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U.S. Technology Policy

A Draft Study

Office of the Assistant Secretary for
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U.S. Technology Policy

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EXECUTIVE SUMMARY

INTRODUCTION

This paper discusses U.S. technology policy in its relationship to the Nation's economic welfare and makes specific recommendations for an improved policy.

The goal of U.S. technology policy should be to maximize our capacity to develop and utilize technology for national purposes. Market economic criteria alone are not adequate for making social choices and for determining the national goals which technology policy should help achieve. Many non-economic factors are important in formulating a national technology policy, including the protection of the ecological system, the quality of employment, and the effects of technology on life styles. A comprehensive discussion of these important non-economic factors is outside the scope of this paper.

Since technology is a pervasive force throughout society, it is affected by a large variety of Government actions. In the context of this paper, U.S. technology policy is the sum of actions taken by the Federal Government affecting the production, diffusion, and utilization of technology. The elements comprising the policy lack unity and coherence. The pluralistic development of U.S. technology policy has resulted in a national technology enterprise with considerable strengths. But the fragmentation, incoherence and sometimes contradictory aspects of the various elements of the policy hold some disadvantages for the U.S., particularly in a world no longer dominated by U.S. technology.

BACKGROUND

Contributions of Technology to U.S. Economic Development

It has been estimated that technological innovation was responsible for 45 percent of the Nation's economic growth between 1929 and 1969.

A comparison of technology-intensive manufacturing industries with other industries in the period 1957-1973 shows that:

° Technology-intensive industries grew 45 percent faster;

° Employment in technology-intensive industries grew 88 percent faster;

° Productivity in technology-intensive industries grew 38 percent faster; and

° The ratio of price to unit output increased 44 percent less in technology-intensive industries.

Disquieting Trends

Recently, some disquieting trends have appeared in the Nation's inventiveness, entrepreneurship, productivity, and international trade:

° The U.S. share of patents filed worldwide and the number of U.S. patents awarded to U.S. nationals has decreased in the last decade.

° The number of innovative technology-based companies that are starting in the U.S. is much less than a few years ago.

° The U.S. worldwide lead in productivity, measured as GNP per civilian employee, has narrowed by 50 percent since the 1950's, and current U.S. productivity growth is below its historical trend.

° The Nation's large favorable balance of trade in products of R&D-intensive industries has come to depend primarily upon exports to developing countries and Canada.

We cannot establish definite relationships between the disquieting economic and technological trends, or even agree on how "disquieting" they are. Nevertheless, the trends are serious enough to require that U.S. technology policy be studied to identify weaknesses and opportunities for improvement. That study is the subject of this paper.

CONTRADICTORY ELEMENTS OF CURRENT DE FACTO POLICY

In this paper the elements of the current technology policy are discussed under the following headings:

° Production of technology,
° Diffusion and utilization of technology in the domestic economy, and
° Diffusion and utilization of technology internationally for achieving foreign policy objectives.

The elements pertinent to each of these areas are set forth in terms of concerns and possible alternative remedial actions in the appendix to this summary. Many of the actions are not mutually exclusive.

Many of the elements are contradictory in their effects on innovation:

° The innovation incentive of patent protection is undermined by compulsory licensing.

° The support of long-range undirected basic research is called for at the same time that the "Mansfield Amendment" restricts DoD to mission-oriented research.

° Government-industry cooperation in large R&D projects of national concern is promoted at the same time that Federal patent policy discourages this cooperation.

° Cooperative industrial R&D on high risk, expensive projects to alleviate national problems is desired, but is discouraged by antitrust attitudes.

° Technological innovation is called for at the same time that tax and regulatory barriers are erected to innovation.

° The economic benefits of exporting technology-intensive products are desired at the same time that overly restrictive controls on exports are imposed.

RECOMMENDATIONS FOR AN IMPROVED NATIONAL TECHNOLOGY POLICY

A coherent national technology policy needs to be developed in order to maximize the U.S. capacity to develop and utilize technology to achieve national purposes. The solid definition of, and reasonable degree of continuity in, a consistent Federal technology policy would promote private sector investment in technological innovation.

Several of the actions discussed in the appendix of this summary are new to the U.S. and, in our opinion, necessary to the formulation of a coherent policy, while others can be implemented by continuation and/or straightforward expansion of ongoing programs. We recommend that eight particular areas should receive priority attention in order to achieve the economic gains a coherent policy would foster:

° Industrial Technology Analysis Office (Appendix D, I)*
Every proposed national policy, whether or not obviously technology related, should be evaluated for its potential impact on technology. The means for such analyses are lacking. An industrial technology analysis office should be established immediately in the Department of Commerce. This office would evaluate proposed U.S. Government actions against the goal of U.S. technology policy to maximize the capacity to create and utilize technology for accomplishing national objectives. It would perform analyses of technico-economic indicators related to economic and industrial growth and productivity; technological factors in foreign trade and direct foreign investment, including costs and benefits of technology transfer; resources (manpower, capital, etc.) applied to the generation and acquisition of technology; effectiveness of various governmental policies in promoting the Nation's technological health; legal, regulatory, institutional and other barriers to technological innovation; and social cost-benefits of currently debated or anticipated major technological developments.

° Industrial R&D (Section III, A)
Some types of industrial R&D of high potential social value are not being performed because the economic rewards to individual companies are not great enough and the risks and costs are too high. The Federal Government should investigate direct (grants, loans, etc.) and indirect (tax, regulation, etc.) means of promoting the needed technological innovation in the private sector.

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*These references cite the relevant part of the full report.

° Modification of regulatory inhibitions on innovation (Section IV, A, 1)
The present regulatory climate contains unnecessary disincentives for technological innovation. Under the Office of Science and Technology Policy leadership, actions should be undertaken to strengthen the required data base, and to develop more appropriate mechanisms for deciding on acceptable risks and developing optimum regulatory strategies. Also, more adequate assessments of the probable impacts on technological innovation, as well as costs vs. benefits of such regulatory strategies, are needed.

° Improving the climate for starting technology-based enterprises (Section IV, B)
The U.S. economy is losing a traditional growth stimulus because the present tax and regulatory climate is not conducive to the start-up of new advanced-technology companies. The Departments of Commerce and Treasury should work with the Securities and Exchange Commission to investigate a variety of possible remedial actions.

° Innovation information for state and local governments (Section IV, C, 2)
The present scattered Federal Government pilot programs aimed at providing innovation information to state and local governments are not adequate to supply the needs and to capitalize on the potential for productivity increases in these sectors. The existing demonstration projects should be administratively consolidated and strengthened.

° Export promotion of technology-intensive products (Section V, A)
The economic benefits of technology-intensive products exported from the U.S. are being less and less fully realized. Additional foreign markets must be developed for nonmilitary technology products. This is especially necessary to create employment opportunities to compensate for those that may be lost if foreign military sales by U.S. aerospace and defense-related industries are reduced. The Government should work with industry to streamline further the various export control procedures and reporting requirements, to shorten the list of commercial products or technical data requiring specific permission to export, to continue reducing delays in the various export licensing processes, to improve efforts in market identification and analyses for technology-intensive products, to develop better Federal promotional practices, and to improve the relevant financing policies to be more competitive with foreign countries.

° Export control of design and manufacturing technology (Section V, B)
Export control involves the Departments of Commerce, State, Defense, as well as the Energy Research and Development Administration, NASA, the Nuclear Regulatory Commission, the National Security Council, and the Intelligence Community. A recent turnabout in Defense thinking, increased concern of the Congress, and new attitudes on arms exports and nuclear proliferation indicated by the Carter Administration have created the need and opportunity for a greatly improved policy. There

is no satisfactory interagency means for addressing these issues, nor is consultation with industry any better. Both Commerce and Defense have elaborate committee structures that are foundering because top-level leadership is lacking. The Executive Office of the President, through the OSTP or the NSC, should assume leadership in developing an export control and technology transfer policy which better serves both U.S. national security and economic interests.

° Technological support of less-developed countries (LDC's) (Section V, C) Technology issues relevant to LDC's have been receiving too low priority. An unsound policy in this field could have very large adverse impacts on the economy and on foreign relations. A U.N. Conference on Science and Technology for Development in 1979 requires the establishment of a U.S. policy which contributes to the progress of LDC's while being consistent with U.S. interests. The Departments of State and Commerce should work closely with industry to promote cooperation in industrial R&D and to assist technological infrastructure development in LDC's.

APPENDIX TO THE EXECUTIVE SUMMARY

SUMMARY
OF
CONCERNS GENERATED BY THE ELEMENTS OF CURRENT DE FACTO FEDERAL TECHNOLOGY POLICY
AND
POSSIBLE REMEDIAL ACTIONS

PRODUCTION OF TECHNOLOGY (Section III)

A. Industrial R&D

Concern: Industrial research of a generic and "overhead" nature needs to be performed, but because the near-term economic rewards are not enough and/or the risk is too great, the research is not being done. Similarly, much research with a large potential social return but small economic return is not being done.

Possible Actions: Direct Support

(a) Establish a Department of Commerce (DoC) industrial R&D support program.

(b) Alternatively, DoC should participate in NSF's RANN Program.

(c) Establish a Federal institute for industrial R&D.

(d) The Office of Science and Technology Policy (OSTP) should recommend and monitor the distribution of funds to individual Government agencies to support applied, mission-oriented R&D carried out by industrial firms in support of the agencies' programs and national needs and capable of commercialization.

Possible Actions: Tax Incentives

(a) The Experimental Technology Incentives Program (ETIP) in cooperation with the Treasury Department should conduct experiments and studies in which tax breaks are examined for their effect on innovation (Congressional approval may be needed).

(b) Congress should consider the likely effect of tax changes on technological innovation.

The tax changes to be considered should include the following possibilities:

- Increase substantially the tax investment credit for R&D plant from the present 10 percent to, e.g., 25 percent.

- Increase tax depreciation allowances for R&D plant.

- Provide new special tax credits or equivalent cash payments to industrial R&D performers. R&D would be defined in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose.

- Trade the present tax credit for investment in plant and equipment (10 percent) for tax credit or equivalent cash payments for expenditures on industrial R&D.

- Provide new tax credits or equivalent cash payments for incremental industrial R&D.

- Provide new tax credits or equivalent cash payments for incremental R&D in chemicals and capital goods industries.

B. Patent Incentive

Concern: The patent system is in danger of being eroded, so that the incentive it traditionally has provided for innovative product development is not being fully realized. Confidence in the patent system needs strengthening through the adoption of procedures to enhance the validity of patents.

Possible Actions:

(a) The Department of Commerce should assume the lead role in developing an Administration position on patent revision legislation which is consistent with the needs of the patent system.

(b) The new Administration should adopt a position of selectively revising existing law and not continue support of the previously introduced comprehensive patent revision bills.

(c) The views of the Department of Commerce concerning patent law revision should be brought to the attention of Congress, whether or not they also become the Administration position.

C. Basic R&D Support

Concern: Federal and private sector R&D programs are increasingly mission-oriented and do not provide an optimum level or mode of support for unfettered basic research.

Possible Actions:

(a) OSTP should work with the various Federal agencies to determine an appropriate level, mode and distribution of support

for basic R&D, consistent with the economy's long-term need and its ability to support R&D-- and make the level reasonably stable over time.

(b) The Administration should conduct a study of the impact of the "Mansfield Amendment" on basic R&D and, if found detrimental to the country's interest, propose that the "Mansfield Amendment" be repealed.

D. Skilled Scientific and Technical Manpower Development

Concern: Skilled manpower development for science and technology is too often out of phase and focus with demand.

Possible Action: OSTP should develop the coordinated Government policies and programs which are necessary for a long-term supply of skilled S&T manpower, including blue collar craftsmen, with an appropriate occupational and skill mix.

DIFFUSION AND UTILIZATION OF TECHNOLOGY IN THE DOMESTIC ECONOMY (Section IV)

A. Reduction of Regulatory and Social Barriers to Innovation

Modification of regulatory inhibitions on innovation

Concern: Regulations which are based on inadequate knowledge or which are developed without sufficient analysis of their total impact may unnecessarily have an adverse affect on technological innovation.

Possible Actions:

(a) Under OSTP leadership, determine and modify those regulations and existing policies which inhibit innovation.

(b) Establish in the Department of Commerce a unit to assess the impact of regulations on technological innovation.

(c) Base all future regulations on the outcomes of rigorous analyses of social cost-benefit ratios, and require rejustification of regulations on a regular basis.

Modification of antitrust laws to permit cooperative R&D

Concern: Some cooperative R&D leading to socially useful technological innovation may be inhibited by antitrust laws.

Possible Actions:

(a) ETIP in cooperation with the Justice Department should conduct experiments and studies which test the effect of

antitrust law relaxation on cooperative R&D to see if such relaxation will lead to socially desired innovation.

(b) Introduce legislation to relax antitrust restrictions on R&D cooperation by small firms but not large firms.

Credibility of scientific information

Concern: Procedures should be improved by which scientific information and (often disputed) interpretations, relevant to controversial governmental decisions, are placed before policy-makers and the general public.

Possible Actions:

(a) Institute a "science court," in which impartial experts would examine data and direct adversary argumentation in order to determine the state of scientific information (separated from value judgments) bearing on major national issues.

(b) Adopt (a) on an experimental, time-limited basis.

(c) Work through existing institutions (professional societies, universities) to better sensitize and train scientists concerning maintenance of objectivity and integrity as "expert witnesses" on controversial issues.

Educational publications

Concern: There is lacking a systematic effort to generate and distribute publications to inform the general public about the consequences of major technological developments and decisions.

Possible Actions:

(a) Continue the present system under which individual Federal agencies prepare and distribute educational publications whenever they see a need to inform individuals about technological changes.

(b) Increase agency efforts for education and provide a central coordination.

(c) Reduce Government effort, and assume the task would be taken over by private publishers who are better at promoting sales of publications.

B. Improving the Climate for Starting Technology-Based Enterprises

Concern: The climate for the start-up of new technology companies, including the contribution of tax and securities regulation, should be improved.

Possible Actions:

(a) The Department of Commerce through ETIP should work with the Securities and Exchange Commission on analytical research and policy experiments to develop an efficient regulatory structure -- one which provides both sufficient investor protection and sufficient access to equity capital for small technology-based firms. For instance, it appears that:

° Rule 144 should be relaxed to increase the liquidity of both venture capitalists' portfolios and the markets for individual company's securities.

(b) The Department of Commerce should conduct studies with the Department of Treasury to determine the advisability of implementing the following measures, and submit recommendations to the President six months after initiation of the studies:

° U.S. Government to provide guarantee for some portion (such as 50 percent) of loans granted by SBIC's or other financial institutions to new technology-based enterprises;

° U.S. Government to provide more generous capital gains tax treatment to new technical enterprises;

° U.S. Government to allow corporations, estates and trusts to invest in Subchapter S corporations and to receive benefits of Section 1244 stock;

° IRS to allow "good will" to be written off in merger accounting before tax rather than after tax;

° U.S. Government to provide for more favorable stock option incentives to founder and key personnel of new technical enterprises by (a) increasing the qualified options time from the current five to ten years, and (b) postponing the tax on income derived from the exercise of non-qualified options until the shares have been sold rather than paying the tax at the time the option is exercised;

° IRS to make investments in new technology-based enterprises (by individuals, institutions and corporate entities) tax deductible until the investments are sold, analogous to certain real estate transactions;

° IRS to provide for a graduated corporate income tax rate structure to benefit new technology-based enterprises; and

° IRS to reduce or eliminate corporate tax on dividends

(c) The Department of Commerce through the National Technical Information Service, in order to maximize the impact of available venture capital, should administer the funds for developing entrepreneurs presently administered by NSF/RANN. Some of these funds could be used to establish a nationwide system of small technical enterprise associates programs with engineering educational institutions patterned, for example, after MIT's Associates program. These programs would provide eligible enterprises with ad hoc advice on management, new product development, marketing and technical "trouble shooting" on a continuous, cost-free or subsidized basis.

(d) The Department of Commerce, working with the Securities and Exchange Commission and the Treasury Department, should conduct a forum for major investment institutions to discuss the potential and problems of investment in advanced-technology companies, particularly in the start-up and early growth stages, in order to generate more venture capital.

C. Enhancement of Diffusion of Innovations

Collecting, organizing, and disseminating information

Concern: The existing network of public and private information activities for promoting technological innovation has significant weaknesses, contributing to slower-than-desired technology diffusion, with loss in productivity and national competitiveness.

Possible Actions:

(a) The appropriations and staff of the National Technical Information Service (NTIS) should be increased to mount the necessary collection effort.

(b) Ensure use of NTIS services by other U.S. Government agencies.

(c) Expand the Government's information analysis activities.

(d) Create a unified, national industrial technology extension service.

Innovation information for state and local governments.

Concern: There is need for an innovation information system to serve adequately state and local governments.

Possible Actions:

(a) Create an information clearinghouse to collect, organize, and disseminate technological innovation information for state and local governments.

(b) Consolidate the existing field demonstration programs of various Federal agencies into a DoC program.

(c) Place high priority on the policy-making responsibilities of OSTP for effective transfer of Federally-developed technology to state and local governments.

(d) Provide categorical grants to the states to aid them in developing internal means to express their technological needs and work toward meeting them, drawing on any resources available.

Consumer technology information services

Concern: Insufficient information on consumer products and services results in extensive economic loss, and prevents the potential of market forces for stimulating innovation from being realized.

Possible Actions:

(a) Expand the Department of Commerce effort to provide consumer information services on product performance and product servicing, and increase the Department's consumer technical education focus.

(b) Proceed with existing consumer information efforts supplemented by the proposed National Voluntary Consumer Product Information Labeling Program.

Product standards generation

Concern: Lack of a clear cut, national product standards policy inhibits economic growth and disserves public interest.

Possible Actions:

(a) Support the Purpose of Title I (National Standardization) of the Voluntary Standards and Accreditation Act of 1977 (S. 825), but with certain modifications.

(b) Prepare new legislation to establish a national policy for maximizing the effectiveness of the U.S. product standards effort, particularly that of the voluntary standards-setting community.

(c) Continue through the Interagency Committee on Standards Policy (ICSP) to promote interagency cooperation and coordination with the private sector.

(d) Plan jointly with the private sector standards community (possibly through the ICSP) to identify present needs and their possible resolution.

Stimulation of innovation through Federal procurement policy

Concern: Federal procurement policy in its present form does not adequately stimulate technological innovation even though some improvement has been achieved recently.

Possible Actions:

(a) Rely on ETIP experimentation with Federal procurement policy to foster policies favorable for innovation.

(b) Make creation and diffusion of innovations a more prominent objective of all Federal procurement policy.

Federal patent policy

Concern: The great variety of existing Federal patent policies with their emphasis on Government ownership of inventions is a hindrance to the commercialization of technology developed with Government funds.

Possible Action: The Administration should introduce the draft bill developed by the Government Patent Policy Committee.

Funding of commercialization of selected Government inventions

Concern: Most Government-owned inventions are not commercialized, indeed much Government-funded R&D is not exploited for patentable inventions, so that U.S. taxpayers do not obtain an adequate return on their investment in R&D.

Possible Actions:

(a) Continue the present NTIS program alerting potential users to the existence of Government-owned inventions at present funding and staff level.

(b) Fund the commercialization of selected Government-owned inventions.

DIFFUSION AND UTILIZATION OF TECHNOLOGY INTERNATIONALLY (Section V)

A. Export Promotion of Technology-Intensive Products

Concern: No integrated system presently exists either for determining U.S. and foreign barriers, in particular non-tariff barriers, to increased U.S. exports of technology-intensive products, or for formulating coordinated steps toward lowering those barriers, including rejection of any unnecessary proposed new controls, as well as removal of any unnecessary present ones which restrict the export of products.

Possible Actions:

(a) Establish a policy board for export control, including the international transfer of technology per se. The board would be composed of the President's Science Advisor, Director of the National Security Council, Director of Defense Research and Engineering, Assistant Secretary of Commerce for Science and Technology, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, Deputy Administrator of the Energy Research and Development Administration (ERDA), Deputy Administrator of NASA, and the National Intelligence Officer for Economics of the Directorate of Central Intelligence, from among whom the President would appoint a chairman. The board would establish a working group composed of carefully selected individuals from the Government and private sector who would aid in developing positions on broad policy issues. In addition, the board would establish a set of joint Government/industry committees of experts encompassing all the technologies in the three major areas of export concern -- military products, nuclear power, and commercial technology-intensive products. These committees would provide specific scientific and technical advice to the policy board regarding the products requiring validated licenses. The board would establish the technological guidelines for use by the agencies responsible for administering the controls. All existing Department of Defense (DoD) and Department of Commerce (DoC) committees, whose functions would be replaced by this single interagency board with its coordinated set of Government/industry advisory committees, would be abolished.

(b) Negotiate a shortened International Export Control Coordinating Committee (CoCom) List and a streamlined means for keeping it updated. Both a shorter current List and a systematic method for keeping it in step with technological advances would be expected to result from implementing (a).

(c) Develop new DoC program(s) to achieve, for selected industrial sectors, a sound assessment of the relative level internationally of technologies, and the direction and velocity of their progress toward applications in order to provide aid to industry in planning what products to export.

(d) Assist industry -- particularly firms shifting from military-related to industrial, technology-intensive products -- to achieve expanded export levels through improved market identification and analyses, better Federal promotional practices, and exposure of foreign governmental protective practices.

(e) Improve existing means by which Government and industry together can develop a more effective international trade strategy that accommodates the increasingly expanded emphasis on technology embodied in exportable products.

(f) Continue the efforts to simplify the various export licensing procedures of DoC, Department of State and Nuclear Regulatory Commission/ERDA and so lessen the delays encountered by exporters.

(g) Improve the financing policies of the Export-Import Bank.

B. Export Control of Design and Manufacturing Technology

Concern: No Government agency is responsible for the continuing assessment of foreign technology developments in non-communist countries. This omission contributes to present export controls inadequately protecting national security and economic interests that involve critical design and manufacturing technology.

Possible Actions:

(a) Establish the interagency board described in A(a).

(b) Require DoD to provide a continuing technical assessment of its position vis-a-vis the USSR, or other potential adversaries, and identify for DoC those areas of commercial technology which it recommends for control to all foreign destinations. This would be accomplished in the course of the board's work if A(a) and B(a) are implemented.

(c) Establish within the Science and Technology Secretariat of DoC (See Appendix D, I) a capability for the analysis of technology developments in non-communist countries, based upon

information available from Government and industry sources, to assess if more control of technology per se -- particularly military-related technology which could become commercially significant -- is advisable. This DoC activity could provide analyses to the interagency board described in A(a) and B(a).

(d) Determine the consequences of making all exports of U.S. "frontier" technology per se (i.e., data and know-how related to the design and/or production of specific militarily-significant products or processes) subject to Government approval (validated license) based on the potential impact on the balance of payments, employment opportunities, national security and the U.S. responsibility vis-a-vis the political, strategic, and economic interests of the international community.

C. Technological Support of Less-Developed Countries (LDC's)

Concern: A program of technological aid to LDC's needs to be developed which contributes to the progress of LDC's and is consistent with the economic needs of the U.S. free enterprise system.

Possible Actions:

(a) Participate more actively in the international effort to develop a mutually agreeable "Code of Behavior" for multinational corporations and to encourage multinational corporations to invest in LDC's.

(b) Organize additional U.S./LDC joint commissions for mutually beneficial economic and technological collaboration.

(c) Organize consortia of developed countries to participate jointly in commission-type programs for economic and social development with specific LDC's.

(d) Work through the World Bank to plan and execute the industrial development of Third World countries.

(e) Expand the level of support for technological development in traditional ways.

(f) Promote mutually advantageous cooperation in industrial R&D not being pursued by U.S. private interests.

(g) Assist technological infrastructure development in LDC's.

D. International Product Standards

Concern: U.S. trade interests are likely to suffer unless the U.S. is more effective in development of international product standards.

Possible Actions:

(a) Propose a joint Federal/private sector study to identify U.S. needs in the international standards area, assess existing measures to meet these needs, and prepare an action plan to meet unfulfilled needs.

(b) Support Title II (International Standardization) of the Voluntary Standards and Accreditation Act of 1977 (S. 825) but with certain modifications.

I. INTRODUCTION

The purpose of this paper is to discuss U.S. technology policy in its relationship to the Nation's economic growth. The paper raises concerns over the adequacy of present policy, discusses possible actions for improvement, and recommends steps to achieve an improved policy.

For this paper, "technology" is defined as the aggregation of methods, materials, and devices used to provide goods and services. "Technological innovation" occurs when new aggregations are created for providing novel and/or better quality goods and services, or for providing already available goods and services at lower cost and with fewer resources.

Technology and technological innovation have played, and will continue to play, an important role in achieving our national goals, whether these be in the:

- economic sphere - increasing employment, holding down inflation, enhancing productivity, increasing capital supply, maintaining a favorable competitive position in international trade;
- political sphere - providing an adequate defense capability, meeting Third World demands, obtaining reliable sources of energy and materials and using them efficiently; or
- humanistic sphere - protecting the ecological system; creating more humane working conditions; providing more adequate food supplies, housing, transportation, communications, and health care; and achieving a more equitable distribution of income.

In formulating a national technology policy, it is important to consider the non-economic aspects, as well as the economic aspects, since market criteria alone are not adequate for making social choices and for determining the national goals which technology policy should serve. However, a comprehensive discussion of these important non-economic factors is outside the scope of this paper. Here we focus on U.S. technology policy in its relationship to the Nation's economic health.

Historically, technology has made important contributions to the Nation's economic growth. Recently, however, some disquieting trends have appeared in both indicators of technological health and indicators of economic health. Section II briefly discusses the historical contributions of technology to economic growth, and the disquieting trends.

It is difficult to establish definite relationships between the disquieting trends in economic and technological indicators, or even to agree on how "disquieting" a particular trend is. Nevertheless, the existence of the trends, and the past contributions of technology to favorable trends in

economic indicators, calls for U.S. technology policy to be studied to identify weaknesses and opportunities for improvement in its contribution to economic health. This study is the main purpose of this paper, and is carried out primarily in Sections III, IV, and V.

In this paper, U.S. technology policy is discussed in terms of the actions taken by the Federal Government affecting:

- the production of technological innovation;
- the diffusion and utilization of technology throughout the domestic economy; and
- the diffusion and utilization of technology internationally for achieving U.S. foreign policy objectives.

The elements of the present policy which affect these areas are summarized in Section II-C.

Sections III, IV and V discuss each of these three areas of technology policy in turn. In each section the major relevant elements of the policy are identified, concerns with these elements are raised, and possible alternative remedial actions (some novel and some already implemented to some degree) are discussed with their pros and cons. Many of the actions are not exclusive. Several of the elements and possible actions of the national technology policy addressed in the paper do not fall primarily under the purview of the Department of Commerce.

Technology is so much a part of all activities both private and government, that absent a deliberate effort, the overall set of elements comprising national technology policy, not surprisingly, lacks unity and coherence. This rather random policy formulation is even more understandable given the rapid pace of U.S. (and world) technology development, ever increasing dependence on more and more sophisticated technology, and the variety of interests involved. The pluralistic development of the various elements of U.S. technology policy has resulted in a national technology system with considerable strengths. Nevertheless, the fragmentation, incoherence and sometimes contradictory aspects of the various elements hold some disadvantages for the U.S. as it interacts with a world no longer dominated by U.S. technology as it was after World War II. Section VI discusses the need for a coherent, integrated national technology policy and proposes some areas of actions requiring priority attention to achieve an improved national policy. Immediate actions that the Department of Commerce could take to contribute more adequately to the development and implementation of a coherent policy are discussed in Appendix D.*

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*See Appendix A for a brief historical review of recent developments in U.S. technology policy. Appendix B is a summary of elements in the technology policies of foreign governments. For easy reference, the Appendix to the Executive Summary lists our concerns with current U.S. technology policy along with possible remedial actions; and Appendix C lists in tabular form the possible technology policy actions with their pros and cons.

II. BACKGROUND

A.. Contributions of Technology to U.S. Economic Development

In 1875, the U.S. per capita GNP, valued in 1975 prices, was $1,000. One hundred years later it had increased sevenfold. In 1875, 45 percent of the U.S. population was involved in farming. Today less than 5 percent of the population is so occupied. During these hundred years, the farming population declined by 53 percent, whereas the non-farming population multiplied 8.2 times [1].

	1875	1975
Per capita GNP (1975$)	1,038	7,136
Total U.S. population (million)	45.0	212.7
Farm population (million)	20.3	9.5

Since 1950, the U.S. has been widely perceived as possessing the most fortunate citizens: economically highest advantaged, best protected militarily, enjoying the most opportunities for avocations, etc.

During these 100 years, significant U.S. technological innovations in the manufacturing and agricultural sectors (and U.S. adoption of innovations from abroad) contributed singularly to the U.S. quality of life. Some familiar examples are:

PIVOTAL U.S. INVENTIONS

1876	Telephone
1879	Electric Light
1884	Automatic Typesetting Machine ("Linotype")
1891	Motion Picture Projector
1903	Airplane
1907	Electronic Vacuum Tube
1908	Conveyor Belt for Assembly
1911	Harvesting Combine
1923	Iconoscope Electron Scanner (Television)
1928	Mechanical Cotton Picker
1935-50	Synthetic Textile Fibers
1937	Xerography
1942	Nuclear Reactor
1946	Electronic Computer
1947	Continuous Coal Miner
1947	Electronic Transistor, followed by Integrated Circuits
1954	Stimulated Emission of Radiation (MASER, followed by LASER)
1958	Satellite Communications
1967	Optical Waveguides

The most comprehensive statistical analysis of U.S. economic growth, that made by the Brookings Institute's Edward F. Denison, treats the period 1929-1969 [2]. "Advances in knowledge", "education per worker", and "economies of scale" -- three major factors in technological innovation -- were responsible for 85 percent of the productivity increase in that 40-year period (p. 139). This increase, Denison estimates, accounts for 45 percent of the U.S. economic growth during those 40 years (p. 130). MIT's Robert M. Solow, on the basis of a slightly different analysis, comes to essentially the same conclusions [3].

