COM-72-11412

Technology Enhancement Programs in Five Foreign Countries

Office of the Assistant Secretary for Science and Technology

U.S. Department of Commerce

DECEMBER 1972

Distributed By:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

COM-72-11412

TECHNOLOGY ENHANCEMENT PROGRAMS IN FIVE FOREIGN COUNTRIES

Country Sections by:

Suellen Halpin (Canada)
Donald W. Corrigan (France)
John C. Schleter (Germany)
George C. Nichols (Japan)
Stephen S. Karp (United Kingdom)

George C. Nichols, Project Director
John A. Birch, General Advisor

Department of Commerce
Office of the Assistant Secretary
for Science and Technology

December 1972

BIBLIOGRAPHIC DATA SHEET	1. Report No. COM 72-11412	2.	3. Recipient's Accession No.
4. Title and Subtitle: Technology Enhancement Programs in Five Foreign Countries			5. Report Date: December 1972
			6.
7. Author(s): Dr. George C. Nichols, et al.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: Office of the Assistant Secretary for Science and Technology, Department of Commerce			10. Project/Task/Work Unit No.
			11. Contract/Grant No.
12. Sponsoring Organization Name and Address: Office of the Assistant Secretary for Science and Technology, Department of Commerce			13. Type of Report & Period Covered
			14.
15. Supplementary Notes			

16. Abstracts Competition among nations to penetrate foreign markets for their industrial products has led the governments of most of the advanced countries of the world to use a variety of technology enhancement mechanisms and programs. Purpose of these programs is to stimulate invention and innovation and the development, transfer, and application of new technologies through the use of subsidies, tax, and other incentives, government procurement, joint ventures, R&D investment in designated industrial sectors, low and no-interest loans, and other mechanisms in collaboration with the private sector. This report examines the major technology enhancement programs initiated in recent years by Canada, France, Germany (Federal Republic), Japan, and the United Kingdom. The experience of these countries with such programs is of interest to the United States at this time particularly in relation to the newly-initiated Experimental Incentives Program that is being implemented by the National Bureau of Standards (Department of Commerce), and the National Science Foundation. In addition to the technology enhancement programs, the report contains a discussion of the involvement in each country within which science

17. Key Words and Document Analysis. 17a. Descriptors

and technology is developed and implemented and the government-private sector interaction. A bibliography is included at the end of each country's section.

17. Key Words and Document Analysis. 17a. Descriptors

Technology Enhancement
Technology Promotion
Technology Development
Technology Utilization

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 334
	20. Security Class (This Page) UNCLASSIFIED	22. Price $9.00

FORM NTIS-35 (REV. 3-72) THIS FORM MAY BE REPRODUCED USCOMM-DC 14952-P72

TABLE OF CONTENTS

GENERAL OBSERVATIONS

This report is a study of the principal technology enhancement programs, mechanisms, and incentives used in the civilian sector in each of the following five countries: Canada, France, Germany (Federal Republic), Japan, and the United Kingdom. A detailed presentation of the material for each country is given in five separate appendices at the end of the main body of the report.

What is a government technology enhancement program? For the purposes of this report, a government technology enhancement program is one which is designed to promote invention and innovation and the development, transfer, and utilization of new technologies through the use of subsidies, tax incentives, government procurement, low-interest loans, and other similar mechanisms in collaboration with the private sector.

The motivations behind such programs may, in most instances, be purely economic - increased competitiveness in world markets, improvement in the balance of payments, creation of new employment opportunities - but they also involve the generation of new technologies and their application or exploitation in the private sector. Other motivations may reflect concern with industrial self-sufficiency in relation to national security and desire to improve the "quality of life" or to enhance the national image.

A large number of such programs has been in operation in Europe and Japan for sometime. In the United States, the programs of the National Aeronautics and Space Administration and the Atomic Energy Commission, both of which underwrite the development of new technologies and the construction of prototype models, are, perhaps, the best examples of programs that would qualify under this definition. A limited number of programs in MARAD, NIH, DOT, EDA, SBA, the Agricultural Experimental Stations, aimed at developing prototypes or new technologies, and the 7 percent tax investment credit would also be considered examples of technology enhancement programs and incentives. With only a few exceptions, however, most of these latter programs have been initiated by the individual agencies concerned and do not indicate the kind of national policy or commitment that the U.S. space and atomic energy programs indicate.

experience. The following are some general thoughts and observations on those programs based on the findings of this study concerning the experience of the five countries mentioned above.

The overall objectives of technology enhancement programs in the five countries are more or less the same and vary only in the mechanisms used to achieve those objectives. They are:

1. To improve the country's competitiveness in foreign trade. This is the long-range objective to which somehow and to some extent all other objectives are subordinated.

2. To strengthen the country's technological infra-structure, including relationships between government, industry and universities. This is a shorter-range objective, but basic to the accomplishment of the first objective.

3. To focus efforts of government laboratories, firms, and universities on specific areas of technology believed to offer promise for national pre-eminence.

4. To retain in domestic hands control of designated "growth" industries that incorporate new advanced technologies.

5. To enhance national prestige.

6. To imporve the "quality of life."

The effectiveness of technology enhancement programs appears to be greater in those countries in which national science and technology (S&T) policy and goals, particularly as they affect designated industries, are well-defined and less subject to change. In Japan and France, government involvement in the formulation of S&T policy and the implementation of technology enhancement programs has been direct and substantial, in Germany less so, but still significant. In Canada and the United Kingdom, doubt about the nature and extent of government involvement may have contributed to the lack of effectiveness of several such programs.

Effective management of technology enhancement programs seems to require the establishment of an S&T agency at the highest level of government to perform a planning and coordinating function for the S&T programs of all the other agencies in the government. In all five countries examined, this function is performed by an agency at the cabinet or ministerial level. In France and the United Kingdom, the same agencies also manage most of the technology

A variety of technology enhancement mechanisms and incentives currently in operation in the five countries are, in effect, designed to encourage the commercialization, utilization, and diffusion of newly-developed technologies and products throughout industry. In this manner, modernization of equipment and facilities and increased industrial productivity are not only accelerated but made part of a continuous process of industrial technological renovation; e.g., Preproduction Order Support Program and Investment Grant Program (U.K.), first-year depreciation allowance and tax deduction on newly-acquired fixed assets (Japan), and PAIT (Canada).

The stimulation of invention and innovation and the commercialization of research findings that are in the public interest and appear to have a good industrial potential, have received strong support by the governments of the five countries. All have established a special agency to deal specifically in this area: e.g., CPDL (Canada), ANVAR (France), JRDC (Japan), NRDC (U.K.), and Garsching Instrument (Germany). These agencies evaluate research findings primarily of government research laboratories and institutes, although the last four also accept applications from private research laboratories and private inventors. All five agencies underwrite part or the full cost of developing a new technology or product and require repayment of their investment plus the payment of royalties only in the event the venture is successful.

Two of the five countries under consideration have established special, government-supported independent lending agencies to provide development funds at favorable terms to qualified applicants. They and most of the others have initiated special programs to accomplish the same objectives; e.g., JDB and two lending institutions for small- and medium-sized enterprises (Japan), CNME and IDI (France) and Launching Aid (U.K.).

Because smaller and medium-sized firms normally face problems that are directly related to their size, most of the governments have established several technology enhancement programs and incentives that are especially designed to stimulate R&D activities and the application of newly-developed technologies in such firms; e.g., Financial Support for R&D in Industry (U.K.), two lending institutions and special tax incentives (Japan), IDI and Aid to Pre-Development (France).

The establishment of research associations and joint ventures both among private firms and between a government agency and one or

INTRODUCTION

Competition among advanced nations in the sale of their internationally-traded products, especially high-technology products, has increased greatly in recent years, and will become even more intense in the years ahead. This competition for market penetration and acquisition is the result of concerted efforts exerted by several countries during the last 20 years to modernize plants and other facilities, to restructure their industrial complex and upgrade the technological base of the country, helping thereby to capture a "fair" share of the world market for their industrial products. In addition, these countries have initiated a variety of civilian technology enhancement programs designed to encourage the development and application of new technologies through R&D investment and productivity enhancement in designated industrial sectors, promotion of joint ventures, and the use of tax and other incentives.

The United States is perhaps the only advanced nation in the free world which has not undertaken national programs to stimulate technology development in the civilian sector. It has, of course, provided considerable financial support of basic research, and has spent enormous amounts of money on R&D contracts to industry in connection with the country's defense and space exploration programs. Although the "spin off" to the civilian sector resulting from these expenditures (e.g., computers and civilian aircraft) has been rather limited, the programs helped the nation to attain technological leadership and a competitive advantage in world markets. That position remained virtually unchallenged throughout the fifties and the sixties.

Until recently, the United States had not even considered the question of government support to technology enhancement programs in the civilian sector. One reason was doubt about the effectiveness of such programs, particularly when applied to the U.S. cultural and institutional environment, and a second was inexperience in technology enhancement in areas other than space and defense. A third reason was the lack of adequate data and information to allow an objective evaluation of the potential impact of such programs, or the performance of cost-benefit analyses, or, more importantly, an assessment of the alternative uses (and potential benefits) for the government funds involved.

U.S. Congress, and specially-appointed Presidential task forces, as well as a number of private professional organizations to study various interrelated aspects of technology, such as: technology development/technology applications/technology assessment/technology forecasting/technology transfer/technology enhancement/technology utilization/technology and foreign trade/technological innovation/productivity/government procurement/national goals/federal support of applied research. Most of these studies point out the pervasive nature of technology in modern society; its contribution to economic growth and to the quality of life; potential pitfalls; means for stimulating its development and utilization; and the roles which the private sector and the government should play in this technological environment.

In the fall of 1971, the government launched a top-priority effort called the New Technology Opportunities Program. The objective was to establish a program to apply advanced technology toward solving critical domestic problems, to stimulate innovative developments, to increase the competitiveness of U.S. products abroad and, in the process, to provide employment opportunities for U.S. scientists and engineers. The culmination was a set of proposals based on responses from federal agencies. Information and suggestions were furnished with respect to potential opportunities for using new technology; the likelihood of obtaining non-federal support; barriers to implementation of suggested technologies; required changes in anti-trust and patent law practices if research and development is to be encouraged; Federal government incentives which might be offered to industry in order to stimulate innovation and higher productivity. These proposals proved helpful in the preparation of the President's Budget Message to the Congress for FY 1973, and later in the drafting of the Presidential Message on Science and Technology submitted to Congress on March 16, 1972.

