers across boundaries of academic disciplines.

*Committee on Public Engineering Policy, Priorities in Applied Research: An Initial Appraisal, National Academy of Engineering, Washington, D.C., 1970

RANN's special purpose is to find ways to do things better, or to do new and better things, in reaching to satisfy national needs. To do that, RANN has sought ways to tie the scientific and technical capabilities of the country, especially those in universities, more effectively to industry; and, within the public sector, it has sought to involve all levels of government--federal, state, and local--in the research and application of results.

RANN has had to break new ground in its effort to organize, manage, and use applied, problem-oriented, multi-disciplinary research. It had to be sure that users did exist and could be identified so that they could be joined effectively with research sponsors, managers, and performers. Inherent in all of this were infinite problems, requiring an element of risk-taking in problem selection and even more difficulties in implementing widely and sensibly the results of applied research.

FORMULATION OF NEW INITIATIVE AREAS

RANN has long recognized the requirement to identify and rank national needs for priority attention. Thus, RANN commissioned COPEP in 1972 to undertake a thorough review of national problem-oriented research priorities and their relationship to RANN's then-existing program. The resulting report, Priorities for Research Applicable to National Needs, was one of RANN's inputs for programs in the 1974-76 period.

Progress toward RANN program goals and changes in the overall social and technical setting are accompanied by calls for attention to new program areas. Some of these calls arise by way of opportunity-breakthroughs in basic research; others by the impact of the utilization efforts within RANN programs. But most calls for new initiatives by RANN arise from sufficient definition of new problems to permit conceptualization of a strategy for attacking them and access to an adequate pool of research performers to conduct the necessary applied research and utilization effort.

An example of a new initiative chosen by RANN for emphasis and support is the resource area which has been newly targeted for program action. The remaining narrative of this section is based in large measure on interviews with both RANN staff and outsiders concerning how the new program on resources was developed. The pattern described, with improvements gained through experience, is expected to become the generic process in future RANN efforts to open new program areas.

When an area for possible emphasis is identified, a RANN staff task force determines if there is a possible role NSF can play by gauging the state-of-the-art in that specific technological field. When an area has been identified and tentatively selected for emphasis, 12 to 15 short-term reports (in a typical case) are commissioned.

Upon review of the commissioned papers, a draft program plan is written and circulated for evaluation, both internally and externally. While the plan is being refined, staff members meet with representatives of appropriate federal agencies to determine their concern with the specific topic in their mission R&D areas. In addition, RANN staff members meet with representatives of the affected industry, state or local government (through seminars, discussion groups and one-to-one discussions) to determine the state-of-the-art in the target field. On the basis of these discussions, a revised program is constructed. Further development involves discussion with members of RANN's Federal Interagency Advisory Committee, during which officials of various concerned agencies comment on the proposed program.

Having gone through some version of this process, the new program initiative is first reviewed by RANN's Office of Exploratory Research and Systems Analysis (ERSA). Staff members here review the five-year plan, with emphasis on the basis for selecting or discarding potential programs from an array of technological options for meeting specific research needs. Included among the additional determinations made at this stage is the setting within RANN for the furtherance of the new program area.

Although RANN maintains numerous linkages between universities and industry, the emphasis in new program initiatives is, subject to funding limitations, less on the linkage itself than on finding the best performer for the research required. RANN's identification of resources research as a new area produced considerable interest in the research community. Both the academic and industrial sectors submitted early proposals permitting RANN choice in performer selection. Ultimately, program solicitations may become a more important part of RANN's resource program planning. If so, RANN's strong emphasis on utilization will influence selection, together with appropriate insights into the marketplace and users.

PRIORITIES AND PLANNING

Overall, RANN is committed to defining, planning and mounting projects on selected new problems. After identifying a generic problem area, RANN seeks a set of crosscutting viewpoints to address it. These viewpoints emerge from both centralized and de-centralized planning and evaluation functions that serve new and ongoing RANN programs. The central planning, budgeting, and evaluation responsibility rests with the director* of RANN and his chief deputies. Each operating division and office also has a planning officer. Planning officers, relevant central planning staff, and the Deputy Assistant Director for Analysis and Planning comprise the Research Applications Planning Committee. An Evaluation Committee, with representation from the operating divisions, assists in the design of evaluation procedures for ongoing activities. With continued evolution implied, the management form described will be an organizing framework for future new candidate program areas of RANN.

Although the administrative structures for defining, designing, and evaluating RANN programs are important elements in assuring formalization of their styles, they are not notably different from procedures with similar objectives, used conventionally by other parts of NSF or by other agencies. The RANN program does possess traits, however, that distinctively mark it apart. The next section examines some of the traits that distinguish RANN and charge it with special kinds of problems and opportunities.

*The director of RANN is formally the NSF Assistant Director for Research Applications.

ALTERNATIVE APPROACHES TO EFFECTIVE UTILIZATION OF RANN RESULTS

(The Implications of Some Strategies)

When COPEP was requested to undertake this study, the charge from RANN was as challenging as it was broad:

> The study will highlight and illuminate a series of issues related to the selection, conduct, and application of problem-oriented research. The objective of the study is to compare and recommend alternative strategies for dealing with the issues associated with the above described research delivery system. The ultimate product will be a report setting forth alternative and recommended strategies and advice to RANN with respect to these issues for various types of research and user community situations.

Given the scope of the inquiry, it was essential to identify key ideas in order to determine the report's perspective.

The committee felt that the study should not be limited simply to a review of RANN's delivery systems in the application of problem-oriented research. Broader questions of overall purpose and direction were involved, and long-range goals had to be considered.

First, there was the difficult question, explicit in RANN's title, of addressing national needs. Clearly, any assessment of RANN's effectiveness would depend on the interpretation of that term. Was the need to be considered within the context of all types of social delivery systems? Was RANN's scope limited to national needs already identified, or should it be dealing with the leading edge of newly emerging priorities? What is a national priority? Can all priorities be reliably addressed in normative and quantitative terms such as, "to improve a specific art by a specific amount by a specific date for a selected user-public at no more than a stipulated unit or total cost?" In what terms should goals be expressed?

In general, COPEP believes that RANN's program areas should be limited to a manageable number, but RANN should not be reluctant to expand its horizons into somewhat risky areas of research. While RANN's focus should always be determined by national needs (as perceived at the time), it should guard against a defensive or overmanaged posture and remain free to interpret national needs with flexibility and latitude.

Second, RANN does not exist in a vacuum. Its funding is "not overly generous," and it works within a political environment, subject to the exigencies of Congressional oversight. The agency is obliged to interact and coordinate its activities with the federal systems and its hierarchies. In COPEP's view, additional funds, specifically earmarked for staff increases would result in improvements in the management and utilization of program results. Consequently, RANN should be understood within the context of stipulations in appropriations acts and the relevant NSF legislation, particularly after NSF was given license to move into the field of applied research in 1968.

Third, RANN is a relatively new program, with a short and often tumultuous history of funding and support. COPEP would underline the finding that RANN's mission is to fund applied research, not to operate programs. Priorities have been subject to the press of public opinion, and RANN experienced several organizational changes in a short time. As a result, too much should not be expected of the program. RANN is beset with the problem of unreasonable expectations, which can cause friction between the Congress and the NSF, and between the program officers and the grantees. AS Mark Lappe suggests in the February 28, 1975, issue of Science:* "the proliferation of false (rather than falsifiable) hypotheses may be a sinister symptom of the heightened stakes for scientific success in research areas in which public expectations have been grossly inflated."

Fourth, the evaluative perspective should include a discussion of whether or not RANN's programs were actually impacting national problems--and if not, what barriers were obstructing that effort. This question raises the issue of whether RANN should cease its activities at the point of potentially successful transfer. Also, it introduces a subsidiary question of RANN's involvement in actual product development in any way, and the means appropriate to change, correspondingly, the scope of enablement of NSF's organic act.

*"Accountability in Science," Letter to the editor, Science 187(4178)696-7.

Fifth, rather than propose a panoply of changes for RANN organization, the assessment should generate alternatives and suggest how those alternatives would lead to differing technological paths and to differing means of dissemination to and utilization by possible users.

The charge to COPEP had been specific in its request for "issues related to the selection, conduct and application of problem-oriented research." Before the evaluation could take shape, the key issues in each category had to be identified. Based on the responses of committee members, COPEP grouped the issues which would form the basis of the report.

SELECTION ISSUES

RANN's Assumptions, Premises and Biases

Are RANN's programs biased in favor of capital, energy, and technology-intensive productivity? Is that the proper definition of productivity, especially during a period of energy and capital shortage and high unemployment?

If this bias were deeply held, it could lead to activities creating further centralization of resources, greater synchrony and wider amplitude of cyclic economic swings, and a narrower distribution of wealth. These questions bear directly on the RANN commitment to national needs, however defined.

Furthermore, RANN should make a clear distinction between effective marketplace demand and national or individual need.

The Role of RANN, Its Uniqueness and Impact

Special uniqueness lies in the breadth of its multidisciplinary, problem-oriented research, together with its emphasis on utilization and concern with anticipating areas of national need where no other federal agency is significantly at work.

In this regard, RANN has a special role in interacting with universities--in many respects making them more relevant through the pursuit of grants for practical, useful research. But greater relevancy to RANN, however, may jeopardize the character and role society and academia expect of universities. These expectations should be taken into account, especially in site selections.

Less certain was the precise nature of RANN's impact. Since RANN has, among other things, the explicit responsibility to conduct technology assessments, the degree to which RANN undertook impact analyses of its own projects is important to understand. Particularly important is the end product of the applied research. Should RANN do product development similar to the type of activities carried out by the Department of Agriculture and the National Institutes of Health, or should its major objective be to mobilize the innovation community, without regard to actually solving a particular problem? Each of these emphases, of course, would produce a different definition of impact.

The Problem of Framing National Problems

National problems can be defined in a variety of ways: systemic, incremental, reductionistic, among others. While an overly narrow definition would clearly be inadequate, a holistic approach may bring in so many variables and considerations that it effectively becomes a deterrent to doing anything at all.

Goal-setting

RANN goal selection begins with general guidance provided by studies conducted by ERPA. In addition, the Research Applications Planning Committee plays an important coordinating role, evaluating and analyzing priority options. Ultimate selection of new goals from these analyses is made by top RANN officials. Observing this progression in priority-setting, COPEP suggested that a formal apparatus--such as the RANN Advisory Group--be reestablished to give continuing outside advice and counsel on goals and emphases. This apparatus was reestablished in December 1975, and is meeting semi-annually.

New Directions for RANN and Special Areas for RANN Emphasis

In view of RANN's generally successful record and the variety of directions already explored, new--totally new--viable approaches are very limited in number. Among new directions, COPEP considered the possibility of a kind of franchising technique where, on an executive-branch-wide basis with the proper policy backing, RANN would try to use the incentive-heavy programs of some of the other federal agencies at one of a number of delivery systems.

For example, conditions might be imposed on grants or subsidies requiring the use of selected techniques or products whose development was completed or certified by RANN.

In view of the increasing emphasis on the special problems of cities, RANN should expand its assistance to local and state governments to find means to use modern technology in solving urban problems. Urban consortia, now in use by RANN, exemplify the social device RANN may consider and extend.

Limitations of RANN

RANN should not involve itself with technology development, especially not in product development. Rather RANN should limit its activity to funding applied research, understanding transfer problems for the receiving group, and taking an active role in the transfer itself. RANN fulfills its charter when it transfers a research result to another agency or organization in the procession of research deliverers.

RESEARCH PERFORMANCE ISSUES

RANN'S Linkage and Interaction with Other Organizations and Communities

Technology use and transfer to federal agencies, the manufacturing community, and certain qualified university and industrial groups can be accomplished by RANN project managers. COPEP's examination of RANN's coordination with other organizations has led it to conclude that RANN has forged the best and most relevant linkages to other organizations among all federal civilian research programs. Interagency workshops, industrial symposia and even trade-type shows were among alternative new approaches suggested to help assure more effective utilization linkages.

Experience of Other Nations and Organizations

The experience of other national problem-solving systems suggests that there are advantages and disadvantages to excessively efficient delivery systems. If the goal has been exhaustively researched and the impact determined, such national programs can be enormously successful.

However, examination of the comprehensive and interlinked system in Japan suggests that if the goals are insufficiently clear, the immediacy of change can have detrimental effects. The positive effects of both damping (questioning) and feedback (reporting) mechanisms on problem-solving were emphasized as tactical opportunities that might be built into any parallel RANN strategy. RANN's solar heating and cooling programs are examples of cross-sector development whose progress should be carefully analyzed.

OTHER ISSUES

The issues of institutional malfunction and the various barriers to innovation and use should be examined by RANN in detail. Means of incentives for overcoming institutional barriers might be explored, especially to induce first use or willingness to risk failure.

APPLICATION/UTILIZATION ISSUES

RANN's Emphasis on Utilization

RANN has devoted an increasing share of its budget toward directing and mobilizing its utilization effort, now about 20 percent of RANN's FY 1976 budget. However, RANN should not be viewed as a major source of final solutions for national problems.

RANN will find that utilization strategies vary with particular areas of emphasis--health, transportation, municipal services, and on whether the technology is new or old. Accordingly, recent reorganization moves within RANN (for example, placing utilization responsibility clearly within the line divisions) are expected to provide a more effective structure than was the previous network of research utilization managers within the Intergovernmental Science Research Utilization (ISRU).

RANN'S Effectiveness and Criteria of Effectiveness

Defining parameters for effectiveness is never simple, and that was the case in the RANN study. While any determination of effectiveness must take into account the context in which national problem-solving is attempted, it must also involve seeing the limits--as well as the potential for applied research. However, RANN's small percentage of project failures argued a high degree of effectiveness in practical terms.

Interest Groups - Their Impact on Utilization

National interests are always aggregates of individual interests. However, RANN should seek out and support a diversity of individual interests in a program area, identify the vested interests in each case, and define the means whereby a technology is more likely to be promoted than suppressed.

RANN should analyze the prospective impact of a technology on the various groups previously deprived through lack of solutions to needs. These analyses should distinguish clearly between "users" and "consumers" of the technology. The results should help assure that RANN's programs and plans do not inhibit the separate, but related efforts of the private sector.

Analyses of interest should take into account that consumers are as concerned about the suppression of technology as they are about promotion. Solar energy, for example, is perceived by many as a technology that has been near a state of shelf-readiness for years, but "suppressed" by promoters of fossil-fueled devices. RANN might consider strategies that would capture this unique form of skepticism and convert it into a type of user-pull mechanism.

UNIQUENESS OF THE RANN PROGRAM

The uniqueness of the RANN program is implicit, from the above discussion, but deserves to be explicitly stated. An earlier COPEP report stated: "In assessing the impacts of new technology, private industry and traditional mission-oriented agencies of government almost invariably select subsystems for study and manipulation without looking at the larger system in which important effects are occurring. Moreover, other significant subsystems are often not studied at all because they lie outside the obvious concern of existing mission-oriented agencies."*

RANN should perform outside of those restrictions and with a broader vision. The national needs on which RANN is now focusing--the environment, expanding the resource base, and greater public- and private-sector productivity--demand research that is inclusive rather than exclusive. The problems transcend geographic boundaries, political subdivisions, or specific corporate interest.

Simply, solutions are not to be found where research is narrowly hamstrung by artificial or arbitrary limits defined by academic disciplines, or where missions are restricted by legislative fiat, or by the particular hardware or services of a single profit-making corporation. Thus, the programs of RANN are unique in their broad approach and definition. They are also unique in the realm of application and use.

Each RANN project is required to have a utilization plan, developed at the beginning of the research by both the RANN program manager and the principal investigator, and, to the extent possible, involving the ultimate user or users. Overall utilization plans have been developed for selected programs as well. Present plans call for completing these across-the-board in the near future.

*Committee on Public Engineering Policy, Priorities in Applied Research: An Initial Appraisal, National Academy of Engineering, Washington, D.C., 1970, pp. 12-13.