Michael Boretsky, U.S. Department of Commerce, has analyzed the U.S. manufacturing industry, the sector that shows the impact of technological innovation much more directly than does the economy as a whole [4]. He compares, during the 1957-1973 period, technology-intensive industries with other industries.* He distinguishes these two types of industries by (1) the percentage of the value added that is expended on R&D, (2) the percentage of employment comprised of scientists and engineers in functions other than R&D, and (3) the number of craftsmen employed compared to the number of operatives and laborers [4]. Technology-intensive industries grew 45 percent faster, their employment 88 percent faster, and their productivity 38 percent faster than other industry; and their contribution to inflation (measured by changes in the ratio of price to unit output) was 44 percent lower.**

Average Yearly (1957-1973)	Technology Intensive	Other Industry
Real output growth rate (%)	5.5	3.8
Employment growth rate (%)	1.5	0.8
Productivity increase (%)	4.0	2.9
Inflation growth (%)	0.9	1.6
Foreign trade balance ($B)	+8.1	-4.0

B. Disquieting Trends

The National Science Board report, "Science Indicators - 1974" [5], which was transmitted to Congress by President Ford on February 23, 1976,

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*In Boretsky's classification, technology-intensive manufacturing industries include chemicals, nonelectrical and electrical machinery and equipment, transportation equipment and ordnance, and instruments and controls. Not-technology-intensive industries comprise all other manufacturing industries; most notably textiles and apparel, iron and steel, nonferrous metals, furniture, and glass products. The technology-intensive industries perform approximately 80 percent of U.S. industrial R&D.

**Productivity increase is defined as growth in real national income per person employed and so is interpreted as increased output per worker.

shows some disquieting trends involving technology. Of particular interest here are the trends exhibited in the Nation's inventiveness, the starting of technology-based companies, productivity and international trade.

Inventiveness

Patent activity is an indicator of the technological progress of a country, although it should be kept in mind that some inventions are not patented, not all patented inventions ultimately are incorporated in marketed items, and inventions vary greatly in their technological and economic significance [6].

The U.S. share of patents filed worldwide has decreased in the last decade:

Patents*Issued to	1963	1973
U.S. Nationals	66,715	66,935
Foreign Nationals	274,947	360,353

(*multiple filings counted only once)

This table shows that foreign inventors obtained 31 percent more patents in 1973 than in 1963, whereas U.S. inventors, even though the U.S. population increased by 11 percent in this period, were granted only 0.3 percent more patents in 1973 than in 1963.

The foreign inventors' share of patents issued by the U.S. Patent and Trademark Office has increased:

Patents Issued to	1963	1975
U.S. Nationals	53,619	50,155
Foreign Nationals	12,782	26,271
Foreign/U.S.	1:4.2	1:1.9

In several areas of technology, foreign inventors have become indisputable leaders. For example, in the following subject areas the foreign inventor share of U.S. patents during 1973-1975 is:

	Percent
Still cameras with electric film advance	86
Electromagnetic fluid pumps	83
Metalcasting using electrodes	81
Photoelectrically controlled cameras	81
Polypyridyls	80
Multiple piston actuated disc brakes	78
Rotary screen printing machines	77

	Percent
Azole derivatives	77
Blast furnace fuel	77
Multiple component lenses	76
Electromechanical oscillators	74
Pyrazolines and pyrazolidines	73
Textile machine bobbin doffing apparatus	72
Regulated radiant energy systems	68
Fermentations	66

A study by Gellman Research Associates, Inc. of 500 major new products and processes worldwide, over the past two decades, suggests a marked decline in U.S. innovation. Of these 500, the U.S. was responsible for 82 percent of the major innovations in the 1950's but it accounted for only 55 percent by the mid-1960's. Moreover, the fraction of American innovations rated as "radical breakthroughs" declined nearly 50 percent in the period 1967-1973 compared to the period 1953-1959 [5].

Technology Company Start-ups

In 1972 there were over 400 small-company public issues of which approximately a quarter were for small technology-based companies. The number of innovative technology-based companies that have started recently is much less. New small technical company issues (for companies with net worth of less than $5 million) amounted to $349 million in 1969, $6 million in 1974, $10 million in 1975, and - with improvement in the stock market - $15 million in the first two months of 1976 (corresponding to an annualized figure of $90 million) [7,8].

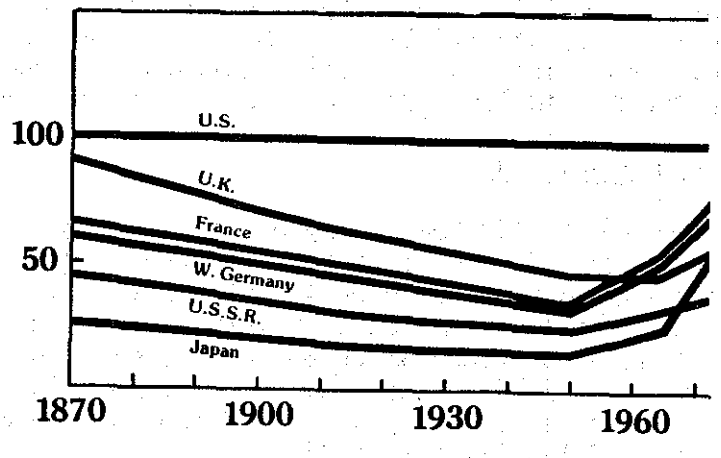
The decrease in start-ups of advanced-technology-based companies is cause for concern, because experience shows that such enterprises have been sources of competitive vigor in the economy for domestic and international commerce. In particular, such enterprises have historically been the sources of large numbers of new jobs.

Productivity

The Nation's productivity depends on many factors, including total capital investment. Technology also contributes, although the contributions of R&D and technological innovation to the economy are presently understood in broad and general terms only. The contributions of R&D and innovation to economic growth and productivity are believed to be "positive, significant, and high" [5].

U.S. productivity growth in all sectors dropped from an annual average rate of 2.4 percent from 1870-1966 to 1.5 percent from 1966-1973 [9]. Part of the drop is associated with the economic slowdown, the influx of youth (inexperienced) into the labor force, inflation, and regulatory requirements; but part of the drop has been attributed to a decline in the ratio of R&D to GNP [10].

An international comparison shows that the U.S. productivity gain between 1960 and 1974 is smaller than that of Japan, France, West Germany, the United Kingdom, and the USSR -- a fact which some feel attests to the success of our foreign policy of aid for reconstruction following World War II. Although the United States still has the lead in productivity in terms of GNP per civilian employee, this lead has been reduced dramatically. The productivity gap has narrowed by 50 percent since the 1950's, with most of the decrease occurring in the late 1960's.



Productivity
GNP per Civilian Employed Compared to U.S.

Although the U.S. productivity gain is smaller in a relative sense, it is larger than any other country in absolute terms [11].

GROSS DOMESTIC PRODUCT PER PERSON

Country	1961	1971	Ten-Year Gain
U.S.	$7,990	$13,420	$5,430
Japan	1,180	4,410	3,230
France	3,550	7,900	4,350
W. Germany	3,250	8,010	4,760
U.S.	3,100	5,550	2,450

These data show the U.S. gain between 1961 and 1971 exceeds Japan's total position in 1971; however these data are not corrected for inflation or devaluations.

Since the middle sixties, the U.S. has experienced not only a relative decline in labor productivity growth, but also a relative decline in capital productivity growth, defined as output per dollar's worth of investment in plant and equipment. From 1947 until 1966, the value of fixed capital (plant and equipment) invested by the private sector in 1947 dollars grew about 15 percent less rapidly than the value of its output (private sector part of GNP), but since 1966, the value of this capital grew some 21 percent faster than the value of output as these data show:

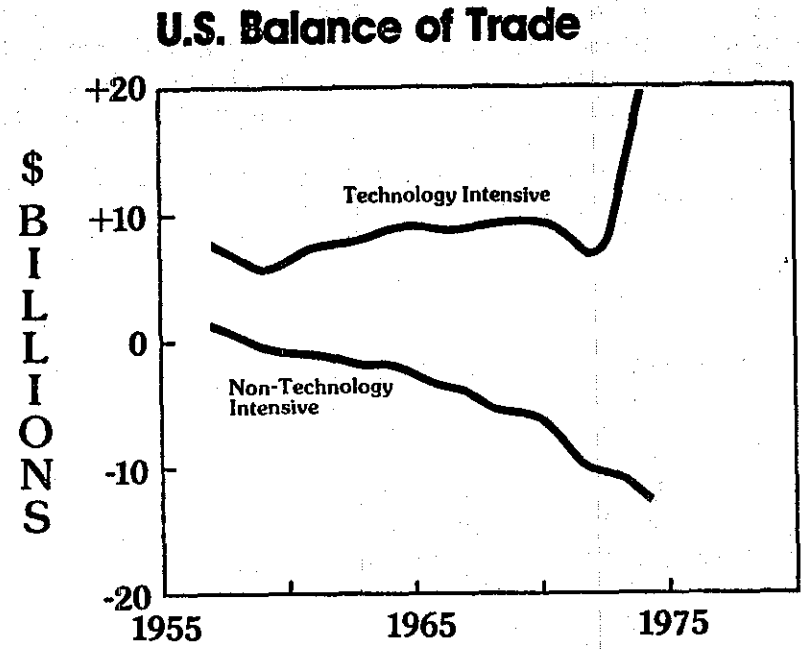
	1947-1965	1966-1973
1. Average annual growth of private GNP in constant dollars, % per year	3.9	3.8
2. Average annual growth in value of private nonresidential capital stock (gross value of plant and equipment) in constant dollars, % per year	3.3	4.2
3. Ratio of growth of capital to growth of GNP (2:1)	0.85	1.21

The service sector of the economy is far from realizing the potential of science and technology for increasing its productivity. The importance of this sector is evident from the fact that it now employs one-half to two-thirds, depending on definition, of the U.S. work force [12]. Currently, the service sector contributes little to the U.S. balance of trade. Furthermore, productivity improvement in the service sector has been significantly lower than in the manufactured goods sector [12].

The cost of producing a business letter is 40 percent higher than it was 10 years ago [13]. The expenses of state and local government - which employ one out of six workers in the United States - have increased sixfold in the past 20 years [14]. Salary increases for state and local government employees amounted to 188 percent between 1953 and 1973 compared to 141 percent for manufacturing employees [15]. Modern information handling techniques and automation have great potential for reversing these unfavorable productivity trends in the service sector and for improving the quality of these services, and could be applied if capital were available.

Balance of Trade

The U.S. continues to enjoy a large, favorable balance of trade in commodities produced by R&D-intensive industries.



However, the favorable balance of trade in these technology-intensive commodities has come to depend primarily upon exports to developing countries and to Canada. Our trade in manufactured products with Europe has not improved much since 1971, the year of the first devaluation of the dollar. Moreover, a deficit balance developed with Japan in the mid-1960's and continued through 1973, largely because the U.S. imported electrical machinery, professional and scientific instruments, and nonelectrical machinery [5]. To some economists these trade trends represent a decline in America's economic position because of the "catching up" of industrial competitors. In Kindleberger's (and our) view, the discouraging element is that we are no longer replacing dying exports with a new wave of innovative exports [16].

C. Overview of the Elements of Current De Facto Policy

The existence of the disquieting trends in technological and economic indicators described in the previous section, and the historical contributions of technology to favorable trends in economic indicators mentioned in Section IIA, call for an examination of U.S. technology policy in its relationship to U.S. economic health.

Current U.S. technology policy is not a coherent national program, but is rather the sum of a large number of sometimes contradictory actions taken by the Federal Government which directly or indirectly affect technology. The elements of technology policy can be categorized in many different ways. For instance, they can be listed in rather cumbersome fashion according to the agencies with primary responsibilities in various areas. Two alternate categorizations are presented in the discussion of foreign experience in Appendix B.

In this paper, the elements of the national technology policy are discussed under the three main headings:

- The production of technological innovation;
- The diffusion and utilization of technology throughout the domestic economy; and
- The diffusion and utilization of technology internationally.

Each of these three areas is affected by many elements of Federal policy.

The elements of technology policy discussed in the paper that are most directly pertinent to the production of technology are those related to:

- promoting industrial R&D,
- supporting basic R&D, and
- assuring skilled S&T manpower availability.

These include:

- providing investment incentives through the patent system.

These elements are discussed in detail in Section III, where for each element the present Federal Government practice is described, a concern is raised with the present practice, and one or more remedial actions (some new and some already partially implemented) are discussed with their pros and cons.

The technology policy elements associated with the diffusion and utilization of technology domestically may be grouped under the broad headings:

- reducing regulatory and social barriers to innovation,
- improving the climate for start-ups of small technical enterprises, and
- enhancing diffusion of innovation.

The reduction of unnecessary regulatory and social barriers to innovation involves measures for:

- assessing and modifying regulations,
- modifying antitrust laws to allow cooperative R&D,

- ° establishing the credibility of scientific information, and
- ° publishing educational materials on technological issues.

The climate for starting new technical enterprises is affected by all of the measures for reducing barriers and for promoting innovation diffusion, and in addition by specific tax and securities measures and by programs for providing services and advice.

The enhancement of innovation diffusion depends on measures for information transfer:

- ° collecting, organizing and disseminating information,
- ° providing innovation information to state and local governments,
- ° providing consumer technology information services,

and measures for:

- ° generating standards,
- ° stimulating innovation through Federal procurement,
- ° promoting inventions from Federal funding through Federal patent policy, and
- ° funding commercialization of selected Government inventions.

All of these elements of technology policy for diffusing and utilizing technology in the domestic economy are discussed in Section IV.

The technology policy elements affecting the diffusion and utilization of technology internationally can be grouped under the headings:

- ° controlling sensibly the export of design and manufacturing technology,
- ° promoting exports,
- ° supporting technological growth of less-developed countries, and
- ° developing international standards.

These elements are discussed in Section V.

In many cases, the elements of the present de facto technology policy are contradictory. For instance:

- ° The innovation incentive of patent protection is undermined by the compulsory licensing forced in the name of antitrust.

- ° The support of long-range undirected basic research is called for at the same time that the "Mansfield Amendment" restricts DoD to mission-oriented research.

- ° Government-industry cooperation in large R&D projects of national concern such as energy production is promoted at the same time that Federal patent policy discourages this cooperation.

- Cooperative industrial R&D on high risk, expensive projects to alleviate national problems is desired, but is discouraged by antitrust attitudes.

- Technological innovation is called for at the same time that tax and regulatory barriers are erected to innovation.

- The economic benefits of exporting technology-intensive products are desired at the same time that overly restrictive controls on exports are imposed.

There is need for a coherent national technology policy which would at the very least provide resolution of contradictory measures.

III. PRODUCTION OF TECHNOLOGY

The production of technology depends on the application-oriented results of industrial R&D, the investment incentives provided by patent protection, the fundamental background knowledge provided by basic R&D, and the availability of skilled scientists, engineers and technicians. In this section, each of these subjects will be discussed in turn. For each, the relevant elements of current technology policy will be identified, concerns with these elements will be raised, and possible remedial actions with their pros and cons will be discussed.

A. Industrial R&D

New materials, new devices, new products, new techniques, and new processes are created in all three economic sectors, i.e., for-profit enterprises, not-for-profit institutions, and all levels of government. The creation of these manifestations of technology by applied research and engineering is heavily influenced by Federal policies and practices.

The U.S. Government has funded specific applied research and engineering in a number of technical fields, in response to its responsibility for:

- providing society or assuring its provision with public goods, most notably national defense, public safety, education, health care, certain types of transportation, and communication;
- ensuring that the quality of the physical environment is preserved and improved;
- conducting its own operations, especially those which collect, process, communicate, and preserve large masses of information;
- aiding industry that is fragmented into units too small to carry out effective technology development, such as in farming, food processing, and fishery technologies; and
- exploiting technological opportunities of clear national impact or avoiding national loss of prestige when risks and costs are too high to be undertaken solely by private interests, e.g., the exploration of space, and the development of nuclear and solar energy technologies.

The development of Federally-funded technology has been mainly carried out by private organizations although the U.S. Government has nearly 100 major in-house laboratories and development centers, and completely supports 39 large privately-operated development centers.

The bulk of Federally-funded, but private-sector executed, applied research and engineering originates in DoD, NASA, and ERDA, whose policies have consistently stressed the importance of contractor R&D.

Both DoD and NASA buy large amounts of advanced-technology hardware and software in support of their mission, so it is reasonable to expect their support of contractor R&D. DoD grants back to the contractor about 2 percent of the purchase price of advanced-technology equipment as an "independent R&D" fund. No other agency is authorized to support R&D this well.

In recent years, the total expenditure for R&D in the United States has shown a steady decline. This is in sharp contrast to the steady (and in one case dramatic) increases found in many industrialized foreign nations. For instance, in the period 1969-1973:

	Percent Change During 1969-73 in Total R&D Expenditures in 1969 Dollars
United States	-3
USSR	+43
West Germany	+40
Japan	+74
France	+11

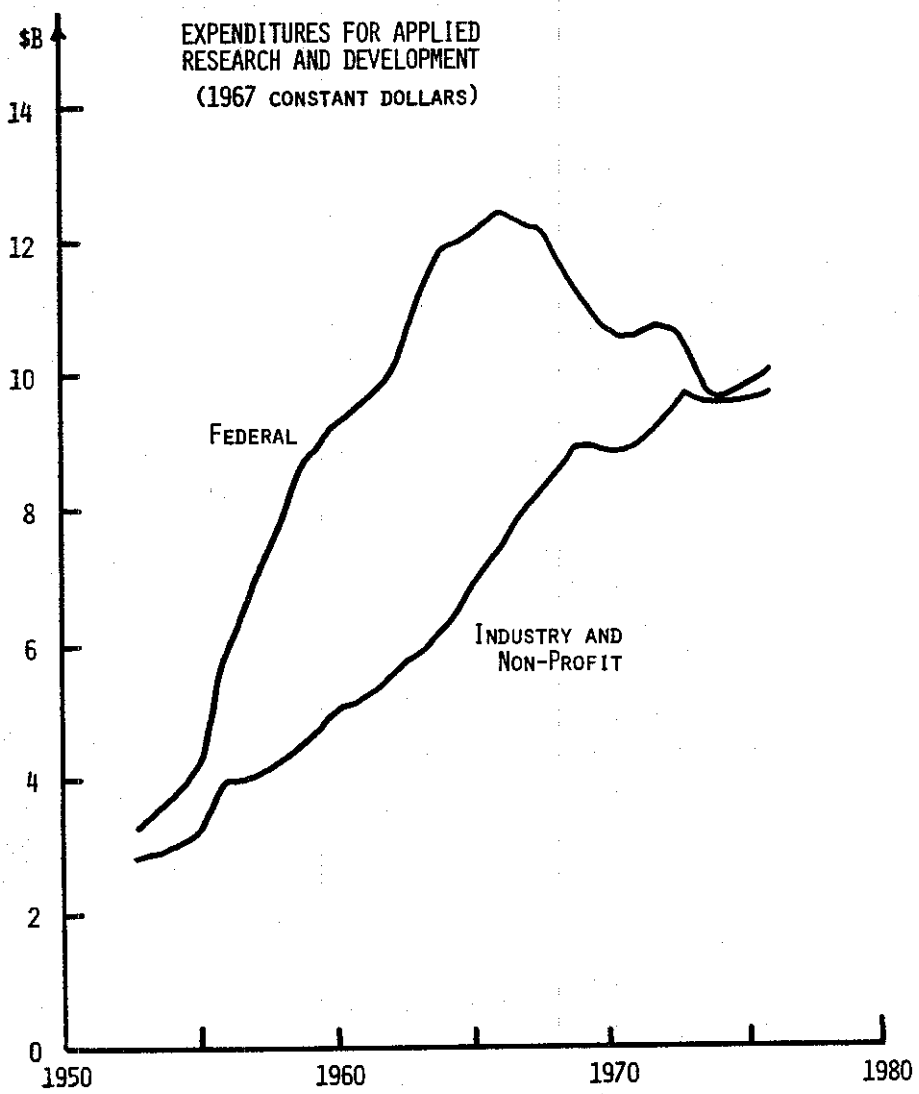
Moreover, since World War II, most of the R&D effort in European countries and Japan has been oriented toward civilian economic development whereas in the U.S. the major emphasis has been on defense and space objectives [5].

	Percent of GNP for Civilian R&D in the 1960's
United States	1.2
West Germany	1.7
France	1.6
Japan	1.5

Support of science and technology in the United States has either leveled off or decreased in most scientific disciplines [17].

	Percent Change in the U.S. Expenditures 1969-1974 (in 1969 dollars)
Total R&D	-6
Federally-funded total R&D	-15
Federally-funded basic research	-13
Federally-funded applied R&D	-16
Privately-funded total R&D	+7
Privately-funded basic research	-3
Privately-funded applied R&D	+8

Federal spending for applied R&D decreased markedly from 1966 to 1973, whereas industry and non-profit institutions have been spending an ever increasing amount. In total, in the past 20 years spending on applied R&D has approximately tripled (in constant dollars). This is a more rapid rise than either industrial production or deflated GNP had in that period. Nevertheless, the amount of Federal funding has decreased recently, and the bulk of it is for specific mission-oriented work. The types of applied R&D that might not be supported with this distribution of funding are some important to U.S. economic growth: for example, generic R&D projects whose fruits cannot be captured by individual firms, such as combustion, industrial enzymes, and programmable machining [18].



The Morrill Act of 1863, an expression of U.S. Government support for general technological innovation in the private sector, enabled the establishment, by direct grant of Federal land and money of state-operated colleges to promote the agricultural and mechanical arts and to train their practitioners. Much of the development of U.S. agriculture, as well as the pre-World War II U.S. manufacturing industry, relied heavily on the applied research and engineering performed in the "Aggie" colleges and by their graduates.

Today, however, there is no similar, broadly-based Federal program for promoting general technology development in the private sector. Rather, each Federal agency promotes the creation and development of new technology related to its subject mission. In general, the guiding beliefs behind Federal activities affecting the development, diffusion and exploitation of technology in manufacturing have been that commercially applicable manufacturing technology is only developed by the private sector, and that the self-interest of each firm acting in the marketplace will ensure optimum diffusion of the technology to other firms and its exploitation by them.

Concern: Industrial research of a generic and "overhead" nature needs to be performed, but because the near-term economic rewards are not enough and/or the risk is too great, the research is not being done. Similarly, much research with a large potential social return but small economic return is not being done.

Possible Actions: Direct Support

(a) Establish a Department of Commerce (DoC) industrial R&D support program.

Direct support of industrial R&D, based on the efforts of some foreign nations, has been frequently recommended for U.S. Government adoption. Such a program is not without risk, both of failure and of criticism. The U.S. Government has successfully supported much applied research in solid-state electronics, but its support of alternative automotive power systems has been unsuccessful.

An experimental DoC industrial R&D program focused on problems generic to a large number of firms is a possible action. These funds would be used to support R&D of high potential and general interest to an entire industrial sector, e.g., catalytic processes, combustion technology, programmable production techniques, industrial enzymes, ultra-precision machining, etc. Most of the projects would arise from unsolicited proposals, to allow maximum private sector initiative and participation in the choice of projects. These funds would supplement mission agency (such as DoD, ERDA, and EPA) funds which often do not carry research to

the point of successful commercialization or which focus on more specific projects. The funds would be used only for generic, "bottle-neck" or some other R&D which would be in the long-term interest of society but which is not being undertaken by the private sector in response to other options either because of a too great uncertainty, too great cost of the project, or too great fragmentation of the industry that would be the primary beneficiary of the project.

The suggested DoC program would be a small analog of the DoD programs for supporting (1) the development of technology relevant to DoD-purchased items, and (2) diffusing technological innovation in manufacturing processes employed to produce DoD material. The payoff of the DoD program is large; on some 60 manufacturing innovations studied, the payoff is 15:1 on investment [21]. Much of this technological innovation will only slowly, if ever, reach the attention of the majority of U.S. manufacturing firms in the absence of a concerted DoC program.

Critics of this approach express concern that governments do not have enough feel for the marketplace to make wise investments; that companies, in fact, might use this mechanism only to support marginal projects; and the R&D costs are only a very small part of the costs of technological innovation and do not form the main barrier [9,19,20].

(b) DoC should participate in NSF's RANN Program.

The National Science Foundation operates a limited applied research and engineering grants program -- Research Applied to National Needs (RANN). A possible action would be for DoC to participate in the management of the RANN program in order to emphasize applied research and engineering which would benefit the manufacturing and services sectors.

The advantage of this action would be the avoidance of the "new program" image.

The major disadvantages would be the lack of truly effective DoC influence on the level of R&D funding; the academic orientation of NSF management, including its grants and contracts office; and the competing demands from non-industrial applied research

(c) Establish a Federal institute for industrial R&D.

Another alternative would be to create the capabilities within the Federal Government to perform the desired generic industrial R&D. This alternative, compared to the previous one, would give greater control of the program to Federal authorities, and could be said to be more responsive to "public" needs and less of a "giveaway" of tax monies to business and industry.

The disadvantages are more substantive. Coupling the R&D to commercialization would be more difficult because of both communication and legal problems. It would require creating a new Federal agency, with expensive R&D facilities and staff. The choice of projects would be less susceptible to the influence of market requirements.

(d) The Office of Science and Technology Policy (OSTP) should recommend and monitor the distribution of funds to individual Government agencies to support applied, mission-oriented R&D carried out by industrial firms in support of the agencies' programs and capable of commercialization.

The industrial R&D projects would meet the criteria of (a) high risk and/or low economic return and (b) large social return or conservation of critical national resources. Most would arise from unsolicited proposals to maximize private sector initiative and project selection. Because of its familiarity with industry, the Department of Commerce could suggest non-burdensome standardized treatment of proposals from industry, and help industry in fostering industrial research in interagency negotiations.

Since most of the costs and risks are incurred after the R&D state, support should be available for the marketing and initial production phases of the innovation process, as well as the R&D stage. This support could take a variety of forms (e.g., loan guarantees on venture capital for starting businesses and providing working capital in initial commercialization phases).

Possible Actions: Tax Incentives

The conduct of industrial R&D is also affected by Federal tax policy. For instance, there is a tax credit for investment in plant and equipment, first instituted in 1964 with the rate of 7 percent, suspended in 1972 and reinstituted in 1974 with the rate of 10 percent. There is little, if any, quantitative evidence regarding the degree to which new technology is developed faster with this mechanism than without it.

(a) The Experimental Technology Incentives Program (ETIP) in cooperation with the Treasury Department should conduct experiments and studies in which tax breaks are examined for their effect on innovation (Congressional approval may be needed).

This incremental approach would yield valuable information at modest cost.

(b) Recommend that the Congress consider the likely effect of tax changes on technological innovation.

This would require advance studies by the Office of Technology Assessment, Congressional Budget Office, Library of Congress, Joint Economic Committee,

or others. In view of the chaotic state of tax laws and pressures for special favors, this issue may be ignored in tax reform.

The tax changes to be considered in the studies of (a) and/or (b) would include the following possibilities:

(1) Substantially increase the tax investment credit for R&D plant from the present 10 percent to, e.g., 25 percent.

The program would be economy-wide and easy to administer. There would be some net increase in R&D. There would be no interference in private decision-making by bureaucrats, nor would there be any proprietary issues.

On the other hand, the net increase in R&D would probably be relatively small even though costly to the Treasury, because the credits would have to be available not only to those performers who would not do the R&D unless such increased credits were available, but also to those who would do it anyway. Hence, the ratio of the net increase in private outlays on R&D to the loss of tax income to the Treasury could be low. Moreover, the policy would provide an opportunity for fraud because of frequent indistinguishability of R&D plant from production plant.

(2) Increase tax depreciation allowances for R&D plant.

This option has the same advantages as option (1).

The disadvantage is that depreciation represents only a small fraction of the total cost of R&D, and an increase in depreciation would only mean a temporary postponement of tax payment, rather than forgiveness of the tax. Thus, the net increase in private outlays on R&D could be very small, if not nil, because of the small marginal incentive.

(3) Provide new special tax credits or equivalent cash payments to industrial R&D performers. R&D would be defined in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose.

This also has the same advantages as option (1).

The disadvantage is that the kind of incentives that would substantially increase industrial R&D throughout the economy would subsidize not only incremental R&D but also ongoing projects, and the latter would be tantamount to substitution of public funds for private funds. Hence, the ratio of the net increase in private outlays on R&D to the net expenditures of public funds would be very low, if not nil. Moreover, the policy would be conducive to fraud, as is probably the case with all broad policies.

(4) Trade the present tax credit for investment in plant and equipment (10 percent) for tax credit or equivalent cash payments for expenditures on industrial R&D.

The basic rationale for the present tax credit for investment in plant and equipment is promotion of modernization and productivity growth. Some careful recent studies [22] have come to the conclusion, however, that investments in plant and equipment are largely a function of pressure of demand on industries' capacity and not of these tax incentives. Consequently, from the overall social policy point of view, the tax credit for investment in plant and equipment might be considered as a tool of income redistribution and not a tool for promoting productivity growth, and hence, growth of income. From this it follows that to the extent the trade of tax credit for R&D expenditures for tax credit on plant and equipment would generate more R&D and, hence, growth in productivity, the trade-off would be beneficial to society. Moreover, the trade-off would not require additional tax expenditures for the purpose.

However, in an inflationary economy, tax credit for expenditures on plant and equipment helps to counteract antiquated rates of depreciation and, therefore, the policy might socially be equitable even though formally it might look as if it were a tool of income redistribution. Thus considered, both sets of tax incentives might be necessary. However, as things are now, it seems rather ridiculous to use the excuse of social desire to improve productivity to essentially offset the adverse impact of inflation. The trade-off would most probably be also opposed by the business community, especially non-technology-intensive industries, macroeconomists, and, perhaps, quite a few people in the Government.

(5) Provide new tax credits or equivalent cash payments for incremental industrial R&D.

The policy would be economy-wide, and would undoubtedly increase the private outlays on R&D (the size of which would depend on the size of the tax credit or equivalent cash payments); there would be little or no substitution of public funds for private funds; and the ratio of the net increase in the private outlays to the expenditures of public funds would most likely be relatively high. Moreover, the program would be relatively easy to administer and there would be little or no growth of bureaucracy and little or no interference in private decision-making. Nor would there be any proprietary issues.

On the other hand, the policy would appear to penalize companies presently doing appreciable R&D. (However, if a 3-year moving average were accepted as a base for a given year's credit, the

discrimination favoring firms which had not done much R&D in the past would disappear over time.) Moreover, the policy would be conducive to usual types of fraud.

(6) Provide new tax credits or equivalent cash payments for incremental R&D in chemicals and capital goods industries.

This policy would increase the private outlays on R&D (the size would depend on the size of the incentive) in the industries whose output has traditionally been most conducive to domestic productivity growth and favorable foreign trade performance for the economy at large.

The advantages and disadvantages would be the same as in the previous option.