A novel proposal in the President's Budget Message was to initiate an experimental incentives program (later on designated by the Department of Commerce as the Experimental Technology Incentives Program - ETIP - and by the National Science Foundation as the Experimental Research and Development Incentives Program - ERDIP). Through actual experience in cooperation with the private sector, this would identify the nature and effectiveness of "a variety of incentives and mechanisms to stimulate the generation and application of private research and development in ways that will make our economy more competitive, improve its productivity, and provide new technological solutions to national problems." Determination of useful techniques for encouraging technological advances in the private sector would subsequently assist the government in formulating a technology enhancement program appropriate to the country's needs. The President has requested $40 million for the proposed program to be administered jointly by the National Bureau of Standards (NBS) of the Department of Commerce, and the National Science Foundation (NSF). Congress

The material for each country is presented in summarized form in the main body of the report and in a more detailed form in a separate appendix at the end of the report. The material in the appendix is organized in two parts, the first of which discusses the environment for science and technology. The environment for the promotion, development, and application of S&T policy differs widely from one country to another. In fact, the central government, by the nature and extent of its participation in initiating S&T policy, becomes the most important determinant of the environment in that country. Accordingly, three aspects were chosen for discussion in each country: government involvement in science and technology; organization for S&T policy development and implementation; and government-private sector relationship and interaction. The second part of each appendix is an analysis of the major current technology enhancement programs and mechanisms in each country.

Several reasons account for an observable disparity in size among the individual appendices:

1. The availability of pertinent printed material varies substantially from country to country, particularly with regard to material published in English. Although some of the material printed in the native language was reviewed, the constraints of time prevented a thorough review of all available material.

2. The number, level of position, availability and responsiveness of the officials interviewed differed from one country to another. In general, individual responsiveness was good to excellent, but different ratios of private sector to government interviews prevailed.

3. The number and variety of technology enhancement programs and their directions to date are by no means homogeneous. For example, technology enhancement programs were initiated in one country almost immediately after World War II, but only in the late 1960's in another.

4. The government participation and government-private sector interrelationships are quite different in the several countries under study. In general, the amount of material available was proportional to the degree of government action and interaction with the private sector.

5. In all countries studied, the governmental organizational structures for S&T policy development and implementation

even more of a deterrent to comparison. It was found that, even though the overall concept and purpose in terms of program objectives was the same in several countries, the scope and modus operandi were quite different, the programs having been adapted to meet national needs and conditions.

Evaluation of the economic impact of technology enhancement programs in measurable, quantitive terms was made difficult by the lack of sufficient data and the fact that nearly all such programs have been introduced by the government as being "in the public or national interest." Moreover, with only a few exceptions, most programs have been in operation too short a time to permit an evaluation of impact and effectiveness. According to the officials contacted, these government programs were introduced primarily to advance the technological base of the country and to increase the competitiveness of its products in foreign markets. Although not explicitly stated, another purpose was to maintain a high degree of economic independence (and national prestige) in technological areas and industries deemed essential to the future growth of the country by keeping domestic control of those technologies and industries. Innovations, development of new technologies and new, high-technology industries at home, the scientific and technological training of the labor force, and faster economic growth were all expected as by-products of this effort. Using these objectives to assess effectiveness, most officials conceded that these programs have, for the most part, proved to be acceptable and sufficiently successful to warrant continued, if not increased, support by government.

This report is therefore limited to an analysis of programs, mechanisms, and incentives related to technology enhancement initiated and supported by the five governments under consideration. It does not attempt to evaluate those programs individually, or to compare effectiveness from one country to another.

TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS IN CANADA

Up to the 1950's, few facilities for research and development were operated by private industries other than the chemical, and pulp and paper industries. The government maintained some in-house establishments for R&D, but industry imported the outputs of R&D activities conducted by their parent companies in other countries. Realizing the importance of science and technology as a means of improving the nation's economic growth and world stature, the Canadian government instituted a number of incentive programs designed to encourage R&D activities in industries directed toward both Canadian and world markets.

Although industry participation in Canadian-based research and development has increased tremendously over the last 10 years, at least in part as a result of the government's financial incentives, there has been some controversy concerning Canada's return on its investment. A recent Senate Commission study on science policy has called attention to weaknesses in the programs and has criticized the government for failure to coordinate efforts. Since the release of the Commission study, a new Ministry of State for Science and Technology has been established, with responsibility to review current science policy and programs. The government is currently reflecting on its past experience and is seeking to generate a viable "strategy" or "plan" for future national efforts in the broad field of science.

The responsibility for science policy formulation rests with the Cabinet, and is exercised through its Committee of the Privy Council on Scientific and Industrial Research. Science policy is reflected in the budgeting of funds to be applied to science and technology and in the actions of those departments which spend the research money. Implementation of this policy is manifested through: Crown activities in public and private enterprises; National Research Council contract research; Department of Industry, Trade and Commerce technology enhancement programs; consortia arrangements; and provincial government services to industry.

Interaction with the private sector is affected primarily through the government technology enhancement programs and by the fact that the government owns some business enterprises, either wholly

Title to patents, designs, data, and other materials resulting from the project remain with the company, and are not transferable without DITC approval. More than 500 projects at the cost of over $57 million have been funded since 1965 and the program has been well received by industry.

The objectives of the Industrial Research and Development Incentives Act (IRDIA), also operating under DITC, are to assist industry to undertake R&D projects, expand existing R&D activities, and equip R&D facilities to perform the work. IRDIA is designed to relieve industry of some of the financial burdens of maintaining R&D facilities. Assistance is provided in an amount equal to 25 percent of capital expenditures for R&D work in the year of application and 25 percent of the average increase in expenditures over a base period of the immediately preceding five years. IRDIA grants are not subject to federal income tax and are in addition to the normal 100 percent deduction of all expenditures for scientific research. Estimated expenditures for FY 1972-1973 are $32 million, only $1 million more than FY 1971-1972. In practice, IRDIA does not seem to actually encourage new research projects, but rather eases the financial burden of current ones. The fact that funds are applied for retroactively at least partially accounts for the apparent lack of increase in expenditures.

The Program to Enhance Productivity (PEP), under DITC, provides grant assistance to companies to aid in undertaking feasibility studies to determine whether productivity can be improved by introducing new methods, changing operations, or rearranging the plant. Grants of $50,000 or less are awarded to cover not more than 50 percent of the cost of the study. Money disbursed through PEP in FY 1971-1972 amounted to only $200,000.

In addition to the aforementioned programs, each of the provinces has a number of technology enhancement programs administered by a provincial research council or a government department which is assigned the responsibility for industry, trade and commerce matters.

Another mechanism for indirect government support of technology enhancement in industry is provided through the establishment of consortia. Consortia arrangements are condoned, even encouraged, by government in the interest of avoiding duplication of research, pooling of resources, and spreading of risks. There are a number of consortia or joint venture arrangements presently operating in which the government, industry and university sectors are participants.

TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS IN FRANCE

The government of France has been extensively involved in the promotion of science and technology since the early 1960's. The promulgation of the Fourth National Economic Plan (1962-1965) marked the overt official recognition of the relationship of science and technology to industrial development, thereby laying the foundation for future government involvement. The Fifth Plan (1966-1970) gave priority to strengthening the competitive capacity of French industry in the world market, while the present Sixth Plan (1971-1975) appears to be an extension of the Fifth Plan. The current science and technology policy appears to have become more pragmatic, with a set of goals better specified and more likely of attainment than the superseded goals from the De Gaulle era. High technology industries, such as electronics, chemicals, and measurement instruments, are still being given priority within a framework of promoting industry in general, but government emphasis on selected industries is being somewhat reduced in favor of more broadly applicable research and development.

The formulation of S&T policy in France is accomplished through the research portion of the National Economic Plan and the Annual Civilian Science Budget. The General Delegation for Scientific and Technical Research (DGRST), under the Ministry for Industrial and Scientific Development (MDIS), is the central government agency concerned with S&T policy formulation. With respect to the research portion of the Plan, it receives submissions from all research establishments, both public and private. It coordinates and elaborates these submissions and then transmits them to the Research Commission of the Plan, which serves as an arm of the National Planning Board. The DGRST also serves as the coordinating agency for the Annual Civilian Science Budget requests from agencies within the MDIS, as well as from other ministries. Among the agencies which receive the highest priority and greatest levels of funding are those concerned with atomic energy, space, oceanography, telecommunications, and the government research laboratories. The DGRST is the principal agency which dispenses government contracts for industry research and incentives for development.

has proved attractive to industry. One measure of the success achieved is the amount of actual reimbursement, which is about one-third after only six years that the program has been in operation. Projected government cost for 1972 is $42 million.

The Letter of Agreement is a mechanism by which the government encourages a company to undertake a large project that entails substantial initial production costs. The mechanism has thus far been used only in exceptional cases, such as the development of the Caravelle and in the computer industry, but there is increasing interest in this type of incentive. By a Letter of Agreement, the government guarantees to the company the difference between actual sales and the company's break-even point if the sales are lower; that is, the company is insured against loss. The Letter of Agreement also serves as a method for obtaining low interest credit to help finance production. The cost of this program to the government has not been disclosed.

The Agence Nationale de Valorisation de la Recherche (ANVAR) is an independent public corporation established in July 1968 for the purpose of stimulating invention and the commercialization of innovation. ANVAR collects research results and inventions from public and private laboratories, selects those of possible interest to business and industry, and offers them to industrial and commercial firms most likely to make the best use of such inventions. Total spending for 1972 is expected to be $3 million, two-thirds of which will be government funds and the remainder from license revenue. ANVAR maintains close contact with government and university laboratories to locate useful inventions, while at the same time keeping abreast of the needs of various industries. Inventions are also submitted for consideration by independent inventors and private laboratories, but the public sector is ANVAR's primary source of technology. Of the 1,000 files for possible inventions considered each year, only 250 are retained for possible use, and 200 of these are from government laboratories. If a market survey to determine the economic worth of an invention is favorable, ANVAR will file the necessary patent application either in its own name or the name of the responsible company or person. In some cases, ANVAR becomes the owner of the invention, in others it only helps the owner to obtain commercial development. The next step is to find the most competent firm to handle development and, if possible, the marketing as well. ANVAR is more likely to grant an exclusive license if the firm is willing to assume some of the cost of development. ANVAR, however, may assume the full cost of

TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS IN THE FEDERAL REPUBLIC OF GERMANY

The Federal Republic of Germany (FRG) is a federation of ten states. The Western Sectors of Berlin, which continue under occupation status, are also fully integrated into the economic, scientific and cultural systems of the Federal Republic. At the close of World War II, before full powers of self-government were returned to the FRG, the individual States began to revive the scientific establishments within their territories as had existed before the war. Universities and their research centers were rebuilt and pre-war research institutions were re-established. Industrial firms began to regenerate. The scientific base, traditionally a major factor in the economy and the lives of the people, began to expand. Financial problems soon faced the States, and they banded together to assist each other in the operation of their scientific organizations.

