NATIONAL ACADEMY OF ENGINEERING

TECHNOLOGY TRANSFER AND UTILIZATION

Engineers and Overcoming the Interface

TECHNOLOGY TRANSFER AND UTILIZATION: Recommendations for Redirecting the Emphasis and Correcting the Imbalance

A report prepared by the
COMMITTEE ON TECHNOLOGY
TRANSFER AND UTILIZATION
of the
NATIONAL ACADEMY OF ENGINEERING
for
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SUMMARY

With a few exceptions, the vast technology developed by federally-funded programs since World War II has not resulted in widespread "spin-offs" of secondary or additional applications of practical products, processes, and services that have made an impact on the nation's economic growth, industrial productivity, employment gains, and foreign trade. In this report, a committee of the National Academy of Engineering studied the transfer and utilization of this kind of technology with a view toward solving critical national problems and providing greater public benefits.

After examining 25 federal departments and agencies, the committee found: Although federally-funded research and development totaled $17 billion in FY 1973 -- of which nearly $1 billion went into the collection, processing, and dissemination of information about the resulting technology -- only $43 million (or 0.25 percent of the total R&D budget) was spent to stimulate substantial and profitable secondary uses of the technology.

One major recommendation, accordingly, calls for shifting the focus of federal concern from simply telling commercial users and local governments about promising technologies to actually transforming technical information into ultimate uses that fulfill public or private economic and social needs. To do this, the committee proposes that the federal government spend about $1 billion annually to correct this imbalance.

The committee identified fundamental inadequacies in the process of technology transfer and utilization. To overcome these shortcomings, it suggests that the government, in collaboration with innovators, suppliers, and users, adequately define the opportunities in terms of specific needs or ultimate uses, market characteristics, economic payoff, and public benefits, and match these opportunities with the available technology.

A key element that the committee recommends in order to carry out utilization activities is the provision of incentives and tools such as adaptive engineering, seed financing, and marketing assistance.

The report declares that in no way do the recommendations mean to imply that the federal government should become a competitor to the private entrepreneur. The federal role should be, the committee states, one of stimulating and assisting, not one of inhibiting or discouraging the nation's industrial sector.

In carrying out its charges and developing its findings, the committee assumed that there was a substantial amount of useful technology generated in federal laboratories that is potentially available for wider public benefit. The committee suggests that this hypothesis must be tested by the National Science Foundation, the agency that commissioned the study.

Finally, the committee questions whether experimentation is a necessary prerequisite to the implementation of the policies recommended in the report.

MEMBERS OF AD HOC COMMITTEE AND CONTRIBUTORS

Chairman: *Mr. Joseph H. Newman, Senior Vice President, Tishman Research Corporation, New York, New York

Members: Dr. Guy Black, Professor of Business Economics, The George Washington University, Washington, D.C.

*Dr. Robert W. Cairns, Executive Director, American Chemical Society, Washington, D. C.

Dr. Richard N. Foster, Associate, McKinsey & Company, Inc., New York, New York

Dr. Aaron J. Gellman, President, Gellman Research Associates, Inc., Jenkintown, Pennsylvania

Professor Harold P. Green, The National Law Center, The George Washington University, Washington, D.C.

Mr. Porter Homer, President, Public Technology,Inc., Washington, D. C.

Dr. Charles N. Kimball, President, Midwest Research Institute, Kansas City, Missouri

Mr. Lawrence Levy, President, Interprise Corporation, Framingham, Massachusetts

Mr. Wilfred S. Martin, Senior Director, Corporate R&D, The Procter & Gamble Company, Cincinnati, Ohio

*Dr. Bruce S. Old, Senior Vice President, Arthur D. Little, Inc., Cambridge, Massachusetts

Mr. J. Richard Perrin, Owner, Perrin Associates, Encino, California

**Mr. Harvey J. Sarles, President, Narragansett Capital Corporation, Providence, Rhode Island

*Dr. Eric A. Walker, Vice President, Science & Technology, Aluminum Company of America, Pittsburgh, Pennsylvania

*Mr. James F. Young, Vice President, General Electric Company, New York, New York

*Member, NAE

**Mr. Richard P. Whitney, Vice President, Narragansett Capital Corporation served as the alternate for Mr. Sarles.

Contributions to the committee's work were made by the following:

Representatives of Members:	Joseph M. Carlson, Public Technology, Inc. Robert E. Roberts, Midwest Research Institute Laddie L. Stahl, General Electric Company
COTTU Staff:	T. W. Adams, Executive Secretary Philip L. Chabot, Jr., Research Assistant Mary L. Basiliko, Secretary Pat A. King, Secretary
Consultant:	Herbert A. Wilson, Executive Secretary Experimental R&D Incentives Program Study, National Academy of Engineering
Editorial Assistance:	Joanne Shapiro, McKinsey & Company, Inc.
Secretarial Assistance:	Marion C. West, National Academy of Engineering Stella Marzot, Tishman Research Corporation

TECHNOLOGY TRANSFER AND UTILIZATION

INTRODUCTION

Background. Through its Experimental Research and Development Incentives Program (ERDIP), the National Science Foundation (NSF) is responsibile for gathering evidence concerning various incentives that the federal government can use to increase the application of science and technology for the public benefit. At the initiative of ERDIP, the Foundation requested the National Academy of Engineering to establish a Committee on Technology Transfer and Utilization (COTTU). The committee began operating in July 1973.

Charges. In specific charges to the Academy, the NSF requested that COTTU:

- Identify the major federal agencies that have conducted programs directed toward technology transfer and utilization;
- Determine and describe the methods used by those agencies in advancing the programs;
- Evaluate effectiveness of these methods;
- Assess the extent to which these agencies have evaluated their own methods; and,
- On the basis of the background information developed, recommend policies that the NSF or the federal government should consider.

Scope and Viewpoint. In continuing discussions with the NSF and independently as the study progressed, the committee agreed that it should attempt to identify those attributes of the process and programs that limit the secondary and/or additional applications of government-generated technology; make constructive suggestions for overcoming these constraints; outline feasible federal initiatives that would significantly speed up technological utilization, and, finally, recommend a new approach and direction for the NSF's experiments that are designed to increase the knowledge of the inadequately understood process of technology transfer and utilization.

The committee believes that an acceleration of technological developments, consonant with economic forces and responsive to the perceived needs of the country, can result from a revision of certain federal policies and procedures. It also believes that this would, in turn, contribute to the solution of some critical national problems as well as provide other benefits.

Membership. The 15 members of the committee have diverse expertise and experience. As innovators, suppliers, and users, they have conspicuous records in technology transfer and utilization. They represent various professions -- engineering, law, economics, investment banking, large and small business management, and applied research. This diverse background enabled the committee to address not only the pragmatic managerial and socio-economic aspects of the problem, but the institutional implications as well.

Methodology. In carrying out its charges and developing its findings, the committee surveyed the relevant literature, identified 25 federal agencies conducting programs of technology transfer and utilization (Appendix), interviewed officials of these agencies, evaluated the written responses of selected agencies to a questionnaire, held wide-ranging discussions during three committee meetings with virtually full attendance, and particularly drew upon its own accumulated professional experience and judgment.

During its deliberations, the committee did not fully agree on every point under discussion, but there was complete agreement on the major themes and the final recommendations.

For a meaningful study base, the committee developed three fundamental postulates:

(i) On the basis of current knowledge, it is possible to take steps toward improving the transfer and utilization of technology.

(ii) There is a substantial amount of useful technology generated in federal laboratories potentially available for wider public application.

(iii) It is in the national interest to stimulate the transfer and utilization of technology from the federal government and its contractors in order to meet present and anticipated needs by other users and thereby foster economic and social growth in the United States.

While the committee has been mindful that the expressed concern of the NSF is with technology originating in federal laboratories, the basic process of technology transfer and utilization is also applicable to the products of research from universities, research institutions, industrial laboratories, and other sources, whether or not such activities are supported in whole or in part by federal contracts or grants.

LIST OF TERMS

Technology - The application of scientific knowledge or engineering designs or processes; any hardware device, equipment, or system; special laboratory or test facility; or specially trained person.[1] Also services and ideas are included. In general, it is the body of scientific and engineering knowledge of how to make something that will be purchased in the marketplace.

Technology Transfer - The process of collection, documentation, and successful dissemination of scientific and technical information to a receiver through a number of mechanisms, both formal and informal, passive and active.

[1] U. S. General Accounting Office, Means for Increasing the Use of Defense Technology for Urgent Public Problems (Washington, D. C.: U. S. Government Printing Office, December 1972) p. 5.