Notwithstanding all cons and problems, options (4) -- trade the present tax credit for investment in plant and equipment for credit for industrial R&D, or option (5) -- provide new tax credits or equivalent cash payments for incremental industrial R&D, merit serious consideration.

B. Patent Incentive

The U.S. Government has ever since the Constitution was enacted encouraged privately-funded development of new technology by providing U.S. patents to inventors. The inventor is granted a short-term (17 years) monopoly in return for publication of the invention.

In recent years the U.S. Government has also placed great emphasis on the antitrust concepts, namely there should be free competition in goods and avoidance of all forms of monopoly. Some have perceived the patent system as being in conflict with antitrust principles, although in fact they complement one another and both ultimately benefit the consumer. Nevertheless, antitrust thinking has tended to weaken traditional patent incentives.

The U.S. patent system plays an important role in providing incentives to inventors and entrepreneurs to invent, innovate, and invest in new technology directed to public needs. If the system is to be effective, however, the public must have confidence in the certainty and reliability of protection provided by a patent grant.

The worldwide accelerating progress of science and technology and the proliferation of technological information in recent years has made it increasingly difficult for the system to perform its Constitutional mandate to promote the progress of the useful arts. The time available

to patent examiners to search an application is limited, and not all the prior art may be available to them in each case. The procedures for obtaining patents have been criticized because of their ex parte nature.

Efforts over the past 10 years to revise our patent laws have been singularly unsuccessful. Past failures to enact revision legislation have been attributed to disagreements within the Executive Branch between the Departments of Commerce and Justice over the proper scope of patent law revision. Notwithstanding a "unified" Administration position and an Administration bill since 1973, Congress has been unable to assemble a legislative package that appropriately balances the economic and social considerations involved to best serve the public interest. The Department of Commerce, including the Patent and Trademark Office, has disagreed with many of the provisions of the Administration bill.

Few of the alleged problems of the patent system require legislative solutions. Some innovations, which could be made under present Department of Commerce authority, are out of the question with current budgetary limitations. Even if the funds were available, however, some solutions could be unreasonably expensive in terms of the benefits which could be expected to result. And some tend to impose unreasonable costs on applicants. A number of the various patent revision proposals can be accomplished through the Commissioner's rule-making authority. Such a rule-change package has been proposed and has been the subject of a public hearing. It is expected that adoption in whole or in part of these proposed changes in the Patent and Trademark Office rules of procedures will improve the practice and may make unnecessary some of the legislative proposals.

Concern: The patent system is in danger of being eroded, so that the incentive it traditionally has provided for innovative product development is not being fully realized. Confidence in the patent system needs strengthening through the adoption of procedures to enhance the validity of patents.

Possible Actions:

(a) The Department of Commerce should assume the lead role in developing an Administration position on patent revision legislation which is consistent with the needs of the patent system.

Perhaps the most advocated change in existing law has been for procedures to expand the opportunities for the public to bring information concerning patentability to the attention of the Patent and Trademark Office. We favor a provision for public participation which provides effective participation in a less costly manner and with less potential for harassment of the inventor than in the provisions supported by the 1973

Administration bill. Our proposal would provide for prelitigation reexamination, i.e., at any time during the term of a patent, new prior art could be submitted to the Patent and Trademark Office for its consideration, and must be submitted for its consideration before it could be used in any litigation. Legislation clarifying the law in the following areas could also effect desirable improvements: permitting voluntary, binding arbitration of patent disputes; making the right of assignors and licensees of patents to contest the validity of the assigned or licensed patent subject to certain conditions which are equitable to all involved parties; and permitting joint applications where two or more individuals have jointly contributed to the subject matter in at least one claim of an application.

(b) The new Administration should adopt a position of selectively revising existing law, and not continue support of the previously introduced comprehensive patent revision bills.

Quite possibly, the difficulty which has been experienced in achieving patent law revision reflects the fact that legislation of the scope previously considered may not be the best solution. This is not to say that improvement is not needed, but rather that comprehensive revision may not be the best method of achieving the needed improvements. The Executive Branch should adopt a selective revision approach to existing law, modifying only those provisions where a demonstrated need requires revision.

(c) The views of the Department of Commerce concerning patent law revision should be brought to the attention of Congress, whether or not they also become the Administration position.

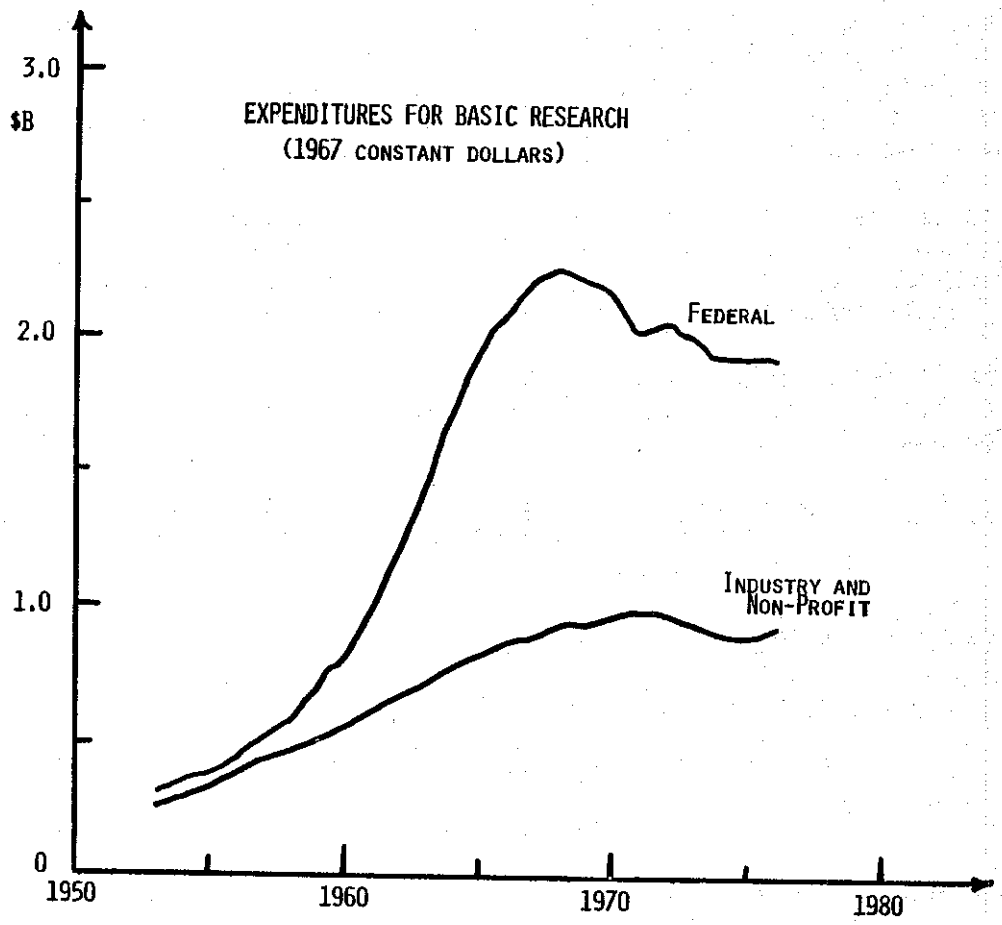
Because of the Nixon-Ford Administration's desire to present a unified position on patent revision legislation, the Department of Commerce for some time was not able to express its views concerning this legislation to the Congress. The debate over the proper course of patent law revision took place largely within the private forum of OMB, without the benefit of hearings or public participation. On September 14, 1976 then Secretary Richardson communicated the views of the Department to Congressman Rodino, Chairman of the House Judiciary Committee. Congress needs to have the benefit of the views of the agency primarily concerned with administration of the patent system and to hold hearings so the public may convey its views.

C. Basic R&D Support

The fundamental knowledge of nature which undergirds the technology exploited to provide human needs and wants is derived from basic research. Such work is mostly done in universities and similar institutions, frequently funded, as a direct result of Presidential and Congressional actions, by the National Science Foundation and the National Institutes of Health. Other Federal agencies which fund or perform themselves some

basic research are DoD, ERDA, USDA, EPA, and DoC's NOAA and NBS. That small part of these agencies' overall budgets devoted to basic research is by Congressional action directly related to their statutory missions. A recent provision ("Mansfield Amendment" PL 91-441, 1970) made this requirement very explicit for the large DoD research and engineering appropriations.

Expenditures on basic research in constant dollars since 1953 are shown in the following figure.



This decrease, coupled with mounting inflation, has had a negative impact on the conduct of basic R&D. Many universities, the Government's prime contractors for basic R&D, have been brought near bankruptcy recently.

Companies are finding it difficult in a climate of inflation, recession, and small profit margins to spend much on long-range research. In order that the basic knowledge from basic R&D will fuel technology innovation at an adequate pace, the contacts between the recipients of Federal funds for basic research, primarily universities at approximately $3 billion/year, and industrial firms must be solid. The gradual assumption by the Federal Government of the dominant role in supporting basic research in the universities has potentially the harmful result of lessening the incentive and opportunity for industry to perform this type of research. It thus becomes imperative that increased contact between universities and industry be fostered.

Many in the private sector have complained that the "Mansfield Amendment", which requires that funds provided by the Defense Department to companies for independent, long-term R&D must be spent on mission-related work, has curtailed the amount of long-range research previously performed in many companies.

Increasingly, complaints are raised in the academic research community that Federal research money is provided with too many strings attached. Research projects are overly "targeted", or their subjects are too minutely defined and bureaucratically determined [23].

The recent decrease in the number of radical innovations, usually the result of basic R&D, may reflect a suboptimal degree of Federal funding for basic R&D.

Concern: Federal and private sector R&D programs are increasingly mission-oriented, and do not provide an optimum level or mode of support for unfettered basic research.

Possible Actions:

(a) The Office of Science and Technology Policy should work with the mission agencies to determine an appropriate level, mode and distribution of support for basic R&D, consistent with the economy's long-term need and its ability to support R&D - and make the level reasonably stable over time.

There is essential agreement among all interested parties that the support of basic research is a proper Federal Government function, extending even to the education and training of its practitioners. Disagreements are focused on amount and mode of support, areas of science to be supported, and training of scientists and engineers. It may be difficult to select objective criteria for determining an appropriate level of basic R&D support.

(b) The Administration should conduct a study of the impact of the "Mansfield Amendment" on basic R&D and if found detrimental to the country's interest, propose that the "Mansfield Amendment" be repealed.

The emphasis of the "Mansfield Amendment" on relevant, targeted DoD research may be detrimental to the conduct of the basic research which is necessary for sustained technological development of the country. Since DoD provides a substantial proportion of the Federal funds for basic R&D, a change of policy in DoD research dollars could have a large impact.

D. Skilled Scientific and Technical Manpower Development

Technological innovation requires people possessing special skills. Scientists and engineers must gain new understanding of the natural laws and discover novel applications. Creative people must invent, alone or in organized groups such as those frequently found in industrial laboratories. Other ingenious people must recognize and apply technology "not invented at home," an activity that might involve purchasing rights to use patents owned by foreigners. Every brand of technician and craftsman is necessary. Technological innovation cannot happen without people who can design, construct, and manage complicated production systems; control quality; help others use innovations; and recognize needs that can be met with an emerging innovation.

Federal employment, subsidies to manpower and education (some $10.6 billion in 1975), and procurement have a major impact on S&T manpower availability and demand. After a rapid growth of manpower in engineering and science in the post-World War II years - in large measure the product of the GI Bill - sharp declines reflecting shifting national priorities occurred in these labor markets in the late sixties and early seventies. Federal expenditures declined in engineering-sensitive activities in relative and absolute terms, and these brought about a sharp fall in starting salaries as well as in the number of students entering this field. The alternate conditions of over and under supply have led to substantial increases in costs and personal hardships of R&D scientists and engineers.

There is evidence that the U.S. has fallen behind in comparability of employment of civilian R&D scientists and engineers against other industrially developed nations, although caution must be exercised in making international comparisons because of differing definitions. Western Europe and Japan were 30 percent ahead of the U.S. in the percentage of GNP spent on civilian R&D during the 1960's. The number of scientists and engineers engaged in R&D per 10,000 population has increased between 1963 and 1973 in all major countries (USSR, Japan, West Germany, France) but not in the U.S. since 1969.

Moreover, in the U.S., there has been a shift in manpower trained in science and technology to work in other areas. Between 1968 and 1974, the employment of scientists and engineers increased by only about 90,000 from 1,543,000 to 1,632,000. In this time span, however, the country's educational system produced some 750,000 new scientists and engineers. Assuming a normal attrition rate of the employed, 2 percent per year, and 2 percent unemployment rate of total S&T manpower, as reported by the Bureau of Labor Statistics, these figures imply that the 1974 employment of people classified as scientists and engineers was short of the available manpower trained in those disciplines by about 400,000. Hence between 1969 and 1974, these 400,000 trained in science and technology had to look for jobs in fields other than the professions for which they were trained.

Concern: Skilled manpower development for science and technology is too often out of phase and focus with demand.

Possible Action: The Office of Science and Technology Policy should develop the coordinated Government policies and programs which are necessary for a long-term supply of skilled S&T manpower, including blue collar craftsmen, with an appropriate occupational and skill mix.

A long-term skilled manpower supply was provided satisfactorily by market forces in the past. The post-Sputnik emergence of Federal advanced-technology efforts upset the supply-demand balance; first draining scientific and technical talent away from the civilian economy, later causing a massive shift of scientific and technical professionals to other jobs. Also there is evidence that the mix of specific skills needed by our advanced-technology economy is not matched by the current output of professional and paraprofessional schools. It has been reported, for example, that in 1974 our engineering schools produced fewer mining engineers than was the demand of one company in the mining industry. The demand of the mining industry in that year was quite atypical, but the fact that the number of graduates was not sufficient to meet the demand of one company illustrates the point.

A coordinated manpower policy is not without its difficulties, since political pressures in the Government may not be conducive to wise management of technical manpower. Such a program could be considered another Government "intrusion" in the historically free market process of supply and demand. In addition, formulation of optimal policy in an environment of dynamic technologies and hundreds of agencies and thousands of educational institutions, might be very difficult if not impossible.

IV. DIFFUSION AND UTILIZATION OF TECHNOLOGY IN THE DOMESTIC ECONOMY

In general, but with some notable exceptions, the guiding beliefs behind Federal activities affecting the diffusion and utilization of technology in manufacturing have been that commercially applicable manufacturing technology is only developed by the private sector, and that the self-interest of each firm acting in the marketplace will ensure optimum diffusion of technology to other firms and its utilization by them. The Department of Justice, however, questions these beliefs, and has aggressively pushed demands that some privately-owned technology be made available to all.

Several Federal agencies that themselves produce technology have mounted technology diffusion and utilization programs. There is, however, no broadly-based, coordinated Federal strategy for actively promoting the diffusion of commercially important manufacturing technology. This is not true in two other technology-intensive fields: agriculture and health care. In both these fields, there are planned, coordinated, and heavily-funded Federal programs to provide the stimulus needed for rapid technology diffusion and utilization.

The elements of Federal policy affecting the utilization and diffusion of technology in the domestic economy is discussed in the following under the headings:

A. Reduction of unnecessary regulatory and social barriers to innovation

   1. Modification of regulatory inhibitions on innovation
   2. Modification of antitrust laws to allow cooperative R&D
   3. Credibility of scientific information
   4. Educational publications

B. Improving the climate for starting new technical enterprises

C. Enhancement of diffusion of innovations

   1. Collecting, organizing, and disseminating information
   2. Innovation information for state and local governments
   3. Consumer technology information services
   4. Product standards generation
   5. Stimulation of innovation through Federal procurement policy
   6. Federal patent policy
   7. Funding of commercialization of selected government inventions

Each of these elements will be discussed in this section, with concerns over present policy raised and possible remedial actions identified.

A. Reduction of Unnecessary Regulatory and Social Barriers to Innovation

1. Modification of Regulatory Inhibitions on Innovation

Very little attention is being devoted, either legislatively or administratively, to modifying the existing regulatory structure in a way which would improve the climate for beneficial technological change.

For example, the climate for innovation is affected by the increased number of environmental regulations introduced in the 1970's because of increasing degradation of the environment by the waste products of industrialized society; the high rate of introduction of new synthetic chemicals (around 1,000 per year); the depletion of some natural resources; and the ecological, health, and aesthetic impacts of large energy products. At present, it is not clear whether these regulations have had a net positive or negative effect of innovation although it is quite clear that they have had a negative effect on capital productivity.

In addition, increased environmental controls affect innovation indirectly by placing a demand on energy. For instance, a recent study [24] of the iron and steel industry has shown that 10 percent of the energy budget is required for environmental protection. Additional requirements for energy are of special national concern today: despite a more than 50 percent increase in energy prices relative to all other prices since 1973, and despite the significant potential which exists for energy conservation [25], energy usage per dollar of economic output in the U.S. has decreased only slightly since the oil embargo.

	1973	1974	1975
Energy (quads of BTU)	74.7	72.9	71.1
Gross domestic product (in billions of 1972 dollars)	1225.7	1203.7	1181.3
Energy/GDP (economy-wide) (relative to 1973 level)	1	0.994	0.988
Energy/GDP (industry) (relative to 1973 level)	1	0.963	1.030

How much of a constraint or stimulus limited and expensive energy will be to innovation is far from clear. For example, until Middle East oil was discovered in huge quantities in the late 1940's, the predictions of scarce Western Hemisphere oil stimulated large R&D programs on synthetic fuels and shale oil in major petroleum company laboratories, as well as in the Department of Interior's Bureau of Mines. These programs were abandoned until the OPEC oil embargo again began to stimulate national interest.

As another example, compulsory licensing of privately held patents to other domestic and foreign potential users is increasingly demanded by

the Department of Justice in the name of antitrust. Between 1941 and 1959 as many as 107 judgments were issued (13 in litigated cases and 94 by consent). These affected such giant sources of technology as:

American Telephone and Telegraph Co.
Western Electric Corp.
IBM Corp.
General Electric Co.
Westinghouse Electric and Manufacturing Corp.
Radio Corp. of America
Hughes Tool Co.
Bendix Corp.
Combustion Engineering Corp.
Minnesota Mining and Manufacturing Co.

Surveys of the literature on the direct impact of antitrust activity on innovation have found that the antitrust remedy of compulsory licensing has not been especially successful in generating widespread licensing and utilization of the technology in question. Furthermore, companies subject to compulsory licensing in antitrust decrees have reduced their patenting activity [26].

Some regulations are based on inadequate knowledge, and are too hastily imposed.

There is a need to develop predictive methodologies which would permit the determination of adverse consequences in advance of the promulgation of regulations. The data base on regulatory impact has not been sufficient to provide clear directions to regulatory reformers. Recent studies indicate that some reform ideas may not be well founded, and also that some conventional wisdom may be more myth than fact. (See, for example, the forthcoming report for ETIP, Analysis of the Dynamics Underlying Regulatory Changes Having a Significant Effect on Innovation, Charles Waters Associates.) Fortunately, both Administration and leading Congressional reform bills have called for a timetable specifying data gathering leading to regulatory changes by 1980. Hence, it is critical that more objective information be gathered and analyzed as soon as possible. To some extent, knowledge about the process of regulatory modification and the resulting impact can only come through experimentation with careful evaluation.

Concern: Regulations based on inadequate knowledge or developed without sufficient analysis of their total impact may unnecessarily have an adverse affect on technological innovation.

Possible Actions:

(a) Under the Office of Science and Technology Policy leadership, determine and modify those regulations and existing policies which inhibit innovation.

Specifically:

- ° Encourage further selected, intensive studies on regulatory impact such as the Council on Wage and Price Stability, Productivity Commission sponsored work on the steel industry.
- ° Conduct comprehensive study reviews of general regulatory impact, at least to ascertain the extent to which current literature is accurate.
- ° Experiment with more appropriate mechanisms for recommending acceptable risks and for developing optimum regulatory strategies.
- ° Design and implement regulatory policy experiments through ETIP and other sources in as many regulatory areas as are feasible, keeping in mind the need to fashion a general change model.
- ° Integrate and coordinate current Government and private sector regulatory reform efforts involving representatives of all the participants: experts, advocates, regulators and legislators.

These actions could provide large benefits to society at large at little cost. Studies and experiments are called for since it is not known conclusively whether regulations on the whole have had a net positive or negative effect on innovation. It would be instructive to identify the characteristics of regulations and the regulatory process which have been found to be beneficial, to serve as a guide for future action. OSTP could draw on the resources of several agencies, and would be in a position to bring the recommendations to the attention of high-level policy-makers.

On the other hand, there would probably be opposition by affected interest groups. Most regulatory policy changes would require Congressional approval. Some would claim that enough is known about the shortcomings of regulations and the regulatory process now that remedial actions could be taken without the need for additional studies.

(b) Establish in the Department of Commerce a unit to assess the impact of regulations on technological innovation.

This would build on ongoing activities of the Department. Moreover, the Department has close ties with industry and could use these to obtain the information on impacts.

A disadvantage of this concept could be that the findings might be suspect because of the close industry ties of the Department.

(c) Base all future regulations on the outcomes of rigorous analyses of social cost/benefit ratios, and require rejustification of regulations on a regular basis.

° Encourage experimentation with different approaches to cost/benefit analyses within regulatory agencies of various degrees of regulations.

° Conduct detailed evaluations of current analytical methods by comparing actual results with prior analytical predictions to determine where better predictive methodologies need to be developed.

° Strengthen sources of data used in analyses conducted independent of agencies, e.g., by COWPS, OMB, OTA, etc.

° Require industry to provide more complete cost data than heretofore available to regulators (e.g., NHTSA/EPA and the auto industry).

These actions have a high potential for benefiting consumers and industry. On the other hand, they could delay desirable regulatory processes; the cost of analyses may become significant; and the "rigorous social benefit/cost analyses" may be difficult to perform.

2. Modification of Antitrust Laws to Permit Cooperative R&D

High risks and large investments are involved in the development of many new energy, materials, environmental control and other sophisticated civilian technologies. This has led to the desirability of industry-Government and multi-company cooperative research and development programs. However, companies are reluctant to engage in these cooperative efforts because of their perception of the Government's antitrust posture. U.S. companies are placed at a disadvantage in both the domestic and international markets with respect to foreign companies whose governments encourage and participate in joint R&D undertakings.

Present antitrust opinion frowns on cooperative R&D among competing firms because it is construed as a form of collusive behavior tending to restrain competition. Antitrust action tends to modify the structure of industry (i.e., reduce economic concentration obtained by vertical or horizontal mergers). Studies by Kamien and Schwarts [27] have shown a generally weak relationship between market concentration in an industry and the rate of innovation.

Studies by Nelson [28], Freeman [29], and Scherer [30] indicate that firms gain from cooperative R&D performed by trade associations engaging in basic or exploratory research. Research leading to specific products is avoided both because of fear of antitrust action and because of a desire to complete with differentiated products.

Concern: Some cooperative R&D leading to socially useful technological innovation may be inhibited by antitrust laws.

Possible Actions:

(a) ETIP in cooperation with the Justice Department should conduct experiments and studies which test the effect of antitrust law relaxation on cooperative R&D to see if such relaxation will lead to socially desired innovation.

ETIP now has a related project (not involving antitrust law relaxation) to demonstrate the effectiveness of group action in R&D to develop flame retardant treatment for fabrics. The experiments and studies could address the problem of how best to relax antitrust laws so as to encourage additional R&D while preserving the stimulus of competition.

(b) Introduce legislation to relax antitrust restrictions on R&D cooperation by small firms but not large firms.

It is appropriate to focus on small firms since they cannot individually devote the necessary resources to carry out high risk, high cost projects. Problems here include the monitoring of firms to insure that qualified firms are not engaged in anti-competitive R&D.

3. Credibility of Scientific Information

Many of the participants in the regulatory process (e.g., ad hoc committees of experts, special interest advocate groups, public and communications media) have no statutory or continuing responsibility or accountability to the overall process. They do not add to the base of our knowledge or understanding of the problem to be resolved. As a result, the measurement or estimate of the risk in question is not being made more precise at the time when judgments are made on the acceptability of the risk to be controlled.

Many policy decisions of national and international importance rely in considerable part on sophisticated scientific data and their interpretation. Neither decision-makers nor the interested public can readily judge the reliability and objectivity of such information, especially when scientists disagree over the validity and significance of the available data. Recent instances include the issues of safety of nuclear power generation; effectiveness of proposed ABM defense systems; effect of aerosol sprays on the upper atmosphere; and a host of other complex problems.

Such information and interpretations are made available today mainly through (a) publication and discussion in scientific journals, (b) reports by advisory panels or task forces of technical experts, and (c) presentations in public forums, such as Congressional hearings and meetings of the National Academies and professional societies. Significant shortcomings have been widely noted: rhetoric and emotionalism displace scientific objectivity; opposing experts fail to address each

others' arguments; implicit assumptions and "mind-sets" go unexplicated. Informed decision-making is impeded. Eloquent descriptions of the deficiencies, and tentative prescriptions of remedies, have come from industry, academia, and Government itself. To cite Senator Jackson: "One often wishes that advisers with different points of view would confront each other directly and in public so that hidden or unstated assumptions could be revealed and the different modes of analysis explored." [40]

Concern: Procedures should be improved by which scientific information and (often disputed) interpretations, relevant to controversial governmental decisions, are placed before policy-makers and the general public.

Possible Actions:

(a) Institute a "science court," in which impartial experts would examine data and direct adversary argumentation, in order to determine the state of scientific information (separated from value judgments) bearing on major national issues.

This approach [41] would provide an inexpensive and efficient means to clarify the scientific facts and uncertainties, clearing the way for more rapid adoption of valuable technological innovations and rejections of harmful ones [42].

On the other hand, it could not compensate for gaps in relevant data, might unduly expand the influence of science's "senior elite," and could find troublesome the identification, extraction and development of consensus on "the scientific component" of heated public issues.

(b) Adopt (a) on an experimental time-limited basis.

A science court experiment would permit a flexible exploratory approach to the evolvement of a new institution with a most difficult role.

However, a "likely to be transient" Court might not command the same commitment and dedication from participants.

(c) Work through existing institutions (professional societies, universities) to better sensitize and train scientists concerning maintenance of objectivity and integrity as "expert witnesses" on controversial issues.

This approach would avoid the radical step of introducing a Science Court.

Its necessarily slow pace and its continuing reliance on ability to maintain objectivity under stress mark it as a worthwhile supplement to (a) or (b) rather than a substitute.

4. Educational Publications

An informed and sophisticated electorate is essential to the best use of technology in a technology-intensive society. The responsibility of the Government to inform the public about anticipated consequences of governmental actions is well established. It has been argued that the Government has a responsibility to inform the public about consequences of any anticipated changes, whether due to Government action, technology, natural forces, or any other factor. Almost every U.S. department and agency has now in effect public information policies and operations which seek to inform the public. Some of the outputs have been outstandingly effective and warmly welcomed. Recent NBS educational publications on energy conservation are one example. Many USDA consumer pamphlets are also effective. Under a more formal approach, the whole NBS standards program, including physical standards and "paper" standards, is a means for advancing public understanding of technology.

These efforts involve comparatively unambiguous issues. For many other technological changes the issues are complex and many-valued and a suitable educational program would be most difficult to present. The other side of the coin is that a significant fraction of the public is both unwilling and unable to comprehend the whole picture.

Concern: There is lacking a systematic effort to generate and distribute publications to inform the general public about the consequences of major technological developments and decisions.

Possible Actions:

(a) Continue present system under which individual Federal agencies prepare and distribute educational publications whenever they see a need to inform individuals about technological changes.

Some examples show that the present approach can be effective. Moreover, no new organizational structure would be required, and there would be no additional demand on budgets.

On the other hand, many present publications are ineffective. Technological problems are too complex to present in a haphazard fashion, with the outputs of some agencies contradicting the outputs of others. At present, many technological changes are not properly handled, and effective use is not made of TV and other media.

(b) Increase agency efforts for education and provide a central coordination.

A coordinated approach could have a greater educational impact, with fewer important issues being inadvertently neglected. This would, however, require budget increases, and coordinating offices without management and budgetary authority are seldom effective.

(c) Reduce Government effort, and assume the task would be taken over by private publishers who are better at promoting sales of publications.

This approach utilizes the skills of the private sector, and reduces Government manpower and budget requirements.

However, it is likely that only "best seller" issues would receive attention and coverage would be very haphazard. It would be easy for partisan viewpoints to prevail.

B. Improving the Climate for Starting Technology-Based Enterprises

Inflation (average annual rate of inflation from 1970 through 1975 was 6.6 percent), the low average rate of return (profit on sales by all U.S. manufacturing firms averaged 4.6 percent and return on stockholders' equity averaged 11.5 percent in the same period) are making capital formation very difficult. All sorts of enterprises are suffering the ill effects. For instance, the aerospace industry reports that its plant and equipment lifespan has been increasing over the 1965 to 1974 time span from a ten-year maximum life in 1965 to 15 years in the 1970's. Its inability to replace obsolete equipment is asserted to cause operating inefficiencies and a retarded productivity growth because it cannot utilize the most advanced technology [31].

Another negative effect caused by capital shortage is the difficulty new companies have "getting started." The number of innovative technology-based companies that have started recently is much less than a few years ago. In 1972, there were over 400 small-company public issues of which approximately a quarter were for small technical companies. New small-technical-company issues (for companies with net worth of less than $5 million) amounted to $349 million in 1969, $6 million in 1974, $10 million in 1975, and - with the improvement in the stock market - $15 million in the first two months of 1976 (corresponding to an annualized figure of $90 million) [7,8].

Some of the decrease may be due to the two recessions since 1969 and to the reduced procurement by DoD and NASA for products embodying advanced technology; however, these possible explanations cannot be separated from the fundamental problems of inflation and capital shortages.

The decrease in "start-ups" of advanced technology-based companies is cause for concern, because experience shows clearly that such enterprises have been principal sources of the structural and competitive vigor of the economy in domestic and international commerce.

A number of recent reports have argued that restrictive regulation has also contributed to a significant reduction in the net expected return

and therefore in the size of the venture capital market. Two of these reports were sponsored by the Commerce Technical Advisory Board (CTAB). One by R. Morse and J. Flender [7] used some limited sales and employment data to indicate that growth rates of technology-based firms are higher than those of other types of firms. The Morse and Flender report also pointed out that the flow of venture capital to new, technology-based firms has contracted significantly in recent years. Morse and Flender attributed this reduction in the size of the venture capital market to a reduced average expected return relative to risk on investments in these firms that resulted from poorly conceived regulation and also from a structured shift by the economy in general away from technology investments to investments associated with lower levels of risk and quicker but lower overall rates of return. The other CTAB report by William Pietenpol [32] summarized testimony taken by the Department of Commerce from venture capitalists and entrepreneurs. The consensus of the testimony was that regulations on both tax and securities have significantly reduced the reward/risk ratio and hence the flow of venture capital.