Soon after the Federal government was formed, the States were in need of further assistance. Agreements were reached whereby major research institutions were equally supported by Federal and State funds.

The Federal government, in recognition of the importance of science to the economy of the country and in reaction to the achievements of the great world powers, initiated the First Nuclear Energy Program in support of "big science[1/]." As basic and applied research and the industrial base continued to grow, programs were added in the fields of space research, civil aviation and data processing. Later, emphasis shifted from programs which were reactive to foreign achievements to those whereby technology could be applied toward the solution of problems of society and improving living conditions.

Plans, policies and priorities are determined by means of a complex interaction between representatives of Federal and

---

[1/] The term "big science" reflects the scale of operation necessary for many of the programs related to modern technology in terms of the number of people engaged, the size and cost of equipment used, the combination of scientific disciplines involved and the large outlays of money required.

are often encouraged to jointly establish third corporations, chartered as profit-making or non-profit corporations. Government contracts allow the inclusion of items for independent research in areas related to the contract. Tax incentives encourage research by firms, investment in R&D-related activities and facilities, and the creativity of individual scientists and inventors. The right to remuneration commensurate with the importance of a discovery is assured an inventor by law. Finally, aspects of patent law encourage rapid utilization of new discoveries.

Within the framework of direct and indirect support, large programs are operated in areas of nuclear energy, space research, civil aviation, data processing, oceanography and new technologies, including environmental protection.

By means of the nuclear energy program, a nuclear industry has become competitive in world markets. The R&D base has been established in the field of space research and, in cooperation with other nations, research satellites have been orbited and application satellites are under development. Aircraft companies in cooperation with European neighbors, are nearing production of a large commercial aircraft. Small and medium-size computers are being manufactured to recognized standards, and efforts are being expanded in the areas of large computer systems and data processing applications. First efforts are being made to utilize food and mineral resources from the world's oceans.

The program in the area of new technologies is expected to produce applications of science and technology by means of which living conditions may be improved. Such areas as communications, transportation, health, food and the environment are of immediate concern.

In sum, science and technology policy has evolved in the last 22 years, assisting in the successful re-establishment of the resources of science and industry within the FRG. Building on these established resources, present policy addresses the utilization of science and technology for objectives more relevant to present and future societal needs. These goals will be accomplished by means of government-industry promotion of science through national programs and international cooperation.

TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS IN JAPAN

Science and technology, in particular the application of technology to industrial uses, has been a key element in the modernization and economic development of Japan for more than a century. Throughout, the Japanese government has been at the center of this effort, lending its authority and support. After World War II, the rebuilding and restructuring of the Japanese industry, the establishment of new technology-intensive industries, and the raising of the country's technological base to a more advanced level were accomplished substantially through the importation, modification, and assimilation of foreign technology, although heavy government subsidies and the dedicated determination of the Japanese people were equally important factors.

The Japanese government has established a complicated system of interlocking agencies, advisory councils, quasi-public corporations, industrial R&D laboratories, and mandates, and has participated in the launching of a large number of technology enhancement programs. Every ministry in Japan to some degree promotes science and technology, but at least two agencies have this goal as their primary charter. The Science and Technology Agency (STA) formulates basic national policies for science and technology and provides overall coordination in areas in which inter-ministerial research cooperation is essential (e.g., atomic energy and space development). It also participates in the formulation of the S&T budgets of the ministries. The Ministry of International Trade and Industry (MITI) through its Agency of Industrial Science and Technology (AIST) promotes R&D work in mining and manufacturing industries, coordinates the R&D activities of affiliated institutes and laboratories, and manages the national R&D projects (discussed below). MITI also exercises considerable authority over technology imports: it screens applications from domestic companies for technological assistance contracts with foreign firms, the type and flow of foreign technologies into the country, and the selection of recipients of tax and other incentives for channeling technology investment to designated industries in the national interest. MITI's policy has been to balance the "need" of technology imports against protection of the domestic industry from unrestrained competition, thereby ensuring industry's steady growth and, insofar as possible, retaining control in Japanese hands.

The National R&D Program was started in 1966. It consists of nine fully-subsidized projects that are urgently needed by the country to develop new advanced technologies, to keep abreast of developments in other industrialized countries and to maintain the growth momentum of the domestic economy. These projects are, in essence, laying the foundation for the development of whole new industries (the "sunrise" industries of the future) which will create new competitive opportunities abroad and raise the standard of living at home. The current projects in the program are: (1) magneto-hydrodynamic generator (1966-1972, $15 million); (2) super-high-performance electronic computer systems (1966-1971, $28 million); (3) desulfurization process (1966-1971, $2.6 million); (4) new process for olefin products (1967-1973, $11 million); (5) sea water desalting and by-product recovery (1969-1975, $14 million); (6) remote-controlled undersea oil drilling rig (1970-1974, $14 million); (7) electric car (1971-1975, $14 million); (8) pattern information processing system (1971-1978, $97 million); (9) turbofan engine for aircraft (1971-1975, $19 million). So far, MITI appears to be pleased with the progress and prospects of these projects and plans to continue its support, except for project (4) which was cancelled in April 1972, since a decrease in the demand for naptha reduced the urgency to develop a new process. There have been no significant cost or time overruns to date. All of the major Japanese industrial firms are involved in one or more of these projects and are cooperating fully with the government.

Among the large number of Joint Government-Private Sector Technology Projects, those under the atomic energy, space, and ocean development programs have received large amounts of funds and high priority for implementation. They are discussed in the appendix in detail. Financial participation by the private sector in these joint-venture projects varies from a token 3-5 percent to as much as 50 percent of the total cost, depending on the overall cost of the project, the risk involved, and other comparable factors. Joint-venture programs and projects, particularly those involving large national technological development, are normally carried out under quasi-government "Corporations under Special Charter" established especially for the purpose. Each corporation is first funded by the government plus the contribution from the private sector, remains under government control for the duration of the program, and eventually qualifies for special development loans from the Japan Development Bank.

Technology enhancement activities in the Atomic Energy Program, for which $182 million was allocated in FY 1972, are carried out private companies involved to ensure that they acquire all available knowledge on the advanced technology being developed. Eventually, one of the participating companies is chosen to receive the newly-developed product (e.g., a prototype power reactor) for commercial production, or the prototype (pilot) plant for private operation. To facilitate commercialization of the new technology, the government may recommend the extension of concessional loans through the Japan Development Bank.

In addition to the direct financial support of the aforementioned programs, the government uses a large variety of tax and other incentives designed to encourage private investment in R&D and to foster commercialization and diffusion of newly-developed technologies. Most prominent among those incentives are: (1) a 25 percent tax deduction on R&D expenses if they represent an increase of up to 12 percent over the highest R&D expenses since 1967 (50 percent for the portion of expenses above 12 percent); (2) a first year accelerated depreciation equivalent to up to one-third of the acquisition cost of machinery, equipment, and facilities related to the use of a newly-developed technology; (3) a 50 percent tax deduction on newly-acquired fixed assets, including buildings, during the first three years following the purchase of these assets; (4) full amortization of expenditures incurred by companies in connection with the establishment of an association or a cooperative, or expenditures incurred by an established association to purchase new equipment and machinery or to build a new plant facility; (5) development and equipment loans at favorable terms through the Japan Development Bank, a government-owned financial institution. Small and medium sized enterprises are provided additional tax and other incentives, as well as loans on liberal terms through two special government-financed and one partially government-financed lending agencies.

Patents resulting from R&D work performed for the government or in government laboratories belong to the government, usually the sponsoring agency. As a result, several government agencies have accumulated a large number of patents. Patents owned by AIST may, as a rule, be licensed to any company on a non-exclusive basis, with royalties going to the government. An exception is made in the case of patents obtained under projects which are part of the National R&D Program. The government may retain a few of those patents and some of the rights; the remaining patents are licensed to the participating companies on an exclusive basis for a period of one to two years, after which the patents may be fully licensed to any company.

TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS IN THE UNITED KINGDOM

Government involvement in science and technology dates back to 1916, when a Department of Scientific and Industrial Research (DSIR) was first established as a focal point within government for matters relating to applied research and development. Research Associations, intended to foster the diffusion of R&D throughout potential industries, began to function in number during the early 1920's. Under the Labor Government reorganization, responsibility for the industrial sector was consolidated in the Ministry of Technology (MinTech) which took over, by stages, the sponsorship of a wide range of industries. By 1970, MinTech had responsibility and sponsorship for virtually the whole of the electrical, electronic and mechanical engineering industries, including electrical and mechanical engineering products generally, motor vehicles, electrical and process plant, civil and military aircraft and aircraft engines, and shipbuilding.

The Conservative Party returned to power in 1970. In October of that year, MinTech was dismantled and the Department of Trade and Industry (DTI) was formed. Since then, two policy trends have become evident: the decentralization of government support for R&D, with control reverting to "mission" agencies, and a change from an "activist" role, with government seeking to lead, control, and stimulate R&D in industry, to a "hands-off" attitude. The quasi-governmental Industrial Reorganization Corporation (IRC), which had been one of the primary mechanisms for government direction of industry, was abolished in May 1971. Other programs have been instituted to promote and sustain faster economic growth, to secure the expansion and modernization of industry, to alleviate problems of regional imbalance, and to assist industry to meet the challenge of the European Economic Community. These programs are designed to perform many of the same objectives as the IRC without direct intervention by government, hence there appears to be some softening of the "hands-off" policy.

Government policy for science and technology is established by Parliament and implemented by Parliamentary Acts. The focal point within government for applied R&D is the Department of Trade and Industry. All of the programs which implement government the feeling that the program involved high public expenditure and did not achieve the intended objectives. The program benefitted firms whether or not they were profitable, and discriminated against service industries.

The objective of the Financial Support for R&D in Industry program is to further the practical application of the results of scientific research. It provides support to relatively small firms and to research associations and universities for which the cost of R&D may be too great to sustain. The level of spending has been increasing yearly and is now about $9.3 million per annum. On research projects whose results are to be disseminated freely (e.g., work done by research associations or universities), DTI has contributed up to 100 percent of the cost. For development projects aimed at a marketable product, the government has typically contributed about 50 percent of the cost. Despite the benefits which have accrued to industry after more than 10 years of operation, this program has not yet become a financial success. Some revenues have been derived by the government from levies, but these amount only to about 10 percent of the government's investment.

The Grant Program to Research Associations provides financial help to groups of firms with similar interests to set up research associations to carry out industrial and product research cooperatively. Grants usually cover five-year periods and are normally reviewed prior to renewal. The amount of the grant is usually a fixed percentage of the income provided to the association by its industrial members. In addition, special non-recurring grants may be made available for capital improvements, such as new buildings and expensive plants. Grants totaled approximately $10.7 million in 1970. Although the objectives of the program have to some degree been accomplished, the extent of success in small firms is considered to be limited, largely because only a small fraction of the small firms in any industry hold membership in research associations.