In sum, the uniqueness of RANN programs derives not only from the breadth of this multidisciplinary, problem-oriented nature, but also from this special emphasis on use, and RANN's concern with anticipating areas of national needs where no other federal research-supported agency is significantly at work. However, for RANN, as for other federal programs, the application of research relevant to national needs is not easy.

To apply its research results effectively, RANN must overcome massive human as well as institutional barriers. Both resist change, preferring the comfort of doing things as they have been done, even if badly, or at most, moving slowly and incrementally to make small changes or improvements.

Within industry, changes must have a discernable cost-profit benefit. In government, changes must be palatable not only to elected and appointed officials, but to the workers involved, often their unions, and, of course, ultimately to the people who are the consumers of governmental services. Even when these goals are met, however, it is obviously impossible to formulate an unchanging blueprint for technology transfer uniformly applicable to the many variations of public and private organizations that might be users of the technology.

Within similar organizations sharing similar goals, like municipal governments seeking better ways for solid waste disposal, there are, nonetheless, great variations in people, pressures, and policies. There is not now, and probably can never be, a catalog of established designs which can be taken from the shelf to ensure utilization of research by groups trying to reach particular goals.

In spite of the fact that the potential of technology for improving urban services is recognized by local government administrators, innovation has been especially slow in urban markets. With little incentive for industry to introduce change in the fragmented marketplace of local governments, efficient technology delivery has not occurred.

RANN has developed a range of innovative attempts to foster the delivery of usable results to both the public and private sectors. For example, RANN's demonstration projects of support of telemedical services have helped integrate the interests of the private physician, the commercial supplier of services, and the public sector (e.g., prison) user.

Applied research in social systems is never as neat as similar research on industrial hardware. For example, results in the service delivery research now being conducted by RANN may come to fruition over a span of several years. Each stage may have its own utilization implications and some new implications for research priorities. Thus,

intermediate results may need to be fully evaluated before the next step may be undertaken.

Testing and evaluation are more difficult and less precise in the area of social systems than areas of hard technology. But, even where barriers of timing and testing can be solved, implementing social changes threaten institutions and people. The resulting stubborn resistance should not surprise observers who note that RANN research goes to the heart of how governments participate in service delivery, exercise their policy powers, and utilize their personnel. Such research is hard to implement in anything like its pure form and even more difficult to evaluate objectively.

Industry has its own barriers to the timely utilization of research results. Questions of appropriate interest, overall market strategy, definition of a diffused and disaggregated market, financing, potential profits, and propietary rights of patents must all have to be considered, even when feasibility and utility are clear. Unfortunately, the definition and potential resolution of a national need are not enough.

The National Academy of Engineering's Committee on Technology Transfer and Utilization (COTTU), in a study of 25 federal agencies involved in research and development, defined additional barriers to utilization.

> Inadequate attention is paid to the definition of opportunities that are indicated by market studies, cost-benefit evaluations, and measurements of potential impact. Insufficient effort is given to organizing certain prime participants such as innovators, users, and suppliers, for the purpose of matching technology with needs.
>
> Insufficient support is offered to adaptive enginnering, financing, marketing, and other steps to implement application.*

In the end, RANN's success will be measured by how well it overcomes these impediments as it seeks utilization by various constituencies.

*Committee on Technology Transfer and Utlization, Technology Transfer and Utilization, National Academy of Engineering, Washington, D. C., 1974.

RANN'S APPROACH TO UTILIZATION BY VARIOUS CONSTITUENCIES

RANN invested approximately $17 million in utilization-related activities in FY 1975. A significant part of this investment funds symposia, workshops, and user coloquia.

Since the transfer of technology is not yet a mature art, RANN's approach to utilization is neither dogmatic nor limited to traditional forms of dissemination. It is pragmatic and active where it can be, seeking whatever ways are available to see that research results find application. (See the Appendix--Viewpoints on Research Utilization.)

Historic governmental practices make the task of research difficult. In industry, for example, for every dollar spent in research, 20 more may be spent in utilization and marketing efforts to achieve an acceptable payoff. Within government, on the other hand, with the exception of the Department of Agriculture, the reverse is true. In the best situations, as in RANN, utilization dollars may amount to 20 percent of research expenditures, but overall, it is as low as 9.25 percent.

RANN, therefore, has tried to develop policies, procedures, techniques, and infrastructures to facilitate utilization. Each RANN program manager has primary responsibility for ensuring the utilization of research outputs from his grantees. At the same time, RANN's Intergovernmental Programs are developing networks which are used to facilitate reception and application of RANN and other R&D results by public sector users. The Intergovernmental Programs have as their primary objective the facilitation of the integration of science and technology and the policy planning and program operations of state and local governments.

As part of its activities, Intergovernmental Programs are developing a series of network and state, regional, and national levels to facilitate science and technology utilization. Examples of Intergovernmental Programs activities include: a big-city technical consortium (all U.S. cities over 500,000 population and 6 urban counties--more than

34 million people, a technology information exchange, an Urban Technology System (UTS)--27 cities ranging between 50,000 and 500,000 in population size, use of professional associations, special multi-city innovation groups, and a federal laboratory consortium. Other projects focus on the heightening of state executive and legislative branch organizations capacity for the application of scientific methods and technologies.

The objective of the big-city consortium is to create a system for developing ranked user needs and for applying technology to solve the problems of the nation's largest cities. The technology information exchange provides state and local governments with synthesized data from RANN and other research programs presented in language that is understandable by government officials. It also receives feedback about the value of the products of RANN research. More than 100 cities provide matching funds for the consortium and technology information exchange programs in the form of subscriptions to Public Technology, Inc. These activities are seeking to become self-supporting. In the meantime, an institutional mechanism for continuing interaction has been created.

The Intergovernmental Programs seek to utilize existing networks where possible, and to avoid creating new institutions and mechanisms. Thus, the Foundation is striving to develop new and innovating means to tie users more completely into the research process from start to finish. An integrated approach to applied research is the proper course for RANN, which should continue to broaden its community of contacts.

RANN APPLIED RESEARCH: THE GENERAL PROCESS*

THE SETTING AND STRATEGIES FOR APPLIED RESEARCH

Short-to-long-term goals of society call for corresponding plans and strategies for marshalling the elements that participate interactively in achieving those goals. Typically, research program plans stress means of expediting the accomplishments of the technical research. Although this accomplishment is a necessary step on the path to success, practitioners of technology recognize that its attainment does not ensure effective or timely utilization of research results.

Singular emphasis on the ongoing research programs also does not require or prepare for the selection of programs that will follow and succeed those underway. Priority-setters are not wholly courted by researchers. The latter focus more on the possible outcomes of their specialty effort. Researchers are often accused of taking their cues from their own insights concerning the progression of studies they ought to undertake during their careers. This allegation depicts the sort of problem addressed by COPEP's analysis of the total setting of needs, incentives, means, and use.

"Effective utilization" presupposes the usefulness and soundness of research results. Even so, competing programs with overlapping goals may all yield useful results. This situation forces decision makers to choose among the sets of results for those most fitting and affordable. Allowances must also be made for outcomes that do not permit utilization, and plans should estimate the proportion of the total program that may be invested in potential non-recoverables before terminating the projects. Those results

*This chapter provides a view of the entire applied research process to furnish a framework for reflecting on cases dealing with specific RANN subprograms. The issues developed herein were aimed at enabling COPEP to identify and describe alternative management strategies for the application and utilization of RANN's research results.

that are less than optimally attractive may be considered research by-products. The need to assure the possible use and applications of these by-products demands attention and effort to enlarge the benefits society may receive from the total program.

Among the techniques to assess these diverse demands, evaluation and analysis are prized by those who furnish decision makers the bases for setting alternative courses of action. The important role these instruments might play in decision makers deliberations imposes requirements on RANN to identify the time, course, and targets of evaluative analyses.

COPEP examined the implementation/utilization management strategies practiced or planned within the RANN divisions. The strategy currently being employed might then suggest other strategies that could be applied to similar future situations. However, COPEP was not charged with formulating tactical details aimed at correcting the course for the specific projects studies.

What are some alternative strategies for managing utilization of research results? The following roster lists and characterizes conventional strategies for research management:

- Technocentric strategies:
  - (a) Push the state-of-the-art
  - (b) Develop technology and services of acceptable economic costs
  - (c) Develop and introduce technology and services easily adopted by users
- Time-horizon strategies:
  - (a) Crash programs
  - (b) Short-term projects
  - (c) Intermediate-to-long-term projects
  - (d) Mixed-time schedule
- Strategies emphasizing user complexion:
  - (a) University or institute as user-proxy
  - (b) Single firm or single government unit as user example
  - (c) Consortia of users
  - (d) Multiple demonstrations and use by geographically disparate or size differentiated firms or local governmental units

- Incentive strategies:

  (a) Incentive fees for novel proposals
  (b) Incentive fees for performance
  (c) Award of patent title to researcher/ performing organization
  (d) Award of limited exclusive license to users

Specific management strategies drawn from those listed here may be uniquely relevant to certain RANN program forms or goals. The choice of any alternate strategy, however, requires sound and promising utilization plans. In turn, utilization's dominance among the elements of the research delivery system demands that proposed strategies preserve appropriate roles for priority-setting, program-selection, and choice of performer/performing organization. Consideration to each of these three other elements should be given in the conceptualization of alternate management strategies. To be acceptable, alternative strategies also require the availability or development of an adequate data base, as well as the effective communication and dissemination of research results to potential users and the interested public.

Choices offered for RANN's priorities, programs, performers or utilization efforts sometimes defy objective analysis to aid the selection process. Where the desired objectivity cannot prevail, informed judgment reigns. Thus, COPEP attempted to systematize subjective experience and expertise. RANN's requirement for clear options may be better satisfied in future situations calling for the best possible analysis and reduction of uncertainties in implementation of alternate strategies for utilization.

If there were no better justification for interpretive analyses, the demand by potential users would suffice. Users in the public sector want insights into the popularity, safety, resource requirements, and cost of new services, techniques, or products. Private-sector users are, in addition, concerned with economic evaluations drawn from estimates of the required capital outlay, relative labor intensity, market potential, and prospective profit. Although methodologies abound for performing the desired analyses, the means for applying these various techniques are more elusive. Early involvement by prospective users may be the singularly outstanding strategy for ensuring meaningful analyses. However, other strategies (such as objective analyses by third parties to foster utilization) should also be considered.

Comprehensive analyses of any major RANN program area are costly and time-consuming. Some researchers contend they are disruptive, since few unobtrusive techniques are available and applicable to evaluate alternate strategies. In addition,

potential users lack confidence in newly devised techniques or arcane analytical procedures. There is also scarcity of analyst-evaluators.

Impact analyses, especially technology assessments, have become increasingly popular and powerful tools for examining effects external to the direct goals of technical activities. As the prospective "user" of alternate management strategies, RANN requires: (1) judgments about the relative facility of extracting impact analyses via alternate strategies; (2) insight into the likelihood that an alternate strategy could create a more-or-less desirable impact; and (3) opinions on the reliability of quantitative comparisons of impacts of alternate strategies.

Roles in Priority-Setting

Although formal priority-setting techniques possess advantages over informal, reactive practices, their efficacy is limited when RANN is confronted by limited pools of talent and money, or by the press of crisis-type quick response situations. Highly qualified individuals, speaking for competing and conflicting priorities, vie for a share of limited funds. Legislators and the public, in times of technological crisis, press for answers to national problems. Failure to respond can lead to funding difficulties and may even heighten the crisis.

An easy pliancy in priority setting may harm intermediate-term plans for well conceived research programs which require assurances of continued funding. The Committee thus endorses clear objective structures and procedures for priority setting, which would enable it to defend resulting priorities against more subjective pressures, should these arise. RANN might wish to consider different avenues for establishing priorities. For example, with additional funds, the RANN staff might be enlarged or reorganized to afford critical masses of several skills and specialties, operating as designated planning and priority-setting entities. Working entirely within the Directorate, such a staff unit would have superior access to appropriate key NSF individuals to present cases and argue their merits. In arguing for any such expansion, RANN would have to deal with criticism from research performers acquainted with past procedures that have permitted the researchers themselves a larger role in priority-setting.

Alternative Means for Priority-Setting

Any priority-selection strategy or process should be responsive to the appearance of an unexpected crisis in need. It should also possess criteria permitting the accommodation of revolutionary new processes, techniques, or products. (This is an element of "technology-push" that has met with disproportionately good success: the unplanned emergence of an unexpectedly superior development as a fait accompli. National prestige or economic factors can draw such developments into the priority mainstream.) The operational features of priority-setting impose more difficult problems for RANN than do criteria-setting or other administrative techniques. RANN management strategies should answer the question: How are priorities set so the results of RANN research will be effectively used?

Alternate strategies for priority-setting include:

- Creation of a priority-planning group within RANN to link goal-setting with planning.
- Use of advisory groups.
- Convening representative leaders of private and public-sector users.
- Retention of consultants possessing expertise in future trends and representing a variety of specialties.

RANN priority-setting should include participation by the potential sources of the priorities. These participants, who can be more important than a newly conceived tactic in priority-setting, include:

- RANN management.
- The White House (e.g., OMB, Domestic Council, Science Advisor) and the Congress.
- Mission agencies and their advisory committees.
- Users (e.g., state and local government, industry, labor movement).

- The public (e.g., public interest groups, civic groups, opinion polls)
- Technical, social and informational (including the media) middlemen
- And, of course, the research community itself--the suppliers of research results.

Within this unstructured setting, RANN has the opportunity to set and achieve its priorities. The question is: How shall RANN call upon these sources?

Selecting Applied Research Program Targets

RANN's responses to priorities are evident in their program areas, which create opportunities for others to help answer national needs. However, the formulation of program plans from priorities does not proceed linearly; indeed the logical appearance of the resultant RANN program belies the complexity of the integrating process that identifies and structures them. Alternate management strategies for effective utilization take cognizance of the accompanying need for alternate approaches to program selection.

While future evaluators of candidate RANN programs may generate a wholly new and systematic set of selection criteria, the criteria currently employed for selecting among RANN program (project) opportunities include:

- National importance
- Cost benefit payoff
- Leverage
- Readiness of technology and skills
- Capability for successful research
- Need for federal action
- Unique position of NSF as the only federal agency whose mission is solely the support of research

Other criteria (e.g., funding requirements, soundness of utilization plans) may be added when deemed necessary by RANN or others to fit specific program areas, temporary situations, or project structures. Especially in programs devised to give greater emphasis to policy outputs than to technical results, RANN should rely upon the following: peer-group review, source-evaluation panels, consultant-advisory panels, and panels comprising RANN personnel, users and research suppliers. The relative and comparative merits and "pairing-traits" of these diverse approaches suggest that two or more of these selection procedures might be combined.

Performer-Selection

Success in applied research programs lies not only in their intrinsic quality, but in the benefits they bring to the user sector on behalf of society as a whole. Unlike basic research, problem-oriented research cannot be justified on the basis of knowledge gained alone. Aimed at satisfying the nation's needs, RANN's applied research programs are necessarily related to value terms, such as: time, money and manpower; benefits, risks and profits; and rewards and penalties. Relying upon a mix of disciplines among research performers, applied research management requires scientific investigation coupled with the insightful leadership of other occupations. To ensure that the results of RANN programs are effectively applied, RANN should examine and respond to competition among potential performers, performing organizations, and initial users of research results.

One prevalent opinion holds that project awards that fall within RANN's general program rubric should be made to the originator of the proposal. The opposing viewpoint is that work statements should be generated by RANN with responses, in the form of solicited proposals, evaluated against detailed and objective criteria.* Proposal of both solicited and unsolicited proposals leaves a community of unsuccessful bidders who may be future performers for RANN projects.

RANN should consider impacts of differing forms of competition and qualification for support in performer-selection. It may prove impossible, however, for RANN or any agency to distinguish between the program proposed and the investigator who proposes it.

*See, for example, the discussion of "Top-Down" vs. "Bottom-up" management strategies in the Committee on Public Engineering Policy, National Academy of Science, Washington, D.C.

RANN publicizes priority issues and selected program areas chosen as targets for responsive action within the community of most likely performers. Means include seminars, briefings, mailings of program announcements, and insertion of notices in publications such as the Commerce Business Daily. The issue of primary outreach is thus addressed from the perspective of recruiting highly qualified candidates whose participation in RANN activities is advantageous for the performer, performing group, and society.