On the other hand, a recent Charles River Associates (CRA) study for ETIP [33] concluded that there are no significant internal imperfections in the venture capital market. If this allegation is correct, there would appear to be no justification for Government intervention in this area.

The CRA study found the impact of securities regulation to be relatively minor. However, this conclusion requires some qualification: First, the primary objective of the study was to assess the internal nature and structure of the venture capital market. Regulation, which is an externally imposed effect, was added to the study after it was begun and as a result received less priority. Second, the CRA study was the first comprehensive economic analysis of the venture capital market, and only limited resources were devoted to any one topic.

The impact of regulations on venture capital flows is still not well understood.

Further analysis of the impact of securities regulation on technology-based firms seems especially warranted. This is because of the almost total dependence of this class of small firms on equity as a source of funds. These firms obtain almost 50 percent of their external financing in the form of equity but only 13 percent in the form of long-term debt. For comparison, when all small manufacturing firms are grouped together, the amount of external financing obtained through equity issues drops to 8 percent while 24 percent is raised through the sale of long-term debt.

The difference in the composition of long-term financing is explained by the fact that technology is an intangible asset, especially in its early stages of development. Consequently, there is substantial uncertainty with respect to its economic potential. In addition to this lowering of the expected rate of return to adjust for risk, the relatively long

development time usually required to achieve commercialization pushes the expected income stream relatively farther into the future and thus the additional discounting lowers the technology's value again.

In addition, internal funds contribute only 1 percent of the technology-based firm's total flow of funds, while for all small manufacturing firms the contribution is 25 percent. This is because the technology-based firm requires substantial amounts of time and money to develop a new technology. During this period little or no cash flow is generated. Therefore, even if the firms have access to long-term debt markets, they would be strained to make interest payments (which would, of course, include a risk premium).

Finally, equity offers the investor greater potential return on his risky investment than do relatively fixed income securities. Thus, because equity provides long-term financing, no immediate requirement to finance it, and offers investors a potentially higher rate of return, it is the dominant source of funds for the small technology-based firm. The message is, therefore, that securities regulations must be carefully conceived so that they not only provide necessary protection for investors but also do no inhibit access to this source of funds.

Concern: The climate for starting new advanced technology companies, including the contribution of tax and securities regulation, should be improved.

Possible Actions:

(a) The Department of Commerce through ETIP work with the Securities and Exchange Commission on analytical research and policy experiments to develop an efficient regulatory structure -- one which provides both sufficient investor protection and sufficient access to equity capital for small technology-based firms.

For instance, it appears that SEC Rule 144 should be relaxed to increase the liquidity of both venture capitalists' portfolios and the markets for individual company's securities. Reduced liquidity prevents the venture capitalist from turning over his portfolio of small firms at an optimum rate, whether the objective is to maximize a profit or minimize a loss. The constraint on the liquidity of an equity investment, the type of investment which is most relevant for small technology-based firms, results from SEC Rule 144. This rule was instituted to protect investors from unstable "new issues" markets. It is ironic that reduced liquidity can itself be a destabilizing force.

(b) The Department of Commerce conduct studies with the Department of Treasury to determine the advisability of implementing the following measures, and submit recommendations to the President six months after initiation of the studies:

° U.S. Government provide guarantee for some portion (such as 50 percent) of loans granted by SBIC's or other financial institutions to new technology-based enterprises.

This type of policy is in wide use abroad, especially in Japan. Though the recent study for NBS/ETIP by the Charles River Associates [23] argues that our small, technology-based firms currently depend almost entirely on equity as a source of funds, there is no reason to believe that they would not change their pattern of financing if the availability of loan funds were improved. Indeed there is evidence that such entrepreneurs very much want to retain equity in their fledglings.

° U.S. Government provide more generous capital gain tax treatment to new technical enterprises.

Preferential tax treatment can be justified if it can be determined that structural changes in investment conditions have caused a relatively greater increase in the levels of risk associated with investments in small technology-based firms. The Morse Report [7] makes this assertion. The question is, however, whether this policy would generate sufficiently large funds to make the difference or whether some other policy, such as reduction of the enterprises' taxes, would do this better. The Charles River study estimated through a sensitivity analysis that a 10 percent reduction in the capital gains tax would, at most, increase the flow of venture capital by 10 percent. This could mean, if this cursory analysis is correct, additional financing for only about 25 additional firms per year.

° U.S. Government allow corporations, estates and trusts to invest in Subchapter S corporations and to receive benefits of 1244 stock.

This measure would undoubtedly promote investment in new technical enterprises, but also lead to some speculative excesses.

° IRS allow "good will" to be written off in merger accounting before tax rather than after tax.

° U.S. Government provide for more favorable stock option incentives to founder and key personnel of new technical enterprises by (a) increasing the qualified options time from the current five to ten years, and (b) postponing the tax on income derived from the exercise of non-qualified options until the shares have been sold rather than paying the tax at the time the option is exercised.

Due to inflation and increased regulation, start-ups require more money than was needed five to eight years ago. It is therefore even more important today than in the past to provide strong incentives for starting new technical enterprises.

Though it is not clear that more liberal founder stock options providing longer term equity investments would not dilute the expected rate of return for other investors, especially venture capitalists, the option merits serious consideration as a means to attract more founders of new enterprises.

- IRS make investments in new technology-based enterprises (by individuals, institutions and corporate entities) tax deductible until the investments are sold, analogous to certain real estate transactions.

This would greatly reduce the risk of the investments and, hence, greatly increase the flow of investable funds into such ventures.

However, the policy would remove "dollar control" of the quality of the enterprises to be created.

- IRS provide for a graduated corporate income tax rate structure to benefit new technology-based enterprises.

This policy would facilitate internal generation of liquid funds at the time when the attraction of outside capital needed for expansion is most difficult. Moreover, the policy would be consistent with the general philosophy of U.S. society underlying the "progressive" income tax structure.

- IRS reduce or eliminate corporate tax on dividends paid out.

In addition, to maximize the impact of venture capital availability, it is suggested that:

(c) The Department of Commerce through the National Technical Information Service, in order to maximize the impact of available venture capital, should administer the funds for developing entrepreneurs presently administered by NSF/RANN.

Some of these funds could be used to establish a nationwide system of small technological enterprise associates programs with engineering educational institutions patterned, for example, after MIT's Associates program. These programs would provide eligible enterprises with ad hoc advice on management, new product development, marketing and technical "trouble shooting" on a continuous, cost-free or subsidized basis.

(d) The Department of Commerce, working with the Securities and Exchange Commission and the Treasury Department, should conduct a forum for major investment institutions to discuss the potential and problems of investment in advanced-technology companies, particularly in the start-up and early growth stages, in order to generate more venture capital.

Many large investment institutions do not entertain proposals for funds of the small magnitude required for the initial growth stages of new technology-based companies. A case should be made, and the Government's encouragement should be expressed, for using some of their discretionary funds for the start-up and initial growth of technical companies. Although many losses were incurred in the 1960's for these types of high-risk investments, the investments suggested would be relatively small percentages of the overall portfolios of large investment institutions. Moreover, the loss potential in this area would be mitigated by the opportunity for large capital gains in successful ventures.

C. Enhancement of Diffusion of Innovations

1. Collecting, Organizing, and Disseminating Information

The importance of the collection, organization, and diffusion of scientific, engineering, and technological information as a Federal Government activity has been recognized and supported for many years, beginning with President Jefferson. The major Federal departments and agencies active in science and technology have information diffusion programs. For instance:

- The Commerce Department's National Technical Information Service (NTIS) collects, organizes, and promotes nationwide awareness and use of new technical information, espeically that generated by Government agencies. The information is contained in technical reports, technical notes, data files, and Federally-owned patent applications. NTIS also collects, organizes, and promotes nationwide awareness and use of computer programs and models (software) generated by all Federal agencies.

- NASA partially funds the operation of nine "technical application centers" from Connecticut to California which provide literature searches for industry, and has "technology coordinators" in NASA field centers to bridge the gap between NASA experts and industry questioners. NASA also funds a computer software clearinghouse at the University of Georgia for public sale of NASA computer programs and models.

- The Department of Defense has a well-funded program (ca. $114 million in 1977) for diffusing and exploiting manufacturing tecnnology important to lowering the cost of DoD-procured items.

° USDA continues to fund, jointly with the states, an agricultural technology development and application service in each state and county in the Nation.

However, the Federal programs are not formally coordinated and are not focused to serve the needs of the manufacturing and service sectors. They do not include significant technological information produced by the private sector and by foreign nations, and are not, in general, known to the smaller firms or used by them.

Private sector activities in information diffusion must, of course, be profitable, and this criterion limits their role in what is, to some extent, an educational enterprise.

The statutory authority of NTIS is partially adequate to perform the task, but staff and money limitations have resulted in its coverage being restricted mainly to Federal agency reports.

The resultant lack of a unified Federal information program has led to considerable overlapping and duplication of effort, while tolerating a large tap in coverage of significant technological information produced by the private sector and by foreign nations. In most other industrialized nations there is a central coordinating or operating agency, and NTIS has recently begun negotiations with the French and Japanese agencies to collect more local technological information.

A major problem in NTIS' collecting non-Federal information is its demand that the source pay for the collection and organization (by NTIS) of the contributed information. This has been made necessary by OMB's refusal to seek an appropriation for this purpose.

Problems for the consumer, on the other hand, are created by the redundant overlapping Federal activities supplying information. NASA, ERDA, DoD (and some bureaus in DoC) maintain information dissemination operations competitive with NTIS in specific fields of technology. The Government Printing Office also competes with NTIS on a limited basis, and NTIS must abide by the rigid GPO Printing and Binding Regulations, which are not designed for a self-supporting agency.

U.S. Government agencies produce tens of thousands of different publications each year, and the potential user has great difficulty in knowing about the existence of useful information.

The aggregation of large collections of information and the issuance of bibliographies and indices to these collections do not satisfy important user requirements for data and information, e.g., within the information centers the information can be so voluminous and poorly stored as to defy reduction and ultimate retrieval. Increased widespread use of computerized information handling techniques can and should help here.

Furthermore, reading a technical report of analysis is not the best way to absorb complex, new information. A dialog with experts is often required. The Federal laboratories have thousands of such experts working in nearly all technological fields. The problem is to connect potential users with the best amount of recorded information and the backup experts in an efficient, effective manner.

Concern: The existing network of public and private information activities for promoting technological innovation has significant weaknesses, contributing to slower-than-desired technology diffusion, with loss in productivity and national competitiveness.

Possible Actions:

(a) The appropriations and staff of NTIS should be made adequate to mount the necessary collection effort.

Some advantages would be:

- increased support for and use of NTIS by Federal agencies;
- increased likelihood that NITS could collect substantial amounts of valuable proprietary and foreign information;
- increased support for NTIS from U.S. libraries who are vocally critical of NTIS failure to live up to its very broad charter (i.e., "from whatever sources, foreign or domestic, as may be available"); and
- increased usage of NTIS services by the public, at incremental or marginal costs of operation (no new facility would be required).

The disadvantages would be the reversal of previous Administration policy to make NTIS self-supporting in its collection efforts and the need to find staff and funds. A possible disadvantage might be concern by the GPO that NTIS would, thusly, get more leverage with the source Federal agencies.

(b) Ensure use of NTIS services by other DoC bureaus

As the NTIS Organization Order is written (DAO 30-7A), other DoC bureaus have the prerogative of deciding whether to utilize its services. Two DoC bureaus, DIBA and Census, are sparing users of NTIS, preferring to maintain independent information dissemination activities. Since the adoption of new technology often hinges on market and other economic data, NTIS efforts to promote technological innovation are made less effective by these separate operations.

(c) Expand the Government's information analysis activities.

In many cases, available information is couched in terms understandable only to specialists in the field. To promote more complete utilization of this information, a systematic effort should be made to interpret and condense the information, and to advise on its quality, so that it would be useful to a broader audience. The NBS National Standard Reference Data System is an example of such an effort.

Disadvantages are that this would involve additional budget and that manipulation of data may not be cost effective, since information specific to each user's needs is often best decided by the user.

(d) Create a unified, national industrial technology extension service.

This action has been suggested many times in the past 15 years, as some leaders, public and private, foresaw the trend away from U.S. technological dominance in many areas of technology, and the need for increased productivity in all sectors. Most suggestions have paralleled the USDA Agricultural Extension Service, which is a cooperative state-Federal program. The purpose of the proposed service would be to promote the rapid diffusion of technological innovation throughout U.S. business and industry.

Many other industrialized nations have such a service, but in the U.S. there are only uncoordinated, fragmented activities. The Small Business Administration and the DoC's Field Offices offer very limited technical assistance; their activities reflect, and are reflected in, their non-technically experienced staffs. NASA has several field offices and field agent teams to promote the transfer of NASA technology. Some 20 states have field agent organizations varying greatly in size and outreach. Almost 70 Federal laboratories have banded together in an informal consortium designed to promote more utilization of their expertise and special facilities.

Advantages would include:

- the user being able to have one, locally-accessible gateway to all relevant technology (the increased ease of access would greatly increase technological information usage);
- elimination of duplicative effort by Federal agencies, with resultant administrative savings;
- probable support from GAO and the Congressional S&T Committees; and
- continuation of the Executive Branch's Departmental Reorganization (1972) thrust.

Disadvantages of the proposed scheme would be the need for a small (10-15) DoC staff plus funding for the Federal share of the extension service. There would also be reluctance in NASA, SBA, and possibly other agencies to integrate their technology extension services into a single Federal-state operation.

2. Innovation Information for State and Local Governments

The Federal Government has several scattered small pilot programs aimed at providing innovation information to state and local governments. A Federal Laboratories Consortium with 70 member laboratories operates in a semi-official way to assist state and local governments to become more capable of utilizing technology, and to have their needs for technology better addressed by the Federal R&D program. NSF/RANN's intergovernmental science program has supported, through Public Technology, Inc., demonstration projects in 27 cities; the Council of State Governments, as well as the National Conference of State Legislatures, also have supported demonstration projects. NASA and NSF, jointly or separately, fund three nationwide programs to promote the application of technology to state, county, and regional government units. The technology being promoted is usually NASA-generated. The programs involve stationing a technically-trained individual in approximately 40 city or county offices, and also the fielding of several teams of NASA-trained experts who look for potential applications of NASA technology. Although the focus is on non-industrial applications, manufactured items are frequently needed to solve the problems. EDA funds the establishment of (primarily) state-university-based industrial extension services and has helped establish 15 units so far. All of these programs are small, and the combination is not adequate to supply the needs in state and local governments.

Serving the technological and other innovation needs of state and local governments is seriously hampered by the lack of an effective information system serving that sector. The sheer number of state and local governments - 38,000 receive revenue sharing funds - makes an information delivery system difficult. Employment in this sector increased 165 percent from 1950 to 1973, and productivity has not significantly improved.

Since productivity increases in state and local governments will be closely related to capital goods purchases and investments (e.g., computers, telecommunication devices, trucks), U.S. industry has a large stake. There is yet, however, no coordinated governmental program to bring the full Federal, state, and local governmental resources to bear on the needs of state and local governments.

The situation is analogous to the pre-1965 situation in U.S. education. There were large Federal educational laboratories spending hundreds of millions on applied research and 20,000 school districts untouched by the research results, but receiving several billions of dollars for support of traditional practices. There was no mechanism for rapidly bridging the gap between research and practice; education was a non-technology sector.

A solution in education was the establishment by the Office of Education of an educational innovation information system (ERIC). This system is like other Federal mission-oriented information systems; it collects, organizes, and supplies copies of publications relevant to educational innovation.

Other branches of state and local governments have suddenly been thrust into a situation in which innovation is necessary, but they lack an integrated information system serving their needs. They also have a great need for applied research focused on their problems, and several Presidents have repeatedly stressed the need to integrate this requirement into Federal R&D programs. An integrated information system would assist in collecting and organizing research needs of state and local governments.

Concern: There is need for an innovation information system to serve adequately state and local governments.

Possible Actions:

(a) Create an information clearinghouse to collect, organize, and disseminate technological innovation information for state and local governments.

It would be efficient to add this function to the ongoing NTIS operations, which already serve several thousand state and local government units with currently available NTIS products. This would also avoid added overhead.

Although this action would be a positive response to the policy statements listed above, it would require a small additional staff to manage the program, and considerable (ca. $1/2 million) money to develop the nationwide collection apparatus to pay for the organization and promotion of the information, and to underwrite the initial use of the clearinghouse by state and local governments.

(b) Consolidate the existing field demonstration programs of various Federal agencies into a DoC program.

This action would recognize the continuing need for referral, interpretive, stimulative, and demonstration services in order to obtain the desired innovation in state and local governments. This sector is similar to agriculture (especially in earlier times) and education in its fragmentation, sensitivity to influences (sometimes capricious) beyond its control, and general unawareness of the possibilities offered by technological innovation. It would probably require a continuing Federal program for 10 to 20 years or more to incubate the essential reorientation of state and local governments.

Since nearly all current Federal monies supporting field demonstration and service projects in this area come from NSF and NASA, some resistance to DoC's "takeover" would be expected. However, NSF continues to call its support "experimental" and appears to be disinclined towards continuing projects.

(c) Place high priority on the policy-making responsibility of the Office of Science and Technology Policy for effective transfer of Federally-developed technology to state and local governments.

This Office should work with the private sector, state and local governments, and Federal Government organizations in identifying the most effective transfer mechanisms, and with Federal policy-making bodies such as the Office of Management and Budget and the Civil Service Commission in planning for and implementing the funding and staffing requirements of an effective program.

A broad policy plus resources to implement this policy will be required to make significant impact in a reasonable time. Involvement of state and local governments, as well as the private sector in the planning, will assure the support of reasonable transfer mechanisms.

On the other hand, OSTP is not, and should not be, an operating agency. To date, policy-making in the Executive Office of the President has not been well followed up by problem solving in the operating agencies. Bridging this gap must be addressed, at a minimum, by OSTP fulfilling its statutorily mandated role vis-a-vis OMB in budget review of the entire U.S. Government science and technology effort.

(d) Provide categorical grants to the states to aid them in developing internal means to express their technological needs and work toward meeting them, drawing on any resources available.

Since problems often involve much more than the technological component in their solution, individuals close to the need will be most effective in providing an affordable solution.

However, lack of understanding of the Federal system and specialized interests of state and local employees will make it difficult to maintain a broad network of technology transfer agents. This option would not capitalize on the experience already gained to the degree option (b) would.

Options (a)-(d) could all benefit from broad Federal support for technology transfer provided; for instance, by mandating that each agency creating significant technological output should place at least a fixed fraction of its manpower in the dissemination activities serving state and local governments; and by supporting the establishment of training opportunities for technology transfer agents in Federal organizations.

3. Consumer Technology Information Services

The importance of market forces in stimulating innovation has been pointed out in recent studies [9,34]. These market forces can be realized optimally only if consumers are provided with adequate and simply-presented information for making wise decisions. A voluntary consumer product

information labeling program is presently under development in the Department of Commerce.

This is an appropriate time to launch a consumer information program. A recent study has indicated that Americans find something wrong with 28 percent of their purchases of goods and services; they complain about 33 percent of these faults; only 57 percent of the complaints result eventually in consumer satisfaction.

Consumer problems with products and product servicing are costly -- products are discarded prematurely, materials are wasted, much time and resources are devoted to resolving consumer complaints, sales are lost, and consumers are unable to make the rational choices necessary to maximize satisfaction from limited incomes.

Concern: Insufficient information on consumer products and services results in extensive economic loss, and prevents the potential of market forces for stimulating innovation from being realized.

Possible Actions:

(a) Expand the Department of Commerce effort to provide consumer information services on product performance and product servicing, and increase the Department's consumer technical education focus.

Such an expanded effort would consist of three interrelated technical facets -- provision of product performance information, provision of product servicing information (such as for automotive and TV repair), and in increased education focus for consumers, retailers, servicing personnel, and manufacturers in order to promote more efficient consumer purchasing decisions based on sound technology. Much technical expertise to conduct this effort exists in the Department, in the National Bureau of Standards, and much policy-making expertise in the Office of Product Standards.

This comprehensive and coordinated national consumer services effort should reduce consumer financial loss and dissatisfaction, facilitate product and servicing investment decisions, stimulate competition and sales based on quality and price, and reduce state and local expenditures now required to process consumer complaints.

There are, however, technological and other limitations to such an effort. For example, some products may have so many significant performance characteristics that selection for labeling purposes may result in uneconomic allocation of productive resources. Additional resources would also be required for effective implementation. In addition, the cooperation needed from the private sector cannot be taken for granted. Cooperation by other agencies should also be sought.

On the other hand, resolution of the consumer information problem is unlikely to occur in the absence of a comprehensive, coordinated attack. The Federal Government is in the unique position of being able to serve the interests of all Americans; that is, all those who are impacted by the problem -- consumers, manufacturers, distributors and retailers, even state and local government. The fact that the benefits of the program will be disaggregated extensively among consumers and business also calls for a Federally-coordinated effort.

(b) Proceed with existing consumer information efforts supplemented by the proposed National Voluntary Consumer Product Information Labeling Program.

In this case, no special DoC effort would be made to develop an effective program to provide information on product servicing or provide the extensive education focus found in (a) above. This more restricted approach would probably have a lower benefit-cost ratio because unlike in (a) there would be a lower tendency for individual, yet related projects, to reinforce each other, and a smaller opportunity to eliminate wasteful conflicts and overlapping. It would, however, not require as much resource expenditure as (a) would.

4. Product Standards Generation

NBS promotes, nationwide, through voluntary non-Federal organizations, through service to regulatory agencies, and through its own programs the adoption of a compatible set of meaningful technologies:

- a modern system of weights and measures for commerce;
- standards of physical measures for process control and engineering;
- prescription and performance standards for industrial and consumer products;
- laboratory and field test methods and on-site calibrations for research, engineering, production, health care, and safety; and
- evaluated data on materials and matter for research, development, engineering, manufacturing, and commerce.

These basic programs are absolutely essential to the functioning and development of the U.S. industrial sector, and reflect longstanding publicly-endorsed policies.

There have, however, been criticisms leveled at the present system of generating standards.

The first problem identified in the 1974 report on Voluntary Industrial Standards in the United States by the House Committee on Science and Astronautics was "the lack of a national policy for domestic and international standardization."

The proposed Voluntary Standards and Certification Act of 1976 (S. 3555) contained the following findings, inter alia:

> Section 3(9) "The procedures for promulgating standards, for accepting products for testing, inspection, and certification, and for insuring aggrieved parties due process are inadequate and vary from organization to organization."
>
> Section 3(12) "Built-in safeguards to protect consumers and to eliminate restraint of trade problems inherent in the standardization process are lacking."
>
> Section 3(13) "The lack of a uniform policy with respect to domestic standardization policies has impeded the effectiveness of the U.S. participation in international standardization activities, which may have far-reaching consequences on balance of trade and balance of payments."

In a recent draft of a proposed study on this subject, the American National Standards Institute (ANSI) states that: "we have no national policy with regard to standards and certification, no official Government policy or position and only limited means of developing a cooperative Government-private program to work effectively on behalf of U.S. international (and national) trade and commercial interests," and further that "while there has been a Government presence, organizational mechanisms and procedures are seldom adequate to accommodate a vastly increased and influential role for Government."

Included within the general problem and as a manifestation of it is the lack of a clear commitment to develop and use performance-type standards whenever these may appropriately be substituted for certain standards of design, materials, or methods of manufacture which impede technological innovation.

Concern: Lack of a clear cut, national product standards policy inhibits economic growth and disserves public interest.

Possible Actions:

(a) Support the Purpose of Title I (National Standardization) of the Voluntary Standards and Accreditation Act of 1977 (S. 825) but with certain modifications.

This bill was introduced March 1, 1977. Title I provides for the development of a uniform national standardization system for all standards and certification activities undertaken by the private sector. In hearings on a similar bill, S. 3555, on June 21, 1975, the Department of Commerce indicated support for the overall purpose of Title I -- to assure that the public interest will be protected and due process observed in the voluntary standards activities carried out by the private sector. However, the Depearment expressed

its concern about the rigorous regulatory framework of the bill and its awkward procedures. In addition, the Interagency Committee on Standards Policy (chaired by Commerce) has prepared guidelines for the participation by Federal agencies in private sector standards activities. It is anticipated that OMB will publish these guidelines in an OMB Circular, shortly. While these guidelines are not a substitute for Title I of S. 825, they are consistent with its objectives. Available information indicates that the private sector standards community is strongly opposed to S. 825.

The Department of Commerce is now reviewing the provisions of S. 825 with a view towards formulating a Department position.

(b) Prepare new legislation to establish a national policy for maximizing the effectiveness of the U.S. product standards effort, particularly that of the voluntary standards-setting community.

This approach results in (1) an opportunity for appropriate Federal funding of priority standards projects, (2) an opportunity to strengthen the national standards system by providing a solid basis for closer cooperation between the public and private sector and for the Government to supply appropriate guidance as this system develops, and (3) an opportunity to cover related standards matters, such as the assurance of due process.

In preparing such legislation, the Government would work with key private sector standards interests in order to arrive at a mutually satisfactory resolution of important issues, and thereby maximize the efforts of the private sector in the public interest. The new bill could be proposed as an alternative to S. 825, or constitute the basis for suggested modifications to such a bill.

(c) Continue through the Interagency Committee on Standards Policy (ICSP) to promote interagency cooperation and coordination with the private sector.

Substantial progress on this front has been made since the ICSP was re-established about a year and a half ago. This Committee provides the only active Federal Government forum to exchange information on U.S. standards policy and make Government-wide policy recommendations. No significant disadvantages have been identified for this Committee's continuance. Section 209(a) of S. 825 provides for the establishment of an interagency committee on international standardization policy to assist the Secretary of Commerce in his responsibilities under Title II (International Standardization).

(d) Plan jointly with the private-sector standards community (possibly through the ICSP) to identify present needs and their possible resolution.

Such an approach has the obvious advantages and disadvantages of any joint private sector/Government undertaking. The principal advantage would be

the possibility of arriving at mutally agreed solutions and recommendations; the principal disadvantage may be that the recommended solutions lack authority or are too weak. The standards community would probably be favorable to the approach at this time. An earlier effort of this nature produced a useful report -- the LaQue Report of 1965, the report of the ad hoc Panel on Engineering and Commodity Standards.

5. Stimulation of Innovation through Federal Procurement Policy

Present procurement policy, as outlined in the Federal procurement regulations, favors procurement made with maximum competition, using Federal specifications, and the awarding of contracts to the low acquisition price bidder. While these principles are designed to insure that Federal procurement will be made in an open, fair, and honest manner, they tend to result in the purchasing of products with the lowest common denominator with respect to technology. On the other hand, use of procurement specifications, while departing from the normal policies of procurement, can at the same time satisfy the requirements of fair, open and honest procurement and provide incentives to suppliers to bring technological innovation to Government and commercial markets.

Federal procurement policy as a means for speeding diffusion and exploitation of new technology is being addressed by the NBS Experimental Technology Incentives Program (ETIP). Since ETIP's start three years ago, it has successfully helped several agencies to incorporate routinely in ongoing procurement much more cost-effective practices. ETIP's experiments are being evaluated to determine if Federal procurement can be used as a lever to accelerate technology diffusion in producing non-military items.

Concern: Federal procurement policy in its present form does not adequately stimulate technological innovation even though some improvement has been achieved recently.

Possible Actions:

(a) Rely on ETIP experimentation with Federal procurement policy to foster policies favorable for innovation.

The procurement experiments of ETIP have demonstrated the possibility of cost-effectively modifying the procurement practices by improved specification establishment and by applying life cycle costing. It is planned that future experiments should be in the area of value incentive provisions. The ETIP experimentation mode of working closely with various agencies is an effective means of introducing new procurement concepts to the agencies.

On the other hand, it remains to be seen if these experiments will foster continuing innovation. The experiments are limited in size and scope, and may not be the fastest means of implementing innovation-stimulating procurement practices throughout the Government.

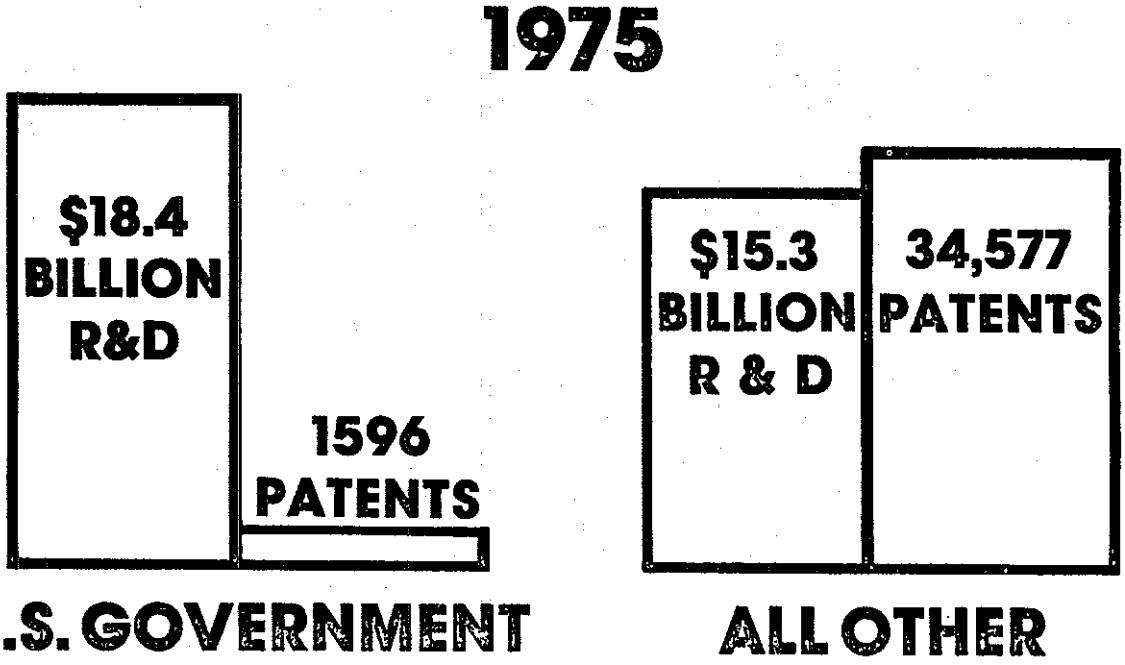
(b) Make creation and diffusion of innovations a more prominent objective of all Federal procurement policy.