The transfer process begins when it has been established that a technological advance has significant relevancy in a directed or different application and that a necessary adaptation can be made. The process occurs naturally between participants who understand what has to be done to permit effective utilization.

Technology Utilization - The process through which government research and technology is transformed into processes, products, or services that can be applied to actual or potential public or private needs. It may also mean the secondary or horizontal application of a technology that has been developed for a particular mission and, after modification and diversification, fills a different need in another environment.[1] Utilization is therefore a broader concept than transfer, inasmuch as it emphasizes the ability and/or willingness of an entrepreneur from either the public or private sector to apply an available technology to an ultimate use or the creation of a marketable end-product or service.

Innovation - The process that broadly ranges from the invention or conception to marketplace acceptance.

[1] Ibid. It should be noted that the General Accounting Office used this as the definition for "technology transfer," but the COTTU members felt this function was more appropriately part of "utilization."

Innovator - The one who introduces, champions, and/or manages new technology whether or not he is the actual inventor or discoverer.

Supplier - The one who applies technology to produce a product or service. The concept refers to the manufacturer or adapter of a technology (usually a private sector, profit-making company or a consortium of private firms, or under certain circumstances, a partnership of public and private entities).

User - The ultimate purchaser of the technological product or service. The concept refers to the final consumer, which implies that the product or service is purchased and then applied in a useful way.

STEPS TOWARD TECHNOLOGY TRANSFER AND UTILIZATION

The transfer and utilization of technology is a complex, non-linear process, comprising a number of dynamic steps that occurs in varying degrees in a substantial portion of American industry today. Understanding this process is essential to understanding this report. COTTU has defined the steps as follows:

- Collecting, organizing, and storing the results of research and development (R&D) -- i.e., the technology.

- Publishing and disseminating the R&D information.
- Identifying a need and evaluating the technological requirements that must be met to satisfy it. (At this point the potential users are identified and the technology adapted or modified to meet their needs.)
- Matching of the available technology with the specific need or ultimate use, determined with the aid of the potential users.
- Executing a continuing series of relevant cost-benefit analyses.
- Defining the market potential and the other parameters that should help to determine the potential utilization.
- Examining the possible consequences that may result from fulfilling the needs and their impact.
- Locating the potential "suppliers" who are able and available to translate the technical information into practical reality.
- Determining resources and other requirements necessary for suppliers to produce the product, service or process.
- Associating the suppliers and users so they can agree on the standards, characteristics, performance, and constraints of the product, service or process.

Fails to include possibilities of otherwise rights.

- Performing the adaptive engineering necessary to develop the product or service or to acquire any missing elements.
- Establishing a business or implementation plan to determine production and operational costs.
- Acquiring the necessary financing.
- Creating a marketing plan, production of the product, service or process and implementation of its sale at a price a purchaser will pay.

These steps, the committee recognizes, are not a rigid or orderly structure. In some cases the sequence may be different or random, in others certain steps may overlap. Some steps may require modification and iteration to meet particular circumstances. For instance, there may be several competing teams or combinations of users, suppliers, and innovators pursuing similar objectives, and at some stage particular participants may drop out, change course, or make some other accommodation.

The committee also realizes that the process of technology transfer and utilization as defined here may not be applicable to every case. The importance of each of the steps varies according to the nature and character of the market pursued and the personal or collective perspective of the innovators, suppliers, and users.

Both in the private sector and the public sector, the problem of technology transfer involves a linking of the technologies at one extreme with needs at the other by means of a complex "brokerage process." At the technology end, there is a body of knowledge which results from R&D for primary mission purposes but, nonetheless, has numerous potential secondary or horizontal applications. At the other end, there is a set of societal needs that will utilize some combination of the technologies. Once these needs are defined, the brokerage process serves as the catalyst to help match the needs to the technologies. This mechanism is characterized by a randomness, a many-to-many coupling, and a great deal of entrepreneurship which sets the process apart from the more orderly situation in which a single mission need is recognized from the beginning.

Initial technology utilization occurs when the customer or user makes the first decision to purchase a product, service, or process in a significant quantity. Full transfer and utilization happens when widespread public benefits are realized, regardless of whether the benefit is direct or indirect (e.g., an indirect benefit may be an increase in productivity through improved efficiency).