Launching Aid is the equivalent of an interest-free loan for development of civilian aircraft and engines. The amount is proportional to the initial estimated costs of design, development, start-up and "learner" costs, repaid to the government by levies on sales. The underlying objective is earning foreign currency and reducing imports in cases where the level of risk involved and the high financing required exceed the capacity of the company concerned. The amount of Launching Aid for a project is an agreed proportion of the launching costs, based on an initial estimate. It is usually not more than 50 percent.

were less than $8 million for 1970-1971. The cumulative net borrowing now amounts to $65 million out of the $132.5 million provided for by the Act of 1967. The benefits accrued to industry are numerous, including: development of new technologies and products; increased competitiveness in world and domestic markets; increased productivity, employment, production, sales, and exports. NRDC estimates that about $265 million worth of manufacture in the United Kingdom would not have taken place, but for the NRDC activities.

APPENDICES

APPENDIX I

ANALYSIS OF PROGRAMS AND MECHANISMS IN CANADA

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

CPDL	Canadian Patents and Developments Limited
DITC	Departments of Industry, Trade and Commerce
IDAP	Industrial Design Assistance Program
IRAP	Industrial Research Assistance Program
IRDIA	Industrial Research and Development Incentives Act
NRC	National Research Council
ODC	Ontario Development Corporation
ORF	Ontario Research Foundation
PAIT	Program for the Advancement of Industrial Technology
PEP	Program to Enhance Productivity
PRRI	Petroleum Recovery Research Institute

PART I

THE ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Part I of this appendix discusses the environment within which science and technology policy is developed and implemented. The discussion is presented in three sections as follows: Government Involvement in Science and Technology; Organization for Science and Technology Policy Development and Implementation; and Government-Private Sector Relationship and Interaction.

A. Government Involvement in Science and Technology

Prior to World War II, Canada's technology base was largely concentrated in non-industrial areas such as agriculture, mining and fisheries. The industrial population was primarily composed of affiliate or subsidary companies of British and U.S. corporations which relied, for the most part, on their parent corporations for research and development work.

The Canadian government in 1916 formed a governmental research body, the National Research Council (NRC), a Crown Corporation, for the purpose of stimulating and encouraging research activities in universities and in the industrial sector, as well as conducting its own research programs. With the advent of World War II, much of NRC's research activities were devoted to defense-oriented research and development and to nuclear energy research. At the War's end, responsibilities for these activities were removed from NRC and distributed to newly-formed corporations owned by the Canadian government, which were established for the purpose of performing research in these specific areas. This shift of responsibility made it possible for the NRC to concentrate once again on its original purpose.

Up to the 1950's, few facilities for research and development were operated by private industries other than the chemical and pulp and paper industries. The government maintained some in-house establishments for R&D, but industry imported the outputs of R&D activities conducted by their parent companies in other countries since foreign investors were generally reluctant to establish new research facilities at the sites of their branch or subsidiary companies. The Canadian government, realizing the importance of science and technology as a means to improve the nation's economic growth and world stature, instituted a number of incentive programs designed to encourage research and development activities in industries directed toward both Canadian and world markets. Initially, the programs were to a great extent concerned with defense-oriented research; as defense spending diminished, program emphasis was shifted toward practical applications of scientific and technological developments to industries in the civilian sector.

Although industry participation in Canadian-based research and development has increased tremendously over the last 10 years, at least in part as a result of the government's financial incentives, there has been some controversy concerning Canada's return on its investment. A recent Senate Commission study on science policy in Canada has called attention to weaknesses in the programs, and has indicted the government departments charged with science and technology activities and program administration for failure to coor-

B. Organization for S&T Policy Development and Implementation

The responsibility for science policy formulation rests with the Cabinet, and is exercised through its Committee of the Privy Council on Scientific and Industrial Research, composed of those government Ministers whose departments and agencies are concerned with scientific activity (such as the Minister of Industry, Trade and Commerce and the Minister of Energy, Mines and Resources). The Committee meets to discuss the nature and organization of the science programs of the various departments, as well as the level of funding required for implementation. Program proposals and budget requests of the Committee are submitted to the Cabinet through the Treasury Board.

"Science Policy" is reflected in the budgeting of funds to be applied to science and technology and in the actions of those departments which spend the research money. Implementation of this policy in relation to industrial development is manifested in the following ways, as discussed below:

1. Crown activities in public and private enterprises;

2. National Research Council contract research, information services, and R&D incentive programs;

3. Department of Industry, Trade and Commerce incentive programs, and information services;

4. government allowance of consortia arrangements; and

5. provincial government services to industry.

1. Crown Activities

Crown corporations, owned by the "Queen" and established by Parliament under the Government Companies Operations Act of 1946 to perform specific tasks in Her behalf, have been formed to engage in a variety of public service-type activities, ranging from atomic energy research to the operations of an airline. These corporations are created in the same manner as public corporations but all shares, except for a limited number which may be owned by those appointed to the Board of Directors, are held in trust by the particular Minister of government to whom the corporations are responsible.

Under the Government Companies Act, the Canadian government is able to promote reseach and development independently or

- Industrial Design Assistance Program (IDAP) and

- Program to Enhance Productivity (PEP)

DITC's budget for its incentive programs is approximately $75 million per year, representing about 30 percent of the Department's total budget. The programs are administered by the Department's Office for Science and Technology.

4. Consortia

Interpretations of Canadian law are not restrictive regarding combined efforts of competing companies. Thus, consortia arrangements are condoned by government, and on occasion, may even be encouraged, particularly in the oil industry. The advantages of avoiding duplication of research, pooling of resources, and spreading risks so that no single company stands to suffer greatly if the venture fails make these arrangements attractive to both industry and government.

5. Provincial Services

Each of the provinces provides services administered either by a Provincial Research Council or by a government department assigned responsibility for matters related to industry, trade and commerce. For the most part, the Research Council programs provide information services and contract research. The departmental programs are primarily technical and managerial advisory services directed at provincial growth.

The Province most active in R&D incentive programs is Ontario; its programs, as well as a few of the programs in other provinces, are discussed in Part II.

C. Government-Private Sector Relationships and Interaction

The government of Canada affects industrial development in a number of ways. In addition to the various programs for direct financial and advisory assistance to overall industrial development, the government owns some business enterprises, either wholly or partially, and also maintains a capital equity interest in joint ventures with industry.

PART II

MAJOR TECHNOLOGY ENHANCEMENT

PROGRAMS AND MECHANISMS

Part II of this appendix discusses the technology enhancement programs and mechanisms which are currently in operation in Canada. This discussion is presented in five sections as follows: Programs of the National Research Council; Programs of the Department of Industry, Trade and Commerce; Provincial Programs; Income Tax Allowances, and Consortia.

A. Programs of the National Research Council

The National Research Council is a Crown Corporation, established to foster and support scientific and industrial research in Canada. The NRC has instituted a number of assistance programs in conformance with this stated purpose; two of these programs will be discussed here for their pertinence to technology enhancement: the Industrial Research Assistance Program (IRAP) and the Industrial Post-doctorate Fellowship Program. Also discussed are the NRC's information and patent services:

1. Industrial Research Assistance Program (IRAP)

The purposes of the IRAP program are to stimulate industry interest in scientific research, to encourage the establishment of new research activities in industry, and to expand ongoing industrial research. The program is designed to provide assistance in the form of grants for salaries of professional scientists and engineers who are assigned to approved research and development projects. As a rule, IRAP approval is given to those proposals which concentrate on long-term applied research and development projects.

The program was established by the National Research Council in 1962, and NRC has invested approximately $44 million in IRAP assistance to date. The average contribution per project is approximately $50,000 per annum.

Applications for assistance consist of a detailed project proposal, plus resumés and background information on the staff members who are to be supported through NRC. A small secretariat, composed of experts in the subject field of research, reviews and assesses the project for its scientific merit and the capabilities of the company and its staff. The proposal is then submitted for final approval by a committee composed of representatives from several government agencies.

Both industry and NRC are satisfied that IRAP is a successful program. Approximately 230 projects are currently being funded through IRAP, with participation by the following industries, among others: pharmaceuticals, chemicals, food products, aircraft, and iron and steel manufacture. Assistance is relatively easily obtained in that little "red tape" is encountered in the administration of the program.

The amount of assistance granted to a project through the IRAP program amounts to approximately 40 to 50 percent of the

Fellowships are awarded by the NRC Scholarship Committee on the basis of the candidate's academic qualifications and career potential. The committee also considers the company and its proposed program of work. Awards are granted for a 12-month period and are renewable for another 12-month term provided that the candidate and the company are both agreeable to the extension.

More than 75 companies have already expressed an interest in participating in this program and interest seems to be growing. However, the program is only 2 years old and, since it is a 2-year program, its success or failure cannot yet be realistically judged. Nonetheless, it appears to be well received by industry and to have satisfied the fundamental purposes for which it was instituted.

3. NRC Information and Patent Assistance

The results of in-house research performed by the NRC are made available to industry through printed publications distributed by:

- the National Science Library, maintained by the NRC and serving as the nucleus of Canada's scientific and technical information network;
- the Technical Information Service, a division of NRC which, on request, provides industry with free information and advice on technological matters through its field offices; and
- Canadian Patents and Developments Limited (CPDL) is a subsidiary company of NRC which acts as the government's primary patenting and licensing agency. The CPDL handles patent matters associated with research in government departments and agencies, research councils, and Canadian universities.

Patent proposals are submitted by individual departments or organizations to CPDL where they are assessed for originality, market feasibility, scientific value, cost of development, production and market. Patented inventions are licensed to industry for manufacture. If licensees are willing to do development work, they may recover a portion of their costs by negotiating with CPDL regarding royalty allowances or exclusive rights for a specificed period of time. CPDL may also fund

- competitiveness of the product or process once the marketing stage has been reached;

- patentability of the product or process and the country in which application for patent will be made; and

- technical problems and risks, and the foreseeable method of approach to be used for problem solution and risk reduction. (To be funded, a project must be founded on a sound technical base. Experts in the relevant field will evaluate the proposal for technical features.)

Approved projects are awarded a cash grant not to exceed 50 percent of the estimated total cost of the project. Funds are disbursed to the company on a monthly or quarterly basis, whichever is more appropriate. These disbursements, called "monthly progress payments," provide for costs incurred during that period.

Companies receiving grants are required to exploit the results of a project in foreign and domestic markets by working from a manufacturing base in Canada whenever economical to do so. Title to patents, designs, data and other materials which derive from the project remain with the company, and are not transferable without the Department's approval.