A notable RANN initiative, in this regard, was 11 seminars held around the country during May and June 1975. Approximately 6,000 persons attended these seminars, which were arranged by the American Society for Engineering Education (ASEE). RANN management staffers described current and future programs with academic, industrial, state and local governments, and nonprofit institutional representatives. The seminars were aimed at providing a better understanding of RANN, and to encourage research proposals.

The recruitment and selection process may result in dislocations and other costs. RANN seeks to avoid such dislocations, to assure performer pool continuity, and to ensure against loss of momentum in the utilization of research results.

Outreach and Identification of Potential Researcher

The seeming infinity of results afforded by science and technology leads some executives to believe that any goal that is conceivable is likewise attainable. This belief does not correctly value training nor the time and resource components of both the physical and behavioral sciences. However, the most likely cause of frustration arises from the shortage of individuals skilled in solving particular problems.

Fortunately, current RANN programs do not appear to be endangered by lack of any critical research skills. However, successful plans to launch new or expand continuing RANN programs will require coupling them in the pools of skills most relevant to the disciplines and crafts necessary for their furtherance. RANN managers should have access to intellectual inventories more trustworthy than the mere claims of those who submit proposals.

The Executive Inventory and similar data banks maintained by the Civil Service Commission exemplify the inventory record that would be servicable to RANN. Regretably, no reliable or easily accessible current listing of non-governmental professionals exists. With increasing or changing demand for highly trained investigators in several

disciplines. RANN should consider supporting and/or maintaining and developing a list.

Launching and expanding investigations or demonstrations in complex systems research may deplete the available worker-specialists in given problem areas. As a result, RANN may be forced to consider alternate means of continuing the research in the face of the skill scarcity. Alternatively, NSF may weigh its role in founding curricula or educational centers capable of increasing the number of available individuals with training relevant to RANN program needs.

RANN current programming recognizes the complex patterns of multidisciplinary, problem-oriented research. Some projects are specifically aimed at providing an improved understanding of the interdisciplinary and interinstitutional barriers and channels of the research delivery system. RANN needs functional linkages that will provide a human reservoir capable of initiative in priority-setting, insight into investigative research, and effective action in research utilization. Although not all of these necessary functions are within the control of either RANN or its researchers, the linkage among them is essential to successful utilization.

Most of the research performed for RANN programs will be conducted by teams housed in previously established organizations. Although the impact of research strategies on these organizations will be discussed later, their own conventions and traditions influence and limit performers in various ways.

Industrial firms, public agencies, and university research units all have budget, schedule, and other related administrative protocols aimed at perpetuating those organizations and their activities. Their reward system, promotion policy, and publication and publicity practices are naturally not established for the specific furtherance of RANN's programs. However, each of these may be susceptible to change that would provide a fruitful ambience for some RANN programs, without endangering the organizations' central goals.

Roles of Research Institutions

Research institutions--public or private, academic or industrial--offer both resistance to change and leverage opportunities for any proposed set of alternative strategies. In whatever manner they participate in RANN programs, institutions must protect their fundamental interests. Such interests may well prove to be the conduits that alternate strategies should attempt to explore and support.

Performing organizations are compensated for conducting RANN research by income and the opportunity to play leadership roles in emerging areas of applied research. However, the income does not attach to a long-term contract, and RANN's applied research goals may not be consistent with the goals customarily perceived, for example, by science departments in teaching institutions. Alternate strategies might enrich the rewards through such means as contingent long-term awards, assistance in patent exploitation, or endowing applied research journals with greater prestige than derives from their current repute as "trade press."

In simplistic terms, research institutions qualified to house RANN research programs will be those whose staff, financial, and administrative resources enable them to contend for project awards. These institutions include universities, institutes, and firms whose facilities and competency endow them with attendant repute. RANN's plans allow for the specific needs of its program participants, including the need to satisfy RANN's expectations for the timely and effective delivery of research results, and the institutions's need for assuring its own continuance. RANN's need for alternate strategies for inducing the formation or participation of qualified institutions takes into account the need for the continuity of the institution to fulfill its roles, and the ease of transferring the project from the institution to preferred successor institutions.

Alternative strategies for highly beneficial participation by institutions in RANN's programs may confront geographic or other parametric defects in the community of institutions currently accessible to RANN. Geographic problems might be creation of new regional centers to help meet RANN's priorities. Thus, if alternate strategies suggesting specific new centers or institutions were to lead to ongoing demands for more competence in various applied research, RANN should encourage NSF's Education Directorate to establish departments and curricula paralleling demands in the social, physical, or engineering sciences. Means of enabling universities to perceive and respond to these opportunities should be devised as incentive components of alternate strategies for the effective utilization of RANN results.

Alterations in the reward systems (e.g., salary, tenure, promotion) of participating or proposed institutions should be considered from both the viewpoint of their likely favorable influence on the generation and utilization of RANN results and from the aspect of their jeopardizing the conventional structure of similar institutions. In balance, RANN will need to formulate such matters in a value-scalar array.

Quality Maintenance in Research Programs

The dominant feature in assuring research quality is the skill of the performers. In the course of conducting applied research, however, changes occur which evoke uncertainties about ways to continue and to improve utilization. RANN's project evaluation committees respond to such changes by revising the overall plan or strategies for that program area.

Safeguards should be built into the evaluation procedures, however, to ensure against the disruption of the project itself by the evaluation technique. For example, progress reports are intrusions upon research performers' schedules, and the question of their value to RANN may be raised. If such reports are of value as documentation only, alternative means of monitoring the advancement of progress might appropriately be substituted or added. RANN should consider increasing or presenting the following patterns or procedures for evaluating work in progress:

- Review and evaluation by RANN staff members in a special committee (as now practiced)
- Peer-group evaluations
- User-group evaluations
- Outside contractor evaluations
- Mixed peer group user-evaluations
- Review by one of the foregoing groups and evaluative monitoring by another group

While all advantages and possible disadvantages should be considered in weighing alternative approaches, wider employment of user-group evaluations, in addition to peer views, would improve the effectiveness of RANN project outputs.

In addition to the simple evaluation of programs versus goals, RANN, which now arranges for outside review of technical reports, should consider the adequacy of editorial review of papers for principal journals. If this review is found to be inadequate, RANN should recommend that appropriate federal agencies foster the improvement of journal referencing and the use of relevant journals to exchange evaluative viewpoints through letters-to-editors. RANN would wish to define its role in helping to design such media for constructive controversy.

Since RANN is committed to the successful utilization of its research results, means of linking evaluation with quality assurance merit attention. RANN may assure the reliability of implied claims by calling for incentives, such as prizes, to be awarded after the claims have been verified in subsequent research or used. Terms and conditions of the award will probably be accepted more favorably by researchers if they do not hinge upon the quality or level of effort by subsequent participants in the system. Any incentive policy is a more fundamental concern, however, than the specific incentive or sub-strategy RANN might apply.

RANN's needs for quality maintenance also call for consideration of research by-products in the evaluation of the overall program output, including results of apparent direct value specifically related to the defined goal, rather than distant effects that are more properly considered within the framework of a technology assessment. By-product utilization may call for a planned departure in the schema of program activities. Thus, RANN may need secondary strategies as alternatives in exploiting the use of by-product goods or services.

Ultimately, RANN should anticipate termination of projects that encounter intractable technical or societal obstacles. RANN's evaluation committee should at an early stage of a project apply evaluation procedures that can evince signals of failure. The advantages of foresight will be especially significant to RANN in avoiding criticism of a program area yielding questionable results or lacking in soundness.

Prompting Dissemination and Application of Research Results

The scientific community is not agreed on a method which, if followed, would lead to predictable success. However desirable graphic or schematic illustrations of the progression of results toward utilization may be, there are, at best, only logical displays of the network. Real-world workers must necessarily take note of their nonlinearity.

Since dissemination and application are indissolubly coupled with utilization, publicizing research results is an integral component of the application process. Effective dissemination of research results involves providing enough information to convince users of both the soundness of the data base and to provide sufficient incentive to justify expenditure on the new state-of-the-art.

The means used for dissemination are widely known--seminars, publications, and demonstrations. The criteria and the relative emphasis given to each are tied to the

perceptions and factors that motivate potential user managers within firms or state and local governments. Successful RANN utilization efforts depend on identification and trials of alternative strategies whose implementation might guide in the selection of information dissemination routes.

Different points of departure occur for the private vs. public-sector channels for information flow and for utilization of research results. The different constituencies (stockholders vs. voters) means of financing (loans and share sales vs. land levies and taxes), and other features cast the private executive into quite a different mold than that of the public administrator or elected official. Opportunities to take credit or share blame for successes or failures are significantly different in the two areas. Close examination of specific cases will permit RANN to design alternate strategies for each sector. In both cases, acceptable alternate strategies would cultivate an atmosphere of confidence for the dissemination of credible information. To make such alternatives available, RANN may have to break with traditional approaches and introduce new dissemination techniques for effective utilization. For example, approximately two years ago, RANN made an award for an intensive system design effort for a RANN-wide communication and information network.

Promoting Utilization

Institutional mechanisms that can foster or retard the effective use of research results are described in the case reviews (See Chapter VI). These findings focus on means to integrate the collection of forces, whether in the public or the private sector. In each case, RANN plays the important role of research sponsor, but may need a more explicit definition of the boundaries of that role. For example, greater encouragement by RANN may be required to promote utilization demonstrations in the public than in the private sector.

In both the public and the private sectors, researchers play the performing role--providing solutions in terms adequate for equally skilled practitioners of the product art. In both sectors, users search for means to satisfy wants or needs of a client-consumer or constituency. In all cases, the transfer between sponsor, researcher, and user represents a linkage-action for which breakthrough improvements are sought.

Coupling of the separate components--support, research, and use--is RANN's most important function in the research delivery system. Favorably linking appropriate strategies will probably suggest additional action to gain user participation at an earlier step in the system. However, the prospect of specific user involvement in such matters as priority-setting would call for RANN's thorough examination of the specific primary actors in the utilization realm of actual RANN projects. All roles should be defined as clearly as possible.

RANN's Role in Utilization

Unlike mission agencies, RANN's goals are expressed in more purposive than operative terms, e.g., to focus scientific research on societal problems of national importance with the objective of contributing to their practical solution. By implication, RANN's role in utilization is thus limited to a contributory role in problem-solving. At the very least, the role includes assurance that the research results are used. RANN should examine long-term perspectives in order to clarify the overall need and the means for satisfying utilization management requirements. By continuing to provide function for utilization, planning, and management, RANN may become the source of staff for the next agent in the process, RANN thus encountering periodic spin-offs of staff and necessitating recruitment of program managers for new areas. Alternate strategy components might include general expansion by RANN, creation of new mission agencies when appropriate or creation of a unit within RANN to arrange effective transfer of applied research results to cognizant mission agencies. In each case, RANN should assure an effective link to the user-sector and also the continued opportunity to address newly defined national needs.

As has been suggested, the optimal coupling role for RANN may change from private-sector to public-sector programs. Private-sector users will probably become cost-sharing partners early in the demonstration and design phase of projects. However, public-sector users (school boards, human relations commissions, etc.) may represent client-customers requiring a persisting and supportive input from RANN/ISPT. Accommodation for this possible need should be provided in anticipating and studying such eventualities as bond issues, referenda, or other elements of the political-administrative system. Such events tend to delay rapid introduction of new techniques or products at the community level. In either sector, RANN will recognize, and should assure the critical importance of momentum, when utilization

has once overcome inherent inertias of the respective user sector.

Research Performer's Role in Utilization

When a development has been seasoned by testing, the utilization researcher applies a preferred methodology to the field development and use of the product or technique. Utilization research performers optimize the use of developments (emphasizing function and system), in contrast with the emphasis on synthesis by researchers who conceive and prepare the product or service. There is a generic difference between the two functions, although some classes of RANN research permit a continuum of involvement by one small team. The strategy that maintains the team's effectiveness from concept through use may defy analysis and should simply be sustained. However, many research programs in the private sector and most of those in the public sector suffer delays at transfer points because of the need to educate the next succeeding team.

Some agencies are concerned that capable researchers are not interested in the practical research sphere. However, Jencks and Riesman* found that even academic investigations are not over-particular about the areas in which they work, but strongly prefer to choose or rely on their own methods.

In economic and career terms, the opportunity cost to the utilization researcher (that is, the value of other, lost opportunities) must be less or appear less than the value of extensive participation in the specific RANN program. The utilization performer should be made aware of several potential functions:

- Evaluation of the adequacy of information sources
- Presentation and demonstrations for user decision makers
- Preparation of papers, operating manuals, and economic estimates
- Arranging for technology assessments
- Serving as a "stand in" for the ultimate user, thereby demanding favorable cost benefit features from the system or product

*The Academic Revolution, Doubleday, New York, 1968, p. 516

Each of these functions requires a technique equally as demanding as the scientific method applied at earlier stages in the program. Thus, RANN's applied research calls for strategies that can identify, attract, and hold the performers who forge the utilization link in the research-delivery process. Coupling utilization performers with the actual user-sector requires understanding the goals and operations of users and their possible requirements for the continued participation of utilization researchers. Stipulation of users' goals and operations should assist in sustaining the interest and participation of researchers.

Users' Involvement in Utilization Research

RANN programs can benefit most from the earliest possible involvement by users. RANN seeks and implements strategies that permit user participation in priority-setting as a member of some collective group, society, association or community. Overall, RANN's best utilization stragegies will be those that optimize readiness, without sacrificing the quality or timeliness of priority-setting and other events in the research delivery process that precede reduction to actual use.

Users are expected to furnish the staff, facilities, and funding at levels proportional to the direct benefits they received. The means users apply for assessing these benefits, for raising funds, and recruiting staff are naturally concerns of RANN. As with previously described features, effective strategies for understanding user issues are sought for RANN's future consideration. This understanding may sometimes be brought out most helpfully in face-to-face conversations.

In fostering utilization, RANN is also aware of the probable benefits to users (public and private) who enjoy first rights to use them. Means users employ to anticipate rewards vary, as do the strategies emphasized to encourage competition and avoid unjust enrichment. Understanding those means will help RANN create favorable climates for utilization, such as giving exclusive lead times.

Users in the private sector must respond primarily to stockholders' interests; in the public sector, responses of elected officials will anticipate the needs and setting of the local community. In each case, RANN's alternative strategies may appeal to users indirectly through cultivation of a favorable milieu for the research results among stockholders or among the body politic. Indirect approaches (e.g., public notices) within alternative strategies may persuade prospective users to deploy user scouts while

programs are in progress, improving the quality of both the competition for first use and the level of user response. RANN should continue to involve users and utilization researchers in the research process from problem-definition through proof-of-concept and replication. Trial efforts of such a strategy would be more profitable in the public-sector program areas than with private-sector firms.

Actual cases provide evidence to gauge the relative promise of specific tactics and alternate strategies. Rewards and risks to all participants in the research-delivery system should be reviewed in the context of specific cases, with special emphasis on utilization, as the following section on case studies permits.

RANN CASE STUDIES

OBJECTIVES OF CASE STUDIES

The purpose of the study was not to analyze or evaluate specific programs. The principal focus is on strategies for the management of utilization. This requires, therefore, some illustrative discussion of how RANN decides what to do and how it applies what has been done. The original study proposal stated:

> The study will highlight and illuminate a series of issues relating to the selection, conduct, and application of problem-oriented research. The objective of the study is to compare and recommend alternative strategies for dealing with the issues associated with RANN's applied research delivery system. The ultimate product will be a report setting forth alternative and recommended strategies and advice to RANN with respect to these issues for various types of research and user-community situations.

COPEP examined four principal elements in the research delivery process: priority-setting for programs, performer-selection, site-selection, and, ultimately, the whole process of research performance and utilization. The evidence has been collected in four case studies, providing real-life operating scenarios in these diverse program areas.