I. INADEQUACIES OF FEDERAL TECHNOLOGY

The vast technology developed by mission-oriented federally-funded projects since World War II has not generally resulted in highly visible "spin-offs" of widespread secondary applications. Beyond such notable innovations as jet aircraft, antibiotics, radar, nuclear power, and other developments in electronics, chemistry, and health care springing from a few agencies, the committee was unable to identify major secondary contributions from federal R&D programs to the gross national product, level of employment, balance of trade, corporate profitability, industrial productivity, or the quality of life in the United States.

While the Department of Agriculture often is cited as a major contributor to technology transfer and utilization, the committee considers that the agency's basic output responds directly to its mission and therefore results mainly in primary applications. There are other civil agencies that also perform R&D, resulting in primary applications.

The methods generally used by federal agencies for transferring technology involve the passive techniques of collecting, screening, indexing, storing, and disseminating scientific and technical information upon the specific request of a potential user. These methods are not fully effective because they depend upon: the ability of the prospective user to define the technology he seeks; the procedures used to search and

identify the requested information; the format in which the data is provided to the requester; as well as the skill of the user in assimilating the knowledge, evaluating its relevance, and adapting the technology to meet a specific need.

More active methods which involve personal interplay between innovators and potential users, frequently assisted by third party change agents or multidisciplinary teams, are used less often by the federal government. When used, they tend to be more effective than the passive methods. Nonetheless, these active attempts by the federal government have also proven inadequate for the most part.[1]

In examining the problem, the committee assumed that two factors could limit the secondary or horizontal applications of federally funded technology:

- An insignificant amount of federal technology has been revealed which could be economically used in secondary or horizontal applications, providing widespread public benefits.
- A plethora of structural and institutional barriers exist in the federal government and the private economy to prevent the efficient and effective utilization of this technology.

[1] U.S. General Accounting Office, op. cit. pp. 8 and 13. Cf: M. Frank Hersman, "Technology Utilization in the Public Sector," in Science and Technology Policies: Yesterday, Today, and Tomorrow, G. Strasser and E. M. Simons, eds. (Cambridge, Mass.: Ballinger Publishing Co., 1973). pp. 79-93.

The committee was not charged with addressing the first assumed factor, and accordingly offers no opinion about its significance. Instead, it has accepted the hypothesis that useful technology does exist in the federal laboratories. However, the committee strongly feels that this hypothesis must be accepted or rejected and recommends that the NSF or another appropriate federal agency:

> *Now, and periodically in the future, test the assumption that there is a substantial amount of useful federally funded technology available for beneficial, widespread secondary application by conducting a survey of selected federal laboratories, using a team of experts representing a variety of disciplines, as well as the technological innovator, supplier, and user; also determine if comparable technology from other sources is already available or being used.*

In the event that little or no significant technology can be found through the above approach (or if technology from any other source is known to be available) then any effort to overcome structural and institutional barriers in federally-funded programs is considered impractical. Still, federal efforts to overcome analogous barriers in the private sector would be worthwhile because useful technology does originate there.

Hence, the committee extensively investigated the second assumed factor, particularly as it applies to

the federal government, and determined that significant barriers exist to the effective utilization of technology. It identified two critical impediments within the federal government which are, in general, classified as:

1. Inadequacies in the process for satisfying user needs with potentially promising federal technology, and
2. Inadequacies in the environment for fostering effective secondary utilization of this technology.

The remainder of this report deals with the committee's specific conclusions concerning these inadequacies and recommendations for corrective action.

II. OVERCOMING THE INADEQUACIES

The federal government must pay attention to the weaknesses in the process of secondary utilization of technology.

For utilization to be successful, the government must make certain that:

- *Proper emphasis and balance is maintained between transfer and utilization.*
- *Worthy projects are defined and selected, and*
- *The steps of the process are taken in a consistent and comprehensive way.*

The committee's policy recommendations are intended to point the direction of an appropriate government response that could motivate both the private sector and the non-federal public sector to transfer and apply technology for greater public benefit. The recommendations are designed to avoid undue government intervention, organization, or bureaucratic obstacles. In addition, the proposed policies also lend themselves to experimental evaluation.