The PAIT program has been well received by industry. More than 500 projects have been funded under PAIT assistance since establishment of the program in 1965. The chemicals, electronics and machinery industries have been the most active in this general program.

The Department of Industry, Trade and Commerce has established as a criterion for PAIT "success" as an incentive program that at least 50 percent of the projects funded achieve either the production and sale of new products or the introduction and use of new processes in industry. To date, the program has satisfied this criterion.

2. Industrial Research and Development Incentives Act (IRDIA)

IRDIA's program objectives are to assist Canadian industry in undertaking research and development projects, expanding existing R&D activities, and equipping R&D facilities to perform the work. It is a general program designed to relieve industry

(c) the corporation is free to exploit the results of all such scientific research and development in all export markets

he shall conclude that such scientific research and development is likely to result in benefit to Canada if successful."

The payment of grants under the IRDIA program is based on expenditures incurred by industry for R&D during the fiscal year or that period for which income tax is reported. IRDIA grants are not subject to Federal Income Tax and are in addition to the normal 100 percent deduction of all expenditures for scientific research.

The government has estimated that IRDIA expenditures in Fiscal Year 1972-73 will amount to $32 million. Fiscal Year 1971-72 expenditures were originally predicted to be $31 million, but had already exceeded that figure by March 31, 1972.

The government's expenditure figures for IRDIA seem to reflect that this program has had only minor effect on increased R&D in industry. Monies disbursed under IRDIA in the past 2 years have increased by less than $1 million, and the projected increase for Fiscal Year 1972-73 is also under $1 million. In practice, IRDIA does not seem to actually encourage new research projects, but rather eases the financial burden of current or concluding ones. The fact that funds are applied for retroactively at least partially accounts for the apparent lack of increase in expenditures.

3. Industrial Design Assistance Program (IDAP)

Two goals have been set for the IDAP program:

- improvement of Canadian design quality, thus helping to expand sales; and
- attraction and retention of industrial design talent in Canada.

Under IDAP, financial contributions for short-term projects (i.e., on the order of 2 years) are made to manufacturing companies which demonstrate interest in design improvement through the employment of industrial design services. Grants are awarded subject to the technical and commercial feasibility of the project proposed.

part, the research council programs provide informational services and contract research. The departmental programs offer primarily technical and managerial advisory services directed toward provincial growth.

The Province of Ontario is the most active in R&D incentive programs.

1. Ontario Development Corporation (ODC)

Created in 1966, the Ontario Development Corporation (ODC) has the primary objective of encouraging industrial and economic growth in the Province of Ontario by means of financial and advisory assistance to business and industry. The Corporation is managed by a Board of Directors comprised of representatives from business, labor and financial institutions. The Board is responsible to the Provincial Legislature and reports through the Ministry of Trade and Development.

ODC has two programs of financial assistance, provided in the form of performance loans and term loans. Performance loans are made available to industry for locating new operations in designated areas of the province considered to be "slow growth." These are not of further interest for the purposes of this report.

Term loan programs are intended to assist small, Canadian-owned companies which are engaged in manufacturing or service industries to expand their operations, improve productivity and establish or increase exports, all with a view to stimulating economic and industrial growth. Eligible businesses include those service industries which are closely allied to manufacturing, such as machine shops, food processing industry, printing and allied trades. A small business is defined as "one in which the owner's investment does not exceed $300,000." The maximum allowable loan is $50,000, and repayment of the debt may be spread over a 10-year period.

There are four types of assistance under the Terms Loans Program:

- "Venture Capital for Canadians" Fund;
- Pollution Control Equipment Loans;
- Tourist Industry Loans; and
- Industrial Mortgages and Leasebacks.

is limited to a maximum of $500,000. Repayment of the loan may be extended over a period up to 20 years. Under certain circumstances, the ODC will consider leasebacks or rental arrangements in some slow-growth areas. In such cases, the Corporation purchases the facilities and leases them to the company.

ODC's advisory assistance program provides secondary industry with information and direction on "what is available and where" with respect to technical and management assistance to solve its problems.

When qualified to do so, staff personnel discuss and offer advice on matters of a technical nature. Every effort is made to explore all the possible avenues open to the firms to increase their potential.

2. Ontario Research Foundation (ORF)

The Ontario Research Foundation is an independent, non-profit organization, established in 1928 by a special Act of the Ontario Legislature. The Foundation reports to a Board of Governors comprised of representatives of the industrial, commercial and scientific fields. The primary objective of the ORF is the development of industry in Canada, especially in Ontario, through the practical application of science and technology. It conducts long and short range research and development projects for both industry and government on a contract basis.

Large and small companies and government agencies present their problems to the Foundation. After review and discussion with the client, the ORF prepares a written proposal for consideration. Emphasis is placed on problems of a technical nature, with little or no consideration given to management assistance. The proposal includes cost figures and time frame for the completed project. ORF representatives and client companies maintain close liaison until the project has been completed. All inventions and innovations and any information resulting from ORF research are the property of the client company. For the most part, ORF's clientele consists of small companies with staffs of 50 to 100 people.

The research is performed at cost to ORF, thus furnishing an economical means for small companies to employ research services and providing a special purpose R&D facility to augment existing facilities in larger companies.

E. Consortia

Another mechanism for indirect government support of technology enhancement in industry is provided by acceptance of consortia. A consortium is a temporary alliance of two or more business firms in a common venture. Consortia arrangements are condoned by government and, on occasion, may even be encouraged, particularly in the oil industry. The advantages of avoiding duplication of research, pooling of resources, and spreading of risks so that no single company stands to suffer greatly if the venture fails make consortia attractive to both industry and government.

There are a number of consortia or joint venture arrangements presently operating in Canada in which the government, industry and university sectors are participants. The Petroleum Recovery Research Institute (PRRI) located in Alberta, exemplifies such a consortium.

The PRRI is a private, non-profit company. It was incorporated in 1966 under the Alberta Companies Act for the purposes of (1) conducting fundamental research in the field of petroleum recovery and (2) aiding the petroleum industry through education regarding new recovery techniques.

The membership of PRRI currently includes more than 35 independent firms. Its rolls are open to any oil or gas producing company upon payment of an annual fee ranging from $1,000 to $10,000. Fees for individual companies are based upon production and the extent to which the member company participates in (1) other research activities in the Province and (2) the educational program of the Institute. These fees, combined with an annual contribution from the Alberta government, amounted to $195,000 for Fiscal Year 1970-71.

The Provincial government of Alberta is represented by the Minister of Mines and Minerals, the Director of the Alberta Research Council, and the Chairman of the Oil and Gas Conservation Board. University representation includes the Deans of Engineering of the Universities of Alberta and Calgary.

The Institute is located at the University of Calgary, which provides space and facilities as well as maintenance, utilities and computer time at no cost to the Institute. The Research Council of Alberta provides administrative services to the Institute, such as purchasing, payroll and auditing, also without cost.

Other consortia arrangements, such as Panarctic Oils Ltd., operate somewhat differently from PRRI. Panarctic began with a number of small companies which held leases to land in the Arctic Islands where oil and gas deposits were discovered. Those companies were unable to exploit the deposits individually. The Federal government intervened with a 45 percent equity interest in a consortium composed of the small companies and the Crown.

BIBLIOGRAPHY

Department of Industry, Trade and Commerce, Doing Business in Canada, Federal Incentives to Industry, Information Canada, Ottawa, 1970.

__________, Industrial Design Assistance Program, Queen's Printer, Ottawa, 1970.

__________, Industrial Research and Development Incentives Act, Queen's Printer, Ottawa, 1970.

__________, Program for the Advancement of Industrial Technology, Queen's Printer, Ottawa, 1970.

__________, Program to Enhance Productivity, Queen's Printer, Ottawa, 1970.

Dominion Bureau of Statistics, Canada Year Book 1970-71, Information Canada, Ottawa, 1971.

Science Council of Canada, Background to Invention, 1970 Special Study No. 11, Queen's Printer, Ottawa, 1970.

__________, Fourth Annual Report 1969-70, Queen's Printer, Ottawa, 1970.

__________, Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing, October 1971, Report No. 15, Information Canada, Ottawa, 1971.

__________, The Multinational Firm, Foreign Direct Investment, and Canadian Science Policy, December 1971, Special Study No. 22, Information Canada, Ottawa, 1971.

APPENDIX TWO

ANALYSIS OF PROGRAMS AND MECHANISMS

IN FRANCE

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ANVAR - Agence Nationale de Valorisation de la Recherche
(National Agency for Research Development)

CCRST - Comite Consultatif de la Recherche Scientifique et Technique
(Consulting Committee on Scientific and Technical Research)

CEA - Commissariat a L'Energie Atomique
(Atomic Energy Commission)

CGE - Compagnie Generale D'Electricite
(General Electric Company)

CII - Compagnie Internationale de l'Informatique
(International Information Company)

CIRST - Comite Interministeriel de la Recherche Scientifique et Technique
(Interministerial Committee on Scientific and Technical Research)

CNES - Centre National d'Etudes Spatiales
(National Center of Space Studies)

CNET - Centre National d'Etudes des Telecommunications
(National Center of Telecommunication Studies)

CNEXO - Centre National pour l'Exploitation des Oceans
(National Center for the Exploitation of Oceans)

CNME - Caisse Nationale des Marches de l'Etat
(National Bank of State Commerce)

CNRS - Centre National de la Recherche Scientifique
(National Center of Scientific Research)

DGRST - Delegation Generale a la Recherche Scientifique et Technique
(General Delegation for Scientific and Technical Research)

DTEIM - Direction de la Technologie, de l'Environment Industriel et des Mines
(Directorate of Technology, of the Industrial Environment, and of Mines)

PART I

THE ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Part I of this appendix discusses the environment within which science and technology policy is developed and implemented. The discussion is presented in three sections as follows: Government Involvement in Science and Technology; Organization for Science and Technology Policy Development and Implementation; and Government-Private Sector Relationship and Interaction.

A. Government Involvement in Science and Technology

The French government's increasing involvement in the promotion of science and technology since the early 1960's is largely attributable to the influence of DeGaulle. The promulgation of the Fourth National Economic Plan (1962-1965) marked the overt official recognition that research was a most important factor affecting the development of the nation.

National economic planning had been introduced in France following World War II as a means for coordinating a nationwide effort at reconstruction. The First Plan (1947-1953) concentrated on rebuilding the nation's production capabilities, and thus the economy. The Second Plan (1954-1957) emphasized efficiency and quality of production, rather than sheer quantity, as was stressed in the First Plan. The Third Plan (1958-1961) focused on economic expansion and financial equilibrium. Anticipating the creation of the European Economy Community (the Common Market), the planners were especially concerned with preparing the historically protected French economy for increased open international competition.