The theme of these cases is a theme in unison: RANN's recognition that a set of technical findings represents an opportunity to use them in addressing a national problem; that mobilization of technical resources require federal government participation; and, finally, the strategy for utilization. The four cases were selected to determine whether there are points of departure for utilization strategies planned for the private, public, and private-public sectors.

Approach Used

One program within each of RANN's four divisions was chosen for study and analysis. RANN program managers and other staff members were asked to focus on how they were examining the utilization of RANN research results. COPEP surveyed the relevant literature, pinpointed key areas of concern in the problem-oriented research process, and interviewed investigators involved with the programs in an attempt to relate program data, information, insights, and observations to the overall problem-oriented research process.

Division directors were asked to describe their own utilization considerations, isolating the factors affecting utilization planning and the implementation of research results in his program area. The resulting interview reports were supplemented by additional interviews and discussions. Where fact-to-face discussion would have been possible only through extensive travel, lengthy phone conversations with principal investigators were substituted. Similar discussions were held with personnel of other agencies, with representatives of participating industrial firms, and with representatives of organizations that chose not to bid or were unsuccessful in bidding for RANN awards.

A three-day workshop convened by COPEP in October 1974, attended by some 25 RANN staff members who had received copies of COPEP's interview reports as well as copies of early drafts of the cases, provided an invaluable vehicle for thorough and interactive discussion of the preliminary findings. Completion of the four cases by additional outside interviews then followed.

CASES

Public Service Delivery

Objective

The objectives of the municipal systems and services are to:

- Provide knowledge which will help improve the use of existing municipal resources and improve the effectiveness of municipal governments in delivering public goods and services.

- Evaluate attractive applications of new urban technologies, with emphasis on the ways in which social and technical systems can best be joined.

- Evaluate the benefits and costs of alternative organizations and institutional mechanisms for coping with the problems of municipal governments.

As a program closely linked to RANN's productivity focus, the municipal services and system program was originally in the Social Systems and Human Resources Division (SSHR). Anticipating an emphasis on productivity for FY 1976, SSHR was incorporated into the new Advanced Productivity Research and Technology Division (APRT) in the August 27, 1974, reorganization of RANN. Relying on delivery of public services via telecommunication technology is an element of the municipal services and systems areas.

Program Setting

RANN gave priority attention to community problems. Serious shortcomings in the delivery systems for a broad range of community services were identified and highlighted in many places, including the 1970 and 1973 COPEP studies. RANN's formulation of public service delivery programs attests to its responsiveness to needs expressed by others. RANN's combination of studies and quasi-experiments are intended to be mutually supportive.

In FY 1972--prior to RANN's application-utilization focus--remote service delivery programs were under ERPA. Areas under study during that initial period included: cable TV and its applications, teleconferencing, and city government-community feedback. Projects included: development of a device to enable rapid feedback at citizen-government meetings; a project on videophone use in teleconferencing; a study of franchising cable TV; and the New York City Metropolitan Regional Council's evaluation of remote communication in teleconferencing. Identification and preliminary selection of performers was based in part on past citations to their papers by other workers.

In FY 1973, the "telecommunication services" program was transferred to SSHR (now APRT). The study of rapid feedback from citizens to government found that there are problems of scale in such service systems that can be addressed by the use of telecommunications technology. A study in San Jose, California, addressed the issue of economies of scale by

implementing a school-community feedback system.

Telemedicine projects at Boston City Hospital and in the Dade County, Florida, prison health care delivery system began in FY 1973. In addition, 8 planning grants were awarded (to university performers) in response to 97 proposals to develop capabilities for telecommunications policy. The program format was developed in consultation with the White House Office of Telecommunications Policy (CTP). The proposals came in response to an "Important Notice #458".

The eight planning awards covered the following areas: economics of broadcast TV, state regulations of electronic communication, broadcast cable TV, cable TV service delivery, tradeoffs between telecommunication service and local transportation, and delivery of services by cable TV.

Limited funds restricted the opportunity for follow-on studies in the FY 1974 competition. Six of the original eight awardees joined in the competition to design experiments for public service applications of cable television. Three of these received awards for the FY 1974 program, along with four other institutions.

Two new projects at the University of Michigan got underway in FY 1974. They focused on telemedicine in health care delivery. One project examined features of telemedicine for health care delivery to the sparsely populated area of Farmington, Maine. A wide community of users, including the American Medical Association (AMA), state and local governments, physicians and health organizations (in part, through the participation of the Rural Health Assocuation) were involved with the review of the Maine project.

The Boston City Hospital telemedicine and the Dade County prison health care projects will provide opportunities for competitive analyses.

Seven new projects to design experiments for public service application of telecommunication technology got underway in FY 1974. These projects represented Phase I of the cable TV application program, with three experiments funded for FY 1973 execution representing Phase II. The 7 awards resulted from 49 proposals (25 from universities). Three of the original eight universities (Southern California, Michigan State, and Lehigh) won awards. The other four awards were made to Rand, Denver Research Institute, the Urban Institute, and New York University (NYU). None of the private firms included among the 49 bidders received awards. The three experiments funded for Phase II were developed by Michigan State University, NYU, and the Rand Corporation.

In FY 1975, RANN funded Stanford Research Institute (SRI) to examine experience with teleconferencing. SRI will convene a conference of performers and users, primarily

federal agencies.

In FY 1975, RANN transferred $21,000 to the Commerce Department's Office of Telecommunications to study means to assure technical completeness in the areas of telecommunicated services delivery.

Conferences bringing together RANN personnel, performers, and users are planned.

What comes next? RANN saw the need to evaluate and synthesize the telemedicine studies, and for wide dissemination of reports--especially to medical professionals. Dissemination will end the telemedicine service delivery subprogram activity, insofar as RANN is concerned.

In the citizen-government area, RANN was hopeful that the complete evaluation of the San Jose Unified School District project would lead to options and decisions for future projects. Surveys, some experiments, and data collection will continue.

Cable TV representatives from the Federal Communications Commission (FCC), the principal user of RANN telecommunications data, attend RANN meetings and are involved in selection of future performers. In addition, The Department of Health, Education, and Welfare (HEW) and OTP represent federal agency utilization linkages to this program. The FCC is interested in RANN's cable programs, since it must either change the cable requirements by 1977 or let present rules stand. The FCC may toughen its stand in 1977, and require two-way cable communications.

Starting with $1 million in FY 1972, funding for RANN's telecommunications programs rose to $2.3 million in FY 1973, then dropped to $1 million in FY 1974, and rose again to about $2.9 million in FY 1975. As the base population served in these experimental projects increases, the funding required also increases. This requirement cannot, of course, always be accommodated.

As previously noted, since 1972, program managers have increasingly emphasized utilization/dissemination. Despite the suspicion expressed by at least one RANN staff member that emphasizing utilization may become an overplayed occupation, it does not appear to have dampened the enthusiasm of qualifying organizations. Some requests for a utilization plan have led to approvals of proposals that merely obligate the principal investigator to convene utilization advisory committees. In other, more meaningful situations, the program manager has arranged to serve on such committees. However, not all such cases represent an opportunity for RANN to create a stronger interface with those who vocalize needs and mobilize research results toward their resolution. Instead, they bear earmarks of a "technology push."

Regular contact is maintained by program managers with principal investigators. This contact is by way of telephone or brief progress reports, as well as by site visits.

Service delivery studies have been facilitated by the expressed personal and professional interests of investigators. Yet, RANN staff saw the need to balance investigators' greater interest in satisfying a scholarly appetite for knowledge with that of coupling findings to viable answers to a national problem.

Interaction with potential participants has been arranged or accommodated at some cost. To a degree, the interaction among participants in the Dade County prison health care delivery project has forced changes on the issue of roles. A county hospital, a county prison, the medical school of a university, and a major industrial firm were brought together to supply and test the telemedicine delivery service. The private firm representative stated that his firm took the initiative, but the grant was awarded to the university. In turn, the university subcontracted contract management to the industrial company. Although this tactic represents a detour off the map of the classic "technology delivery system," it represents the result of RANN's careful choice, based on relative and specific competencies of prospective performers.

Conversations with both program managers and principal investigators of the public sector productivity program area illustrated some difficulty in fitting social studies into a solid strategy. The findings strongly implied that more work is required to clarify objectives for utilization, and especially to distinguish between doing research and delivering research results.

The principal goal of RANN implies solutions for national problems. However, both program managers and principal investigators of these projects suggest that, in the main, the projects have not yet lessened the problems

they address. They have chiefly devoted attention to enlarging the resource base; the training of additional researchers, without building a conduit between them and users, is a foreseeable consequence

The intent and plan by ISRU's program manager for this area of emphasis show his attempt to formulate techniques for consolidating service delivery efforts and in a systems approach to utilization. Workshops and symposia are planned to afford productive interaction among researchers and users, hopefully leading to enhancement contracts for verification. In addition, colloquia are planned to define user needs and priorities in the early program planning stage. These approaches are aimed at closing the gap now observed between program results and their subsequent utilization.

Utilization Problems and Activities

Program managers and principal investigators for public service delivery programs stated that the set of RANN programs related to their research present one of the toughest sets of utilization problems within the entire RANN directorate. Although the problems are inferred from assessments of hard statistical and demographic data, potential solutions appear as findings, largely in the form of information. According to those associated with implimentation and application, dissemination and use of the information face at least two problems:

(1) Control settings are difficult to identify and even more difficult to perform unobtrusive observations of the selected control or of the experimental situation.

(2) Societal problems are never totally solved. Even partial attention of a social or community problem usually identifies another problem.

Faced with the complexity and political variables of community problems, those responsible for these programs have assembled and cataloged knowledge about possible solutions. Their utilization activities and strategies emphasize the gathering of data and the dissemination of findings to potential user agencies, such as HEW, the FCC, and the White House Office of Telecommunications Policy.

Dissemination

Reports of studies of the state-of-the-arts in a variety of service areas have resulted from a series of 12 research assessments and planning papers. These reports have been widely distributed to policymakers, planners, and others with an interest in social systems.

Although program managers emphasized utilization in their announcement and later evaluations of study proposals, principal investigators relied largely on conventional publication formats. Thus, use of the literature in the field appears to be a principal dissemination vehicle.

Program managers' symposia convened to discuss results strongly emphasized as tools in dissemination. A wide spectrum of federal, state, and local legislators and key performing personnel are invited to attend. Principal investigators and program managers report high levels of interest and participation in discussions of findings--some of which obtain major media coverage.

It should be noted that evaluation of the assessment studies has been considered, in which the value, approach, thoroughness, and substance of these 12 studies would be reviewed by an outside organization.

Action Areas and Experiments

The experimental delivery of health care to the Dade County, Florida, prison illustrates the chief functions of several service delivery projects.

The prison health care delivery project currently has only minimal dissemination work underway, although the involvement of three organizations (local government, a private firm, and a university) helps assure a nucleus of both dissemination and utilization. The program manager and project director reported interest by other prisons in the findings.

Delivery of health care to prisons, to widely dispersed communities in sparsely settled areas, or to compact ghetto areas represents sufficiently specific problems to justify emphasis by RANN on behalf of local government planners and their suppliers. Consequently, progress at the Dade County prison will be closely watched by community planners and by firms with a commercial interest in communications equipment. Such firms, responding to business opportunities, may serve as the best vehicle for dissemination, according to the firm involved in the prison health care project.

Utilization

Principal investigators who conduct service delivery studies seek to utilize their findings. Actual utilization is performed by a variety of planners, developers, legislators, suppliers of services, officials, financial institutions, and the electorate, all of whom have a stake in successful utilization. RANN has attempted to involve federal agencies who are likely inheritors of the ultimate accountability for use of specific research results. For example, symposia were held to help foster utilization of study findings.

The Dade County project has moved into an implementation mode. Although the University of Miami received the grant, project coordination is in the hands of a private firm with a vested interest in both short-term and long-term sales prospects for the microwave gear. The results of the project have been incorporated by the local community, which responded to the emerging political issue of prison care.

Possible replication sites include other prisons, rural settlements lacking physicians, and other social settings representing problems wherein improved communications could serve a primary function. Likewise, other firms with similar electronic gear and advanced know-how are interested in the progress of this research test.

Patent rights of the principal commercial firms participating in such projects merit review by RANN. If these rights are clarified, the result may be greater and more widespread involvement of private firms in RANN programs, since firms could then build marketing strategies on their proprietary strengths.

Solar Heating and Cooling

Objectives

Approximately 25 percent of the fuel consumed in the United States is used for heating, cooling, and supplying the hot water needs of buildings. Thus, the overall objective of the solar heating and cooling of buildings program is to establish the full technology base for the widespread availability and utilization of solar energy systems. It is designed to help meet the heating and cooling needs of buildings everywhere in the United States to the degree that they are economically viable and socially and environmentally acceptable. To accomplish this objective, a balanced program of advanced research, as well as a series of subsystems tests and system proof-of-concept experiments are carried out.

Program Setting

A program solicitation was given wide distribution in FY 1974. In response, nearly 500 formal proposals for innovative research were received and evaluated by NSF. After careful screening, grants and contracts were awarded to support research aimed at developing advanced concepts.

To further the research program, other initiatives have been undertaken:

- The development of standardized testing procedures to permit comparison of results from different advanced equipments, research projects, and completed solar installations was initiated by a NSF award to the National Bureau of Standards (NBS). Preliminary testing procedures were completed in 1974.

- Through a grant to the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), a comprehensive chapter on currently available solar energy design data is now available for engineers in the latest edition of the ASHRAE Guide Applications Volume, widely regarded as the "Bible" of the American heating, ventilating, and air conditioning industry.

- The proof-of-concept experiments on heating, cooling, and supplying the hot water needs of buildings initiated in FY 1974 by three Phase 0* feasibility studies were continued into Phase I. Special attention and emphasis are being placed upon environmental, social, and economic factors. Phase 0 aimed to identify the combinations of building type, climatic region, and solar-operated systems applications which can be supported with present technology and the research required to broaden the viable applications.

*RANN planning addresses four phases: Phase 0 - Poanning; Phase 1 - Testing and Concept Study; Phase 2 - Developmental; and Phase 3 - Production and Commercilization. RANN-NSF is excluded by law from Phase 2 and 3.

- To accelerate the generation of data on integrated solar energy systems, two laboratories were commissioned. The first, located at Colorado State University in Fort Collins, Colorado, is a single-family dwelling, operated to obtain a calibrated baseline system and to test advanced subsystems.

- The second laboratory is transportable. It contains a complete, integrated solar heating and hot water system and two types of cooling systems. A weather station is also provided. This laboratory collects data on advanced solar systems and solar insulation under a wide variety of weather and environmental conditions at various locations in the United States. It is also equipped to demonstrate and explain the utilization of solar energy systems.

- The data for both laboratories will be used by proof-of-concept experiment contractors to calculate complete system performance.

- Based upon these data and the results of the proof-of-concept experiments, systems will then be designed to meet specialized performance requirements anywhere in the United States.

- Approximately 4 percent of the energy used nationally to heat commercial buildings is used to space-condition school buildings. During FY 1974, under the School Heating Augmentation Experiment, four schools were selected as experiment sites to evaluate large solar heating systems in support of the proof-of-concept program. This project generated valuable retrofit information as well as social acceptance data.

FY 1975 Program

During FY 1975, Phase I of the Heating and Cooling of Buildings Proof-of-Concept Program was initiated by RANN (In January, 1975, this responsibility was transferred to ERDA). Site selection and the number of experiments were carefully evaluated with respect to the need to develop a generalizable data base useful to industrial, architectural,

engineering, building, and financial communities and the need for data on social acceptance, code changes, zoning regulations and environmental improvement. Also, as part of Phase I, optimized systems designs were selected, and critical subsystems fabricated and subjected to performance test and evaluation.

In FY 1975 the Solar Heating and Cooling Laboratory at Colorado State University completed a testing program of "base-line" integrated systems. Having established a calibration, the laboratory will be used routinely to evaluate new subsystems performance.

During FY 1975 and FY 1976 the transportable laboratory field operation program continued to collect system performance and operational data coordinated with real time solar insulation data at several locations in the United States.