Emphasis and Balance

Of the $17 billion spent during FY 1973 on federally-supported R&D, $935 million went into the collection,

organization, and dissemination of technical and descriptive information.[1] Nearly $43 million of that amount -- or 0.25 percent of the total R&D budget -- was authorized to encourage technology utilization. (Figure 1) *The committee therefore concludes that the government must redirect the emphasis and correct the imbalance between the transfer and utilization of technology by increasing the funding for application, adaptation and utilization to at least the same level as that expended for information collection and dissemination; namely, about $1 billion.*

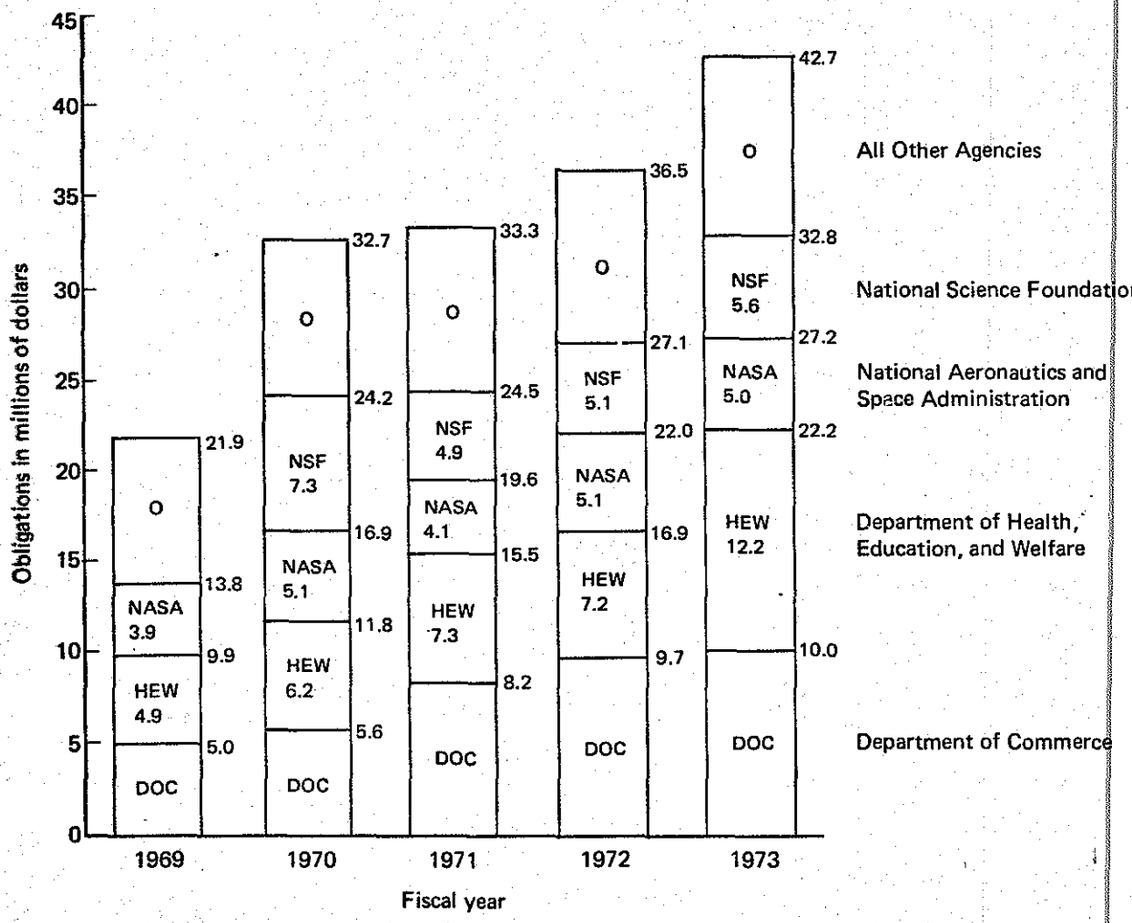
While it is true that most federal agencies have adequate programs for the dissemination of scientific technical information, in support of their internal mission, the committee perceives a real need to make the information more widely available by actively improving the public awareness of its existence and the available sources from which it can be obtained. *The committee therefore recommends that the government: 1) improve the management of federal activities concerned with dissemination of scientific and technical information by consolidating and standardizing their input and retrieval capabilities, 2) enhance the public awareness of the information sources, and 3) make the information available to users at a reasonable cost.*

[1] U. S. Government, Report of the Ad Hoc Group for Federal Obligations for Management, Processing and Transfer of Scientific and Technical Information Data and Technology, FY 1969-73, Prepared for the Office of Science and Technology, Executive Office of the President, Sept. 1972, Washington, D. C.: Government Printing Office, Vol I, p. 90. (Private communication from Office of Science Information Service, National Science Foundation).