Over the long run, this policy might have a high social benefit-cost ratio.

It will probably meet with opposition from beneficiaries of the present policy. Before mandating a Government-wide policy, it would be wise to determine through experimentation the best procedures to follow.

6. Federal Patent Policy

The number of patented inventions resulting from Federal funding is very small compared with the number generated by industry and not-for-profit institutions with their own funds. See the figure below which compares R&D expenditures by U.S. industry and by the Federal Government with the number of patents obtained.* The small number of patents resulting from Government funding is probably associated in part with the different emphases in the aims and types of research conducted with Government and industry funds, but may also be due in part to the small incentive provided by present Federal patent policy.



*Although the number of patents obtained in a given year depends in part on R&D funding in previous years, in the figure both the number of patents and R&D expenditures are given for the same year, 1975, since the relative magnitudes of the expenditures in the Government and private sectors have not changed appreciably over the last few years.

Federal agencies vary widely in their treatment of the property rights to inventions which result from Federally-funded contractor research and development. For example, where the contractor has contributed substantial amounts of money to the development of an invention, and where the investment of additional private risk capital is viewed as necessary to encourage the commercial exploitation of the invention, the Department of Commerce may permit the contractor to retain title to the invention, subject to royalty-free license on behalf of the U.S. Government. The legislation establishing NASA and ERDA envisions that the Government will normally acquire and retain the full property rights, subject to the possibility of waiver to the contractor. Other agencies routinely acquire and retain the full property rights. Applied research and engineering executed within Federal laboratories in support of agency missions also generates U.S. Government-owned patents. About 58 percent of Government-owned patents arise from U.S. employee inventions.

The policy for obtaining protection abroad for Federally-funded inventions is sketchy. Although a 1947 Executive Order designated the Secretary of Commerce as the primary official to protect U.S. technology abroad by obtaining foreign patent protection on Federally-owned inventions, until a year or two ago agencies generally ignored the order, and granted foreign patent rights to their employees. The usual result has been the abandonment of foreign patent protection; NASA and ERDA have been exceptions.

Presently, there are more than a score of statutory policies for handling the proprietary rights on inventions arising from Government-funded R&D. Most of these policies mandate Federal ownership of the inventions. The great variety of policies is confusing to would-be contractors, and the emphasis on Government ownership dissuades some well-qualified companies from taking Government contracts.

A bill has been drafted which would establish for the first time a uniform Federal policy on patentable technology and other intellectual property resulting from Federally-sponsored research and development. The draft bill establishes policies for (1) the allocation of rights to all inventions (contractor and Federal employee) which result from Federal R&D programs, (2) protection of these invention rights through domestic and foreign patenting, and (3) licensing and commercialization of the patented and related technology. The bill provides for contractors to retain ownership of inventions resulting from Federally-sponsored research if they have sufficient interest to seek patent protection and declare an intent to commercialize the invention. The public interest is protected by reserving strong march-in rights to the Government. Enactment of the draft bill would repeal, amend, or abolish the numerous existing differing legislative and Presidential Federal patent policies, and permit maximum utilization of the technology resulting from current Federal R&D annual expenditures of approximately $20 billion.

The draft bill, prepared by the Government Patent Policy Committee of the Federal Council on Science and Technology, has been circulated by OMB to the Executive Departments and agencies for official comment. Upon receipt of the comments, they have and will be accommodated, as appropriate.

Concern: The great variety of existing Federal patent policies with their emphasis on Government ownership of inventions is a hindrance to the commercialization of technology developed with Government funds.

Possible Actions:

(a) The Administration should introduce the draft bill developed by the Government Patent Policy Committee.

The overwhelming majority of policy-level officials, both Presidential appointees and career, now agree with the proposed bill. It is especially noteworthy that the Department of Justice had indicated no objections to the bill, overturning a longstanding policy position set forth in the 1947 Report of the Attorney General, at the Government Patent Policy Committee level but did so during the OMB clearance procedure.

(b) Take no action.

The chances are increasing that the House Committee on Science and Technology, which held hearings on this subject during the closing days of the last session, will itself sponsor legislation in this area, thereby reducing the Executive Branch's influence on the content of patent policy.

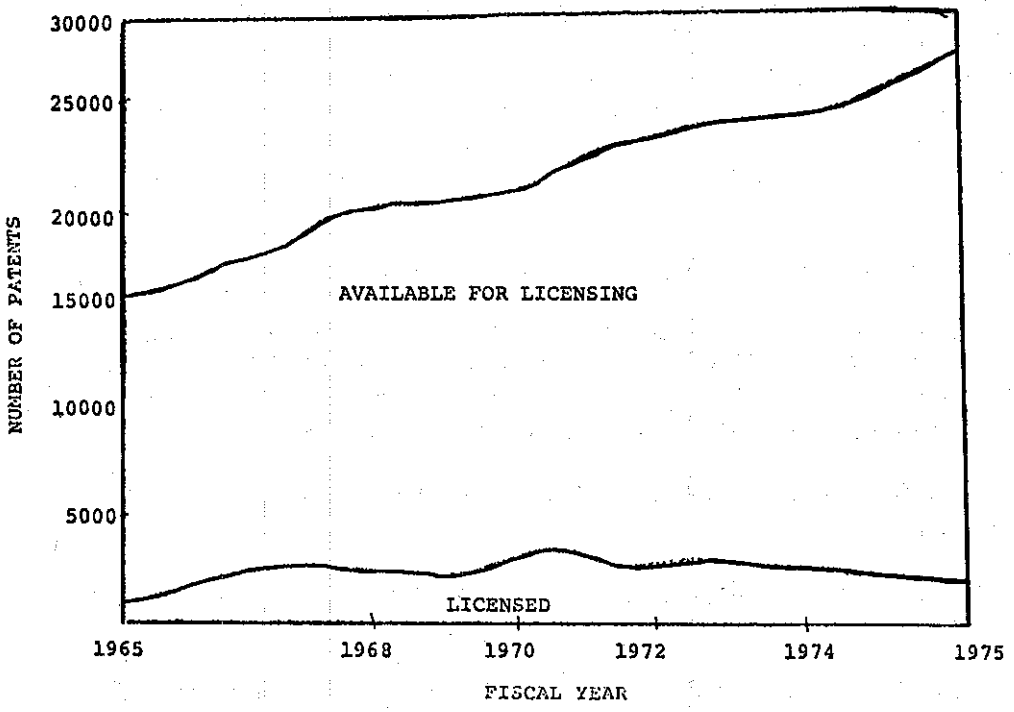
7. Funding of Commercialization of Selected Government Inventions

There are relatively few commercial uses made of Government-owned inventions. In order for a U.S. Government-owned patent to be used by a company, a license must be issued. A tiny fraction of U.S. Government-owned patents available for licensing are actually licensed (see figure on following page).

A partial reason for the lack of commercialization is simple lack of awareness on the part of potential users of the invention; a year-old NTIS program utilizing newsletters, seminars, and exhibits has multiplied several-fold the private sector's awareness level. This program is continuing. Another reason commercialization is no risk is the presumed complexity and uncertainty of getting a license to exploit the invention; the Government Patent Policy Committee is sponsoring a new patent bill which will alleviate the problem.

Perhaps the major reason so few patents issue from U.S. Government-funded R&D is that Government inventions are usually not developed sufficiently to allow a reasonable assessment of commercial potential. Most inventions thus remain in the idea or bench-scale stage. Even those inventions which are fully left undeveloped for other possible applications (e.g., vehicle traffic control). Yet the history of technology has many instances where

U.S. GOVERNMENT OWNED PATENTS



an invention first applied in one field reaches its maximum potential in another field, frequently after considerable time has elapsed (e.g., although the same technology is used for ice-making and space cooling, ice-making had far less impact on U.S. economic development than has air-conditioning).

Concern: Most Government-owned inventions are not commercialized, indeed much Government-funded R&D is not exploited for patentable inventions, so that U.S. taxpayers do not obtain an adequate return on their investment in R&D.

Possible Actions:

(a) Continue the present NTIS program alerting potential users to the existence of Government-owned inventions at present funding and staff level.

The NTIS newsletter is self-supporting, but relies heavily on other Federal agencies to collect and organize information about their inventions. Foreign filing on selected inventions is very small; NTIS will file 25 inventions abroad in FY 1977. The number is limited by agency premature disclosure of the inventions. NTIS licensing of Government-owned inventions has begun on a small scale, but the activity is limited by portfolio size and quality, and by NTIS staff size.

This action would result in a slow growth in commercialization of Government-owned inventions. Some agencies have reported greater licensing activity as a result of NTIS promotion. However, the program has limited potential because of the undeveloped state of most Government-owned inventions.

(b) Fund the commercialization of selected Government-owned inventions.

This action would embrace two somewhat different functions: developing the invention to a prototype stage, where commercial potential could be assessed with reasonable risks; and further promoting its commercialization by sharing start-up costs with the commercial exploiter.

Major disadvantages to this action, other than the money and staff to administer it are:

- the deep-rooted suspicious and "you go your way; I'll go mine" attitudes between Government and industry;
- the dogma that inventions resulting from U.S. Government R&D should be public property, regardless of whether this actually results in non-use; and
- the administrative requirements in managing such a program, which would be similar in size and scope to the largest of private U.S. R&D enterprises.

However, the DoC has been directed by the President to develop plans for more aggressive exploitation of Government-owned inventions, and actions similar to this proposal are becoming routine governmental functions in other nations.

A Government-sponsored invention development and licensing function is performed in every other industrialized nation, and in many of the semi-industrialized nations (e.g., Mexico). The organization performing this function usually obtains proprietary rights to inventions arising out of Government-funded laboratories and frequently assists in the development of privately-sponsored inventions, with a sharing of rights. These nations have set up independent corporations for this purpose because R&D performers usually give this function little or no attention, and the need for management flexibility in a commercial sense.

A variety of financing arrangements are used in other countries to support the development of inventions; including grants, loans, grants convertible to loans in the event of successful projects, and loans convertible to grants in the event of unsuccessful projects.

Such organizations have been successful. Some of them have been very successful, such as ANVAR of France, and its counterpart in Australia. ANVAR consummated nearly as many royalty-bearing licenses in 1975 (many in the U.S.) as all U.S. Government agencies did without royalty, and was completely self-sustaining. The Research and Development Corporation of Japan, a newer organization, is 2/3 self-sustaining on a budget of $10 million. The first of all these agencies, the National Research and Development Council (U.K.) continues to have a record of success.

V. DIFFUSION AND UTILIZATION OF TECHNOLOGY INTERNATIONALLY

The diffusion and utilization of technology to serve foreign policy objectives sometimes is in conflict with domestic policy objectives, but this situation is not peculiar to technology. Rather it is the inevitable result of the need to adjust policies to accommodate rapidly-changing technology within the U.S. and the uncontrollable advances and developments of technology in both communist and non-communist countries. Many benefits accrue to the U.S. from international technology transfer and exchange.

U.S. Government attitudes toward international technology relations have, among other things, led to practices:

- to maintain the freest possible flow of technology across national boundaries, while recognizing that most U.S. technology is owned not by the Government, but by private parties;
- to protect supplies of materials essential to U.S. manufacturing and the domestic economy;
- to exchange technology with developed countries friendly to the U.S. for strengthening of their and our domestic economies;
- to exchange, to a limited degree, technology with many communist countries for reducing potential conflict by strengthening their and our domestic economies;
- to promote international trade, among all nations with whom we have normal relations, and especially U.S. exports of technology-intensive products (including agricultural products);
- to enhance the effectiveness of the United Nations and its affiliated organizations, such as WIPO -- World Intellectual (patents and copyrights) Property Organization -- and UNIDO -- United Nations Industrial Development Organization; and
- to assist the governments of less-developed countries (LDC's) to improve the well-being of their citizens by increased use of technology.

U.S. technology utilization by friendly, but trade-competitive, nations is subject to what some regard as conflicting pressures: the domestic need to increase job opportunities versus the traditional free-flow of technological information and know-how from the U.S.

In the following, the elements of U.S. technology policy relating to the diffusion and utilization of technology for international advantage are discussed under four headings:

A. Export promotion of technology-intensive products,
B. Export control of design and manufacturing technology,
C. Technological support of LDC's, and
D. International standards.

A. Export Promotion of Technology-Intensive Products

Despite the fact that the Department of Commerce (DoC) has active export promotion programs underway, some technology-intensive industries complain that the U.S. Government effort in this area is inadequate. It is charged that the U.S. programs fall far short of those of other industrialized nations in (i) market identification and analyses, (ii) active participation in promotional activities, (iii) cooperation in export control processes, and (iv) competitive financing policies. In the recent study of the telecommunications industry conducted by the Office of Science and Technology,* several recommendations were made by companies for improving our export promotion activities [35].

Concern: No integrated system presently exists either for determining U.S. and foreign barriers, in particular non-tariff barriers, to increased U.S. exports of technology-intensive products, or for formulating coordinated steps toward lowering those barriers, including rejection of any unnecessary proposed new controls, as well as removal of any unnecessary present ones which restrict the export of products.

Possible Actions:

(a) Establish a policy board for export control, including the international transfer of technology per se. The board would be composed of the President's Science Advisor, Director of the National Security Council, Director of Defense Research and Engineering, Assistant Secretary of Commerce for Science and Technology, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, Deputy Administrator of the Energy Research and Development Administration (ERDA), Deputy Administrator of NASA, and the National Intelligence Officer for Economics of the Directorate of Central Intelligence, from among whom the President would appoint a chairman. The board would establish a working group composed of carefully selected individuals from the Government and private sector who would aid in developing positions on broad policy issues. In addition, the board would establish a set of joint Government/industry committees of experts encom-

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*This study may be obtained from the Office of Telecommunications, Department of Commerce.

passing all the technologies in the three major areas of export concern - military products, nuclear power, and commercial technology-intensive products. These committees would provide specific scientific and technical advice to the policy board regarding the products requiring validated licenses. The board would establish the technological guidelines for use by the agencies responsible for administering the controls. All existing Department of Defense (DoD) and DoC committees, whose functions would be replaced by this single interagency board with its coordinated set of Government/industry advisory committees, would be abolished.

The establishment of committees, one for each relevant technology and each composed of experts from both Government and industry in a highly specialized field, would enable the proper expertise to be applied to the difficult questions of the technologies that should be controlled and those that should be decontrolled. It may be difficult initially to establish committees with non-overlapping assignments as well as to develop clear criteria for export control decisions, but industry has considerable motivation not only to participate, but also to expedite success. Having the expert committees report to an interagency policy board would avoid the current overlap of efforts underway in DoD (in International Scientific Affairs and the Directorate of Defense Research and Engineering) and DoC [in the Domestic and International Business Administration (DIBA) Office of Export Administration (OEA)] and elevate the guidance to the Executive Office of the President where interagency disputes are normally settled. The ongoing assessments would provide for generating timely recommendations to the agencies responsible for administering controls in DoC, Department of State and NRC/ERDA on what technologies should be more tightly controlled and what products should be dropped from lists of items requiring the exporter to obtain U.S. Government approval. This "expert committees" mechanism would relieve OEA of the necessity for fundamental technical assessment (for which it is ill-equipped since DIBA is not a technology-based organization) so that OEA could concentrate its traditionally limited and overworked resources on its administrative responsibilities. The same benefits would be expected to accrue to the other administering agencies.

(b) Negotiate a shortened International Export Control Coordinating Committee (CoCom) List and a streamlined means for keeping it updated. Both a shorter current List and a systematic method for keeping it in step with technological advances would be expected to result from implementing (a).

From this effort would come a revised CoCom List to provide U.S. manufacturers and exporters with improved guidance for their marketing efforts to both communist and non-communist countries.

(c) Develop new DoC program(s) to achieve, for selected industrial sectors, a sound assessment of the relative level internationally of technologies, and the direction and velocity of their

progress toward applications in order to provide aid to industry in planning what products to export.

DoC is uniquely qualified to:

- ° make assessments of worldwide industrial technology needs;
- ° bring together public/private sector international forecasting capabilities to supply these needs (for example, by utilizing the results of market research);
- ° project major technology-intensive products of the future and evaluate the likelihood of possible barriers to their export being imposed; and
- ° analyze U.S. product standards and their suitability for world markets.

On the other hand, such DoC programs will face difficulties:

- ° fragmentation of industry into many sectors, and
- ° distrust on the part of industry because of perception that the Government's interest is primarily regulatory.

(d) Assist industry -- particularly firms shifting from military-related to industrial, technology-intensive products -- to achieve expanded export levels through improved market identification and analyses, better Federal promotional practices, and exposure of foreign governmental protective practices.

This assumes there will be joint studies by Government and industry related to balance of payments, barter, and offset. It further assumes that if the Government does not speak up forcefully for more open policies, foreign government protective measures will increase. A well-defined Government commitment to the increase in technology-intensive exports is advocated.

Contraindications are:

- ° lower production costs abroad,
- ° differences between U.S. and foreign product standards [See (c) above],
- ° foreign government bias toward domestic purchases,
- ° export subsidies of foreign governments and other non-tariff barriers,
- ° transfer of U.S. production abroad by multinational corporations, and
- ° foreign government insistence that continued U.S. procurement be tied to foreign replacement and spare parts production (e.g., aircraft industry).

(e) Improve existing means by which Government and industry together can develop a more effective international trade

strategy that accommodates the increasingly expanded emphasis on technology embodied in exportable products.

Because the export licensing process is currently decentralized and allied responsibilities are diffused throughout the Government, industry is often frustrated when trying to elicit sound, timely governmental guidance or responses. Needed is a more effective means to provide manufacturers' views and those of the service industries to be heard by the Government as it develops policies and prepares positions or statements it places before international bodies. The proposed policy board [(a) above] would, if successful, meet this need.

Also needed are a library of translated foreign product standards and specifications, a current log of bidding results on the larger foreign contracts, a compilation of regulatory decisions bearing on international trade, and a worldwide technology directory. The Office of Product Standards in DoC could expand its services to meet these needs.

Opposition may be voiced on several bases:

- ° Maintenance of a complete central information pcint in the face of fragmented governmental responsibilities will be difficult.
- ° There are too many parties involved to permit agreement on the concept.

(f) Continue the efforts to simplify the various export licensing procedures of DoC, Department of State and NRC/ERDA, and so lessen the delays encountered by exporters.

This assumes an active effort by the Administration to move toward a more-nearly free trade policy and to implement as rapidly as possible present DoD efforts to focus national security controls on design and manufacturing technology, rather than on products. An inadequately defined Administration position on international trade policy affecting technology and inadequate DoD allocation of resources to support DoC's OEA efforts to provide exporters with good service are the major reasons for the current delays (up to as long as 18 months) in the issuance of commercial product export licenses. The absence of clearly-defined DoD technical guidance makes it impossible for DoC to provide U.S. exporters with valid advice for developing marketing plans in many potential markets. Furthermore, the delays in issuing licenses create an uncertainty regarding shipment times to markets in countries where payment and other problems exist. In several other countries where comparable licensing requirements apply, the delays and uncertainties are substantially reduced; hence U.S. exporters are placed frequently at a competitive disadvantage.

(g) Improve the financing policies of the Export-Import Bank.

Although the Ex-Im Bank has offered to reduce its rates to meet lower rates of foreign lending institutions, often it does not learn of the lower foreign offers in time to adjust its rates.

In the past, Ex-Im Bank financing has not been used because the interest rates were too high compared to those available in major European nations and Japan which are vigorously seeking world markets. Further, Ex-Im Bank does not get involved early enough in the contract negotiations because it does not discuss financing until there is a signed contract, despite the fact that prospective buyers are not going to sign contracts until they are assured the financing is there. Indicated Ex-Im Bank improvements, therefore, are reduced response time and improved competitiveness in its lending rates.

B. Export Control of Design and Manufacturing Technology

Current Federal policies and mechanisms related to the control of arms, nuclear-related articles and materials, commercial technology-intensive products of strategic military significance and all technology associated with these products are sketched below.

° Technical data commonly used in general education and all other publicly available technical data that do not relate significantly to design, production, or utilization of specific products or industrial processes, including data usually contained in patent applications in U.S. and other countries:

- no restrictions.

° Unclassified technical data developed at U.S. Government's expense, independent of whether they are related to design, production or utilization of specific products or industrial processes:

- The U.S. Government considers these data to be available internationally in the traditional "free flow of ideas" and:

-- Permits the export of such data to all non-communist countries, usually - at least until recently - free of any charge to the recipient. In the future, such transfer may be subject to some "R&D recoupment fee." This policy was promulgated by President Kennedy's memorandum on U.S. Government patent policy of October 10, 1963 which stated in part:

"The public interest is...served by sharing of benefits of Government-financed research and development with foreign countries to a degree consistent with foreign policy."

-- Permits the export of such data to communist countries and Southern Rhodesia if approved by OEA validated license.

° Export of technical data related to the manufacture of products subject to control [such products are specified in the Commodity Control List (CCL)]:

- OEA authorizes the export of all non-military technical data to non-communist countries under various licensing procedures provided, however, that in specified cases the recipient in the foreign country assures the U.S. exporter that it will not reexport either the products resulting from the technical data or the technical data themselves to communist countries without prior specific authorization of DoC. Exports to communist countries are subject to case-by-case approval. Present policy calls for a ban on approval of such exports to Southern Rhodesia, Cuba, Vietnam, Cambodia and North Korea.

° Classified technical data:

- No transfer or export of such data may be effected unless specific approval is granted by the Department of State, DoD, and NRC/ERDA.

° Unclasified technical data related to arms, ammunition and implements of war as described in the Munitions List of the Department of State:

- All such data are embargoed to communist countries and a specific license is required to all destinations from the Office of Munitions Control.

° Unclassified technical data related to nuclear articles, nuclear materials or other nuclear technology:

- All such data are embargoed to communist countries and specific licenses are required to all destinations either by OEA or by NRC. Furthermore, in all cases the Department of State must review and approve the proposed export.

For the most part, these current policies on international technology transfer, exchange and control are based upon the dominant U.S. position at the end of World War II. In that era, because of its significant technological lead, particularly with reference to the USSR, Germany and Japan, the U.S. was able to impose restrictions not only on U.S. exports to communist countries but also on those of our allies. Under the 1951 Battle Act, the export of arms, ammunition and implements of war and any

industrial/commercial products and materials capable of producing such military articles, as well as all related technical data, was prohibited to specific communist countries. Policy implementation of the Battle Act was more specifically implemented in the 1954 Mutual Security Assistance Act, and the present informal consulting procedures with our NATO allies and Japan (CoCom) are continued today under these 1951 and 1954 laws.

Although revisions of the Export Control Act require that the U.S. move toward imposing controls only at internationally-agreed levels and that controls should be removed from products available from other foreign countries, there has never been an adequate effort to assess technology developments in non-communist countries in order to determine what modifications should be made in the CCL. The mere fact that an exporter claims a particular product is produced in some other country, whether in or outside of CoCom, is not sufficient basis for approving the export of the product from the U.S. to a communist country. There is no systematic assessment by the Government, however, to determine the quality and quantity of foreign availability of technology-intensive products. Examination of items on the CCL or CoCom List show that some are of minor military significance to the USSR or are available in comparable quality and sufficient quantity from other countries.

International trade policy negotiations have not provided for a sufficiently free flow of technological products, including what the U.S. considers are valid markets for its commercial products. Many U.S. manufacturers, therefore, have had no alternative but to establish foreign manufacturing facilities or to license their technology in order to gain access to growing foreign markets. This is particularly true for the technology-intensive products, for which the markets outside of the U.S. are at least 25 percent, and in many cases as much as 80 percent, of some U.S. manufacturer's total annual production. This growth of international markets and competition is also taking place in the military and nuclear product area as well. Thus, vigorous efforts must now be made by U.S. international trade negotiators to assure U.S. manufacturers a reasonable share of foreign markets in return for acceptance by the U.S. of sharing our domestic markets with foreign competitors.

The present lack of attention by the Government's technical community to the existing control procedures over design and manufacturing technology to non-communist countries, related to military, nuclear and commercial technology-intensive products, has minimized the ability of the U.S. and its allies to maintain the technological superiority over the USSR we traditionally had. The unnecessary restrictions on U.S. exports of technology-intensive products, combined with the relatively uncontrolled transfer of technology to non-communist countries, may be a factor leading toward the reduction in U.S. employment by some industries which are also facing reduced military requirements.

An element in the technology export control problem is the question of whether it is in the long-term interest of the U.S. to export freely technology per se, as distinct from the export of products embodying the technology. U.S. manufacturers primarily manufacture products for sale and only incidentally are in the busines of exporting technology and technical data. In some cases it is necessary for the U.S. manufacturer to establish a foreign market position for the export of products by agreeing to transfer a certain amount of the production to the foreign country. Whether the Government is able to impose a licensing process which will effectively provide valid technical guidance and control depends upon whether the Government has competent technical expertise informed about the foreign technology capabilities and foreign market conditions facing U.S. manufacturers and exporters. In the absence of prompt, competent U.S. Government guidance, including that affecting national security and nuclear proliferation considerations, U.S. industry has no alternative but to seek arrangements abroad for the production or licensing of its products in order to secure an expanded base for profitable business development.

Concern: No Government agency is responsible for the continuing assessment of foreign technology developments in non-communist countries. This omission contributes to present export controls inadequately protecting national security and economic interests that involve critical design and manufacturing technology.

Possible Actions:

(a) Establish the interagency board described in A(a).

In the process of its establishing technological guidelines for use by the control administering agencies, design and manufacturing technology per se requiring validated licenses would be identified.

(b) Require DoD to provide a continuing technical assessment of its position vis-a-vis the USSR, or other potential adversaries, and identify for DoC those areas of commercial technology which it recommends for control to all foreign destinations. This would be accomplished in the course of the board's work if A(a) and B(a) are implemented.

Present U.S. export controls are administered by DoC and the State Department, both of which consult with DoD as to possible military or other strategic implications. There is presently no requirement or formal procedure, however, for DoD to provide technical criteria or policy guidance in advance to either Department. Thus, decisions can

only be made on a case-by-case basis. One of the recommendations of the recent study by the Defense Science Board [39] was that such a continuing responsibility should be established within DoD. No endorsement of such action has been made by any other Department or the President.

(c) Establish within the Science and Technology Secretariat of DoC (See Appendix D, I) a capability for the analysis of technology developments in non-communist countries, based upon information available from Government and industry sources, to assess if more control of technology per se -- particularly military-related technology which could become commercially significant -- is advisable. This DoC activity could provide analyses to the interagency board described in A(a) and B(a).

At present, various uncoordinated activities by U.S. military, intelligence and other Government agencies are directed to the collection of technical information on commercial and military production capabilities outside of the U.S. While the Central Intelligence Agency has the primary responsibility for foreign intelligence gathering, its main responsibility is to focus on developments within the borders of potential military adversaries. All U.S. manufacturers actively engaged in exporting are continuously and independently assessing foreign market potentials and the strength of their foreign competitors. Some opposition may arise to this new role for DoC. Nevertheless, the existence of such an assessment capability could constitute a far more effective and efficient means than the current fragmented approach in identifying and protecting U.S. interests.

(d) Determine the consequences of making all exports of U.S. "frontier" technology per se (i.e., data and know-how related to the design and/or production of specific militarily-significant products or processes) subject to Government approval (validated license) based on the potential impact on the balance of payments, employment opportunities, national security, and the U.S. responsibility vis-a-vis the political, strategic, and economic interests of the international community.

This additional control would be aimed at minimizing any loss of U.S. product exports and jobs associated with the accelerated buildup of foreign competition with U.S. technology. It would meet with opposition by U.S. multinationals. However, if accompanied by significant reduced control on products, as expected if (a) is implemented, the favorable reaction toward increasing revenues through the more lucrative product sales might overwhelm objections. This new control could result in economic and political retaliation by affected foreign governments. It might also slow down the export process. A systematic study of the type the proposed Industrial Technical Analysis Office (Appendix D, I) could make is desirable to provide policy-makers with data and analysis to back up philosophical discussions on this matter.

C. Technological Support of Less-Developed Countries

Since World War II, the U.S. has contributed technical and financial assistance to the nations of the Third World. This assistance has many forms: financial grants, technical advice, training in U.S. universities, military assistance, funding for multilateral agencies (such as the United Nations Development Program, the World Bank, the International Monetary Fund, the InterAmerican Bank, and others), provision of food, the Peace Corps, and research in American institutions to solve technical problems of the Third World. NASA, USDA, ERDA, NBS, HEW, and EPA have assisted these nations for many years in obtaining access to the worldwide pool of space, agriculture, nuclear energy, product standards, health care, and environmental technologies. More recently, NTIS has helped these countries create effective general technology extension services. Although there is some uneasiness that U.S. technology assistance to LDC's will result eventually in loss of U.S. export markets, the Federal policy remains supportive of U.S. technology utilization by LDC's.

As the economies of the other industrialized countries improve, they too become major contributors to the worldwide assistance program. At the present, many Western European countries contribute a substantially larger share of their GNP to Third World development than does the U.S.

Substantial though the total assistance effort may be, the less-developed countries are saying it is not enough and are vigorously demanding the creation of a "New Economic Order," in which their share of the world's goods will be larger.

A major feature of these demands is improved access to commercially important technology on terms more favorable to their industrial firms than has been customary in the past. They demand that the U.S. Government regulate the behavior of U.S. industrial firms engaged in international trade; that the U.S. Government devote a certain fraction of its R&D expenditures to solution of LDC problems; that the U.S. increase its funding for financial and technical assistance that will help develop the technological infrastructure of the LDC's; and that the U.S. Government make American technology readily available. Some of the actions requested are not within the authority of the U.S. Government, under present law, to grant. Others will require Congressional action on appropriations that may be politically unacceptable. New Federal actions, however, could help LDC's progress toward their technological goals, improve the international political climate and help develop mutually profitable trading partnerships between the U.S. and LDC's.

Concern: A program of technological aid to LDC's needs to be developed which contributes to the progress of LDC's and is consistent with the economic needs of the U.S. free enterprise system.

Possible Actions:

(a) Participate more actively in the international effort to develop a mutually agreeable "Code of Behavior" for multinational corporations and to encourage multinational corporations to invest in LDC's.