In FY 1975, a test standards verification program was conducted to confirm the NBS preliminary testing procedure developed for NSF. The testing procedure will be made available to the private sector as an interim standard and will also be used by NSF grantees and contractors in their projects so that their results will be comparable. Field experience with the standard will help to evaluate its suitability for replication by other investigators.

Evaluation of large systems was continued through the School Heating Augmentation Experiment. The capability to drive air conditioning systems will be evaluated, and during heating seasons additional heating tests will be performed.

The NSF-RANN program was coordinated with the Departments of Defense, Housing and Urban Development and Agriculture, the National Aeronautics and Space Administration, the Postal Service, the Atomic Energy Commission (now the Energy Research and Development Administration), the General Services Administration, and the National Oceanic and Atmospheric Administration.

As a result, proof-of-concept experiments and advanced research were planned in cooperation with other agencies on buildings owned by them and designed to meet their performance requirements. Such cooperation either takes the form of retrofitting existing buildings or work on new construction. (Early projections as to potential impact were based upon new construction only. If retrofitting can be made competitive, the rate of utilization for solar energy would be accelerated.)

Utilization Priorities

In the early months, RANN searched for significant gaps in the overall energy field. The focus of subsequent studies recommended that attention be devoted to waste heat and solar and geothermal energy. Top priority program areas for FY 1975 were air conditioning and collector development.

RANN employed workshops and program solicitations for selecting its solar energy research priorities. Solar energy programs are outgrowths of workshops convened by NASA and NSF in 1971 and 1972.

RANN's workshops brought together industry, academia, government, and (in the specific case of energy programs) public utilities to achieve broad participation in deciding potential project activities and priorities. The workshop activities and the preparation of a report with recommendations reflect a general period of gestation that occurs when a major technological undertaking is contemplated by RANN. These workshop activities, which are a characteristic of RANN generally, led to formulation of several project activities related to solar energy use. The workshops were convened to examine the state-of-the-art and to decide necessary programs. Subsequently, priorities were set and specific program activities were outlined. This was accomplished about February 1973. During the next six months, several reports and papers for subdivisional activities were prepared and published--ultimately in the form of a NSF/NASA solar report.

The NSF/NASA workshop and report were the catalyst for activities now underway in the solar energy program area. It also provided the foundation for objective discussion of the economics and comparative technical superiorities of a range of available options. The workshops were given a practical thrust by the heavy involvement of users. Overall, the program emphasized the potential applications of solar energy in the U.S., since almost all of the country is accessible to insolation (incoming solar radiation).

Program solicitations make up the second principal mechanism used by RANN to select its solar energy research and research priorities. In 1974, a program solicitation drew 450 proposals, from which 35 were selected for awards. In another case during FY 1974, RANN received approximately 550 proposals, of which 26 were selected for awards.

Only two of the companies who responded to the 1974 solicitation also responded in FY 1975. This finding may call for further study, to interpret the relative and perservering interest of industrial firms in RANN activities.

Utilization Issues and Problems

If RANN's new technologies are to be adopted by the private sector, they must meet certain utilization criteria. In the case of solar heating and cooling technology, for example, the new technology must:

- Be technically feasible.
- Require less capital investment and have lower operating costs than alternative heating and cooling methods.
- The private firm involved must find an adequate incentive for participation.

Firms have been subcontractors to universities in some RANN programs. This arrangement has worked only moderately well. Some firms report it to be a cumbersome arrangement.

Two firms independently undertook work related to RANN's program of solar heating and cooling. Both firms bore the development demonstration costs associated with their projects. RANN's schoolhouse projects may have had a catalytic effect on these firms.

Firms with government contracting divisions reported their distress with the law requiring RANN's stipulation for zero-fee and for cost-sharing by industrial firms. They said this provides them little inducement to work with RANN on the higher-risk problem assignments. However, from a comparative point of view, RANN's arrangements are more attractive than the Energy Research and Development Administration (ERDA--formerly the Atomic Energy Commission). For example, ERDA has a declining fee schedule as the contract dollar amount is enlarged, subtracting larger and larger amounts from the company's treasury as the program grows in size.

Private firms have an interest in the heating and cooling program, but some reported that the costs are too great and the business potential too distant to justify their involvement on a large-scale, cost-sharing basis. RANN staff members stated that additional R&D would lower the cost, and therefore attract more firms.

One indication of the level of interest of private firms is often revealed by the identification of the department within the firm given the responsibility for conducting federal contract research. Some companies, for example, have been assigning the accountability for their solar energy program activities to the space and military divisions, rather than commercial divisions which have a strong proprietary interest.

Companies did not participate in RANN solar programs as heavily with their dollars after the first year of the activity. This may be coincident with the fact that some companies began to fund or expand their own solar energy research in 1973. One viewpoint reported to COPEP was that the public stands to lose if private firms are permitted to capture all of the stakes in this vital energy area. This viewpoint held that the federal government should lay its "proper role" in stimulating research and private sector activities, continue to play a significant regulatory role, and seek proper balance between the federal and private sector roles to help develop a national solar energy policy.

Small firms have experienced both advantages and disadvantages in working with RANN. Some of the reported advantages are:

- RANN can assure nationwide attention to a project that could not otherwise be publicized by a small firm.
- Small companies need the financial support RANN can give.
- RANN can give support for demonstration funding with which small firms have difficulty.

Some of the reported disadvantages focus on the administrative procedures for cost-sharing and patent titles, making doing business with RANN too costly for firms just entering solar energy technologies.

Other reported disadvantages are:

- RANN is "too close" to the universities in its working relationships.
- RANN's cost-sharing and fee-forfeiting policies work against the interests of small, often struggling companies.
- Small companies rule themselves out when the federal government requires title to future art and threatens the title to background art.
- Small companies are required to make too large a contribution to high-risk development projects because they cannot capture proportionate benefits in the short term.

- RANN does not give a clear declaration of its thrust and intent before it initiates a specific segment of a major program.

In general, small firms like the potential of working with RANN and need RANN's financial support, but object to the administrative policies that prevent them from moving ahead rapidly.

Large, well-established firms have also experienced advantages and disadvantages in working with RANN. Advantages reported include:

- Reduced costs by working with RANN.
- Improved relationships with the universities.
- Well-conducted demonstrations give companies new market knowledge and attract potential customers. Well-received demonstrations tend to generate enthusiasm and further demonstration.

Disadvantages reported by larger firms include:

- The major societal benefit has accrued to the universities.
- The NSF patent title policy has been too stringent. Companies fear that they will lose proprietorship to inventions in their background art.
- The sense that the company could have proceeded further by working alone.
- A lack of continued dollar support for long-term programs results in lay-offs and the break-up of teams, which manage the program.
- RANN should keep in mind the required balance and trade-off needed between data collection and public relations.*

*Visitors from a number of foreign governments, from all over the U.S., and from various large-and-small companies have come to see Honeywell's schoolhouse heating and cooling demonstration. As an example of RANN's aggressive utilization emphasis in the employment of the transportable laboratory, it was cited in 1974 at the annual meeting of the National Conference of State Legislators, where it was visited by legislators from all over the country.

- The cost-sharing requirement of RANN handicaps some companies because their profit center divisions do not always have dollars available to make contributions to long-range R&D on RANN's behalf.

- RANN's plan to use NASA labs might be a poor substitute for private firms' involvement in solar heating and cooling. This practice probably will not induce a company to take risks based on the results.

Utilization Practices

The solar heating and cooling of buildings project is one of RANN's best attempts to move new technology rapidly and efficiently into the marketplace. The program's importance is illustrated by the fact that it was selected as a cooperative study area between the U.S. and nine other NATO nations. It has received additional international emphasis in the technology exchange program with the U.S.S.R. Among various dissemination efforts of the solar program is the movie "Here Comes the Sun," which has been seen by an estimated one million viewers across the country. The script has been translated into 22 languages.

There is a close working relationship between RANN's Public Technology Project Office (PTPO) and the Advanced Energy Research and Technology (AERT) division in the development of both priorities and actual heating and cooling projects. Whereas PTPO projects at schoolhouses, houses, and in agriculture were typically based on state-of-art technology, near-term AERT results were also inserted into ongoing PTPO projects so that they would be rapidly brought to a level of use. RANN also made arrangements for the joint participation of the Departments of Agriculture, Transportation, and Health, Education and Welfare, GSA, AEC, NBS. These agencies provide eight federal commercial and residence buildings to be fitted with solar heating and cooling equipment.

Trimodal interaction on solar heating and cooling programs involved research information from AERT, phased implimentation planning and verification from PTPO, and management planning for utilization from ISRU. A joint project permitting the gathering of information and the exhibition of solar technologies was established by the construction of a mobile laboratory, which travels from site to site. The laboratory calibrates standards of measurement.

The considerable effort by PTPO to install solar heating and cooling in buildings relates to the terms of the 1974 Heating and Air Conditioning Demonstration Act. The Act provides for NASA and HUD to fit 1,000 houses and 1,000 commercial buildings with the appropriate equipment for new forms of energy conversion, such as solar energy. The replication level of PTPO (two or three repeat installations) enabled an objective examination of a diversity of installation designs. The Act will be implemented in a real-life social setting, testing the public acceptability of a variety of installations in as few as 10 identical demonstration units.

Reports issued from the solar heating and cooling program have received extensive attention, each printing some 2,000 copies. In addition, workshops and symposia were organized and convened by technical societies with regular and increasing frequency. As many as seven heating and cooling workshops were assembled per month in the summer of 1974. Workshop proceedings are regularly distributed to several thousand parties interested in solar heating and cooling techniques.

RANN recognized the timeliness and importance of this program, and endeavored to capture and maintain the interest of various concerned sectors. Workshop symposia have been the most actively employed medium for dissemination. Other approaches used include press releases, briefings of congressional staffs, movies and pictures of experiment sites, and open-house activities for visitation.

A RANN solar energy workshop in June 1974 assembled representatives of financial institutions, builders, technical societies, private firms, and professional engineers--all of whom dealt with solar heating and cooling. With emphasis on the principal interests of ASHRAE, this workshop brought together information on the state-of-the-art in several subfields. It also considered material for a new chapter in the ASHRAE handbook dealing with the design of structures built to accommodate solar heating and cooling techniques.

Solar heating and cooling of buildings reached the proof-of-concept-experiment phase in 1974. Four public schoolhouse sites were selected for the special projects based on: (1) their overall variability in climate conditions; (2) their adaptability to solar energy heat augmentation; (3) their potential for public visibility and community involvement; and (4) the fact that public schoolhouses are among the few non-federal properties eligible for equipment support by a federal agency. The projects were intended to develop performance and operating data on large-scale systems.

This program demonstrated that RANN can move fast to accomplish utilization objectives. Having previously determined that the technical means were at hand, PTPO

solicited proposals, and the formal intent to proceed was announced about December 1, 1973. Four months later, field data were being gathered by teams assembled by four industrial firms, each providing at least minimal cost-sharing. Not all of these firms were eager, at first, to jeopardize their corporate image for a risky exposure in a new area. PTPO staff helped persuade company representatives to study the opportunity thoroughly and rapidly, and exercised close supervision of schoolhouse projects when they were underway.

Another major opportunity arose in 1974 for utilization of solar heating and cooling results. A house in Colorado Springs was selected as the site for this experiment. RANN funded only the instrumentation for monitoring, plus the costs of data analysis. A notable example of the rapid progress being made toward an energy-source alternative, the Colorado Springs house was managed by ISRU because of its heavy utilization emphasis. The experiment afforded ISRU/RANN an opportunity to observe and reflect upon social and political interactions in a community being impinged upon by the introduction of new technology.

RANN has actively explored and defined the legal issue related to solar energy utilization. The American Bar Association held a NSF-supported workshop on legal issues related to solar energy. Topics included taxes, building codes, Federal Housing Administration (FHA) assistance, and zoning.

By late 1974, RANN began contemplating using standing federal laboratories, such as NASA-Lewis, to manage and monitor their solar heating and cooling projects. With fewer than a dozen program managers in both PTPO and the solar portion of AERT, and a $17-million program, RANN's needs for an increased management capability could be answered in part, using NASA staff. However, while still in the planning stage, most of the program was transferred to the new Energy Research and Development Administration (ERDA) in January 1975.

Trace Contaminants Program Area

Objectives

The trace contaminants program is concerned with the environmental consequences of mining and manufacturing, and from the use and disposal of selected metallic and synthetic organic compounds.

The program (with a FY 1976 budget of almost $6 million) focuses on determining the levels of toxic trace substances in the environment, assessing the effects of these levels on

man, animal, and plant communities, and relating these findings to methods of control.

Specifically, the FY 1976 program objectives are to:

- Identify and quantify contaminants resulting from agricultural and mining operations, and the manufacture, use and disposal of products.
- Develop new and improve existing techniques in analytical chemistry specifically applicable to the above objective.
- Assess the potential for damage to ecosystem communities, populations, and biological species (including man) along the contaminant flow paths.

The 1974-75 objectives for this program element--with an approximately equal budget--included the following additional objectives:

- Describe, through modeling and field validation, contaminant transport pathways accounting for change in the quantity, chemical structure, and toxicity of compounds caused by passage of time, differing physical conditions, and the degrading or modifying actions of bacteria and other biological influences.
- Identify and analyze legal and economic incentives (or disincentives) which contribute to environmental pollution by chemical contaminants.
- Design and develop through research novel approaches to decontamination technology, and identify the costs and benefits of alternative abatement strategies.

No evidence was found to explain the disappearance of these logical companion objectives from this program area.

In summary, the trace contaminant program anticipates the possible long-term related needs of the Environmental Protection Agency (EPA) and other agencies, and responds by addressing those needs, where the proposed projects fit RANN criteria for selection.

Program Setting

The program's early emphasis has been on metal contaminants in waterways and on certain airborn contaminants. The waterborne-contaminants programs are nearing completion and, as a result of discussions with users, researchers, public agencies, and private-sector organizations, emphasis is now turning to organic contaminants in waters.

Most trace contaminant programs have required a multidisciplinary approach outside of the traditional academic structures. Functioning within a university or research institute where rigidly structured departmental lines will not bend easily requires a high level of management skill. Team members must be drawn from across departments, schools, colleges, and even campuses. Where various department and administrative personnel are involved, the investigation is implemented and the rewards are shared more easily.

Even where a principal investigator has all the technical qualifications, a university inexperienced with multidisciplinary approaches can be a serious impediment, because of the time needed to demonstrate the benefits of such approaches. The overall requirements of RANN's sub-programs might have been more easily filled if the principal investigators had not been affiliated with the parent organizations.

What, then, if RANN had not been affiliated with the National Science Foundation? Some principal investigators insisted that RANN performs a unique role in the application of research whose results may ultimately lead to regulatory (and potentially adversary) action by EPA. Cooperation seems easier under RANN than if EPA were to have sponsored the research and mandated the response by involved parties.

Utilization Activities

The RANN recipe for utilization places the responsibility for developing the linkage to the user on the performer and the principal investogator. RANN requires the researcher to set forth research utilization plans within the proposal. In addition, the AERT division managers devote a significant effort to analyzing utilization. Both program managers and principal investigators reported that investigators work with potential users.

Some principal investigators have eased utilization by establishing early involvement with representatives of the industrial sector, the pollutant organization, the community, and lawmaking bodies in areas where the affected public is concentrated geographically.

RANN program managers use workshops, seminars, symposia, and proceedings publications to disseminate findings from trace contaminant investigations. Films and conferences are frequently used to promote utilization. Their effectiveness has not been measured, if indeed it can be measured adequately.

These first steps in utilization appear to duplicate the traditional methods of dissemination of basic, but not applied, research. RANN program managers, to be successful, must not assume that publication of results, however salutory, will bring significant utilization. Thus, they have aggressively sought to market their results.

Investigators and program managers, as well as EPA personnel, regard trace contaminant hardware program results as usually more readily usable than soft or informational results. Yet even here,government agencies find market access difficult for their applied research. In one pollutant detector device development program, contact with the marketplace was largely limited to demonstrations at two national trade shows.