FIGURE 1
Between FY 1969-1973 the total obligation for technology transfer and utilization activities has almost doubled, even though its percentage of the annual funds for scientific and technical information activities remained almost constant.

	Fiscal Year				
Obligations (In millions of dollars)	1969	1970	1971	1972	1973
Total Scientific and Technical Information Activities	677.9	740.9	849.3	914.3	935.1
Transfer and Utilization Activities	21.9	32.7	33.3	36.5	42.7
(Percent of Total)	(3.2)	(4.4)	(3.9)	(4.0)	(4.6)

This means that of the total federal budget, approximately 0.02 percent of the estimated obligations for FY 1973 were to be utilized for technology transfer. This is equivalent to 0.25 percent of the FY 1973 federal R&D budget.[1]



Technology transfer and utilization by agency[2]

[1] *Ibid.*
[2] *Ibid.* p. 91.

Selecting Worthy Projects

While the federal agencies generally understand the need to measure the impact of their technology transfer programs particularly with respect to economic payoff and public benefit, few agencies have actually done this on a regular basis, either from the start to establish the potential or as feed-back to determine the effectiveness. Rather, they have tended to measure program output in terms of the people contacted, publications, or study contracts completed. These measures bear little relationship to potential or actual success of the total process of technology transfer and utilization. The committee acknowledges that the process is lengthy, and that direct measures of performance may take considerable time, and that rational measures of potential benefit as well as accountability do not now exist for federal programs of technology transfer. Even so, the committee recommends that the government *require that projects of technology transfer and utilization, prior to the commitment of major federal funding for any implementation activities, should demonstrate:*

a) Reasonable evidence of the potential widespread public benefit,

b) Potential for significantly bolstering the economy and easing pressing national problems, while recognizing, of course, that priorities may change,

c) Little likelihood of causing lasting adverse impacts that are unacceptable when contrasted to the likely benefits,

d) Reasonable agreement among the prime participants (innovators, suppliers, and users) on objectives, benefits, roles, responsibilities, and milestones.

In sum, the government should make periodic reviews for each authorized project of technology transfer and utilization, possibly at progressive steps in the process, to ensure that the four standards listed above are met and that the extent of public benefits are ascertained. Moreover, a specific means for assessing compliance should also be developed.

The spirit of this recommendation is one of a balanced, dynamic and positive outlook rather than negative or static approach. It is aimed at providing some measure of control for the government. Moreover, this recommendation should not be implemented in any way that will, per se, retard or discourage the transfer and utilization of technology.

The committee knows that it is essential to make substantive reassessments of federal projects for technology and utilization. One body of experts may differ with another in agreeing on what is a worthwhile and justifiable undertaking by the federal government.

As it happens, federal activities seldom go beyond beginning steps of the complete process of technology transfer

and utilization which is necessary to bring the fruits of technology to the marketplace. In its study of federal agencies, the committee found:

- 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 the innovators, users, and suppliers, for the purpose of matching technology with needs.
- Insufficient support is offered to adaptive engineering, financing, marketing, and other steps to implement application.

Technology in the form developed by mission-oriented federal laboratories is almost never quite right for transfer into the marketplace.[1] This technology gap exists largely because none of the participants want to assume either the technical or financial risks of product modification, market analysis, and start-up of a pilot operation. Where all the steps in the normal process have been fostered by federal

[1] Cf. David D. Rutstein and Murray Eden, Engineering and Living Systems (Cambridge, Mass.: MIT Press, 1970).

agencies in a kind of "pump-priming" enterprise, there have been payoffs -- notwithstanding the debates that often rage about the adequacy of return on the taxpayers' dollars.