Success in reaching a mutually agreeable code would reduce the acrimonious tone of many governmental and non-governmental negotiations, promote international trade, and heighten international cooperation in other fields. If agreement is really impossible, because of differences in philosophy, continued discussion of the issues, particularly with the U.S. Government as an active participant, could exacerbate already difficult relationships.

(b) Organize additional U.S./LDC joint commissions for mutually beneficial economic and technological collaboration.

Such commissions provide a framework on which an action program can be based; that is, they are a mechanism for identifying projects of joint interest and for carrying them out. Experience with the commissions established thus far is not encouraging; they are slow, bound up in red tape, and not action-oriented. We should learn how to make the existing ones more effective, as a prelude to initiating new commissions.

(c) Organize consortia of developed countries to participate jointly in commission-type programs for economic and social development with specific LDC's.

Such a commission would share the total effort among several countries and may produce innovative ideas for development. On the other hand, reaching agreement in a finite time among the participating developed countries on how to share costs and benefits would be nearly impossible, and such a commission would certainly be more cumbersome and slower to act than a bilateral commission.

(d) Work through the World Bank to plan and execute the industrial development of Third World countries.

The World Bank is a highly respected, effective organization and its intervention would be well-received. Problems with this actions are: the resources of the World Bank are already fully committed; the management of the Bank would say that they already assist economic development through their loan programs and the most urgent need is additional capital for investment; and U.S. priorities would be only one set among many that would be considered by the Bank.

(e) Expand the level of support for technological development in traditional ways.

The many existing channels for technological support, while not altogether efficient, are in place and can be used readily. This option may also prove the least expensive for the U.S. A disadvantage is that support for technological development is given a low priority in the programs of the existing channels, particularly in U.S. AID, where technological development is not one of the areas specified by Congress for AID action. Further, the traditional multilateral mechanisms have not demonstrated adequate effectiveness in such projects.

(f) Promote mutually advantageous cooperation in industrial R&D not being pursued by U.S. private interests.

Duplication of expensive projects could be minimized, while the U.S. could get some return from possibly unique resources (climate, minerals, skills) in the LDC's. On the other hand, choice of projects to satisfy all conditions could be difficult; to avoid conflict with U.S. private interests, the projects chosen could be expensive or those with low probability of success.

(g) Assist technological infrastructure development in LDC's.

Relatively small U.S. resources of money and manpower are required, while the ability of LDC's to undertake many kinds of technological enterprise is substantially enhanced. The disadvantage is that establishment of broad infrastructure may divert LDC resources from projects with more immediate payoff.

In all of the foregoing, the U.S. private sector should be an active participant in developing policies which aid the LDC's while protecting the interests of the private sector.

D. International Product Standards

The rapid growth of technology has resulted in the proliferation of foreign national product standards which may form technical barriers to international trade of U.S. products. For example, different standards for sweep and timing in TV receivers require costly modification of U.S.-made TV's before they can be sold in Europe; hence, U.S. exports of TV's to Europe are negligible.

The development of international standards to reduce the incidence of standards-related trade barriers is accelerating, yet there is a need for at least 10,000 more such standards. The increasing likelihood of national adoption of these international standards could prove trouble-

some for U.S. export (and import) interests if such standards are incompatible with U.S. standards and engineering practices. International standards can become referenced in foreign government regulations and government procurement specifications. The proposed GATT (General Agreement on Tariffs and Trade) Standards Code would give added impetus to national adoption of international standards. Their adoption by developing countries is especially probable. A preliminary study by the National Bureau of Standards found that 52 percent of U.S. exports are highly sensitive to product standards.

Our principal trading competitors are devoting considerable resources to ensuring the compatibility of international standards with their own engineering practices. The Japanese government provides 100 percent of the income of the Japanese member of the principal international standards-writing organization (the Inernational Organization for Standardization); the French government provides about 50 percent. The U.S. Government neither financially supports the U.S. member (the American National Standards Institute) nor officially recognizes it for this important responsibility.

Concern: U.S. trade interests are likely to suffer unless the U.S. is more effective in development of international product standards.

Possible Actions:

(a) Propose a joint Federal/private sector study to identify U.S. needs in the international standards area, assess existing measures to meet these needs, and prepare an action plan to meet unfulfilled needs.

Gaining the positive cooperation of key private sector standards interests would be important. This could prove difficult in view of limited resources in both the Federal and private sectors, and the possible fear by private sector standards interests that such an effort could become a forerunner of unwanted Federal interference in U.S. participation in non-treaty international standards organizations. In any event, the identification of specific problem areas is a necessary step in an attempt to strengthen U.S. effectiveness in international standards activities. The Interagency Committee on Standards Policy (ICSP), chaired by the Department of Commerce Deputy Assistant Secretary for Product Standards, should consider such a study and explore its possible implementation with the private sector.

(b) Support Title II (International Standardization) of the Voluntary Standards and Accreditation Act of 1977 (S. 825), but with certain modifications.

Title II provides a framework to strengthen U.S. effectiveness in international standardization activities. This bill was introduced March 1, 1977. In testimony last year on S. 3555, a similar bill, the Department of Commerce indicated support for the concept of Title II but indicated that its provisions should be carefully analyzed and redrafted to reflect criticisms directed at an earlier bill (S. 1761, the "International Voluntary Standards Cooperation Act of 1973") on this subject.

The Department of Commerce is now reviewing the provisions of S. 825 with a view toward formulating a Department position.

VI. RECOMMENDATIONS FOR AN IMPROVED NATIONAL TECHNOLOGY POLICY

The major elements of U.S. Federal technology policy affecting economic growth have been discussed in Sections III-V. That discussion reveals the lack of broadly-based, systematic, and continuous planning towards a coordinated, national technology policy. Many elements of policy have been carefully conceived and executed with consideration of potential national impact. Others have apparently developed without such planning and without coordination among agencies.

This pluralistic development of the elements of Federal technology policy has led to a technology utilization that has produced very impressive results. Nevertheless, since the U.S. must determine the national interest out of a mix of often conflicting and contradictory goals of relatively narrow-interest groups, the lack of adequate national policy planning in the rapidly changing field of technology is damaging. In particular, the uncertainties associated with the absence of a solid definition and reasonable degree of continuity of Federal technology policy can result in a reduction of the private sector's interest and investment in technological innovation.

Several possible actions which would contribute to a coherent national technology policy have been discussed in Sections III-V. Some of these are new, while others are being partially implemented. The latter can be adequately implemented by continuation and/or straightforward expansion of ongoing programs.

Adequate mechanisms are in place for improving some elements of national policy:

- A continuing dialogue involving the Departments of Commerce and Justice and the Office of Management and Budget is aimed at improving the patent system.

- Concern for basic R&D support and skilled S&T manpower development are part of the statutory responsibility of the new Office of Science and Technology Policy in the Executive Office of the President.

- The improvement of information services is being pursued by the National Technical Information Service, NASA, the Department of Defense, the Department of Agriculture, the Energy Research and Development Administration, and other agencies.

- A uniform Federal patent policy bill has been drafted by an interagency committee, a bill which would greatly improve this element of national technology policy.

The DoC has programs underway in many areas that form what could be integrated into a more adequate national policy:

- Consumer technology is being addressed by the Office of Product Standards and the National Bureau of Standards through new appliance energy efficiency, laboratory accreditation, and consumer product labeling programs.
- Standards activities that impact on two significant barriers to innovation, namely a fragmented market and uncertainty, are the concern of the National Bureau of Standards.
- Federal procurement policies are being improved through the NBS Experimental Technology Incentives Program.
- The commercialization of selected Government inventions is being promoted through the National Technical Information Service.
- The Office of Product Standards is involved in international standards generation.

Some further measures that can be taken by the Department of Commerce to serve more adequately in the Executive Branch as a focal point for technological innovation are discussed in Appendix D. We believe the following would contribute significantly to improved policy:

Industrial Technology Analysis Office (Appendix D, I)*
Every proposed national policy, whether or not obviously technology related, should be evaluated for its potential impact on technology. The means for such analyses are lacking. An industrial technology analysis office should be established immediately in DoC. This office would evaluate proposed U.S. Government actions against the goal of U.S. technology policy to maximize the capacity to create and utilize technology for accomplishing national objectives. It would perform analyses of:

- technico-economic indicators related to economic and industrial growth and productivity;
- technological factors in foreign trade and direct foreign investment, including costs and benefits of technology transfer;
- resources (manpower, capital, etc.) applied to the generation and acquisition of technology;
- effectiveness of various governmental policies in promoting the Nation's technological health;

° legal, regulatory, institutional and other barriers to technological innovation; and

° social cost-benefits of currently debated or anticipated major technological developments.

In 1976 the President's Technology Advisory Group on the Contributions of Technology to Economic Strength requested the Vice President and the Secretary of Commerce to form such an office immediately in the Department of Commerce. We strongly endorse this recommendation.

In addition, we would like to suggest the following areas for priority attention:

Industrial R&D (Section III, A)
Some types of industrial R&D of high potential social value are not being performed because the economic rewards to individual companies are not great enough and the risks and costs are too high. The Federal Government should investigate direct (grants, loans, etc.) and indirect (tax, regulation, etc.) means of promoting the needed technological innovation in the private sector.

Modification of regulatory inhibitions on innovation (Section IV, A, 1)
The present regulatory climate contains unnecessary disincentives for technological innovation. Under the Office of Science and Technology Policy leadership, actions should be undertaken to strengthen the required data base, and to develop more appropriate mechanisms for deciding on acceptable risks and developing optimum regulatory strategies. Also, more adequate assessments of the probable impacts on technological innovation, as well as costs vs. benefits of such regulatory strategies, are needed.

Improving the climate for starting technology-based enterprises (Section IV, B)
The U.S. economy is losing a traditional growth stimulus because the present tax and regulatory climate is not conducive to the start-up of new advanced-technology companies. The Departments of Commerce and Treasury should work with the Securities and Exchange Commission to investigate a variety of possible remedial actions.

Innovation information for state and local governments (Section IV, C, 2)
The present scattered Federal Government pilot programs aimed at providing innovation information to state and local governments are not adequate to supply the needs and to capitalize on the potential for productivity increases in these sectors. The existing demonstration projects should be administratively consolidated and strengthened.

Export promotion of technology-intensive products (Section V, A)
The economic benefits of technology-intensive products exported from the U.S. are being less and less fully realized. Additional foreign

markets must be developed for nonmilitary technology products. This is especially necessary to create employment opportunities to compensate for those that may be lost if foreign military sales by U.S. aerospace and defense-related industries are reduced. The Government should work with industry to streamline further the various export control procedures and reporting requirements, to shorten the list of commercial products or technical data requiring specific permission to export, to continue reducing delays in the various export licensing processes, to improve efforts in market identification and analyses for technology-intensive products, to develop better Federal promotional practices, and to improve the relevant financing policies to be more competitive with foreign countries.

Export control of design and manufacturing technology (Section V, B) Export control involves the Departments of Commerce, State, Defense, as well as the Energy Research and Development Administration, NASA, the Nuclear Regulatory Commission, the National Security Council, and the Intelligence Community. A recent turnabout in Defense thinking, increased concern of the Congress, and new attitudes on arms exports and nuclear proliferation indicated by the Carter Administration have created the need and opportunity for a greatly improved policy. There is no satisfactory interagency means for addressing these issues, nor is consultation with industry any better. Both Commerce and Defense have elaborate committee structures that are foundering because top-level leadership is lacking. The Executive Office of the President through OSTP or NSC, should assume leadership in developing an export control and technology transfer policy which better serves both U.S. national security and economic interests.

Technological support of less-developed countries (LDC's) (Section V, C) Technology issues relevant to LDC's have been receiving too low priority. An unsound policy in this field could have very large adverse impacts on the economy and on foreign relations. A U.N. Conference on Science and Technology for Development in 1979 requires the establishment of a U.S. policy which contributes to the progress of LDC's while being consistent with U.S. interests. The Departments of State and Commerce should work closely with industry to promote cooperation in industrial R&D and to assist technological infrastructure development in LDC's.

We believe these eight elements of technology policy, along with those elements which current programs are adequately (or nearly adequately) implementing would ultimately lead to a much improved, coherent U.S. technology policy. We recommend that the eight elements listed for priority attention be pursued on a pilot basis, with improvements in implementation based on continuous evaluation involving the private sector.

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APPENDIX A

RECENT HISTORY OF FEDERAL EFFORTS IN CIVILIAN TECHNOLOGY

The demonstrated importance of science and technology to the Nation's well-being, along with the trends in our civilian technology efforts, have resulted in considerable debate and study within the Government ever since the beginning of the first Nixon Administration. As a result of a very intense debate within the Administration about the causes of the deteriorating U.S. situation in international trade, President Nixon made the following statement regarding science and technology in his speech announcing New Economic Policy on August 15, 1971:

> Looking to the future, I have directed the Secretary of the Treasury to recommend to Congress in January new tax proposals for stimulating research and development of new industries and new technologies to help provide the 20 million jobs that America needs for the young people who will be coming into the job market in the next decade.

Much the same was stated on several other occasions shortly thereafter, most notably in President Nixon's address to a joint session of Congress on September 9, 1971.

1. Magruder Effort

The proposals of tax incentives for industrial R&D were never implemented. However, from September 1971 to March 1972 the Nixon Administration mounted a top priority effort under the direction of William M. Magruder to produce a package of proposals addressing three goals: the application of high technology know-how to major domestic problems, the improvement of the U.S. position in international trade, and the reduction of unemployment among American scientists and engineers [36]. These goals were essentially the same as President Nixon enunciated on August 15, 1971 and as those in his address to a joint session of Congress on September 9, 1971.

In the Magruder effort, hundreds of Government bureaucrats prepared and evaluated an ambitious list of proposals which, it was estimated, would cost $1.5 billion in FY 1973 and $11 billion through FY 1977 to implement. Thousands of ideas were elicited through several hundred letters to trade associations and individual companies, and over a hundred private sector consultants were called to the White House. An interagency task force explored tax incentives and other financing mechanisms; another task force addressed international technology transfer. The Office of Science and Technology in the Executive Office of the President was organized into nine working groups to cover specific areas (e.g., communications for social needs). Four of President Nixon's top advisors spent several hundred hours reviewing the recommendations.

In spite of this top priority effort, no major proposals were funded and there was no dramatic impact on Federal science and technology policy. Some close observers felt that there were two major reasons for this: (1) the shortage of money for new programs in the FY 1973 Federal budget, and (2) inadequate understanding of the nature of the technological innovation process and how the Federal Government could effectively promote this process [36].

2. President's 1972 Science and Technology Message to Congress

On March 16, 1972, following the Magruder effort, President Nixon delivered a special message to Congress on Science and Technology, the first such message in history devoted solely to science and technology. In this message, President Nixon did not call for new major initiatives but for a clear definition of goals and the careful development of strategies for future initiatives in this area.

(a) Assessment and Experimental Programs. To aid in the development of this strategy, three small study-type programs were established.

° A program office, the Office of National R&D Assessment, was set up in the National Science Foundation to support assessments and studies focused specifically on barriers to technological innovation and on the consequences of adopting alternative Federal policies to reduce or eliminate these barriers. The recently released summary report [34], based on the results of the first three years of this program, concludes that the state of understanding of technological innovation is still too undeveloped to warrant strong conclusions with respect to Government policy to alter innovation behavior.

The two other programs established in 1972 were located in the National Science Foundation and the National Bureau of Standards. These programs were aimed at determining effective ways of stimulating non-Federal investment in R&D and of improving the application of research and development results. Experiments were set up to test a variety of partnership arrangements among the various levels of government, private firms and universities; to explore new arrangements for cost-sharing, patent licensing and research support; and to test incentives for industrial research associations.

° The National Science Foundation program, the Experimental R&D Incentives Program (ERDIP), incurred new obligations of $11.5 million, $10.5 million, $1.8 million, and $2 million in Fiscal Years 1973-76, respectively. Since many of these obligations were for long-term contracts, the actual expenditures for the same periods were $2.0 million, $3.7 million, and $5.0 million. In August 1975, ERDIP was incorporated as a key building block of a new NSF Division of Intergovernmental Science and Public Technology.

° The National Bureau of Standards program, the Experimental Technology Incentives Program (ETIP) incurred obligations of $0.8 million, $6.1 million, $2.7 million and $4.1 million in Fiscal Years 1973-76, respectively. Since most of these obligations were for long-term contracts, the actual expenditures for the same periods were $0.8 million, $0.7 million, $2.0 million and $4.1 million. ETIP has supported experiments in Government procurement, regulations, R&D sponsorship and subsidies, many of which are now entering evaluation phases. Congress has recently developed legislation authorizing appropriations for the ETIP program through September 30, 1978.

(b) Additional Department of Commerce Responsibilities. In the President's 1972 Science and Technology message to Congress, the Secretary of Commerce was also directed to work with the President's Science Advisor to develop plans for a new systematic effort to promote actively the licensing of U.S. Government-owned patents and to obtain domestic and foreign patent protection for technology owned by the U.S. Government in order to promote the transfer of this technology into the civilian economy. The Department's National Technical Information Service (NTIS) is presently conducting a program which involves evaluation of Government-owned inventions and their promotion, foreign filing, and licensing of selected inventions. Promotion is accomplished by publications, seminars, and direct contact with prospective licensees. Foreign patent protection has been filed for over 30 U.S. Government-owned inventions. Although licensing authority was only granted to NTIS very recently, three royalty-bearing license agreements are currently being negotiated, and prospects have been identified for an additional three inventions.

The 1972 Science and Technology message also called on the Department of Commerce to be the focal point within the Executive Branch for policies concerning industrial research and development. The Department was directed to appraise, on a continuing basis, the technological strengths and weaknesses of American industry; to work with other agencies in identifying barriers to industrial progress; and to propose measures to assure a vigorous state of industrial progress. Some work has been undertaken in the Department along these lines, but as is spelled out in Appendix D of this paper, we feel that more can and should be done.

3. Congressional Actions

In line with the Executive Branch's posture, Congress has also moved toward more study of the role of science and technology in our society. Numerous hearings have been held on the subject, including the extensive set conducted during the last three years by the House Committee on Science and Technology on science and technology policy and organization. In 1972, an Office of Technology Assessment (OTA) was established to provide assessments for Congressional Committees of the impacts of

technologies along with analyses of alternatives. OTA's work is supposed to complement that of the Congressional Research Service in the Library of Congress and of the General Accounting Office.

4. Abolishment of OST and PSAC

Two other features of the recent history of the Government's science and technology policy should be noted. One of these was the abolishment at the end of 1972 by President Nixon of the President's Science Advisory Council (PSAC) and his Office of Science and Technology, and the transfer of the function of his Science Advisor from the Director of OST to the Director of the National Science Foundation. The other was a rather drastic curtailment of the Government's funding of R&D and other forms of support of science in real terms, especially from 1972 to 1975.

5. Establishment of OSTP

The policies pursued since 1972 -- curtailment of funding for R&D and other forms of support of science in real terms, postponement of new initiatives pending completion of experiments, and lack of a direct S&T presence in the White House -- have been widely criticized as harmful to the public good. Among the criticisms that have been advanced are the following three:

- First, speedy action is called for to counteract the unfavorable trends in U.S. science and technology; and the longer the delay, the more damage will be done and the more difficult it will be to reverse these trends.

- Second, although the experiments described in 2(a) are helpful, the Government should not wait for definitive results before taking any action, since it is not probable that experiments can lead to definitive results in a reasonable time in such a complex subject as a national technology policy.

- Third, our knowledge of the innovation process and of what makes a country progress technologically, though far from perfect, is sufficient to take certain steps to raise the general level of technological development and to provide a general direction for the effort.

In response to these and other criticisms, and at the recommendation of Vice President Rockefeller, in 1975 President Ford recommended to Congress the establishment, this time statutorily, of the President's Office of Science and Technology Policy. It was proposed that the OSTP would not act as an advocate of science and technology, but rather would provide advice on science and technology matters as they affect

all national policy decisions. The Congress responded to this recommendation and on May 11, 1976, President Ford signed into law the bill establishing an Office of Science and Technology Policy and indicated his intention to make the director his Science Advisor. The law set forth the basic guidelines of the Nation's science and technology policy and requires OSTP, among other things, to advise the President on all scientific and technological issues of national concern, to evaluate the Federal science and technology effort; to assist OMB in reviewing Federal R&D budgets; to assist the President in providing general leadership and coordination in Federal R&D programs; and to report annually to Congress on the state of science and technology in the economy. This law also authorized the President to establish for a period of two years a President's Committee on Science and Technology to explore and recommend to the President the best possible structure and modus operandi of OSTP for the future.

In anticipation of the establishment of the Office of Science and Technology Policy in the Executive Office of the President, President Ford in November 1975, formed two science and technology advisory groups. One group focused on contributions of technology to economic strength ("Ramo Group") and the other was concerned with anticipated advances in science and technology ("Baker Group"). In meetings of the Ramo Group, the need to stimulate innovation was identified as a priority issue, and concern was expressed that no Executive Branch agency has taken a leadership role in stimulating civilian technological innovation [37]. The Ramo Group formally suggested to Vice President Rockefeller and Secretary of Commerce Richardson on May 18, 1976 that the Department of Commerce assume this role.

APPENDIX B

FOREIGN EXPERIENCE IN STIMULATING TECHNOLOGICAL INNOVATION

Several foreign governments have active programs for stimulating technological innovation in the private sector. Many criteria have been advanced for Government intervention in the marketplace. These include situations when the market fails to allocate its resources properly because of:

- lack of information on needs, opportunities and constraints;
- the fruits of a company's innovation activity cannot be completely captured by the company itself;
- the market structure inhibits change;
- market decisions are strongly influenced by political considerations;
- national goals (e.g., security, balance of trade) are served; and
- risks and/or costs are too large for the private sector to handle.

Opinions differ on the acceptability of the various criteria.

Government action to stimulate technological innovation can take several forms. Specific measures can be categorized in a number of ways. For example, in the report of the two-year study directed by MIT's J. Herbert Hollomon and Thomas J. Allen, Jr., of the ways in which the governments of France, Germany, the Netherlands, the United Kingdom and Japan influence technological change, 12 (sometimes overlapping) government mechanisms which impact on technological change are identified, each mechanism comprising a collection of specific programs, institutional laws and regulations [19]. In the order of their decreasing frequency of use by the five countries, the mechanisms are:

(a) reduction of the cost to firms of undertaking innovation (e.g., loans, grants, tax credits, deductions, loan guarantees);

(b) measures to ameliorate adverse effects of technology on the environment and natural resources (e.g., pollution control laws, effluent taxes, tax incentives for pollution control devices);

(c) dissemination of technical information (e.g., information centers, support for cooperative research);

(d) employment of market forces (e.g., Government procurement, performance standards, international trade policies);

(e) reduction of the probability of technical or commercial failure (e.g., technical consultation and testing, market information services, market protection strategies);

(f) influence on the availability, utilization and mobility of managerial and technical manpower (e.g., training programs);

(g) facilitation of market invasion (venture capital, incorporation laws, compulsory subcontracting);

(h) restructure of an industry sector (e.g., mergers, state ownership);

(i) assistance for the generation and utilization of technical knowledge (e.g., R&D support, technology transfer);

(j) amelioration of cost to labor of technological change and internationalization of the human costs associated with innovative activity (e.g., regulations on dismissals, retraining, unemployment compensation, employment counseling, job referrals);

(k) influence on the organization and management of individual firms (e.g., monetary aid contingent on adoption of project management technique and performance of market surveys); and

(l) increase in the rewards to firms for successful innovation (e.g., through policies on patents, licenses, trade regulations, preference taxes).

Of these 12 mechanisms, three [(c) information dissemination, (f) manpower, and (i) technology generation] are concerned with assuring a resource base for technological change; two [(b) environmental and safety controls and (j) lessening labor resistance] are mechanisms to ameliorate the consequences of technological change; and the remaining seven deal directly with the innovation process, itself.

In this five country study, it was found useful for purposes of understanding industry differences in the effectiveness of Government measures affecting innovation, to categorize the 12 mechanisms according to their effectiveness on the three stages of a model of the innovation process developed by James M. Utterback and William J. Abernathy [38, 19]. In this model, a firm is regarded as "maturing" in its innovation strategy through time, beginning with a very flexible or fluid stage of product design, progressing through a transition period of highly technologically competitive strategies, and arriving finally at a more rigid state where primary attention is placed on cost reduction and other market position improvements. Four of the 12 mechanisms are most effective for the fluid stage:

(a) cost reduction,
(c) dissemination of technical information,

(d) employment of market forces, and
(g) facilitation of market invasion.

Five mechanisms impact most effectively on the transition phase:

(e) reduction of risk,
(f) manpower availability,
(i) creation of new technology,
(k) influence on firm organization, and
(l) increase in rewards.

In the final, more rigid stage, the most important mechanisms are:

(b) environmental and safety controls,
(g) facilitation of market invasion,
(h) restructure of the sector,
(j) lessening of labor resistance, and again
(l) increase in rewards.

In the five countries studied, the German government's emphasis was on measures effecting the early stages, whereas Great Britain's emphasis was on the late stages. Japan emphasized mainly funding, technology transfer and regulation. There are also some notable differences in the five countries in the types of government activity encountered among different industries. For instance, reduction in cost through funding (a fluid phase action) is dominant in the computer and electronics industries; technology transfer (a fluid phase action) is dominant in the textile industry, and environment/safety regulations (a final stage activity) is most important in industrial chemicals and autos.

The MIT study showed no strong evidence that the various Government measures were particularly effective in stimulating technological innovation, with the possible exception of environmental and safety regulations which had a positive effect.

A different classification of Government measures affecting industrial innovation is presented in the October 1975 OECD report on policies for the stimulation of industrial innovation [20]. The measures are grouped into three categories.

The first category consists of measures whose specific function is to stimulate innovation. These include aid for industrial research associations, establishment of "brokerage" facilities and mechanisms for transferring technology, measures for aiding industry directly with its R&D (through grants, loans, etc.), and the use of Government laboratories for industrial R&D.

The second category consists of non-specific measures whose main functions are not to stimulate technological innovation, but which affect innovation

through the climate they create. These include information policy measures concerning science and technology, fiscal policy measures, standardization measures and controls, patent and licensing regulations, manpower training, export policy, etc.

The third category of measures is labeled "major programs." These are measures to mobilize resources to stimulate innovation in a particular technological field. For instance, Japan in 1969 instituted a National Research and Development Program focused on nine technologies, including magnetohydrodynamic generation, electric cars, aircraft turbofan engines, pattern information processing, and high-performance computer systems.

France, Sweden, Canada, Norway and Finland emphasize the first category, specific measures. The United Kingdom and Japan use both the first and third categories, specific measures and major programs, whereas the U.S., the Netherlands, and Germany use measures in all three categories. The OECD study found that in general, large-scale enterprises seem better able to take advantage of non-specific policies and policies based on major programs, whereas specific policies seem to benefit all types of enterprises.

The findings and suggestions of the MIT and OECD studies are instructive. On the other hand, caution must be exercised in applying the results of foreign experience to our own nation, because of the substantially larger size of the U.S. economy, and differences in such factors as industry-Government relations and antitrust laws and regulations.

APPENDIX C - POSSIBLE FEDERAL TECHNOLOGY POLICY ACTIONS WITH PROS AND CONS

A SCHEMATIC TABLE OF OPTIONS

Item No.	OPTION	PROS	CONS
A.	ANALYSIS AND PLANNING To provide for a continuous assessment of the country's technological needs and technology development efforts, establish a center for long-term technico-economic systems analysis and industrial technology policy planning: The policies to assure adequate supply of energy and other raw materials, supply of S&T manpower and R&D funds, adequate supply of capital, balance between economic growth and healthy environment, etc. To reflect different viewpoints, the center should be assisted by interagency and government-industry advisory groups.	o The present economic policy advisory mechanism is short-term and ad hoc in nature, and thus ignores technological variables to the detriment of the long-term national interest. o Most initiatives designed to influence technology policy or change priorities will require expenditures of public funds which should be made only on the basis of careful long-term analysis and coherent evaluation of alternatives. o Analysis of this type would be beneficial to decision-making in the Executive Branch, Congress, and private industry on other subjects in addition to technology.	o Some increase in the budget and bureaucracy. o Overlap with some present responsibilities of other agencies (such as assessment of the supply of S&T manpower at NSF).

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY Resource assurance		
1.	Design coordinated government policies which would assure a long-term supply of skilled S&T manpower, including blue collar craftsmen, with an appropriate occupational and skill mix.	o In the past, the country (and the Government) has largely relied on market forces to perform this function. The market forces performed this function reasonably effectively until the Government and other external forces started to "meddle" with the system. At least three observations make the change of the past policy an imperative: (a) The Government's decision to push for space exploration and technologically sophisticated defense capability, initiated in 1957 (emergence of Sputnik) and greatly accelerated in 1961, drastically upset the past equilibrium, by pulling the best scientists and engineers away from civilian technology into the chosen priorities. (b) By the middle of the 1960's, space and defense technology was drastically curtailed. The result of this curtailment has been that between 1968 and 1974 some 400,000 professionally trained scientists and engineers had to look for jobs other than those for which they were trained and, what is even more important, the current output of scientists and engineers has been reduced very much below the level needed by the economy in some fields. (c) An even more disturbing observation is that higher rates of	o Formulation of optimum policy in an environment of dynamic technology might be very difficult, if not impossible. o The program would represent yet "another intrusion" into what historically has been essentially a free social decision-making. [o Potential opposition by some agencies which presently have the jurisdiction over the subject matter.]

Item No.	OPTION	PROS	CONS
B1	(continued from Page 2)	unemployment seem to be needed to hold down inflation rates than in the past. According to the best analysts, this is caused by a growing divergence between the occupational and skill mix of new entrants to the labor market produced by the professional and para-professional institutions of learning and the mix needed by the economy. The practical meaning of this divergence is that the supply of some occupations and/or specific skills is getting increasingly scarce even at times of fairly low economic activity and that some new entrants remain unemployable even in an "overheated" economy.	

Item No.	OPTION	PROS	CONS
B.	PRODUCTION OF TECHNOLOGY (Cont.)		
	Resource assurance		
2.	Determine an appropriate level of the country's effort in basic R&D, consistent with the economy's long-term need and its ability to support, and make this level reasonably stable over time.	o Basic R&D is a sine qua non of sustained technological innovation, especially of "radical" or "pivotal" types of innovation. o Stability in support allows better planned, more efficient, R&D.	o Difficult to find objective criteria for determining an appropriate level of basic R&D.