In the Fourth Plan, science and technology, especially in their relationship to industrial development, were recognized, thus laying the foundation for future government involvement. This plan also initiated a new phase of national planning, assuming social as well as economic dimensions. Emphasis was placed not only on productive capacity, but also on balancing the distribution of benefits between consumption and investment. The Fifth Plan (1966-1970) subsequently gave priority to strengthening the competitive capacity of French industry in the world market. It also emphasized basic research and better dissemination of results to promote practical applications.

The present Sixth National Plan (1971-1975) appears to be an extension of the Fifth Plan. The principal goal is rapid industrial development expected to lead to a 50 percent increase in industrial production and an average annual growth rate of 6 percent. The Plan specifies the proportion of national product to be allocated to research and provides for acceleration of private and government research programs.

Although these Plans have been approved by the French Parliament, they are merely indicative of government expectations electronics, chemicals, and measurement instruments, are still being given priority within a framework of promoting industry in general, but government concentration in selected industries is beginning to be systematically reduced.

France is the third largest trading nation in Western Europe (exports account for 12 percent of her GNP, whereas in the United States they account for less than 5 percent) and about 75 percent of France's exports are manufactured goods. French emphasis on industrial development and economic growth is closely related to a goal of achieving a substantial surplus on trade in industrial products, which, the French claim, is necessary for maintaining the overall trade account in balance. Heavy investment in research and development activities is considered very important to the achievement of this goal. The French government also actively promotes high-technology exports. It does not hesitate occasionally to exert political pressure on other countries in attempts to get them to buy French products.

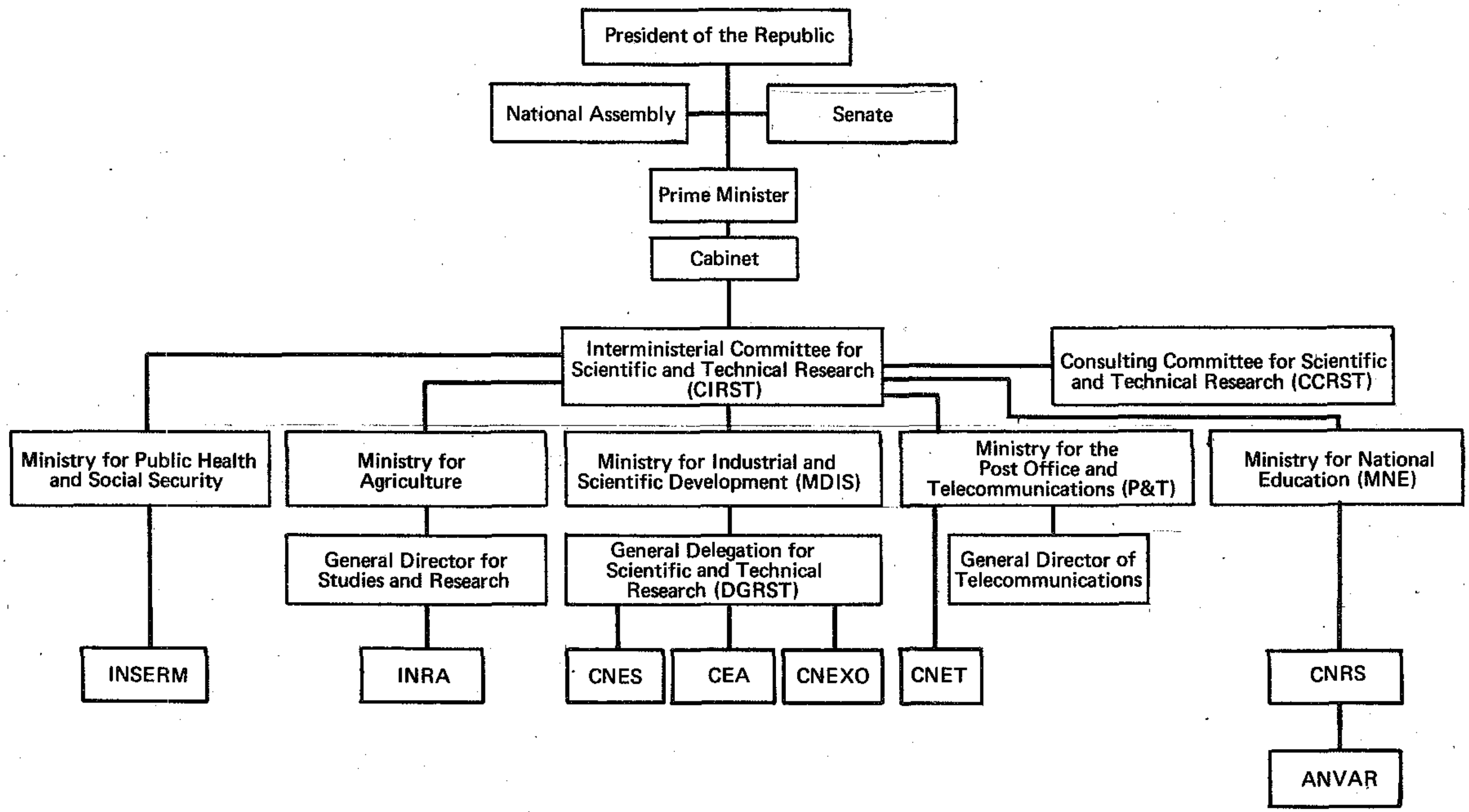
Consonant with the above mentioned factors, the government invests heavily in R&D activities. It is expected to provide approximately 70 percent of the total national expenditures for R&D for 1972 projected at \$3.2 billion. Of the \$2.1 billion to be spent by the government, \$1.25 billion has been allocated to the Civilian Science Budget, \$650 million to military defense R&D, and \$200 million for aircraft such as Concorde, Airbus, and Mercure. Under the Sixth Plan, total R&D expenditures are expected to reach \$5.4 billion by 1975, or 2.5 percent of the projected gross domestic product for 1975. (Government science officials also hope for increased percentage of industry support by that time.)

B. Organization for Science and Technology Development and Implementation

The formulation of S&T policy in France is accomplished through two mechanisms: the research portion of the National Economic Plan and the annual Civilian Science Budget, or "Enveloppe Recherche." As mentioned earlier, the five-year plan, although voted on by Parliament, is not obligatory. Nevertheless, its recommendations serve as important guidelines for the directors of government research agencies when planning their annual budgets. After approval by Parliament, the annual budget provides the funds for specific R&D programs in support of the Plan.

FIGURE 1

Partial Organization Structure for Science and Technology



Under the P&T, the Telecommunications Research Center (CNET) conducts only basic research, and all development work is carried on by private industry under contract with the government. For example, the French General Electric Company (CGE) was recently awarded a $120 million contract to develop an electronic switching system (stored program control) for the P&T. (It may be noted that this contract is only for development, and not for procurement.)

CNEXO, like P&T, has its own laboratory for basic research but a substantial portion of its budget is expended on contracts with private industry. Unlike P&T, CNEXO will rarely be an end-user of any developments; CNEXO is more oriented toward supporting industrial applications. It cooperates with industry on such programs as exploitation of deep sea mineral deposits and the development of deep diving techniques in support of the offshore petroleum industry.

With regard to overall enhancement of industrial technology, the DGRST, with its Aid to Development and Concerted Action Programs, is the principal agency which dispenses government contracts for industry research and incentives for development. The DGRST budget, including $42 million for Aid to Development and $35 million for Concerted Actions, indicates a substantial governmental interest in industrial development. Although ANVAR is specifically concerned with the industrial applications of new technology, its 1972 budget is only $3 million; the proposed budget for 1972 is $4 million. At the present time, ANVAR is of more interest to science policy officials from the standpoint of its method of operation than the degree of its impact. However, they are hopeful that ANVAR will be successful on both counts.

The list below summarizes the various government-sponsored agencies, programs and incentives in support of technology enhancement. These will be amplified in Part II of this appendix.

1. Concerted Actions

2. Aid to Development

3. ANVAR

4. Letters of Agreement

5. Aid to Pre-Development

in the elaboration of special programs, such as Plan Calcul. Lobbying, of course, is prevalent. It is directed mainly at high levels of the Executive Branch whose power is incomparably greater than that of the Legislative Branch.

While business views are being sought by the government, in order that it may fulfill its mission of promoting French economic interests, the government is definitely the stronger side in this dialogue, and it does not hesitate to use its power and to intervene, in order to direct certain private sectors toward objectives which it considers to be in French national interest.

The importance of the French public sector gives the government direct and selective means to influence the private sector. Government enterprises account for 10 percent of national output and the government is the largest employer, buyer, and seller in the market. An additional and equally important factor of government influence is the high degree of control it has over business financing. In the absence of an adequately developed capital market, the government is the main outside source of investment capital which is provided either directly or through government-controlled financing institutions. Overall, about 30 percent of French investment is government funded.

The government's ability to virtually force certain firms to merge was demonstrated in the case of mergers in the aircraft and computer industries. (Mergers are being fostered as means of enhancing the financial and technological capabilities of important industrial sectors.) Basically, however, there is agreement between government and business about the need to restructure French industry and to expand and improve science and technology programs. A catalyst that brought about this agreement was the common concern of French government and of business organizations several years ago over the so-called technological gap. Both government and private sources exploited this topic in highly-publicized public debates, emphasizing U.S. primacy in science and technology as well as the technological and financial power of U.S. giant corporations then investing in Europe. Thus, there was little need for government pressure and persuasion to gain acceptance by French business of science and technology enhancement programs. While subsidies are obviously welcome, business cooperation in these programs reflects a basic belief that the programs are highly needed to enhance French industry position in both the domestic and foreign markets.

PART II

MAJOR TECHNOLOGY PROGRAMS AND MECHANISMS

Part II is a discussion of the various programs and mechanisms used by the French government to stimulate innovation and the application of science and technology. It consists of two separate sections each dealing with government actions designed to enhance technology and productivity, the first in industry as a whole and the other in designated individual industries. The material in the first section is intended to be comprehensive in that it incorporates all existing government S&T programs, whereas that in the second section is merely illustrative of only a few of the major programs, since time and space limitations of the report precluded an equally comprehensive presentation.

A. Government Activities Affecting Industry as a Whole

The section that follows analyzes the principal government activities, including government and government-sponsored agencies and programs related to technology enhancement of industry as a whole.

1. Les Actions Concertees

The Concerted Action program has as its long-term objective the improvement of French industry by helping industry intensify its research through a program of cooperation with university and government laboratories.

There are three short term objectives:

- Improving the international competitiveness of certain industries;
- coordination of research activities, especially between industrial and non-industrial laboratories;
- making large industrial sectors aware of research activities.