ERA made use of RANN's new trace-contaminant data sooner than had been predicted in 1974. EPA is currently using data from RANN's metal contaminant projects in its "rule making" studies. In addition, EPA has awarded a contract to a RANN principal investigator, asking for the preparation of a criteria document on molybendum contamination.

Reflecting on such examples of incremental progress, RANN staff members suggested that broad utilization of trace contaminant program results will be a slow process. One program manager estimated that it may take five years before the success of trace contaminant program utilization can be observed and evaluated. Thus, it may still be timely to consider alternative means for effective utilization of results.

Although RANN collaborates with federal mission agencies (e.g., EPA and Interior), there is no national plan for the utilization of trace-contamination program results. RANN managers indicated that some consideration has been given to a cost-benefit study of such a plan. As with most organizations, the RANN program element responsible for trace contaminants studies relies upon individuals, not routine formulas. Accountability for initiation and coordination of the projects is charged to the program manager.

The progress and results of the trace contaminant program have public utility, private-sector opportunities (or evidence of penalties), and staffing implications for research institutions. Utilization, the hallmark of success in applied research, is currently charged to trace-contaminants program managers and principal investigators.

However, regardless of routine, organizational structures, or absolute levels of funding, the success of utilization via any approach rests with nontechnical talents. Perhaps the investigating teams in trace contaminants studies need a "public-relations personality" to promote effective utilization.

Industrial Productivity (Automation)

Objectives

The major objectives of the industrial productivity (automation) program are are to:

- Develop advanced processing technology to increase industrial productivity, through concepts such as new industrial automation techniques.
- Speed the application of highly innovative technologies for industrial use.
- Transfer technology to the appropriate user sector.

The budget for this program area in FY 1976 is expected to total about $2 million--close to twice the amount for each of the two previous fiscal years. The increase is largely for applied research and utilization of automated production of discrete parts.

Program Setting

The industrial productivity program manager works primarily with the universities and private-sector firms, which, because of their fragmentation, decentralization, and the independent attitude of the civilian sector, require a case-by-case coupling of performer and user to assure effective utilization.

The means forging links between appreciation and conceptualization of needs and utilization of results include communication with and support from: users, the public and their elected representatives and officials, and the various academic and industrial technical communities.

Researchers, users, and the public are direct or indirect performers of RANN productivity projects, but the responsibility for motivating them rests with the RANN staff. How has RANN stimulated these performers, recognizing their differing sources of satisfaction?

For general guidance, RANN has initiated market studies, analyzed the results of such studies and of response to public announcements, and held interactive symposia on broad topics. These activities have, in part, set the scene for RANN's productivity priorities and for the identification of promising program areas.

The FY 1974 projects comprising the industrial automation program were:

1. Industrial Automation Program Guidance, Marcom Applied Systems, Inc -- a survey and analysis of industry's views of manufacturing problems.

2. Computer Aided Manufacture; Illinois Institute of Technology Research Institute -- the creation of ongoing R&D Catalog on industrial automation.

3. Exploratory Research In Modular Assembly; Charles Stark Draper Labs. -- research and experimentation toward a first level of an adaptive and reprogrammable modular assembly system.

4. Advanced Automation Research; Stanford Research Institute -- study and experiments involving the application of artificial computer intelligence to factory functions.

5. Computer Integrated Assembly; Stanford University - problem definition of a complete assembly system and study of computer programming language.

6. Automatic Parts programming; University of Rochester/Gleason Corp. -- study and experimentation on techniques aimed at substantially reducing the effort required to program NC machines for the production of rigid parts.

7. Techniques for Producing Arbitrary-Shaped Surfaces; Mechanical Engineering Department, Massachusetts Institute of Technology -- study of programming and interpolation methods for producing three-dimensional arbitrary surfaces with numerical coded cutting machines.

8. Ship-Frame Bender; Case Western Reserve University -- applied research and proof-of-concept of a computer-controlled hydraulic bending machine which forms steel beams for ships' ribs.

9. Modern Techniques in Service Industries; Electrical Engineering Department, Massachusetts Institute of Technology -- study of the improvement of productivity possible in the food distribution industry through the application of industrial automation techniques.

10. Management of Process Change; Harvard University Business School -- study of economic and psychological barriers which must be dealt with to achieve industrial utilization of advanced technology.

RANN was able to enjoy a foundation of familiarity with technology for industrial automation because of ERPA's explorations in the field earlier as a new opportunity.

Within the bounds of socioeconomic desirability, the automation program area substitutes capital-intensive technical solutions for labor-intensive processes. The former tend to be competitive in the international marketplace and are often viewed with disdain by workers. The potential economic improvements are dramatically large. Ultimately, this program could have a favorable economic impact on some 70 to 80 percent of U.S. manufacture (primarily in batch production) and on perhaps 30 to 50 percent of service industries (primarily in repair and maintenance). One study on a computer-controlled factory of the future estimated a reduction of value-added costs

and in the capital investment required to build and equip such a factory both by a factor of three compared to today's conventional factory.*

RANN's program manager for industrial automation shaped the goals and subsequent project awards by an interactive process. Expert advice was obtained and many unsolicited proposals were considered. Among those providing guidance were the Society of Manufacturing Engineers, the Automation Research Council, and the Interagency Automation Coordination Group. The program manager visited many industry officials to ascertain the need for such a program, that industry was unwilling to fund the effort (although industry spokespersons might admit it was needed), and that work on the selected projects was not duplicating an existing effort. After formulation of the program, industry officials were afforded an opportunity to critique it. Finally, the program was pared down to the budget made available to it.

Unsolicited proposals were considered and awards were made on the basis of a general peer-review evaluation. Considering the linked staffing authority and the time constraints on a single program manager, the selection of performers was based on appraisals of the prospective merits of the proposals and of the repute and motivation of the identified principal investigators.

The program formulation did not rely on inputs from individuals and small concerns. Although they often generate ideas, individuals and small firms cannot participate in program formulation unless they are reimbursed for their expenses and time. As a result, major corporations and universities are the primary participants in RANN's industrial productivity program, although they are not expected to be the principal users.

Since significant utilization of the industrial automation program depends on the direct and thorough familiarity of small and large shop and plant operators with the techniques in use, automation programs form the early stages through completion. Major firms might provide facilities to house investigators who relocate temporarily from university or nonprofit laboratories for the expected duration of the project.

*A.F. Brewer, et.al. "Computer-Based Automation of Discrete Product Manufacture: A Preliminary Discussion of Feasibility and Impact." The Rand Corporation, R-1073, April 1974.

The Marcom study reportedly did not provide useful program guidance, whereas an Automatic Factory study performed by ARPA Rand Corporation/Universal Southern Company appears to have done so. In relying on such studies, however, it is well to keep in mind that an industrial automation program was already underway in 1973 within RANN when Marcom was commissioned to examine approaches to effective utilization. Moreover, Marcom gave RANN a valuable exposition of possible avenues for the application of automation techniques then being developed.

Specific site inspections were made in advance of the awards. Some awardee organizations were previously known performers for another component of NSF. Interspersed were workshop sessions both throughout the program formulation stages and afterwards, covering most facets of industrial automation and attended by representatives of industry, academia, and government. One such session was the Research Workshop on Sensors for Automation, held April 10-12, 1973, at Lexington, Massachusetts, under the sponsorship of NSF, The Massachusetts Institute of Technology (MIT), and the Charles Stark Draper Labs.

Performer Issues

The program has tapped only a fraction of the available technical skills in U.S. universities, nonprofit institutions and industry. However, individuals able to integrate technology, economics, industrial practices, and market appraisals with utilization strategy are in scarce supply. Few professors are acquainted with the latest technology in such a rapidly evolving field, or with the economics and markets involved. Highly specialized training in the technology and its management appears to be available only from industry. Nevertheless, universities have been given grants to implement projects. In part, the purpose is to expose graduate students to the technologies involved, as well as to generate interest among the faculty in developing relevant new courses.

University and nonprofit performers benefit from this program primarily because pioneering projects are attractive to students and faculty. In addition, the required liaison with industry injects "real world" awareness into groups that may tend to isolate themselves from it.

However, costs accrue in enjoying this benefit. Some institutions, especially universities, face psychological and peer-pressures against creating hardware as well as theory. Team leaders reported that peers at some schools disdain both the programs that create "hardware" and those who lead them. Some schools have even allowed their shop facilities to atrophy to the point where they cannot construct models. Consideration has been given to partnership arrangements with industry that could circumvent such problems, particularly tooling-up costs. Principal investigators believe that this approach may also ensure more rapid and effective utilization of program results.

Utilization Issues and Activities

A growing awareness of means for increasing the strength and value of joint government/industry projects is reflected in the RANN industrial productivity program. Demonstrations and presentations have been made to prospective users of research results. Shifting the performance of programs toward users requires that the program manager give attention to the following issues -- some of which are currently addressed:

- Inducing academic performers and institutions to transfer accountability for projects to others as the activity matures and the results become attractive to the business and financial community

- Identifying and championing proper incentives for the industrial/user sector, such as a form of patent exclusivity

- Developing understanding by labor of the impact of automation technology on the work force and working conditions

- "Brokering" with key RANN/NSF officials in a carefully constructed case for Executive Office or Congressional consideration of charging front-end research expenses directly to the public so that increased revenues (through taxation of higher corporate incomes) result when private firms use the automation technology. This argument

may anticipate proposals for enlarged budgets and staff for the industrial automation program, based upon assumptions of improved productivity.

- Ensuring involvement of the private sector user in priority setting and planning. Some industrial organizations would have become more involved if the industrial automation program had included projects in areas of manufacturing related to their interests

- Disseminating information to the user community by such means as endowing new journals or strengthening those in existence, and by fostering the preparation of papers for those journals, that would command the attention of the user sector.

The views of industry, universities, government, and nonprofit organizations, as well as RANN, have been taken into account. All have either been involved in or are the ultimate users of industrial automation program results.

Since utilization is the primary aim of applied research, strategies are sought for involving the user sector in RANN programs early and effectively. RANN now routinely requires a formal statement of utilization plans in grant applications. Examination of these plans showed that awardees satisfied the review process by stating that a user advisory panel or a similar group of representatives of the user sector will be convened periodically. One alternative approach that appears to have been successfully applied is reliance on an existing intermediate equipment supplier.

Interviews with suppliers showed that economic and financial considerations are the major determinants in decisions whether to utilize the fruits of RANN's automation projects. The determination of user benefits requires: comparison with the user's current costs, both in operations and the depreciation of capital equipment; examination of existing investment prospects and labor-relation as well as other legal boundary conditions; and an assessment of the interface problems between the new and old automation techniques or equipment. The program manager works to obtain the confidence of a cooperating firm that, in balance, a project represents an exploitable opportunity for them as users of RANN research results. The program manager negotiated, sometimes at length, to foster the required confidence.

Equipment manufacturers who produce similar machines or devices for the ultimate user have been induced to allocate some of their resources to development and production. This involvement greatly aids chances for a realistic appraisal of the ultimate user market.

RANN's industrial automation program manager has been able to draw significant user involvement into the project for a numerically-controlled steel beam bender for ship construction. In this case, the development phase is to be carried out by a manufacturer of shipyard machinery. The RANN program manager obtained a commitment from the U.S. Maritime Commission to finance the work and to field-test the resulting machine at shipyards. The machinery manufacturer is part of the grantee university team during the applied research phase. The grantee had done a considerable amount of application and utilization thinking prior to proposing this project. Not all RANN projects can be treated in this manner, however.

The beam bender will serve a narrow market as contrasted to a numerically controlled machine that performs mechanical assembly, for example. In many programs, development commitments cannot be obtained from companies before technical feasibility is shown, if then. In some, exclusivity of rights will be a critical problem. In others, reduction of investment risks by manufacturer and ultimate user will be the paramount problem. In all cases, it will be desirable to determine the most likely user in the marketplace, as a start to devising an appropriate utilization strategy.

APPENDIX

VIEWPOINTS ON RESEARCH UTILIZATION

(Adapted from a paper prepared for COPEP
by Alan L. Frohman and Edward B. Roberts)

FRAMEWORK FOR ANALYSIS

Innovation begins with a technological invention or change. While the invention is likely to be an isolated event, the innovation process is complex, non-linear, and involves several elements and phases. (See Figure 1) The indicated stages include idea formulation, technical problem-solving, design and development, and utilization and diffusion in the market. All but diffusion are the concern of this study.

This analysis is not concerned with ways to make the idea-generation stage more voluminous in output, nor technical problem-solving more competent, nor the development stage more efficient--although all of these are worthwhile objectives. The intent is to examine ways in which to better utilize the output of the overall innovation process and how that output can have a significant impact on society.

In the past, efforts to increase research utilization (often called technology transfer) have begun with the outputs of technical problemsolving or product development or even production engineering. From that origin, attempts have been made to increase the rate of adoption or diffusion of these outputs.

However, the earlier stages of the innovation process need to be reconsidered and executed differently in order to obtain more utilizable or diffusable results. The conclusion is suggested by an evaluation of the experiences of both federal agencies and industrial organizations.

APPROACHES TO RESEARCH UTILIZATION

The Federal Agencies

The approaches taken by federal agencies to enhance the commercial utilization of their research results are as varied as the agencies themselves. They range from "passive" functions, such as data retrieval centers, to far more active roles as agents for aiding--and sometimes even sponsoring--the utilization. The following survey of federal programs,

while certainly not exhaustive, cites illustrative programs in each category and describes the major approaches to utilization.

1. Information Dissemination. Foremost in frequency and expense, although not in ultimate impact, is dissemination of information deriving from government-funded programs. The Department of Defense Documentation Center (DDC) is one of the largest users of this office. The DDC collects DOD contractor and in-house reports and publishes and distributes periodic lists of report titles. Qualified subscribers to DDC services can request copies of the reports and are furnished them when security and proprietary interests permit. DDC does not provide any other assistance for the utilization of its massive library of defense technology information.

A similar approach was taken by HEW when it established the National Library of Medicine. Its MEDLARS system--one of the most comprehensive worldwide information systems--permits computer-accessed information search and retrieval from vast files of biological research reports. Moreover, it carries out user-requested development of scientific bibliographies.

A similar library function is served by the National Technical Information Swervice (NTIS) of the Department of Commerce. NTIS furnishes copies of unclassified and non-limited documents produced by federal R&D projects, thereby centralizing the library of materials largely duplicated elsewhere. Literature searching is also possible, but not to the extent found in the MEDLARS system.

A related information dissemination activity is NASA's distribution of Scientific and Technical Aerospace Reports (STAR) reports and International Aerospace Abstracts (IAA), library-oriented aerospace research functions. NASA, however, does not limit itself to this approach.

Perhaps the most "passive" approaches are taken by the Science Information Exchange (operated under contract by the Smithsonian Institution) which limits itself to a referral--not retrieval--function, and by the Small Business Administration, which simply processes small business requests for data and documents.

In contrast, several agencies are extremely active in information dissemination. The Atomic Energy Commission has long been aggressive in diffusing its unclassified R&D results with potential industrial applicability, notably in the areas of radioisotopes and atomic power. Among the methods used are report distribution, manuals, technical information packets and special-purpose seminars. Though short-lived, the Commerce Department's State Technical

Services organization followed a similar approach, utilizing state-level, nonprofit institutions--primarily universities--as its agents for technical information dissemination.

The Department of Agriculture has long been active in this area. USDA has engaged extensively in publishing for the general public, rather than limiting itself to the distribution of scientific reports. In particular, the Department publishes bulletins containing research results in magazines read by farmers and ranchers. In addition, Agriculture has exposed its research findings on radio and television farm broadcasts.