Many federal agency officials are sensitive to the market pull. Accordingly, NASA states:

> "The best method to consistently achieve optimum technology utilization in the private sector is to constantly look at the technology as a firm in the private sector would -- as a means to either make or save money. As long as that perspective is kept in mind and every effort is used to create awareness, the transfer, and more important utilization will occur." [1]

A similar sentiment was expressed by the Department of Commerce, which is a potential supplier of non-engineering elements of technology transfer and utilization:

> "Lack of dependable market and technical information appears to be a significant barrier to the exploitation of new technology. This suggests that the simplest and most straightforward service that government can provide is to act as a source of such information. There is little reason to believe, however, that this approach alone would be sufficient to achieve optimum technology utilization in the private sector." [2]

Although there is an appreciation of this problem in government, little is done about it.

[1] Letter to COTTU from Jeffrey T. Hamilton, Director Technology Utilization Office, National Aeronautics and Space Administration, October 18, 1973.

[2] From the Department of Commerce's answers to the COTTU Questionnaire dated November 1, 1973.

Since the present federal programs of technology transfer and utilization have not been adequately addressed for their total success, the committee recommends that the government *recognize and implement these programs by making certain that any existing or experimental programs embrace the following fundamental activities of the process:*

a) Dissemination of the results and applicability of R&D -- i.e., the technology.

b) Definition of the needs, markets and impact of implementation -- i.e., the opportunity.

c) Organization of the participants -- i.e., the innovators, users, and suppliers who, together, must define the opportunity and match it with the available technology from federal and non-federal sources.

d) Implementation consisting of adaptive engineering, financing, marketing, purchasing and anything else required to produce widespread public benefit profitably and effectively -- i.e., the lubricants or tools.

III. CREATING THE PROPER ENVIRONMENT

Overcoming the weaknesses in the process of secondary utilization of federal technology will not, per se, lead to more beneficial new applications. Attention must be paid to creating a better environment, by the federal government taking steps to ensure that its policies and programs encourage innovators, suppliers, and users of technology to work together in developing worthwhile secondary applications.

Specifically, the government must:

- *Empower and make adequate funds available for federal agencies to advance secondary utilization activities.*
- *Provide incentives and tools, including coverage of technical and financial risks to the participants in the process of technology transfer and utilization.*

Empowering Federal Agencies

At present there is no overall policy guidance or direction for the transfer and utilization of technology from either the executive or legislative branches of government to federal agencies. The single omission

commonly noted is the legislative authority and/or budget line item which would support the required manpower and other costs as well as provide desirable visibility.

In its study of 25 federal agencies, the committee found that their mandates and programs vary widely. Some have specific legislation without programs, others the reverse. Some have modest resources, others do not have specific budgets. And some, while possessing ample authority, accord their programs low priority.

The absence of a proper legal mandate is the single most important constraint preventing agencies from setting up adequate programs. Many agency directors are understandably wary and apprehensive about programs without explicit direction or adequate funding.

Moreover, there is a lack of personnel slots and no specific Civil Service Commission job descriptions exist for those engaged in technology transfer-utilization activities. This is a factor inhibiting the implemention of programs and the recruitment of expert personnel. There are, in addition, no tangible rewards -- often only disdain -- for those civil servants who work in technology transfer activities that are not basic to an agency's assigned mission.

Without a federal policy designed to overcome these constraints, there will continue to be a poor environment in which to accomplish the objectives. Therefore, the committee recommends that the federal government:

- *Empower appropriate federal agencies to set up explicit programs as an added part of their missions with specific charters and guidelines for embarking on these secondary or horizontal application programs.*
- *Make technology utilization a line item in the budgets of federal agencies in order to provide appropriate funding.*
- *Create new Civil Service designations and job descriptions to cover personnel with program skills and expertise. The Civil Service Commission should recognize the profession of technology utilization agent and establish a separate classification series within the General Schedule system from beginning positions to senior executive levels.*

In no way do these recommendations imply that the federal government should become a competitor to the private entrepreneur. The federal role should be one of stimulating and assisting, not one of inhibiting or discouraging the nation's industrial sector.

Providing Incentives

Until now there has been inadequate concern about financial risk, lack of patent protection, or other start-up problems that impede the private sector's ability to bring technology to market. To encourage industry to adapt the products, processes, or services for the marketplace, the government should:

- *Develop and refine tools that will improve a) the identification of high potential technology, b) the predictive process such as market research and c) user need analyses, particularly in enhancing the reliability for defining the opportunity.* [1]
- *Provide some assurance against undue risk to potential financial sources during the start-up or implementation stage of development of innovative technology.*
- *Make available, selectively and experimentally, adequate, inexpensive, and imaginatively bold financing to users in the private and public sectors in order to accelerate the direct*

[1] Cf. Arthur D. Little, Inc. and Industrial Research Institute, Inc., Barriers to Innovation in Industry, Prepared for the National Science Foundation, September 1973. This report concludes that marketing is the principal impediment in the translation of ideas or inventions into our economy.

implementation or to stimulate financial institutions to provide greater investment in new technology enterprises.