The duration of an individual Concerted Action is usually not more than five years, subject to review from time to time and to modification or redirection. Usually, funds are allocated for the first three years, but withheld for the last two years until it is established that the program is progressing to the satisfaction of the DGRST. It is possible that a program will be terminated at the end of the first period if the DGRST is not satisfied with its progress, but that is uncommon.

Concerted Action programs can be extended for a second 5-year period. However, a program which appears to be lasting too long or becoming permanent is transferred by the DGRST to another agency capable of assuming management responsibilities. There have been a number of cases in the past where a Concerted Action program has led to the creation of a permanent agency, such as CNEXO (which is concerned with oceanography) or the Delegation a L'Informatique (concerned with computers). The present policy is to locate programs within existing agencies and to avoid unnecessary proliferation and decentralization.

and whether the development is handled by an industrial or non-industrial laboratory. Passage from research to development is favored by the granting of a loan which is reimbursable only if the program is successful, much as is done in the Aid to Development program. This is most practical when development is pursued by an industrial laboratory. In the case of the non-industrial laboratory, an appeal would probably be made to ANVAR to assist in the commercial application of the research results.

Since the main objective is increased cooperation between industrial and university laboratories, measurement of program success is extremely difficult. In the opinion of some officials in the DGRST, program success is illustrated by continued cooperation between university and industrial laboratories after their contracts with the DGRST had expired. An official in the CNRS also expressed his belief that the program was successful as reviewed from the perspective of improved cooperation between industry and the universities. It was the opinion of one interviewed industrialist that, while the program had merit, there was a long way to go before university-industry cooperation could be considered to be good. One explanation for past failure to cooperate was the absence of a profit motive on the part of the non-industrial scientist. Another industrialist felt that such cooperation was unimportant, at least to his company.

Because it is difficult to trace the work performed in Concerted Actions to the financial improvement of a particular industry, the government has not placed monetary value on the worth of the program. Its relative worth to the government of France may be gauged by the size of the budget, projected at $35 million for 1972.

2. Aide au Developpement des Resultats de la Recherche

The Aid to Development program has as its objectives (both long-term and short-term) the facilitation of the actual development of new products, procedures, materials, and techniques which appear promising from an economic point of view.

The duration of each Aid to Development contract is indeterminant by virtue of the nature of the process of development. Most often, the time frame for reimbursement is fixed from the time the development is adjudged successful but the time needed to attain success is difficult to estimate in advance.

The program was not founded by legislative action, but came into being through an exchange of letters between the MEF and strong probability of successful commercial application, and the societal benefit of success would be a significant reduction of unsightly, if not unhealthy, water pollution.

Aid to Development contracts are usually initiated by requests for proposals from the members of a particular industry. The financial arrangements may differ from one contract to another, but the DGRST never assumes more than 50 percent of the total cost of development; the recipient company must always furnish at least matching funds. The fact that the government money is only reimbursable in the event of commercial success is probably the most attractive feature of the program from an industrial standpoint. Commercial success is defined in each contract before the project is begun, and usually in terms of net profit attributable to the product or process.

One measure of the success achieved by this program is the amount of actual reimbursement. Although the program has only been in existence six years, its present rate of return is about one-third. The DGRST will consider the program completely successful as soon as the return rate exceeds 50 percent. DGRST officials feel that this is a fair measure of success, considering the fact that high risk projects are undertaken. They feel that development within a fixed time frame cannot be used as a measure of effectiveness because of the nature of development projects. In order to gain increased industry confidence in the integrity of the DGRST it has adopted a policy of total secrecy. Accordingly, it was not possible to talk with participants in the program.

3. Agence Nationale de Valorization de la Recherche (ANVAR)

ANVAR is an independent public corporation created to achieve an improved integration of the results of technical research into economic activities. Essentially, ANVAR collects French research results and inventions from public and private laboratories, selects those of possible interest to business and industry, and offers them to industrial and commercial firms most likely to make the best use of such inventions.

ANVAR was created by French law in January 1967, and was established by decree in July 1968. Primarily supported by government funds, it also receives income from licensing of inventions. Total spending for 1972 will be $3 million, Since ANVAR prefers not to invest more than $60,000 in any one project, additional help may be sought through an Aid to Development contract if the costs will be substantial. In that event, ANVAR can still help the development company to meet the DGRST requirement of matching industry funds.

If no firm will participate in the cost of development, ANVAR may assume the full cost of developing a prototype as a means of demonstrating the feasibility of an idea and convincing some company to undertake production. Should ANVAR be forced to take most of the risk of development, it is less inclined to grant an exclusive license.

Whenever ANVAR does grant an exclusive license, a minimum guarantee is always required. Since royalties are in terms of percentage of sales (usually between 5 and 10 percent), the guarantee is also in terms of total sales. If a company fails to fulfill its obligations, the contract may be re-negotiated and the license made non-exclusive. It should be noted that exclusiveness may extend only to France or to the European Economic Community, thus allowing ANVAR to sell licenses on the same patent elsewhere in the world.

Since economic self-sufficiency is one of ANVAR's objectives, income from licenses provides at least one measure of success. At present, ANVAR holds patents on about 660 inventions, but some of those had previously been held by other government agencies and turned over to ANVAR when the latter was established in 1968. Of those patents, only 300 have been licensed, accounting for an income of $1 million in 1971. Having existed for only four years, ANVAR expects to patent 100 inventions and to issue 60 licenses this year.

Most people concerned with ANVAR consider that it is doing as well as might be expected and are convinced that it is fulfilling an important role. However, one contacted individual who is familiar with the agency feels that its approach is backward in that it tries to fit industrial needs to existing technology, rather than encouraging new technology to meet a specific industrial need.

4. La Lettre d'Agreement

A Letter of Agreement is a mechanism by which the government encourages a company to undertake a large project which entails substantial initial production costs. The mechanism has only been used in exceptional cases, such as the provided to the CNME. In accord with CNME's agreement with DTEIM, if a bank demonstrates any reluctance to make a loan without the guarantee, the CNME will agree to share a fraction of the risk with the bank. The $2 million was given to CNME to cover any losses to CNME in making good on the partial guarantee.

There is a little doubt that a Letter of Agreement with a guarantee is a successful stimulant to production of new products. The cost to the government has not been disclosed, but the fact that Letters of Agreement have fallen into relative disuse suggests that the mechanism is too costly. However, renewed interest in the mechanism implies that it may, indeed, have advantages.

5. Aide au Pre-Developpement

This program, which is the responsibility of DTEIM, is designed to aid industrial development of ideas coming from laboratories of Technical Professional Centers. These Centers, supported by a small tax on each company, are really industry associations with responsibility for information flow, standardization, product testing and the like. They usually serve in middle-sized industries with many companies scattered throughout France. Some of these laboratories are also involved in research. Aid to Pre-development is designed to facilitate the industrial application of the results of such research.

The program differs from Aid to Development in that the funds are not reimbursable and the State deals with the Centers, not directly with the firm involved in actual development. In a sense, it is comparable to the operation of ANVAR, except that ANVAR is primarily concerned with the results of research from big government laboratories.

About $2 million will be spent on predevelopment in 1972 with two-thirds of this coming from the government and one-third from the Technical Centers. The average individual development contract is about $60,000.

Essentially, the government contracts directly with a Center to provide money to the industry to develop the Center's research. A second contract is signed between the Center and the developing company defining the work to be done, who will retain ownership, and the amount of royalties to be paid to the Center.

However, IDI has initially confined itself to the U.S., Canada and the U.K. in this regard.

7. Government Procurement

While not a program in direct support of industrial research and development, government procurement is used as a method of obtaining advance credit to finance research and development. If the government agrees to buy a certain product, whether produced or not, the company can take the procurement contract to a bank to obtain a loan. The bank can then ask the Caisse National des Marches d'Etat (CNME), which is a government bank, to guarantee the loan. If the CNME agrees to the guarantee, which is essentially a backing of the government contract, the bank will make the loan at a lower than usual rate of interest, usually 6 percent. The bank is more willing to make the loan and to do so at a lower rate of interest because it is taking no risk; otherwise, the interest rate would be between 8 and 10 percent, depending on the degree of risk.

The company then has low interest working capital which can be used to finance research and development as well as production. In a sense, the company is being paid in advance for products not yet delivered. The method is similar to Letters of Agreement except that government procurement implies an intention to buy that is not present in Letters of Agreement. Apparently government procurement can inspire research and development spending because the CNME prefers to guarantee loans used primarily for this purpose. Government procurement policy is being increasingly used to afford protection from foreign competition to high-technology sectors selected for special development; e.g., computers and measurement instruments.

8. Tax Advantages

The three most significant tax provisions related to research and development are the following:

- expenses relating to scientific and technical research operations are deductible up to the total amount of profits for the year in which the operations were conducted.[1/]

1/Paraphrase from Memento Pratique du Contribuable 1971, Article 142, p. 122 (Taxpayers Practical Handbook).

In connection with this, an act passed by Parliament in July 1972 provides "innovation investment companies" with the same tax advantage as a research corporation. Thus far, Sofinnova is the only enterprise benefitting under the provisions of this act.

10. Credits for Launching New Products

The objectives of this program is to provide working capital for the marketing of new products. Apparently the program exists only within the CNME.

When a company intends to produce a new or improved product or to produce a product using a new technique, there are attendant launching expenses, such as market analysis, and sales promotion. In such cases, the CNME will give credits to cover as much as 80 percent of these costs at a low interest rate, usually between 6 and 8 percent.

11. L'Action Urgente

Urgent action is the misleading title of a DGRST grant program of minor importance to industrial development. Through this program, the government aids mostly university laboratories with small and temporary research problems which deserve financial support, but which do not fit into any Concerted Action program. A budget of $2.5 million is divided between this program and a program for exchange of scientists from France and other countries.

The assistance provided to private industrial laboratories through this program is occasional and is not considered significant in comparison to other DGRST programs.

B. Government Activities Affecting Particular Industries

The section below discusses major programs specially initiated by the government to support and promote productivity in designated industries.

1. Plan Calcul (computers)

Plan Calcul is perhaps the best known example of a French government program in support of a particular industry. At the

2. Plan Composants (micro-electronics) and
Plan Peripherique (EDP peripheral equipment)

In connection with Plan Calcul, the government of France initiated these two Plans in 1965 by signing two agreements with industry to provide financial assistance to research and development of peripheral equipment and micro-electronic components. By one agreement, one company was to receive research contracts up to $16 million and $3 million in loans over a 5-year period. The loans were to be repaid if the research was successful. The second agreement concerning micro-electronic components (integrated circuits) provided that another company was to receive research contracts and R&D loans of $4 million over a 5-year period.

In return for this assistance, the two companies involved were expected to assume primary responsibility for R&D in furtherance of Plan Calcul. Details of assistance to other companies were not available.