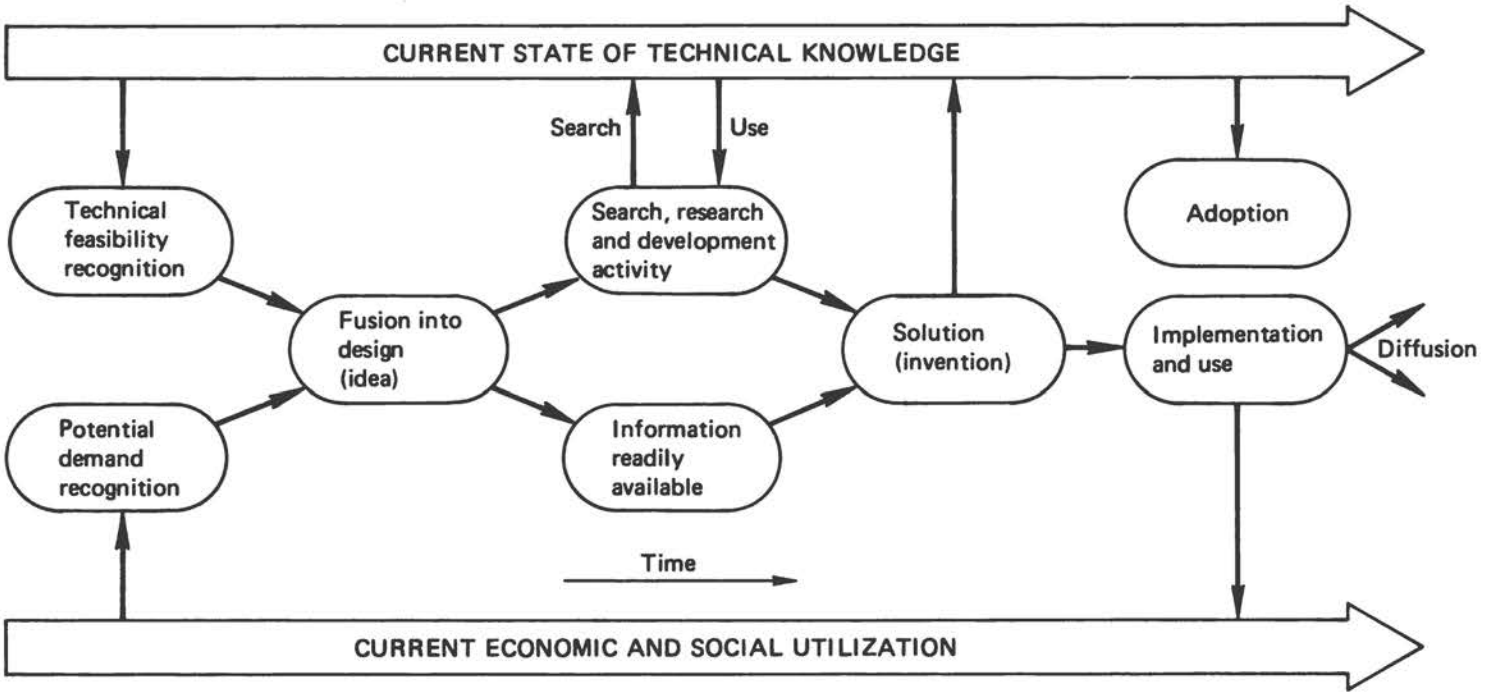
It is difficult to determine the degree to which all these information dissemination activities have actually furthered research utilization. Very little has been documented, and repeated empirical research findings have demonstrated that written communication has a low effectiveness as a medium for technology transfer.

2. Demonstration Projects. Some government agencies have encouraged research utilization by means of funding and executing demonstration projects. The Environmental Protection Agency has financed demonstration uses of new pollution abatement and control technology, and has even provided technical assistance to early users. The Department of Housing and Urban Development has launched major efforts to finance first uses of new construction methods and materials, and has even tried, but with little success, to demonstrate ways of creating new cities. Some initial demonstration efforts by NSF-RANN are described elsewhere in this report.

Particularly noteworthy is the Department of Agriculture's "permanent" institutionalization of the demonstration project. USDA has established a national network of field stations and pilot research farms that provide ongoing research trials conducted in the local environment and with soil and weather conditions that are shared by the local farmer--the prospective utilizer of the research. The continuing character of such field operations provides far more convincing evidence to the hesitant potential user than does a "one-shot" demonstration.

3. Applications Engineering. Both the Atomic Energy Commission (AEC), Energy Research and Development Administration (ERDA), and NASA use a strong coupling activity for matching available technology to the prospective user's needs. Both agencies have undertaken programs to provide applications engineering to foster use of their research results. (The special problem of classified nuclear information led the AEC to establish professional referees at each contractor site and AEC lab to evaluate reports for declassification.)

FIGURE 1 The Process of Technical Innovation



Source: Myers, B. and Marquis, D. *Successful Industrial Innovations.* National Science Foundation, 1969.

The AEC established an Industrial Cooperation Program to disseminate information through seminars, tours, special demonstrations and the like. In addition, the program provided technical assistance to industry in the use of nuclear technology. Indeed, the AEC had the unusual authorization to perform work for private industry when this facilitates technology transfer.

NASA, through its Technology Utilization Program (TUP), has made a significant effort since 1962 to transfer space research results into commercial use. Beyond its information dissemination activities, NASA employed in-house staff and technical consulting firms to prepare briefs of research results judged to have potential. These have been widely distributed to industry, with backup technical packets available for those requesting further information.

As another step toward commercialization, NASA established ten Regional Dissemination Centers (RDCs) to coordinate space research outcomes with industrial technology requirements.

This project was less successful than anticipated, owing in part to a mismatch between technology and needs, and in part to ineffective location and staffing. As a consequence, most of the RDCs were cancelled. Samuel Doctors observed, "The TUP appears to be providing a large number of answers to unrecognized industrial needs."4/ Nonetheless, NASA, unlike most federal agencies, tried to bring its technology directly to possible industrial users.

In a similar attempt at utilization, NASA and AEC jointly undertook an experiment in applications engineering, with the Small Business Administration (SBA) as the coupler to small business firms. However, this experiment was abandoned after a brief trial.

4. Field Agents. The most ambitious and successful government effort at research utilization is the Cooperative Extension Service of the Department of Agriculture. The program is based upon a national network of USDA field agents at the county level. There are an average of three agents per county, ranging from a minimum of 1 to 20 or more in agriculturally intensive areas. The county agent is, in effect, a research salesman for new technology, drawing from national or local results and using USDA field stations or pilot research farms as demonstration sites.

The county agent creates awareness of new research by direct personal contact with farmers. The agent is well qualified and locally respected--as distinct from the typical transfer agent employed by NASA--and can develop a personal rapport over years of working with farmers. The agent works with farmers in solving problems, using state land-grant colleges as backup for expertise and additional

problem-solving R&D, and with no charge to the farmer. The effectiveness of the agricultural research utilization is reflected in the tremendous increase in U.S. agricultural productivity over the past two decades.

5. Incentives and Financial Assistance. In addition to the specific transfer mechanisms described above, different federal agencies also employ patent incentives and direct financial aid. Patent policy is critical since most industrial firms desire--and sometimes require--patent protection before attempting commercial exploitation of a research result. The AEC discouraged such exploitation by its policy of keeping ownership on all its patented research outcomes. In contrast, the DOD cedes to its industrial contractors all rights to research results generated under contract. NASA has a compromise arrangement, reserving the right to keep exclusive patents while claiming that it will probably turn them over to industry in most cases.

NASA provides a nominal financial stimulus by paying its contractors for the costs involved in generating innovation disclosures, even when such disclosures are for non-space-related applications. Similarly, SBA's loan assistance helps finance small companies that may exploit the results of new technologies.

Patent policy, financing, and other utilization incentives are now being subjected to experimental study by two new National Science Foundation and the National Bureau of Standards programs. These efforts are too recent to have measurable results.

6. Summary. All the federal agency approaches described above maximize the exploitation of research outputs in frequency or extent. In general, a large number of these federal programs begin only after the outcomes of the research process have been generated. However, many federal programs have inputs into the original program generation. As an alternative, research utilization can be futhered by rethinking and changing earlier stages of the research process, by intervening in the idea-formulation or the problem-solving process. A better understanding of this kind of innovation can be found in examining the practices of industrial organizations.

Industrial Research Organizations

Over the decade, central research laboratories in industry have evolved in ways which demonstrate their attempt to facilitate utilization of research results. The widespread changes, which include not only self-image, activities and staffing, but elements such as charter, manpower mix and leadership, are too various and complex to discuss

in detail here. However, some selected elements of this change are revealing.

1. Shift in Emphasis. Ten years ago, most central research organizations saw their primary goals as solving technical problems, expanding the frontiers of science, and generating new ideas which would lead to the novel future technologies. The prevalent assumption was that solving technical problems or answering technical questions--that is, generating "good science"--would lead to new technology that could be somehow marketed to the customer. Research scientists and engineers saw their mission in terms of scientific or technical accomplishment,with little immediate concern for the utility of their research.

Management techniques (formalized plans and goals, control systems) and marketing issues (market research, competitive pressures) were not considered relevant. Research utilization activities, when they did occur, were mainly limited to publications, symposia, speeches, and the like. These activities provided limited interplay between nontechnical units of the company and the central research labs.

But with increasing emphasis on the relevance of research, the industrial labs shifted from furthering scientific goals to satisfying market needs. No longer akin to academic departments, labs became more like embryonic technical businesses oriented to market needs.

The creative scientists and engineers had been idea-generators. But only in exceptional cases had they also been able to argue persuasively for their ideas to top management, or manage a diverse set of people. Nor did they often recognize the need for or utilize business, finance and marketing involvement, or handle the more applications-oriented part of a project.

As a result, research labs started hiring more engineers--and in many cases engineers with a strong financial or business aptitude. Some labs, with more later following suit, brought in marketing personnel to supplement the skills of their technical staff. Consequently, the balance of skills shifted from those necessary for idea generation to those necessary for idea utilization.

Increasingly, planning based on assessment of market needs and environmental pressures (new regulations, changing supplies of raw materials, etc.) was undertaken by research managers. One major research lab went so far as to hire a market research firm to help them with the examination of potential products. Research labs also began to test the limits of their charters. Some found it necessary to go all the way to the marketplace to get the data that were sometimes required to convince corporate decision-makers of

a new product's merit. In conjunction with this effort, research organizations began more and more frequently to engage in economic, market, and other nontechnical analyses to check the viability of their product or process. Instead of testing immediately prior to transfer, these tests were done at an earlier stage of the development, before getting the internal support of research managers.

In short, researchers also become "salesmen" of technology. The myth that technology sold itself on its own merits, or that new technology was an inherent "good," no longer existed. If researchers were to see the fruits of their labors, they would have to sell the seeds. The industrial research utilization activities often shifted from passive to active, with special procedures and arrangements set up to facilitate transfer, such as project teams, integrators, personnel transfers, and the like. Some research organizations sought to develop better "customer" relations even in the absence of a technology to market. Realizing that good will and good relations do more for technology utilization than any other factor, several research organizations carry out "user seminars" on topics of interest to potential users.

All of this, of course, is not to suggest that signifcant, even excellent basic research is no longer being carried out. However, the majority of industrial labs have put less emphasis on it now than they did in the past. In general, it can be said that the "R" of R&D has become less a sign of the pursuit of research than a sign of the pursuit of the commercial relevance of research.

2. New Industrial Approaches. Historically, industrial research organizations have employed three general classes of approaches, often simultaneously, to facilitate research utilization: personnel, procedural and organizational link-pin approaches. These classes represent specific activities undertaken in the context of the shifts in emphasis noted earlier. Examples of each class are explained below.

a. Personnel Approaches. The movement of people, use of joint teams, and geographical positioning all contribute to intensive person-to-person contact between the generator and the user of research. Except in basic research situations, these activities are extremely effective in producing understanding, acceptance, and effective efforts toward the utilization of research results. The reason for their effectiveness is stated by Quinn and Mueller:

> To move new technology effectively across each flow point in the organization requires the transfer of three things: (1) information about the technology,

(2) enthusiasm for the technology, and (3) the authority to use the technology. Losses occur if any one of these components is not passed from one group to the next. Thus:

> As one vice president of research said, "A new product is like a baby. You can't just bring it into the world and expect it to grow up and be a success. It needs a mother (enthusiasm) to love it and keep it going when things are tough. It needs a pediatrician (expert information and technical skills) to solve the problems the mother can't cope with alone. And it needs a father (authority with resources) to feed it and house it. Without any one of these the baby may still turn out all right, but its chances of survival are a lot lower."5/

Movement of people can occur out of or into R&D. It can be short- or long-term, and may or may not result in the moved person being returned to his "home base." In transferring a particular research result, the movement of project personnel with it is often a key factor in future success. More than the technology itself is being transferred--the enthusiasm and expertise of those committed to the project can help supply motivation to change. In addition, those who have worked with a project in the past are often the best able to assist in the adaptation of research results to specific user needs once they are understood.

In many cases, industrial research organizations employ a two-way movement of personnel: bringing in project personnel from the receiving unit (who will move back with the project), and moving in-house personnel with a project. Both have proven useful, and the decision to use one or both is dependent upon factors such as ease of movement of particular individuals, manpower strength, workloads, and the like. A major advantage in the use of personnel from the receiving unit is that they bring with them new sets of skills and sensitivities (to the marketplace, technology, corporate directions, etc.) in areas such as marketing, finance, business, and manufacturing, These skills are critical to the extent that they permit the research organization to address nontechnical questions which are often essential for management decision-makers in allocating resources. In particular, such questions concern economic viability (competition, cost of materials, return on investment), market scope (size, segmentation, location), and legal issues. Because of the diversity of issues addressed, teams with a mix of skills and sensitivities add greatly to the probability of successful utilization.

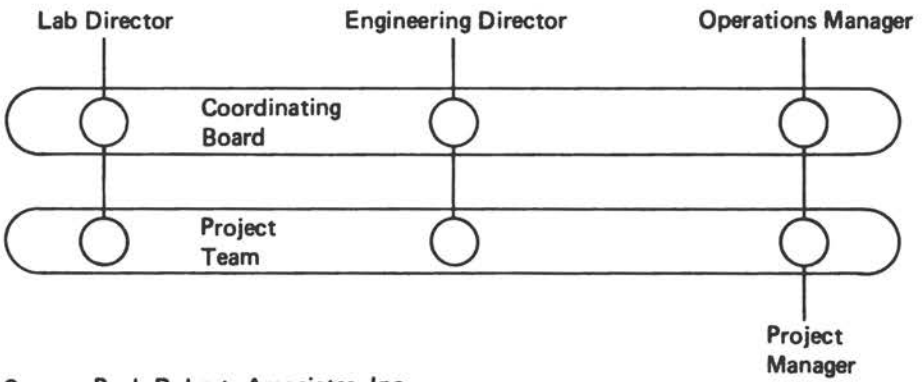
Geographical proximity can also contribute to successful transfers. For the organizations evaluated in this study, it was generally the case that communication markedly decreased as a function of increasing distance. As communication declines, so do understanding and trust, and resistance increases to the thrust of the "outside" organization. As a result, industrial research organizations have found that co-location--whether by housing of personnel under one roof, or the total movement of a laboratory closer to the receiving unit--promotes utilization of research results. Morton, in his book about his experience at Bell Labs, 7/ referred to this pehnomenon when he pointed out the need for "spatial bonds" in the absence of "organizational bonds"-- for example, when the research lab and the receiving unit report to the same person.

b. Procedural Approaches. Examples of procedural bridges are joint planning, joint funding, and joint appraisal of research. These tend to be used less and less frequently by industrial research organizations because they often create forums for raising differences without providing adequate mechanisms to resolve those differences (e.g., person-to-person contact for an extended period of time with less perceived to be at stake).

Joint funding, without adequate contact in other forms, has been found to be of little value, since the sharing of costs often creates expectations among the relevant parties which are difficult to fulfill. The resulting disappointment leaves no one satisfied. Without the commitment and resources to maintain close contact throughout the course of the project, and an intensive follow-up effort, joint planning does not appear to contribute measurably to successful utilization.