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Provision of proprietary rights		
3.	Revise the patent law by modernizing the procedures for obtaining patents and enhance the traditional incentives of the patent system by strengthening public confidence in the social value and legal validity of issued patents.	o Patents, protecting commercialized inventions in the marketplace, provide a critical incentive to invent, invest in development, and disclose new technological developments to the public. All of these are necessary for sustained technological progress. An effective revision of the patent law would call forth not only more industrial R&D, but would also stimulate other aspects of innovation, as well (e.g., commercialization), and the increase in innovation would be economy-wide. o The public cost of appropriately revising the patent law and, hence, to increase innovation, would be minimal. o The policy would cause no interference in private decision-making by bureaucrats, nor would there be any proprietary issues.	[o "Modernization" of the procedures for obtaining patents which would result in excessive cost and potential harassment of applicants would diminish patent incentives and, therefore, adversely affect the Nation's technological progress.] [o There are quite a few people who believe that the patent system plays a minimal role in technological progress and some who would like to restrict it as much as possible. The Antitrust Division in the Department of Justice tends to oppose the revision of the patent law aimed at improvement of the patent incentive.]

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D: direct		
4.	Provide interest-free or low-interest governmental loans to "bonafide" R&D performers, the latter defined in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose.	o The program would be economy-wide. o The program would probably generate more industrial R&D than the market forces would do without it, especially in the area of "big ticket" projects of large corporations. o The program would be relatively easy to administer (banks plus some "arbitration" agency to certify questionable cases). o There would be relatively little interference by bureaucrats in private decision-making and no proprietary issues.	o The net increase in R&D would be on the whole small because of the relatively small marginal incentives, but the Treasury's cost would be substantial because the loans would have to be available not only to those performers who would not do the R&D unless such loans were available, but also to those who would do it anyway. Hence, the ratio of the net increase of private outlays on R&D to expenditure of public funds would be low. [o The policy would provide an opportunity for fraud because of difficulties in defining R&D accurately.]

Item No.	OPTION	PROS	CONS
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D: direct		
5.	Establish a Federal Institute for Industrial R&D (FIIRD) which would disburse Congress-appropriated funds in the form of grants, or through cost-sharing arrangements, for generic, "bottleneck," or some other R&D which would be in long-term interest of society but not be undertaken by private sector in response to other options either because of a too great uncertainty, too great cost of the project, or too great fragmentation of the industry which would be the primary beneficiary of the project. Examples of R&D projects that might be carried out under this program include research on prevention of corrosion, combustion efficiency, computer-aided quality control of products, industrial robots, programmable automation of manufactured processes, recycling of materials, automation and other technological improvements in processes applicable in service industries, etc.	o The program would assure the availability of funds for meritorious projects which otherwise would not be undertaken given the kind of socio-economic philosophy we have; it is the only way for the society to make timely use of all major technological opportunities as they become available. In cooperative R&D arrangements, the ratio of the net increase of private outlays on R&D to the expenditures of public funds might be quite high. o Most, if not all, governments of other industrialized countries support such R&D as a matter of course.	o In some cases, the program would undertake projects which eventually private industry might do itself and, therefore, there might be some substitution of public funds for private funds. o The program would generate some proprietary issues unless the Federal patent policy is simplified as suggested in Section D. o Government bureaucracy does not have a good feel for which projects should be funded.

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal Support of Industrial R&D: Tax measures		
6.	Substantially increase the tax investment credit for R&D plant from the present 10 percent to, e.g., 25 percent.	o The program would be economy-wide. o There would be some net increase in R&D. o The program would be easy to administer (IRS). o There would be no interference in private decision-making by bureaucrats, nor would there be any proprietary issues.	o The net increase in R&D would probably be relatively small but costly to the Treasury, because the credits would have to be available not only to those performers who would not do the R&D unless such increased credits were available, but also to those who would do it anyway. Hence, the ratio of the net increase in private outlays on R&D to the expenditures of public funds would be low. [o The policy would provide an opportunity for fraud because of frequent indistinguishibility of R&D plant from production plant.] [o Present climate is against tax credits.]

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D: Tax measures		
7.	Increase tax depreciation allowances for R&D plant	o The program would be economy-wide. o The program might result in some increase in R&D. o The program would be easy to administer (IRS). o There would be no interference in private decision-making by bureaucrats, nor would there be any proprietary issues.	o Depreciation represents only a small fraction of total cost of R&D, and an increase in depreciation would only mean a temporary postponement of tax payment, rather than forgiveness of the tax. Thus, net increase in private outlays on R&D would be very small, if not nil, because of the small marginal incentive.

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D Tax measures		
8.	Provide new special tax credits or equivalent cash payments (to those having no tax burden) to industrial R&D performers, with R&D defined, as in B4, in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose.	o The program would be economy-wide. o There would be some increase in R&D, the size of which would depend on the size of the tax credit or equivalent cash payment. o The program would be easy to administer (IRS) and there would be no or little growth of bureaucracy (unless the R&D eligible for the incentive were not well defined). o There would be little or no interference in private decision-making by bureaucrats; nor would there be proprietary issues.	o The kind of incentives that would substantially increase industrial R&D throughout the economy would subsidize not only incremental R&D but also ongoing projects, and the latter would be tantamount to substitution of public funds for private funds. Hence, the ratio of the net increase in private outlays on R&D to the net expenditures of public funds would be very low, if not nil. [o The policy would be conducive to fraud, as is probably the case with all broad policies.] [o Present climate is against tax credits, especially new tax credits.]

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D Tax measures		
9.	Trade the present tax credit for investment in plant and equipment (10 percent) for tax credit or equivalent cash payments for expenditures on industrial R&D (R&D defined, as in B4 and B8, in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose).	o The basic rationale for the present tax credit for investment in plant and equipment is promotion of modernization and productivity growth. Some careful recent studies have come to the conclusion, however, that investments in plant and equipment are largely a function of pressure of demand on industries' capacity and not of these tax incentives. Consequently, from the overall social policy point of view, the tax credit for investment in plant and equipment might be considered as a tool of income redistribution and not a tool for promoting productivity growth, and, hence, growth of income. From this it follows that to the extent the trade of tax credit for R&D expenditures for tax credit on plant and equipment would generate more R&D and, hence, growth in productivity, etc., the trade-off would be beneficial to society. o The trade-off would not require additional tax expenditures for the purpose.	o In an inflationary economy, tax credit for expenditures on plant and equipment helps to counteract antiquated rates of depreciation and, therefore, the policy might socially be equitable even though formally it might look as if it were a tool of income redistribution. Thus considered, both sets of tax incentives might be necessary. [o The trade-off would most probably be opposed by the business community, especially non-technology-intensive industries; macroeconomists; and, perhaps, even quite a few people in the government.]

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D Tax measures		
10.	Provide new tax credits or equivalent cash payments (to those having no tax burden) for incremental (e.g., above the level of the most recent 3-year average) industrial R&D (as in B4, B8, and B9, R&D to be defined in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose).	o The policy would be economy-wide. o The policy would undoubtedly increase the private outlays on R&D (the size of which would depend on the size of the tax credit or equivalent cash payment); there would be little or no substitution of public funds for private funds; and the ratio of the net increase in the private outlays to the expenditures of public funds would most likely be relatively high. o The program would be relatively easy to administer (IRS) and there would be little or no growth of bureaucracy. o There would be little or no interference in private decision-making, nor would there be proprietary issues.	o The policy would appear to penalize companies presently doing appreciable R&D. (However, if a 3-year moving average were accepted as a base for a given year's credit, the discrimination favoring firms which had not done much R&D in the past would disappear over time.) [o The policy would be conducive to usual types of fraud.] [o The present climate is against tax credits, especially new tax credit.]

Item No.	OPTION	PROS	CONS ([]=problem)
B.	PRODUCTION OF TECHNOLOGY (Cont.) Federal support of industrial R&D: Tax measures		
11.	Provide new tax credits or equivalent cash payments (to those having no tax burden) for incremental (e.g., above the level of the most recent 3-year average) R&D in chemicals and capital goods industries (as in B4, B8-10, R&D to be defined in accordance with the Financial Accounting Standards Board concept or some other standard specifically designed for the purpose).	o The policy would increase the private outlays on R&D (the size would depend on the size of the incentive) in the industries whose output has traditionally been most conducive to domestic productivity growth and favorable foreign trade performance for the economy at large; there would be little or no substitution of public funds for private funds; and the ratio of the net increase in the private outlays to the expenditures of public funds would most probably be high. o The program would be relatively easy to administer (IRS) and there would be little or no growth in bureaucracy. o There would be little or no interference in private decision-making by bureaucrats, nor would there be proprietary issues.	o The policy would discriminate against (1) "not technology-intensive" industries which most urgently need technological "uplift"; (2) the kind of potential R&D performers outside industry who historically have produced radical new industries; and (3) firms within the chemical and capital goods industries which are doing much formally organized R&D. [o The policy would be conducive to usual types of fraud.] [o The present mood is against tax credits. Because of the discrimination noted above, Congress would probably be especially reluctant to approve this policy.]

Item No.	OPTION	PROS	CONS
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY DOMESTICALLY		
	Information diffusion		
1.	Expand gathering and dissemination of important domestic and foreign scientific and, especially, engineering information throughout the economy, particularly that usable in the technologically laggard sectors of the economy.	o Users, especially small firms, often complain that newest information of the type they require, especially foreign engineering information, is not readily available.	o Impact of such a program cannot be readily ascertained and, hence, the required appropriations might be hard to obtain. o The program probably would require a pilot study to determine whether such a policy would pay off and, if so, how the objective could be achieved most effectively.

Item No.	OPTION	PROS	CONS([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Information diffusion		
2.	Institute a system of timely objective publications which would inform the public about the social consequences of major technological changes -- both beneficial and not so beneficial -- and the available alternatives.	o The lack of such publications has probably been a factor in the growth and popularity of the "anti-technology movement" as well as actual delays in the diffusion of nuclear power-generating technology, delays in the construction of the Alaskan pipeline, etc. o The whole economy would benefit at little cost.	o Some increase in budget and bureaucracy. [o "Balanced" presentation very difficult to achieve.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Information diffusion		
3.	Institute a "science court" to determine the credibility of scientific information impacting on major national issues, separating the determination of fact from value judgments.	o "The Court" would be an efficient means of clarifying the degree of scientific uncertainty underlying major scientific and technological controversies. o Public would be better informed on important scientific debates. o The delays in the use of certain potentially valuable innovations might be greatly reduced and the use of potentially harmful innovations prevented. o Little cost to the taxpayer would be involved.	o Danger of replacing free discussion in science by an authoritarionism of a scientific elite. o Difficult to separate value judgments and facts. o In many cases, relevant facts don't exist, and decisions must be made on the basis of educated guesses.

Item No.	OPTION	PROS	CONS
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.)		
	Information diffusion		
4.	Enhance supply of relevant information to state and local governments; and support research, development, and demonstration on technological improvements usable by state and local governments.	o In terms of productivity improvements, state and local governments are probably the most laggard sector of the economy; any productivity improvement in this sector, because of its huge size, produces large benefit to the society.	o Some budgetary burden to the Federal Government.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Information diffusion		
5.	Establish a consumer technology information center to study and promote strategems, including product life cycle performance information (based on voluntary product performance standards).	o Large segment of the economy could be affected. o Consumer technology would tend to go up, consumers would tend to get "more goods" for their dollars, and industry might benefit from improved market opportunities. o The program would interface with DoC existing National Voluntary Laboratory Accreditation Program, the proposed Voluntary Consumer Product Information Labeling Program, and the enhanced NBS voluntary product performance standards activity proposed in option D6.	o Some incrase in budget and bureaucracy. o The gestation period of a good program of this nature might be very long and costly because consensus on product standards might be slow. [o Some firms in industry might oppose the program as further government intervention.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.)		
	Information diffusion		
6.	Enhance NBS' voluntary product performance standards activity.	o Many sectors of the economy could be affected. o Social benefits of such a policy are likely to be immense (e.g., "industrialization" of the construction industry is virtually impossible in the face of several thousand local building codes in the country; lack of standards for industrial furnaces result in huge wastes of energy; etc.). o The uplift of the Nation's technology would require virtually no outlays of public funds. o Great potential for reducing market uncertainties and enhancing quality product competition.	o The policy might require Federal Government's intervention into traditional locally controlled areas. [o Probably a fierce opposition by vested interest groups.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Federal support of commercialization		
7	Enhance transfer of government-developed new technology to private industry by funding additional development of most promising "candidates" to suit commercial needs, if such funding is warranted by social cost/benefit ratios based on potential commercial users' data.	o Social return of public funds on such investments might in many instances be much higher than could be achieved by alternative policies.	o Probably small impact on the economy at large. o Could substitute public funds for private. If there is a possibility of subsidized development, the commercial development will not be undertaken on a non-subsidized basis. o Potential "proprietary issues" might arise. o Potential benefiting of special groups. o If government patent policy were changed (option C26), this policy might not be necessary.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Federal support of Commercialization		
8	Provide funds for initial commercialization of highly socially desirable inventions developed by private inventors which for reasons of too high risk or uncertain initial demand cannot be commercialized by private interests.	o Social benefits of such policy might be higher than those yielded by many other policies.	o The incidence of such occurrences is likely to be rare. o There would be proprietary problems. [o Deciding which inventions to support might prove extremely difficult.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Federal support of commercialization		
9	Make creation and diffusion of new inventions more prominent characteristic of Federal procurement policy.	o Over the long run this policy might have extremely high social benefit/cost ratio.	[o Probably opposition by beneficiaries of the present policy (vested interest groups).]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.)		
	Reduction of barriers to innovation		
10	Revise the procedures for obtaining patents and simultaneously enhance the traditional incentives of the patent system by strengthening public confidence in issued patents.	o See option B3.	o See option B3.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.)		
	Reduction of barriers to innovation		
11	Revise Federal patent policy (on inventions developed by its funds) so that inventors or their assignees retain rights to their inventions.	o Social benefits of such a policy are likely to be much higher than realized by the present policy since more companies would be interested in working on government contracts and in making use of the innovations which these contracts produce.	[o Congress might not approve such a policy change.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Reduction of barriers to innovation		
12	Modify the antitrust laws and regulations to permit intra-industry cooperative R&D programs in general, or at least a special dispensation decree in cases where duplication of effort because of high cost would be irrational.	o In many instances, and especially so in the area of environment and safety, social benefits of such a policy would most likely be substantial. The benefits would accrue to the entire economy. o Most other countries have pursued this policy for years. o The change in policy would cost society nothing.	[o Probably continued opposition by Justice's Antitrust Division unless the President and/or Congress overrule it.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Reduction of barriers to innovation		
13	Determine and modify those regulations and existing policies of regulatory agencies which inhibit innovation.	o Potentially large benefits to society at large and little cost (cost of a thorough study, for all practical purposes).	[o Probably opposition by vested interest groups.] [o Most changes in regulatory policies would require Congressional approval.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Reduction of barriers to innovation		
14	Make all future regulatory initiatives of the Government dependent on the outcome of a rigorous social cost/ benefit analysis, taking into account the regulated industries' and consumers' (or users') data.	o Dictum of common sense.	o Delays in putting socially desirable regulations into effect. o Cost of analysis. [o "Rigorous social cost/benefit analysis" might be very difficult to achieve.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Reduction of barriers to innovation		
15	Improve manpower retraining, relocation, and pension-transfer programs which would tend to reduce Labor's resentment to technological change.	o The seriousness of Labor's resentment to technological change, except for notorious feather bedding in RR industry, is not known; but such a policy might be desirable for purely social reasons (e.g., maintenance of employable manpower).	o The public cost of "an honest" implementation of such a policy might be prohibitive. [o Labor is generally believed to object to being treated as infinitely mobile, infinitely retrainable, and totally outside the corporate decision-making process. On the other hand, some industry managers maintain that we are extremely fortunate to have as mobile and as retrainable labor as we have.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Reduction of barriers to innovation		
16	SEC to undertake a comprehensive study of the extent to which the evolution of corporate remuneration practices of top executives has adversely affected corporation policies regarding technological innovation, as some researchers maintain; and if found to be so, to promulgate appropriate counter-measures (such as, e.g., placing remuneration of the top executives on a longer time scale of performance with appropriate tax adjustment).	o If the allegations are reasonably near the mark, the social benefits of such an inquiry and policies that would flow therefrom might be immense and affect the entire economy. o Relatively little cost to the tax-payer.	o Some non-profit research institutes or universities might be more appropriate than SEC to do the job. [o Corporate managements would most probably resent such an undertaking.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors; (a) Direct financial aid		
17	Establish a national research and development corporation (patterned after Britain's NRDC, e.g.) to finance innovative activity of independent inventors (NRDC-type of financing: buying developed inventions with appropriated funds and/or proceeds from their sales, including profits; financing new or semi-developed inventions with the same funds.)	o Independent inventors have always been a source of innovations, growth of new technical enterprises, and growth in technical competition in the economy at large.	o Some cost to the Treasury o Small potential impact on the economy. In the last 15-20 years, the small inventor contribution seems to have been much smaller than in the 19th and early in this century. Boston's Route 128 and similar phenomena around Los Angeles were atypical split-offs of military-industrial complex. o If policies were adopted which would improve the availability of R&D funding and the general (economy-wide) environment with respect to innovation (Sections B and C), this "special" policy for independent inventors might be unnecessary.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors; (a) Direct financial aid		
18	Accord initial preferential treatment of new technical enterprises in government contracts.	o Greater certainty of demand for the products of the enterprises and, hence, greater stability and potentially greater survivability of the small enterprises.	[o Hidden (policy-oriented) discrimination [o Most agencies prefer to deal with "proven" companies.] [o Difficult to promulgate in the conditions of continuous "budget" squeeze.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors; (a) Direct financial aid		
19	Arrange with selected engineering educational institutions in the country to organize a nation-wide system of small technical enterprise associates, patterned, perhaps after MIT's Associates (a scaled down "industrial Liaison Program") which would provide the eligible enterprises with ad hoc advice on management, new product development, marketing and "technical trouble shooting" on continuous and cost free or subsidized basis.	o No matter how "sophisticated" a new technical enterprise might, it is most likely to lack some sort of managerial or technical expertise. The program would, therefore, tend to increase the enterprises' efficiency and survivability.	o Some cost to the Treasury. [o No outside advice will help incompetent "enterpreneurs" in critical areas of their activity, especially in marketing which is said to be the cause of over 95 percent of the failures.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors; (a) Direct financial aid		
20	Patent and Trademark Office to give cost free patent protection to independent inventors and inventors affiliated with enterprises with up to $1 million in annual sales.	o The program would facilitate the flow of patents and technical developments from independent inventors and small technical enterprises with the benefit accruing to the whole economy.	o Some increase in the budget and increased burden to the Patent and Trademark Office. o Potentially small impact on the economy as a whole. [o Discrimination (policy-oriented).]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
21	Secure an "adequate" availability of "venture capital" for financing new technical enterprises.	o Creation of new technical enterprises is a sine-qua-non of dynamism and competitive structure in the economy.	o The apparent decline in the rate of creation of new technical enterprises in recent years might be due to recession and decay of DoD- and NASA-related markets rather than inavailability of "venture capital" as such. There seems to be no bias as such in the venture capital market against "sound" small technical enterprises.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
22	Government to provide guarantee for some portion (up to 50 percent or so) of loans granted by SBIC's or other financial institutions to new technology-based enterprises.	o The policy is in wide use abroad, most notably in Japan.	o Some cost to the Treasury, perhaps smaller than proportional to the social benefit if the loans were limited to potentially viable enterprises.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
23	Provide more generous capital gain tax treatment to new technical enterprises.	o Better initial profitability and, hence, survivability of the enterprises.	[o The public and Congressional sentiment grows progressively against preferential tax treatment of any kind.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
24	Allow Small Business Investment Corporations to be incorporated under Sub-Chapter S or to be organized as partnerships so losses can be taken at the individual level.	o This would promote SBIC investment in new technical enterprises.	o It would cost the Treasury some revenue. [o Could become an avenue for speculative manipulation, trading of invention "tax losses," etc.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
25	Provide for greater liquidity of small technical enterprises by (a) broadening SEC Rule 144 or 237 to allow a larger fraction of securities held to be sold in each six-month period; (b) SEC allowing the marketing of unregistered stock on a less restrictive basis; and (c) IRS allowing good will to be written off in merger accounting before tax rather than after tax.	o The managerial ability to obtain liquid funds by issuance of securities is a sine qua non of an unimpeded growth of any new enterprise.	[o The policy would probably be conducive to large incidence of issuance of fraudulent securities and/or artificial inflation of net worth of speculative enterprises -- exactly the kind of phenomena which the SEC and IRS regulations in question are intended to prevent.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
26	Provide for more favorable stock option incentives to founders and key personnel of new technical enterprises by (a) increasing the qualified options time from the current five to ten years, and (b) postponing the tax on income derived from the exercise of non-qualified options until the shares have been sold rather than paying the tax at the time the option is exercised.	o Strong incentives have always been an important element in the success of new enterprises.	[o The policy might be conducive to excessive incidence of speculative creation of new enterprises and counter-productive to their long-term survivability.]

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
27	IRS to make investments in new technology based enterprises (by individuals, institutions and corporate entities) tax deductible until the investments are sold, analogous to certain real estate transactions.	o Would greatly reduce the risk of the investments and, hence, greatly increase the flow of investible funds into such ventures.	o The cost to the Treasury would undoubtedly be in excess of social benefits. o The policy would entirely remove the "dollar control" of the quality of the enterprises to be created, since all failures would be paid for by the taxpayer.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
28	IRS to provide for a graduated corporate income tax rate structure to benefit new technology based enterprises.	o The policy would facilitate internal generation of liquid funds at the time when the attraction of outside capital needed for expansion is most difficult. o The policy would be consistent with the overall philosophy of U.S. society underlying the "progressive" income tax structure.	o Some cost to the Treasury, but most probably smaller than proportionate to the social benefit.

Item No.	OPTION	PROS	CONS ([]=problem)
C.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY (Cont.) Creation of new technical enterprises and aid to independent inventors: (b) Indirect financial aid		
29	Provide more liberal access of independent inventors and small technical enterprises to Government's R&D infrastructure services.	o Help to make the cost of their ventures lower, and performance better, and make possible ventures which otherwise couldn't be undertaken.	o Disruption of Government's work. o Security problem. o Hidden subsidation.

	PROS	CONS ([]=problem)
ITATION OF TECHNOLOGY ADVANTAGE U.S. competitiveness onal trade authoritative official policy t which would reiterate U.S. tion to the free international w of scientific and technological information consisting of all published or otherwise publicly available data, data ordinarily used in educational institutions, and data normally submitted in publishable applications to patent authorities.	o The statement would clarify the Government's traditional position on the issue, which the United States has never compromised nor does it intend to do so in the future, and serve notice to the effect that whatever deviations from this position there have been policy-oriented aberrations rather than fundamental changes in the traditional position.	o None.

Item No.	OPTION	PROS	CONS ([]=problem)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
2.	Legislatively modify all outstanding judicial decrees and administrative orders, while curtailing the issuance of such new decrees and orders, whereby U.S. corporations and/or citizens are subject to compulsory licensing of patents and other innovations to parties outside the United States.	o The decrees and/or orders may be, and most probably freuqnelty are, injurious to the potential U.S. balance of payments, employment opportunities, and general welfare of society.	[o Potential opposition by the Department of Justice.] [o Potential opposition by the Department of State.]

Item No.	OPTION	PROS	CONS ([]=problem)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) <u>Improvement of U.S. competitiveness in international trade</u>		
3.	Increase U.S. effectiveness in (1) international adoption of U.S. national standards and	o If U.S. standards are adopted in more and more foreign countries the likelihood should increase that U.S. industry will be able to compete more favorably with manufacturers of other nations in exportation of U.S. made goods. Since U.S. manufacturers generally are set up to make goods in accordance with U.S. standards, they will have a competitive edge over manufacturers in other countries who are obliged to switch over to new international (i.e., U.S.) standards.	o Internationalization of U.S. standards will make it possible for manufacturers in foreign countries to become equipped to make goods which will be salable in the U.S., and will therefore lead to more exporters from other countries to enter into competition in the U.S. with our domestic manufacturers.
	(2) in eliminating use of standards as non-tariff barriers to trade.	o U.S. policy generally favors free and open trade among nations with a minimum of tariffs as barriers to such trade. The lack of harmonization of standards employed in different nations sets up non-tariff barriers to trade. By promoting such harmonization it is expected that the ability of the U.S. to compete in international trade will be enhanced.	o In any product line which exporters from other nations can compete more successfully with U.S. manufacturers, harmonization of standards will remove a trade barrier which could be used to protect U.S. industry against losses due to such competition.

Item No.	OPTION	PROS	CONS ([]=problem)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
4.	Make all exports from the U.S. of technology, per se, (data and know-how related to the design and/or production of specific products or processes) subject to Government approval (license) based on the potential contribution to the U.S. balance of payments, employment opportunities, national security and the country's responsibilities for the political, strategic, and economic interests of the international community; rather than, as is the case now, either a strict perrogative of private enterprise (non-strategic technology) or subject only to national security and foreign policy considerations (strategic technology.)	o Advanced and market-tested technology related to design and production of specific products and processes is universally considered as the scarcist national resource. Voluminous U.S. exports and transfers of such technology, per se, for use in competitive operations overseas, largely in developed countries, has been injurious to employment opportunities in the U.S. and a major factor in the 1971-73 devaluation of the dollar. Since further devaluation is no longer a viable tool for the purpose, and foreign governments are getting progressively greater command of technology in their countries, including the technology of U.S.-based multinationals, there is no way for our domestic industry to reverse the decline of its international competitiveness except through an increase in the development of new technology and some sort of control of its outflow. Moreover, Congress is highly unlikely to legislate any tax incentive for R&D or some other innovation enhancing funds if the fruits of this R&D, etc., were to continue to flow overseas the way they do now.	o Increase in the budget and bureaucracy. o "Another regulation" of business. [o Change in policy in effect for some 25 years or so.] [o Opposition by foreign governments, including threat of retaliation (which could hardly be too effective because they have little technology superior to U.S. and what they have they control).] [o Opposition by U.S. multinationals.] [o Probable opposition by the Department of State, Treasury, and some other agencies.]

Item No.	OPTION	PROS	CONS ([ ] = problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
5.	Impose a general "national benefit equilization" tax, assuming average "running" royalty fees and average relative contribution to the balance of payments and employment opportunities on all international transfers of technology usable in economic activity abroad which could be competitive with activity in the U.S.	o See option D3. o The policy would have the precedence of "interest equilization" tax used in the 1960's. o Some gain in revenue which would partially offset losses in revenue resulting from the outflow of technology and therefrom resulting losses of production of exportable products.	o Some increase in the budget and bureaucracy, though much smaller than in option D3. Determining appropriate tax and its administration might prove very difficult. o The accepted policy might prove ineffective. [ ] Problems: See option D3

Item No.	OPTION	PROS	CONS ([ ]= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
6.	By an act of law, disallow transfers of new technology based on R&D financed in full or in part by public incentive schemes if any, for a period of 7 years after the initial commercialization of this technology in the U.S.	o See option D3. o This would be much more straightforward than either D3 or D4.	o The policy might affect the U.S. at large only if the Government's support of civilian-market-oriented R&D were much larger than it is today. o The policy would deny foreign countries some of the new technology, the export of which would not be harmful to the U.S. [ ] Problems: See option D3.

Item No.	OPTION	PROS	CONS ([ ] = problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
7.	To minimize the monopsonistic exploitation of U.S. companies, and the U.S. at large, by Eastern bloc countries in their dealings involving transfers of technology per se, make the companies negotiate such deals through an agency of the U.S. Government, or a special public corporation (techport) to be especially organized for the purpose.	o This is probably the only way to achieve a reasonable quid pro quo in this regard	o Some increase in the budget [o Drastic deviation from past and current practices.] [o Resentment of Eastern bloc countries.] [o Opposition of some U.S. private companies.] [o Possible opposition by the Department of State.]

Item No.	OPTION	PROS	CONS ([ ] = problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Improvement of U.S. competitiveness in international trade		
8.	Greatly expand, perhaps by a factor of 2, the export promotion programs of technology-intensive products produced in the United States, subject only to national security considerations.	o Such an expansion would merely match the programs of the more employment-sensititive countries, such as Japan.	o Some increase in the government budget and bureaucracy.

Item No.	OPTION	PROS	CONS (Z7 = problems
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Technological support of lesser developed countries		
9.	Through a more active participation in the international effort to develop a mutually agreeable "business code of behavior" of multinational companies in LDCs and through a set of amendments to or revisions of existing U.S. tax and insurance provisions, arrange for U.S.-based multinational companies' investments and operations to be of more benefit to LDCs (subject, of course, to all other policies which the U.S. has or might have on the books.)	o After long frustrations with their pace of industrial development, the "third world" countries have decided to simply "demand" the developed countries' technological assistance for speeding up this development. The prime target of this "demand" is the United States. Current strategic, political, and economic considerations dictate that this "demand" be taken more seriously than in the past. The demands call for U.S. assistance in the development and/or furnishing of technology appropriate for their conditions (e.g. for the development of industrial processing -- in contrast to extractions -- of their natural resources, and for the development of fairly sophisticated manufacturing industries -- a la South Korea's, Taiwan's, and Singapore's. Accepting such demands as inevitable, including the absorption of imports, U.S. multinational companies would most probably be the best tool for rendering the kind of assistance these countries demand.	o Development of a workable "business code behavior" might prove to be extremely difficult o At least some of the countries might harass U.S. multinationals even if they agree to the "business code" with the result that the multinationals would not be able to deliver the promises and the blame would be directed at the U.S. o The "ethnics" might not adequately participate in the MNC's operations.

Item No.	OPTION	PROS	CONS (C)= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Technological support of lesser developed countries		
10.	Organize a series of bilateral U.S.-individual LDC joint commissions, patterned roughly after the U.S.-Israel commission, which would jointly plan and supervise the execution of the plan for production, technology development and/or acquisition, and marketing of products of the "third world" country industries in question.	o U.S. national preferences with respect to policies on the books and initiatives would most probably prevail. o Participation and "learning" by the "ethnics" might be greater in a binational activity than in option D8.	o In such bilateral arrangements, the U.S. might be presented with demands which it would not be willing to meet and, therefore, the confrontations might aggravate rather than lessen tensions.