- *Grant exclusive licenses for government patents to private companies or negotiate other properietary arrangements where the private use of government technology cannot be obtained otherwise.* [1]

[1] In those cases where the exclusive license is important, it will show up very early in the process and be seen as a barrier to technology utilization at that point. The committee recognizes that this issue is being litigated in the federal courts and this recommendation may become moot depending on the final adjudication.

AFTERWORD

The committee recognizes that this study was by intention limited in its scope -- i.e., it was not expected to design experiments for new ways to transfer the technology from exisiting federal storehouses into the private and public sectors. Nevertheless, the committee does believe -- and some of its members strongly feel -- that any such experiments should be based upon the recommendations of this report, particularly those dealing with carrying out all the steps of the process of technology transfer and utilization, selecting worthy projects, and providing appropriate incentives.

The committee also considers that most of its policy recommendations are both appropriate and feasible for adoption by the federal government without prior experimentation. In fact, experimentation would seem not to be a prerequisite to the policy implementation, since sufficient experience is already available from public and private efforts.

Further, some committee members believe that any federal experiments should concentrate on technologies that are likely to solve the nation's priority problems -- e.g., fuel and mineral resources, energy efficiency, environmental protection, nutrition, health care, etc.

To this end, the NSF should consider seeking joint experiments with mission-oriented agencies to identify the most promising technologies originating in federal laboratories and advance those technologies through the whole process of transfer and utilization.

Even if the NSF should test the assumption but fail to prove that significant and applicable technology exists in federal laboratories, this should not deter the government's effort to seek out potentially applicable technologies from whatever source. Ultimately, the widespread utilization of any technology depends upon the successful accomplishment of all or most of the steps in the process of technology transfer and utilization.

Although the process is still not fully understood, it has been a remarkably useful strategy for the nation's industrial community to achieve worldwide preeminence. Accordingly, some members of the committee emphasize that the orderly involvement of informed people in the process will result in new challenges and directions for future research of immense promise for the nation's welfare.

APPENDIX

Federal Agencies Surveyed By COTTU
Between August and November 1973 [1]

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ATOMIC ENERGY COMMISSION
Office of Industry Relations

DEPARTMENT OF AGRICULTURE
Agricultural Extension Service

DEPARTMENT OF COMMERCE
Maritime Administration
National Bureau of Standards
National Oceanic and Atmospheric Administration
National Technical Information Service
Office of Telecommunications
Patent Office

DEPARTMENT OF DEFENSE
Office of the Secretary
Air Force, Air Force R&D Laboratories
Army, Office of Research and Development
Navy, Navy Technical Information
Naval Weapons Center, DOD Technology Transfer Consortium

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
National Institute of Education, Office
of Research and Development Resources
National Institute of Mental Health,
Development Branch
Social and Rehabilitation Service,
Division of Research Utilization

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Division of Building Technology and Site Operations

[1] The names and addresses of 21 of the 25 agencies surveyed by COTTU were drawn from Federal Technology Transfer, a report prepared for the National Science Foundation, Office of Intergovernmental Science and Utilization, by Todd Anuskiewicz of the George Washington University, dated August 1973, pp. 71-73. The other 4 agencies were added by COTTU when it was learned that significant technology transfer activities were carried out by them.

APPENDIX (Cont.)

DEPARTMENT OF THE INTERIOR
Bureau of Mines, Technology Transfer Group

DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration,
Technology Transfer Division

DEPARTMENT OF LABOR
Manpower Administration, Division of Research
and Development Utilization

DEPARTMENT OF TRANSPORTATION
R&D Policy Analysis Division

ENVIRONMENTAL PROTECTION AGENCY
Office of Technology Transfer

GENERAL SERVICES ADMINISTRATION
Public Buildings Service

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Technology Utilization Office

SMALL BUSINESS ADMINISTRATION
Office of Management Assistance,
Technology Utilization Division