Joint appraisal in an open, frequent and regular fashion, when conducted by all parties who feel that they have a stake in the research, can be useful when coupled with regular project-related interactions among project personnel. This approach has proven successful in one industrial research lab having difficulty transferring its research output to the product lines. A joint project team was organized with working level members from each of three divisions: research, engineering, and the product line. A team member from the product line division was made product manager, since his division would ultimately handle completion of the process. The project manager reported to a coordinating board composed of one member from each of the divisions. Because each member had a rank just under division manager, each had broad resource allocation and decision-making authority. The coordinating board met routinely once a month to evaluate project progress. This

FIGURE 2 Example of Multi-Level Joint Staffing and Evaluation



Source: Pugh-Roberts Associates, Inc.

bi-level, joint staffing and evaluation approach has proven extremely effective in facilitating cooperation and timely decision-making (see Figure 2).

c. Organizational Link-pins. Examples of these bridges include: specialized transfer groups which contain engineering, marketing, and financial skills; the use of integrators who act as third party transfer coordinators; and new venture groups which look for and nurture new ideas. These approaches have proven especially useful, and sometimes necessary, in bringing in new ideas from outside the company's existing product lines or processes. Such groups operate to smooth the transition by which a new idea is turned into an applied product or process. As such, they become "umbrella" organizations for the new idea after technical feasibility has been established.

It is essential that idea-generators perceive the organizational link-pins as elements which promote research utilization, and not as additional obstacles which the idea has to get around. To be effective, link-pin groups need to associate with the project at an early stage, and to assist in focusing and problem-solving. If they come in only near the end of the project, they will be perceived as evaluators. Industrial experience with organizational link-pins demonstrates that they must serve as resources to idea-generators, working closely with them from the initiation of a project.

3. Summary of Approaches. Of the three classes of approaches examined here, those which emphasize person-to-person contact have been found to be the most effective. Procedural and organizational approaches can aid research utilization, but they require an adequate opportunity for continuing interaction among personnel from various organizations which have a stake in the outcome of the work. The industrial processes described here are most applicable in the recognition, idea formulation, and problem-solving stages of the innovation process(Figure 1) or earlier.

EMPIRICAL FINDINGS: KEYS TO EFFECTIVE RESEARCH UTILIZATION

Market-pull versus Technology-push

It is essential to the innovation process that both market needs and technological opportunities be identified. However, several studies have provided persuasive evidence for the importance of increased stress on market needs as a source for research projects if the project is to have a high probability of utilization. Myers and Marquis 8/found that 75 percent of the innovations judged most important by the company had originated in the problems and needs of the marketplace rather than the opportunities generated

by new technical potential.

A British team, looking at unutilized research in a study appropriately titled "On the Shelf", 9/ found that such research was characterized by a lack of market information. Another British study, Project Sappho, 10/ matched pairs of projects in which technologies were competing for the same market. The more successful project in each pair was based on a better understanding of user needs.

Overall, the evidence indicates that market factors or user needs are important in determining not only what technical problems to work on, but what a "utilizable" solution to those problems will be. It suggests the need for clear identification of the user and his needs, and--to the extent that it is possible--how he will react to certain kinds of technological solutions before the technological problem-solving occurs. Technology generated without market considerations may, in certain cases, be utilized after much adaptation. But the research indicates that this approach has a lower probability of resulting in utilized results than does one based on market need.

Critical Functions

A broad range of studies has demonstrated the importance of a mix of R&D people performing different functions in order to move a project from recognition to utilization, as described in Figure 1. Each of these critical functions will be examined here, although some are better recognized than others.

Idea-generation or invention is carried out by individuals who can perceive beyond the obvious and who have the perseverance to push an idea far enough to establish technical feasibility. This function requires conceptual thinking and analy is.

The second critical function necessary in the early stages of innovation is that of the entrepreneur, who pushes the new idea farther forward from technical feasibility, and gets the attention of the relevant public by linking the idea to a potential practical application. This function requires skills in translating the technical breakthrough into a market-relevant product or process.

Equally important at the early stage is the project manager, who usually assumes control after the project has been established and funded. At this point, the project manager organizes the diverse sets of activities (technical, market, financial, etc.) which are necessary to move the product toward the receiving unit. This function includes planning, organization, and administration.

Three other support functions have been found critical: the technical information gatekeeper, the market information gatekeeper, and the sponsor.

The technical information gatekeeper provides the expert technical information about developments in a specific technical field. The gatekeeper reads journals, attends conferences and stays in touch with colleagues working in related fields. The information is channeled to others who can benefit from it. Information is collected from beyond what is needed for a network of associates for whom he, the gatekeeper, is an important contact with the "outside world," and is hence invaluable in assisting their problem-solving efforts.

In a similar fashion, the market information gatekeeper stays abreast of market trends, customer relations and news from suppliers, channeling data to colleagues to help them with their research planning and problem-solving.

The sponsor aids in providing resources for the project, makes connections through his network of contacts to keep up momentum, provides valuable technical and administrative coaching to people working on the project, and helps project personnel to set goals and sees to it that progress toward the goal is appraised. The role will be less effective if the sponsor is seen as a judge or supervisor, or not supportive of the project. Ideally, the project personnel should view the sponsor as fair, objective, supportive and be able to weigh impartially the events which affect the success of the project.

These six functions constitute an ideal distribution of talents and expertise, in which a range of persons with very different skills and sensitivities interact in association with a project. In optimal situations they operate in teamwork throughout the course of a project, with the centrality of their roles shifting over the life of the project during various phases. In this situation, a reward system should be employed which recognizes that different contributions are essential to move a project through to research utilization. Most important, the concept of critical function underlines the fact that neither market nor technical information is sufficient in itself--both are necessary for utilization.

Characteristics of the Receiving Unit

Research on the type of organizations and individuals who innovate also provides suggestions to facilitate utilization of research results. Rogers and others demonstrated the existence of different categories of individuals, according to the point at which they adopt an innovation.

Rogers and Shoemaker 17/ identified five categories based on deviation from the mean time of adoption. The five categories are identified in the figure below.

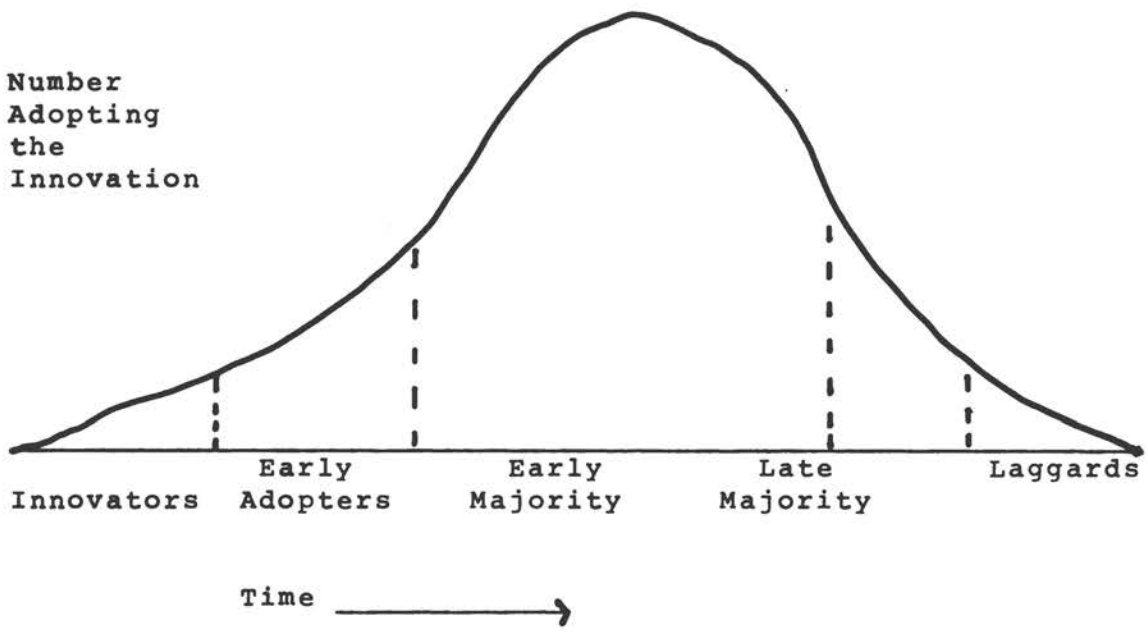


Figure 3

The organizations in the more innovative portion of the distribution display two classes of identifying characteristics. The first class describes personal characteristics of the people in a position to decide whether or not an organization should adopt an innovation. Rogers and Shoemaker concluded from their summary of the diffusion research that the decision-makers in early-adopter organizations are generally better educated, more highly integrated into the social network, more professionally oriented and more cosmopolitan than their counterparts in less innovative organizations. While this can hardly be taken as a universal rule, the study indicates that organizations with this sort of individual in key positions tended to have a higher rate of adoption of innovations than did those which did not.

The second class of characteristics describes the receiving organizations themselves. In general, the size of the organization and its abundance of resources correlate positively with early adoption of innovations.18/ The emphasis placed on following strict rules and procedures within an organization--that is, the degree of formalization is negatively related to the number of attempts to adopt new technology.

Centralization of decision-making was found to relate positively to the probability of successful adoption. Hence, although rigidity made the institutional walls less permeable to innovations, once the innovation was brought inside, centralization of authority facilitated its adoption. 19/

It appears that each of the categories of adopters noted in Figure 3 interacts with the others in the utilization process. Innovators, for example, seem to be the relative risk-takers who provide information for the early adopters about whether they should try the new product or process. Early adopters, on the other hand, seem to be more influential with the majority.

Ideally, then, utilization might be facilitated by selectively targeting R&D projects, demonstration projects, and research results at organizations which appear to be earlier adopters, and/or which have the characteristics associated with innovation. The degree to which this kind of evaluation and targeting is either practical or even possible, however, is uncertain.

SUMMARY AND CONCLUSIONS

The experience of both federal agencies and industry argues persuasively that certain practices are considerably more effective than others in facilitating research utilization, at least under certain circumstances. Study of selected institutions has produced explanations for these differences and additional ways in which to capitalize on them. The following section reviews three major difficulties which characterize the less effective approaches and a corresponding number of advantages in the most effective approaches.

Characteristics of the Less Effective Approaches

1. Overreliance on Change Motivated by New Information. To understand better what constitutes an effective approach, it is important to recognize that one aspect of research utilization is behavioral change. Invariably, as the result of adopting new technology, people's behavior will

be modified. The change will not be limited simply to pushing a button rather than a lever--it may involve interacting with new people, receiving new types of information or learning new approaches. Consequently, research utilization will mean, to one extent or another, initiating and sustaining changes.

Far too often, it is assumed that simply transmitting information about new research to the people whose behavior is to change will produce motivation to change. The logic of the argument or the attractiveness of the potential innovation is assumed sufficient in itself to induce motivation.

If this were the case, the generous funds and enormous activity behind the information storage and retrieval mechanisms noted earlier would be expected to generate considerable motivation for change. These mechanisms are the primary activity of the federal agencies examined here. (Agriculture is the exception.) However, industry and researchers into the process of change have been convinced for years that systems which rely entirely on informational components can never be genuinely successful in motivating change. The research concludes that, at best, new information can create an awareness of an opportunity. It produces no commitment to the opportunity, no skills to exploit the opportunity, nor any conviction as to the benefits of exploiting it. Yet all of these are necessary for eventual trial and adoption of an innovation.

Information retrieval systems and dissemination efforts are not altogether useless or ineffective. However, mechanisms of that kind cannot be relied upon to produce motivation for change to the same high degree found, for example, in the Department of Agriculture field agent program, or other programs which stress approaches based on person-to person contact.

2. Responding to Technological Opportunities. The studies cited earlier confirm that, under most circumstances, an innovation in response to a market need has a greater probability of utilization than one generated by a technological opportunity. This conclusion is supported by the relative lack of success in the application engineering programs attempted by several government agencies. Further support can be found in the shift in emphasis within industrial research organizations from technical problem-solving to filling market needs--motivated by the need to achieve more effective utilization of research results.

Of course, there are many instances in which technology-generated innovations have been utilized. However, they are in the minority, and are characterized by market-oriented

adaption expenses far in excess of initial expectations. There are several reasons for this poor utilization record, among them misunderstandings on the part of the user of the nature, need, or possible benefits of the innovation. In addition, utilization is hindered by the expense of adapting the innovation to suit user requirements and by the condescending attitude which some technology advocates are felt to have.

3. Lack of Clear Market Definition and Familiarity. The relative success of person-to-person technology transfer is largely a function of the rapport developed with the user. This approach also provides the developer with opportunities for contact with, and better understanding of, the user's needs. Both the Agriculture model and industrial models for achieving research utilization are heavily based on the assumption that clear market definition and familiarity is essential for utilization. The two British studies cited earlier confirmed that the lack of adequate market information was the chief cause of unutilized research results.

Market definition, as used here, is not to be understood as study done after the research has already been generated, focused, and developed. Rather, a firm grasp of the user's perceived and real needs prior to development is essential. In other words, there is no such thing as a purely technical decision in R&D. No matter how early in the development cycle of an innovation, each decision has possible consequences for the form, usefulness, cost and appeal of the results in the marketplace. Accordingly it is necessary to have sufficient information about the market soon after the idea formulation stage.

Characteristics of the More Effective Approaches

The previous three points strongly suggest steps to be taken to increase the probability of research utilization: generator-to-user contact and information sharing research based on market needs and clear market identification and familiarity. In general, changes are needed both in the way a project is executed and in the strategies employed to increase the probability of utilization. Suggested changes are outlined below, with their implications for staffing.

1. Significant User Involvement. The major obstacle to utilization of research results is a lack of conviction on the part of the user that adoption of something new is worth the cost of the change. This conviction can, however, be generated by the users's involvement in the

development of the innovation. User participation, especially in terms of personnel transfers, joint undertakings, and formal and informal contacts between gorups, can stimulate this involvement. The USDA uses field agents and the decentralized university system in the same way--as vehicles to increase user involvement. In the case of the field agents, the involvement is direct and the user can often see an immediate correspondence between his concerns and the use of research outcomes.

User involvement in the planning, appraisal, focusing, and testing of research all seem to aid utilization. The argument that users are not sufficiently sophisticated to participate in these activities ignores two points. The user may not have the best information for the solution of problems, still: (1)the primary problem to be solved is a user problem, not a technical problem; and (2) studies in such diverse fields as education, scientific instrumentation and fire services have documented a significant number of user-generated innovations. 21/

Experience in these three fields provides numerous examples in which a user who has been involved in the research process subsequently becomes the strongest advocate for its utilization by other potential users. Each organization, after the research project was completed, became a "salesman" for the technology to its counterparts. In this regard, appropriate attention to the characteristics of the organization and personnel who participate, as well as effective continual mechanisms for involving the user, can aid federal agencies to significantly increase utilization of results.

2. Responding to Market Needs. As seen earlier, research undertaken in response to an identified market need has a greater probability of being utilized. Industrial experience further supports this conclusion. Market research, broadly defined, is an essential part of an effective research planning process. An examination of felt needs and the types of acceptable solutions (in terms of economic, technological, aesthetic, and consumer values criteria) can provide the information which will make the difference between utilization or wasted effort. Consumer involvement in the research process can help ensure the relevance of output to market needs.

3. Providing the Appropriate Mix and Balance of Skills. For effective research utilization to occur, a highly diverse set of activities must be coordinated and carried out by persons with different skills and orientation. Industrial organizations have recognized that multiple skills are

necessary and have brought marketing and management personnel, and scientists and engineers with different orientations, into the R&D organization. Defining and understanding a market need requires knowledgeable people able to evaluate market information. The matching of technologies with market needs calls for technologies able to conceptualize new approaches or ideas. The development of a preferred solution (and the conviction to try it) demands an aggressive advocate for the idea with an understanding of its applications. The management of a full research effort requires a person with the ability to plan, organize, and coordinate diverse activities. Finally, the sponsor provides overall understanding, support (perhaps financial, certainly emotional) and surveillance.

Without the mix of talents necessary to all these functions, research will arrive at the utilization stage only with greater difficulty than necessary, and with a reduced probability of utilization. The absence of key people with the sets of skills to perform these functions can result in characteristic failures in the innovation process, reducing the chances of successful utilization.

In conclusion, achieving effective utilization of research requires careful planning, staffing, and execution of the research effort to determine, <u>from the beginning</u>, what is necessary to facilitate adoption of the results. While there is no way to guarantee successful utilization, the approaches noted above can significantly increase the probability that research output will be adopted by its target users.

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