Item No.	OPTION	PROS	CONS ([ ]= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Technological support of lesser developed countries		
11.	With the close cooperation of other developed countries, organize a series of developed countries - individual "third world" country commissions which would jointly plan and supervise the execution of plans for production, technology development and/or acquisition, and marketing of products of the "third world" countries industries in question.	o Participation and "learning" by the ethnics might be the same as in option D9. o Larger capacity and negotiation power to meet and/or resist the individual countries' demands. o The option seems to be favored implicitly by the Department of State.	o There might be considerable difficulties in working out the developed countries' agreements on conflicting issues and the U.S. would have to take the blame. o U.S. interests might be compromised.

Item No.	OPTION	PROS	CONS ([]= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Technological support of lesser developed countries		
12.	With the cooperation of other developed countries, propose that the World Bank undertake the planning and execution of the industrial development, etc., of the "third world" countries on behalf of the countries in question and the developed countries.	o The policy would be in the spirit of the broadest multilateralism and, therefore, could easily find support in the U.S. and abroad. o U.S. would not be blamed for any errors that might be committed by the Bank. o The Bank's mechanism might be the best tool to resist unreasonable demands on the part of the countries in question.	o U.S. preferences and interests would to a large degree be at the mercy of the World Bank's bureaucrats and the "third world" country experts.

Item No.	OPTION	PROS	CONS ([ ]= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.) Technological support of lesser developed countries		
13.	Continue the traditional method of support of LDCs, with substantial increase in appropriations of foreign aid funds.	o Chances are that the four preceding options listed in this section will prove too disruptive and/or otherwise not workable to the developed countries, and especially so to the United States where the government, including Congress, has little influence on what private corporations do. o This route might represent, at least on paper, a much more tangible support of LDCs than other options. o The developed countries as a whole would probably agree on such a policy more readily than on the other options. o The route would probably prove more attractive to most of the leaders in LDCs than the other options.	o Some of the most vocal and ideologically oriented leaders in LDCs might oppose this policy. [o Congress might be unwilling to appropriate substantially larger budgetary outlays for foreign aid than it does now.] [o Even if Congress appropriated larger funds for the purpose, the Administration might continue to use the larger funds ineffectively.]

Item No.	OPTION	PROS	CONS ([ ]= problems)
D.	DIFFUSION AND EXPLOITATION OF TECHNOLOGY FOR INTERNATIONAL ADVANTAGE (Cont.)		
	International cooperation		
14.	Promote mutually advantageous cooperation in industrial R&D; up to the stage of development and testing, in technology areas where U.S. private interests do not pursue the objective, and with the provision that the U.S. commercialization of the results of the cooperation would be pursued by private interests, both consistent with the traditional industry/government relations in the United States.	o Avoid duplication of independent effort in some costly projects. o Promote international understanding and "good will." o U.S. may learn from other countries in areas where foreign countries have a lead. o No infringement on technological initiatives pursued or likely to be pursued by private U.S. interests.	[o Risk of unilateral technology outflow, especially in areas where U.S. enjoys a substantial lead.]

APPENDIX D

RECOMMENDATIONS FOR IMMEDIATE DEPARTMENT OF COMMERCE ACTION

In 1976, the President's technology advisory group on the contributions of technology to economic strength suggested to the Vice President and the Secretary of Commerce that the Department of Commerce take a leadership role in stimulating technological innovation. The Department has been called on before to serve as the focal point within the Executive Branch for policies concerning industrial research and development. In the President's 1972 Science and Technology Message to Congress, the Department was directed to appraise, on a continuing basis, the technological strengths and weaknesses of U.S. industry; to work with other agencies in identifying barriers to industrial progress; to propose measures to assure a vigorous state of industrial progress; and to promote the transfer of Federally-owned technology into the civilian economy.* As discussed in Sections III-V, some work has been undertaken in the Department along these lines.

For instance, the Department's Experimental Technology Incentives Program has, since 1973, conducted experiments in cooperation with several Government agencies on methods of stimulating innovation (see Appendix A). This program is presently undergoing evaluation, and if the results of this evaluation are favorable, the program could be expanded.

Although work has been undertaken in the Department to promote technological innovation, we agree with the President's Science and Technology Group that more can and should be done.

In particular, we recommend that the Secretary of Commerce, to strengthen national technology policy, take immediate actions within the Department in the following six areas:

Analysis and planning

Fostering industrial R&D
Collecting, organizing, and disseminating information
Providing information to state and local governments
Funding commercialization of selected Government inventions

Providing consumer technology information services

The six areas are shown grouped into three natural functional units related to existing activities. The need for each unit is described in the following, as well as how it would function, and who would benefit from its work.

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*For further recent history of Federal efforts in civilian technology see Appendix A.

I. INDUSTRIAL TECHNOLOGY ANALYSIS OFFICE

A. Introduction

The capacity to analyze the effects of current and proposed national technology policy on the innovation process, the economy, and society, along with the capacity to judge the validity of the various inputs and to integrate the multidisciplinary inputs for decisions of national and international scope, is urgently needed by the governments of all technology-intensive societies. Each U.S. department and agency performs some analysis with varying degrees of thoroughness and success but with limited perspective and objectives. Recognition of the need for the development and selection of sound technical policies which encompass all aspects of Government and which together represent a coordinated U.S. technology policy, has been the motivating force for reestablishment of the science advisory apparatus for the President, for establishing the Office of Technology Assessment in Congress, and for continuing the Commerce Technical Advisory Board.

The idea for analyzing consequences of present and contemplated Government technology policy elements is not novel. Many relevant ad hoc studies have been carried out under former President's Science Advisory Committees, the National Research Council, various White House committees, private "think tanks," and many other organizations. What is lacking is a way of evaluating, integrating, and prioritizing the many inputs available and necessary for a comprehensive national response to national concerns and goals.

There is wide consensus that an office is needed which would analyze the Nation's performance and needs in technology. Attention has been called to the need for this analysis in several quarters, including remarks by J. Herbert Hollomon at a meeting of the President's Science and Technology Group on the contribution of technology to the economy [37] and Congressional hearings [43]. At present, there is no unit in either the Government or private sector which adequately systematically analyzes the technological variables of the Nation, although many Federal agencies analyze various aspects of the Nation's economic, technical and social activities.

It is appropriate that a civil technology analysis office be located in the Department of Commerce. Much of the technological, economic, and demographic information which is required for comprehensive analyses are produced and disseminated by agencies of the Department. The high credibility of the Bureau of the Census, Bureau of Economic Analysis, National Bureau of Standards, and other Department units, would contribute to the likelihood of serious consideration of the analytic results by policy-makers. In addition, the Department's

familiarity with industry and its established contacts with industry will make it easier to obtain the needed information.

B. Conceptual Design

The Office would be located in the Office of the Assistant Secretary for Science and Technology. It would provide the Assistant Secretary with information needed for more effectively serving as chief adviser to the Secretary and other Commerce officials on science and technology matters, and as director and coordinator of the scientific and technological programs of the Department. The Office would generate analyses of importance to the Assistant Secretary for Policy in his consideration of Department policy which have technological content. The analysis results should also be of considerable use to the White House Office of Science and Technology Policy and other Federal agencies.

The Office would perform comprehensive long-range analyses, and would provide an indication of how the U.S. is faring in technology, in comparison with other nations, and in comparison with its past performance and potential. Analyses would be made of:

a. technico-economic indicators related to economic and industrial growth and productivity;

b. technological factors in foreign trade and direct foreign investment, including costs and benefits of technology transfer;

c. resources (manpower, capital, etc.) applied to the generation and acquisition of technology;

d. effectiveness of various governmental policies in promoting the Nation's technological health;

e. legal, regulatory, institutional, and other barriers to technological innovation; and

f. social cost-benefits of currently debated or anticipated major technological developments.

Because of the multifaceted aspects of the listed subjects, the Office staff would be multidisciplinary. The staff would perform analyses, itself, and would also administer contracts for extramural studies.

C. Constituency of Users

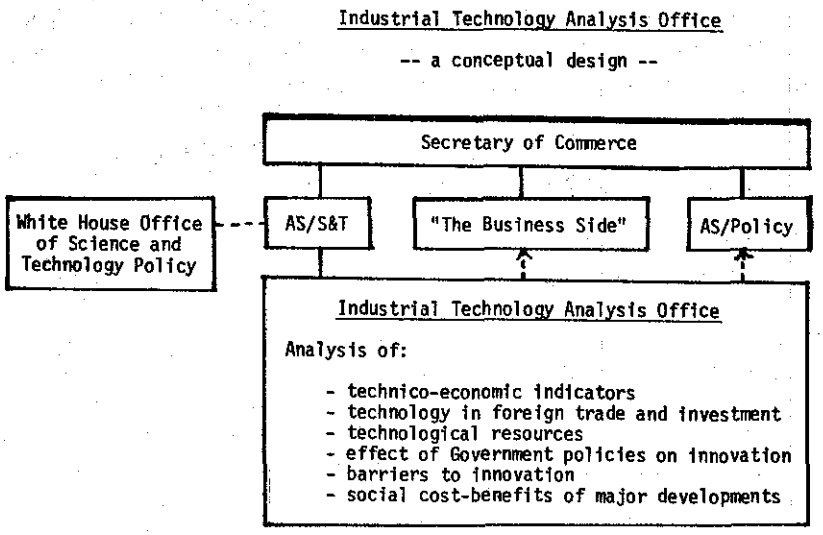
There would be three classes of users:

a. The technico-economic analyses would be useful to the Secretary/Under Secretary of Commerce, the Assistant

Secretary for Science and Technology, and the Assistant Secretary for Policy, in formulating positions and policies on the broad spectrum of issues having technological content.

b. The analyses should be of use to the White House Office of Science and Technology Policy and other Executive Branch agencies, and indirectly to Congress and the private sector, as well.

c. The Office could provide results to the "business side" of DoC for use in its domestic and international operations.



II. OFFICE OF PRODUCT STANDARDS AND CONSUMER TECHNOLOGY

A. Introduction

Recent White House Conferences on Consumer Representation have encouraged Federal agencies to establish meaningful consumer programs. The term "commerce," by definition, must have as one of its principal objectives the satisfaction of consumers.

The successes or failures of the Nation's commerce -- and this includes its industries -- are directly related to its ability to develop and supply products and services which satisfactorily meet the needs and desires of consumers. If consumer interest dwindles and its demands fall off, commerce will also suffer regardless of its ability to supply those demands.

The Department of Commerce, which for many years has contributed to the development of standards for products to meet the highest level of consumer requirements, likewise must provide the leadership essential to the development of programs that are even more visibly consumer-oriented. The clear economic and social interdepence of industry and consumers, especially where they meet in the mainstream of commerce, must be accentuated and the Department is equipped to do this job by employing the resources it has available in its Office of the Assistant Secretary for Science and Technology.

Illustrative of the points just made is the fact that since 1901 the National Bureau of Standards has engaged in cooperative activities with private organizations and other Government agencies that have resulted in many programs directed at benefiting consumers based on voluntary participation of manufacturers. Two such recently instituted consumer-oriented programs are the Voluntary Labeling Program for Household Appliances and Equipment to Effect Energy Conservation, and the Voluntary Program for Appliance Efficiency.

The latter program, whose goal is to achieve a 20 percent reduction in energy consumption of new household appliances by 1980, has thus far resulted in voluntary commitments to seek such energy reduction by appliance manufacturers responsible for over 93 percent of all retail sales of the appliances covered by the program. The appliance energy conservation program has also been widely supported by both manufacturers and consumers. Manufacturers voluntarily participating in the labeling of the first product (room air-conditioners) under this program produce about 95 percent of the units being marketed in the U.S.

It is proposed that the Department of Commerce undertake expanded voluntary programs which would emphasize consumer information on the technical characteristics of selected products, and the improvement in the technology embodied in consumer products. This logically should be conducted by the Office of Product Standards which has for some years furnished the Department's policy guidance not only for the development of such standards but also for the establishment of various consumer-oriented programs. To reflect the full scope of its operation, and simultaneously give greater visibility to the newer consumer functions and enhance their recognition by consumers, it is proposed that the title of the Office be changed to Office of Product Standards and Consumer Technology.

B. Conceptual Design

The Office of Product Standards and Consumer Technology would be located in the Office of the Assistant Secretary for Science and Technology. As a natural expansion of the current functions of the Office of Product Standards it would continue to serve as the arm of the Assistant Secretary, who is responsible for policy guidance of the National Bureau of Standards, in furnishing the initiatives and management needed to utilize technologies employed in developing standards to resolve the technological problems involved in various consumer-oriented programs.

The Office of Product Standards and Consumer Technology would have a two-fold goal. As did its predecessor Office of Product Standards, it would be responsible for improving the contribution of standardization to larger scale and lower cost production of manufactured goods, thereby making improved products available to more and more people. In addition, the expanded office would concentrate on programs for stimulating manufacturers to offer products that are free from recognizable faults and having a quality commensurate with the price being charged. Many of the qualities of goods required by consumers can be defined by appropriate standards covering the materials used and, where applicable and measurable, the ratings and other performance characteristics. Reference to such standards can give the buyer the guidance he needs in making decisions based on recognizable value.

Given the growing awareness of consumers to obtaining optimum goods and services per dollar and the growing importance to the Nation of the need to conserve material resources, the Office of Product Standards and Consumer Technology could effectively merge the technologies employed to satisfy the requirements of the consumer with the technologies employed in standardization so as to:

a. Provide the consumer with trustworthy comparative information about products at the point of sale. This would enable the consumer to make personally optimum decisions in the marketplace that are based on comparisons of important product performance characteristics, such as durability, capability, efficiency, and life-cycle cost.

b. Provide incentives for manufacturers to upgrade the technology in their consumer products. Such an upgrading would result in the conservation of materials, as well as energy. For example, increased conservation of materials could be achieved through improvement in the control of corrosion.

It is envisaged that the Office of Product Standards and Consumer Technology would be active at the interface between manufacturers and consumers in the development of plans and activities aimed at improving

not only product standards and the lot of consumers in the conventional sense, but also at fostering the promulgation and acceptance of product standards and test methods whose very adoption by industry inherently will benefit consumers. Technical support for the programs conducted by the Office would be provided by the National Bureau of Standards, which would be required gradually to expand modestly its technical capability in consumer technology. The functions of NBS would be operational, supportive and analytical. The role of the Office of Product Standards and Consumer Technology would continue to be policy development, coordination and evaluation.

C. Constituency of Users

Former President Herbert C. Hoover declared, on the occasion of his acceptance of an award from the American Standards Association, in 1951:

> "Standards are at the base of all mass production. They make possible more continuous employment by manufacture for stock instead of dependence upon immediate and specialized orders. They have made it possible to conduct this fabulous productive machine with the least amount of spare parts and inventories in the hands of the consumer industries. They have sharpened competition. They have cheapened the cost of production in millions of directions. Thus they have been a factor in our rising living standards. They have enabled thousands of different articles to be placed within the reach of everybody. They do not impose uniformity on the individual, because they make available to him an infinite variety of additions to his living."

These words of President Hoover succinctly sum up the principal objectives of the Office of Product Standards and Consumer Technology, and at the same time suggest the classes of users of the Office's services.

A further illustration of the Office's constituency of users may be seen in the notice published by the Department of Commerce on May 25, 1976 announcing its intention to develop in cooperation with consumers, manufacturers, producers, distributors, retailers, and other interested groups, a Voluntary Consumer Product Information Labeling Program. In essence, this proposed program provides that if the Secretary makes a finding of need to label a particular consumer product with information concerning one or more specific performance characteristics, he would proceed, with the cooperation of the private sector, to develop a performance labeling specification. Once such a final labeling specification is promulgated, manufacturers may volunteer to participate in the program.

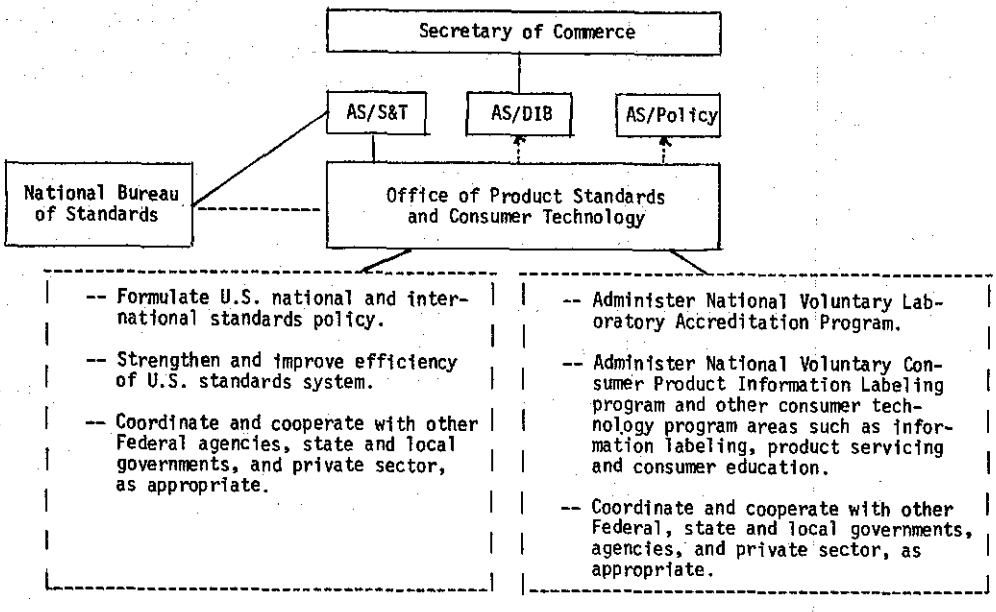
If this plan is carried out as now contemplated, it would offer the cornerstone for a comprehensive consumer technology program. Eventually, this could be augmented by examining and then possibly proposing a variety of suitable strategems to promote the objectives of encouraging consumers to make cost-effective purchases. Some such strategems are new product standards, further development of technical information tailored for consumers, financial options, or some mix thereof.

A still further illustration of the constituent users of the Office's services is the National Voluntary Laboratory Accreditation Program which has very recently become operational. This program was undertaken in response to demands for many years by representatives of the public and private sectors that the Department of Commerce exert leadership in the area of testing laboratory accreditation. Its goal is to provide a national voluntary system for examining, upon request, the technical competence of private and public testing laboratories that serve regulatory and nonregulatory product evaluation and certification needs.

Besides serving its direct or principal constituent users, manufacturers or producers and consumers, the Office would be in a position to formulate plans and recommend positions and policies for consideration by the Secretary and the President. Other Government agencies and the Congress could draw upon its experience and information.

Office of Product Standards and Consumer Technology

-- a conceptual design --



III. COMMERCIAL TECHNOLOGY AND INNOVATION SERVICES

1. Introduction

There are several functions which have in common the enhancement and furtherance of civil sector exploitation of both industrial and Federal R&D. The functions would benefit from close coordination and communication, and thus could form a logical grouping, Commercial Technology and Innovation Services, within the Department of Commerce. These functions are:

(a) technical information dissemination, which would collect, organize, and provide technological information services, based on U.S. Government research and development, to industry and business, state and local governments, and the public. The National Technical Information Service (NTIS) now performs this function, but should do more.

(b) innovation research, which would fund selected research, development, and demonstrations to stimulate greater technological innovation in industry, the service businesses, and state and local governments; emphasizing generic areas of technology in which governmental requirements, market disaggregation, or lack of proprietary rights are dominant aspects;

(c) industrial technological extension services, which would operate as a central broker of technology for application to state and local needs, including the fostering of local industry;

(d) coupling the technology development and expertise capabilities of more than 50 Federal laboratories with the technological innovation needs of U.S. industry, and also with those of state and local governments; and

(e) invention promotion and licensing services which would foster the commercial exploitation of U.S. Government-owned inventions.

NTIS (a) and the patent licensing (e) functions can be expected to achieve self-support. Federal appropriations will be needed for the other functions, and state funding will be required for the extension function (c), already in place in some states.

Most of the operations would be performed outside the Federal Government, either in state and local units, or in private industry. A DoC operating unit would do the planning, coordination, contract management, central information services management, patent and licensing services, and evaluation.

This proposal for a Commercial Technology and Innovation Service unit responds to the October 1975 report of the National Commission on Productivity and Work Quality: "The Commission believes that closer cooperation between the Government and the private sector is needed to improve certain kinds of critical technical change...In such cases, new methods of cooperation between business and Government may be appropriate...For example, military, space, aircraft, and medical developments, as well as significant parts of our electronics and machine tool technology have all been substantially stimulated by public funds." In the proposal's emphasis on cost recovery, it also responds to the Council on International Economic Policy's call for greater recoupment of Government funds which lead to private benefit.

2. Conceptual Design

A more detailed discussion and justification of the several functions follows:

a. National Technical Information Service (NTIS)

NTIS would continue its present self-sustaining operation to provide information services to industry and businesses, state and local governments, and the public. However, the present NTIS programs for technology transfer and for the licensing and foreign filing of Government inventions would be transferred and expanded to other parts of the Commercial Technology and Innovation Services (CTIS).

b. Innovation Research and Extension Services (IRES)

As discussed in Section II, attention has been called to the steadily declining world lead of the U.S. in civil-sector technological innovation and to the need for greater technology utilization in the service businesses and in state and local governments. The IRES would (1) support selected industrial R&D, and (2) provide a better coupling between the Federal technology resources and the needs in the private sector and in state and local governments.

(1) Industrial R&D Support

The U.S. is the only major industrialized nation without a national Government program for enhancing civilian innovation and productivity. Yet increasingly the civilian production plant and markets are influenced by governmental decisions, so that expectations of adequate national innovation and productivity improvement brought about by traditional civilian market demands are being shattered, except in a few products and technologies.

Some technology-intensive electronics companies feel strongly that there is a need in the U.S. to develop more up-to-date manufacturing process techniques [43]. A General Accounting Office (GAO) study on manufacturing technology shows a concentration of advanced technology in a few industries, and concludes that without further action it will not be diffused to smaller or medium-sized firms until 1985 [11]. Productivity can be increased by better design techniques (computer-assisted), by the development of more highly automated machine parts manufacturing and assembly techniques, and by the development of programmable production techniques that will enable quick product change.

Direct support of industrial R&D, based on foreign experience, has been recommended to the U.S. Government. (See, for instance, [37]). Critics, however, express concern that Governments do not have enough feel for the marketplace to make wise investments; that companies, in fact, might use this mechanism only to support marginal projects; and the R&D costs are only a very small part of the costs of technological innovation and do not form the main barrier [9,19,20]. Examples exist both of commercially successful Government-supported R&D programs (solid state electronics) and of unsuccessful programs (alternate automotive power systems).

In view of the need for more U.S. industrial R&D aimed at commercial sector innovation, on the one hand, but also in view of the mixed U.S. and foreign results from past, direct governmental support of commercial innovation, on the other hand, it is proposed that an R&D contracts program be established, but that initially it be a small program ($25 million/year) and treated as experimental.

This program would support R&D of high potential and general interest to an entire industrial sector, e.g., catalytic processes, effluent handling, combustion technology, programmable production techniques, industrial enzymes, ultra-precision machining, etc. These research areas exemplify several kinds of research:

- research designed to get a basic understanding of a process common to many products (e.g., catalysis, corrosion, ultra-precision machining, production techniques);

- research aimed at resource conservation (e.g., combustion of high carbon fuels in light of new emission standards, effluent handling, and solid waste recycling); and

- research in relatively unexplored areas (e.g., industrial enzymes).

The list is not meant to be exhaustive, or to imply that DoC has already selected these areas to be the most important. Rather, it is presented in order to clarify the kinds of research that would be supported.

The projects would arise from unsolicited proposals, to allow maximum private sector initiative and participation in the choice of projects. These funds would supplement mission agency (such as DoD, ERDA, and EPA) funds which often do not carry research to the point of successful commercialization or which focus on more specific projects.

An experimental program, such as this, is proposed instead of a full-fledged operation because of the obstacles, readily visible, to its success. One of the largest problem areas will be to keep the research at a general enough level, so that the results will be widely applicable and will not redound disproportionately to the benefit of a single firm. The support of industry-directed and funded research institutes would be one way of avoiding this obstacle. Another mechanism would be to support research carried out through state research and engineering foundations, such as the one in Pennsylvania.

In any event, coordination with universities would be very important, in order to ensure the involvement of their faculties with the research program, and with the subsequent implementation of the results in industry. An embryonic DoC program in which EDA and NTIS are working closely with about 20 state university industrial extension services, might serve as a nucleus for university involvement.

Peer review of proposals, employing non-DoC reviewers is judged the best method for selecting good research projects. This method would minimize DoC staff requirements and would thereby make it easier to stop the program if it were judged to be unsuccessful. Side effects to be closely monitored would include whether privately-funded research in the subject areas chosen would change magnitude and whether product innovation would be hampered by premature focusing on improving manufacturing process technology. Keeping the research projects at a very general level would tend to minimize undesirable side effects.

The suggested DoC program would be a small analog of the DoD programs for supporting (a) the development of technology relevant to DoD-purchased items, and (b) diffusing technological innovation in manufacturing processes employed to produce DoD material. At present, DoD owns almost 100 manufacturing and assembly facilities and their equipment, although the operating firms are usually considered to be "private enterprise." Among

these firms are units of many of the largest manufacturing enterprises in the U.S., e.g., Boeing, Lockeed, North American Aviation, General Dynamics, and McDonnell-Douglas.

The mechanisms employed by DoD to urge these firms to remain technologically innovative are: (a) an "independent R&D" fund derived from an approximately 2 percent add-on to the price DoD pays for manufactured products, and (b) DoD-appropriation funds directly invested by DoD program managers in technological innovations in the supplier firms. The former fund is invested by the contractor in R&D of its own choice, and amounts to more than $50 million, annually.

The latter program is at a current level of $114 million, annually, and is targeted for $200 million, annually, in a few years. It is run by a small DoD coordinating staff through the military services and defense agencies. It involves engineering and cost analysis, consultation with manufacturing firms, and information exchange. The payoff is large; on some 60 innovations studied, the payoff is 15:1 on investment. Much of the resulting technological innovation will only slowly, if ever, reach the attention of the majority of U.S. manufacturing firms, in the absence of a concerted DoC program.

(2) Extension Services

The fastest growing employment sectors in the U.S. have been the service businesses and state and local governments. While the employment in manufacturing increased 28 percent from 1950 to 1973, that in the services sector increased 140 percent and in the state and local government sector by 165 percent. Productivity is low, and useful output, because of high labor inputs, is expensively produced. The situation has not gone unnoticed. Presidents have repeatedly emphasized that R&D needs of state and local governments should be integrated more fully into the Federal R&D program as a means of improving this situation. Since productivity increases in state and local governments will be closely related to capital goods purchases and investments (e.g., computers, telecommunication devices, trucks), U.S. industry has a large stake. There is yet, however, no coordinated governmental program to bring the full Federal, state and local governmental resources to bear on the needs of state and local governments.

An industrial technological extension service would aim for improvements in the following areas:

° coupling Federal laboratory technology to the technology needs of private firms and state and local governments, utilizing

state-operated field extension agencies as the delivery system;

° coupling state and local government applied research needs to Federal laboratory programs, utilizing state extension agents as the sources of R&D planning information, in addition to major public interest groups (e.g., League of Cities and National Governor's Conference); and

° adapting technology from all sources in order to improve industrial process and product innovation, and the utilization of technology to improve productivity in state and local governments, the service industries, and industry.

The Federal Government presently has several scattered small pilot programs in these areas. A Federal Laboratories Consortium with some 70 member laboratories operates in a semi-official way to assist state and local governments to become more capable of utilizing technology, and to have their needs for technology better addressed by the Federal R&D program. NSF/RANN's intergovernmental science program has supported, through Public Technology, Inc., demonstration projects in 27 cities; the Council of State Governments and National Conference of State Legislatures also have supported demonstration projects. EDA's Technical Assistance Program has assisted in creating 15 state-based industrial extension services, and NTIS is now working with these organizations. The Small Business Administration has a field agent organization to help applicants for SBA loans. All told, some 20 states have field agent organizations varying greatly in size and outreach, and supported by combinations of state, SBA, EDA/TA, NSF, and other funds.

Each of these programs suffers from limitations: SBA is primarily interested in helping applicants for SBA loans; EDA/TA is primarily interested in building state institutional capabilities in economically depressed areas; and NSF feels obligated to portray project support as "research." To date, the Federal laboratories consortium has operated in an ad-hoc manner; it needs to be tied into the Federal R&D process at an operating management level, rather than at its present NSF policy and research level.

The Government Accounting Office has repeatedly called for a centralized technology transfer effort, stressing it in testimony before Congress and in special GAO reports [44].

A DoC industrial technological extension service unit, such as IRES, would build on the results of the existing pilot programs to establish a coordinated nationwide operating program. State-supported field agents would interact, on the one hand, with a central core of experts in DoC who would identify information

sources and appropriate contacts in the Federal Government, and on the other hand with individual firms and organizations such as local Chambers of Commerce. The DoC Field Offices might be helpful as referral offices.

The operating instrumentalities, other than a small Federal core organization, would be at the regional, state, or local level. Experience at all Government levels has been promising; e.g., the New England Innovation Group, Pennsylvania Technical Assistance Program (PENNTAP), and Los Angeles Chamber of Commerce. These organizations would provide an adequately sized, technically trained field agent force. EDA is tentatively planning to extend grant support to another 15 such organizations next year, for a total of 30.

IRES could also use some of the funds for developing entrepreneurs presently administered by NSF/RANN to establish a nationwide system of small technical enterprise associates programs with engineering educational institutions. These could be patterned, for example, after MIT's Associates program, and would provide eligible enterprises with ad hoc advice on management, new product development, marketing and technical "trouble shooting" on a continuous, cost-free or subsidized basis.

c. Invention Promotion and Licensing Services (IPLS)

An existing NTIS unit promotes commercialization of U.S. Government inventions, and also obtains foreign patent protection on selected U.S. Government inventions, and issues licenses under these patents. The commercial attractiveness of these inventions is limited by procedural difficulties in granting exclusive licenses and by the undeveloped status of most of the inventions. Separate efforts are underway to obtain greater flexibility in issuing exclusive licenses. This new program is doing well.

3. Constituency of CTIS

The constituency or audience which would be served by the several CTIS functions would include, in order of importance:

- manufacturing industry
- service industries
- construction industry
- food growing and processing industry
- professional and consulting firms
- universities and colleges
- state and local governments in U.S.

The National Technical Information Service is already in contact with almost 140,000 people or organizations in the above categories. NTIS

has also begun developing cooperative arrangements with patent licensing and invention development organizations sponsored by several foreign governments.