3. Plan Electronique Civile (electronics)

In 1971, the government of France announced a 3-year program to provide funds for research and development to manufacturers of electronics equipment. While details of the agreements are not available, it is reported that the largest company is to receive $60 million. That figure represents about one-half of a request made by that company which first led to the establishment of the Plan. Although the funds are designated as being for R&D, the continued reduction of military orders and a recession in France's major electronics markets suggests that the support is for R&D only in the most liberal sense.

4. Convention Etat - Siderurgie (steel industry)

In 1966, the government of France agreed to provide assistance to the steel industry in return for its commitment to reorganize through mergers, specialization agreements, and investments in non-steel making activities (diversification). By this agreement, the government loaned $500 million to the steel industry at subsidized interest rates. The loan required repayment of interest (3 percent) during the first five years and repayment of capital and interest (4 percent) over the next 20 years.

- developing a new lease/sale formula to allow small firms to afford advanced equipment.

Target annual production increases for heavy industrial machinery and precision instruments have been set at 10 percent and 9 percent, respectively.

ATTACHMENT 1

Partial Organization Structure for Science and Technology

(enclosed in pocket at the end of report)

BIBLIOGRAPHY

John H. McArthur and Bruce R. Scott, Industrial Planning in France, Division of Research Graduate School of Business Administration, Harvard University, 1969.

Gerard Druesne, L'Organisation Administrative de la Recherche Scientifique en France - Notes et Etudes Documentaires No. 3-863, 28 Fevrier 1972.

Ministere du Developpement Industrial et Scientifique, Le Cahier de L'Innovation, 1971.

Commissariat General du Plan, Rapports des Commissions du 6^{e} Plan, 1971-1975, Volumes I & II.

Ministere du Developpement Industriel et Ministere de l'Economie et des Finances, Instruction Interministerielle Aide au Developpement des Resultats de la Recherche, 20 October 1970.

Ministere du Developpement Industriel et Scientifique, "Le Financement Public de la Recherche et du developpement en France," Developpement Industriel et Scientifique, Sept.-Oct. 1971.

________________, Project de Loi de Finances pour 1972, Document annexe, La Recherche Scientifique et Technique en France en 1971, Etat Recapitulatif de L'Effort Financier Prevu au Titre de la Recherche en 1972, Emprimerie Nationale 1971.

Ministere du Developpement Industriel, Decret No. 70-728, du 5 Aout 1970 relatif a la coordination de la politique de recherche scientifique et technique, reprinted from: Journal Officiel du 11 Aout 1970, Page 7616.

Agence Nationale de Valorisation de la Recherche, ANVAR, French National Agency for Research Development Brochure.

Francis Le Febvre, Memento Pratique de Contribuable, 1971 (taxpayers practical handbook).

APPENDIX THREE

ANALYSIS OF PROGRAMS AND MECHANISMS

IN THE

FEDERAL REPUBLIC OF GERMANY

AND

WESTERN SECTORS OF BERLIN

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AIF	Arbeitsgemeinschaft Industrieller Forschungsvereinigungen (Confederation of Industrial Research Associations)
BAM	Bundesanstalt für Materialprüfung (Federal Establishment for Materials Testing)
BLKB	Bund-Länder Kommission für Bildungsplanung (Federal-State Commission for Educational Planning)
BMBW	Bundesministerium für Bildung und Wissenschaft (Federal Ministry for Education and Science)
BMWF	Bundesministerium für Wirtschaft und Finanzen (Federal Ministry for Economics and Finances)
DBR	Deutscher Bildungsrat (German Education Council)
DFG	Deutsche Forschungsgemeinschaft (German Research Society)
FhG	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung (Fraunhofer Society for the Advancement of Applied Research)
FTS	Fritz Thyssen Stiftung (Fritz Thyssen Foundation)
KMK	Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (Permanent Conference of Ministers of Education and Cultural Affairs of the States in the Federal Republic of Germany)
MPG	Max-Planck-Gesellschaft zur Förderung der Wissenschaften (Max Planck Society for Advancement of the Sciences)
PTB	Physikalish-Technishe Bundesanstalt (Federal Physical-Technical Establishment)

PART I

THE ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Part I of this appendix discusses the environment within which science and technology policy is developed and implemented. The discussion is presented in three sections as follows: Government Involvement in Science and Technology; Organization for Science and Technology Policy Development and Implementation; and Government-Private Sector Relationship and Interaction.

A. Government Involvement in Science and Technology

Support of technology is an integral part of the total policy of the Federal and State governments of the Federal Republic of Germany (FRG). Traditionally, the application of science and technology (S&T), particularly in those areas based on chemistry and physics, have contributed greatly to the overall economy of the country. It is accepted that basic research must be performed in the universities, which are classical institutions for education and research, in order to produce the new knowledge required for the advancement of technology. Further, the importance of industrial laboratories in particular, and to a lesser degree, government-financed research establishments, is well recognized as the focal point for R&D and the application of technology. The Federal government considers basic research at the universities and applied research at industrial laboratories and government-financed establishments as an entity requiring close cooperation, coordination and national direction.

A number of factors have influenced the direction of science policy and the involvement of government in support of science and technology, such as the all inclusive scope of "science" in the German context; the concept that teaching and research are inseparable at the university level; the governmental structure of the FRG; the autonomous nature of the large scientific organizations and institutions of higher learning; the promotion of "big science" (designated as priority programs) by the Federal government using public funds; and the structure of the industrial complex.

The German word "Wissenschaft," although usually translated as "science," embraces all facets of human knowledge. Thus, to the German, "science" includes not only basic research in the natural sciences and medicine, but the extension of knowledge through education, research and application in all areas of human endeavor. The universities, including the technical universities (Technische Hochschule), have traditionally been autonomous institutions of higher learning and research as a unit, and the Federal government believes that this autonomy must be maintained with basic research continuing to be an integral part of the university program.

The FRG is a federation of ten states, or Länder, and the Western Sectors of Berlin. However, the Western Sectors of Berlin remain under the control of the Allied authorities and special provisions apply for their administration. For purposes of education and science be discussed in the next section.

A few years after reconstruction began at the close of the war, the States began to experience difficulty in financing education and science. In 1949 representatives of the states met in Königstein and came to accord through a plan whereby the State governments assisted each other in the financing of state research institutions which had a supraregional importance. Known as the Königstein State Agreement (Königsteiner Staatsabkommen), the agreement was initially to last for a 5-year period. It has since been renewed at the end of successive 5-year intervals. At the time of renewal in 1964, further agreements "permitted" the Federal government to assist the states in the joint financing of the two most important autonomous scientific organizations which influence science in the FRG, the German Research Society (Deutsche Forschungsgemeinschaft) and the Max Planck Society for Advancement of the Sciences (Max-Planck-Gesellschaft zur Förderung der Wissenschaften), discussed in later sections. These agreements also "allowed" the Federal government to contribute a part of the construction costs for expansion of existing university facilities and for new universities. The Permanent Federal-State Commission for Science and Research (Ständige Bund-Länder Kommission für Wissenschaft and Forschung) was also established at that time to provide coordination and liaison.

Through amendments to the Basic Law in 1969, the Federal government has been given increased legislative authority in the fields of higher education and science. The Federal government can now fully participate in the establishment of new universities and the expansion of old facilities, as well as in general educational planning. In 1970, the Federal-State Educational Planning Commission (Bund-Länder Kommission für Bildungsplanung) was established. This Commission provides the medium for discussion of questions of common interest in the Federal and State governments arising from this increased legislative authority.

The States still maintain control over the programs of their universities. For example, in order to coordinate research at the universities, minimize duplication of research in various fields and further enhance particular university research centers, a Federal-State program established priority research areas (Sonderforschungsbereiche). The Federal government presently supports at least two-thirds of the cost while the government of the State within which the selected university is located provides the balance, including the necessary facilities and personnel. Each State must approve the establishment of a priority research area within its own universities and thus can control directly its own programs.

Each of these factors has played a role in the recovery of the FRG as a viable, competitive industrial nation and has helped to shape the evolving S&T policy. Programs on the State and Federal levels have fostered the rebuilding of the economic base, so that within 22 years (1949 to 1971) the GNP went from virtually zero to an estimated $235 billion.[2/] In this time period, an estimated $47 billion has been expended for science, including education and defense, by all sources, public and private. Data for more recent years indicate the current trends. In the period 1967 to 1971, expenditures for science from both public and industrial funds in the FRG have increased from about 2.5 to 2.8 percent of the GNP. Expenditures for R&D, from the same sources and for the same period, have averaged about 2 percent of the GNP. The actual expenditures for science in this time period have increased about 70 percent to $6.7 billion including R&D expenditures. For the same sources and time period, the R&D expenditures have increased about 63 percent to $4.9 billion, including an estimated $2.4 billion of industrial R&D, a 60 percent increase over industrial expenditure in 1967.

For the period 1967 to 1971, Federal expenditures for science, excluding defense, have increased about 104 percent to almost $1.6 billion per year. Of this amount, about 40 percent was devoted to "education," the largest portion of which was the federal share for extension and new construction of universities. The financial planning of the Federal government in support of science and technology indicates annual growth rates of about 17 percent, from the present to 1975.

Thus, government involvement in science and technology has increased since the close of World War II. A national science policy has been evolving, initiated by State government efforts directed mainly toward the reconstruction and expansion of the research and teaching capability in all scientific disciplines in order to provide a research base. The first Federal programs for the utilization of new technologies were implemented in conjunction with the reestablishment of this base. These programs, generally related to such isolated sectors of technology as nuclear energy, space and aviation, were largely reactive and were determined or

---

2/ At the present time (July, 1972), $1.00 is about DM 3.20. All dollar amounts cited in these sections on the FRG are based on this conversion. The data are therefore, only approximations, for the exchange rate has varied since the currency reform of 1948. Furthermore, the recent data which are given are generally based on budget estimates rather than on actual expenditures.

- Federal-State coordinating organizations;
- private sector research promotion and implementation organizations;
- private sector research funding organizations; and
- organization interaction.

Within each grouping, only the organizations most important to the study are discussed; this is not to imply that other organizations of lesser importance are not also involved in the complex structure.

1. Planning and Advisory Bodies of the Federal Government

Within the Federal government the ultimate responsibility for policies related to science rests with the Federal Chancelor, who is assisted by a science advisor on his planning staff. In addition, the Federal legislative and executive branches each have an advisory and coordinating committee for science. The Committee of the German Parliament for Education and Science (Ausschuss des Deutsche Bundestages für Bildung und Wissenschaft) implements these functions for the Federal Parliament (Bundestag), and the Cabinet Committee for Education and Science (Kabinett-ausschuss für Bildung und Wissenschaft) serves to interrelate economic and social policy with educational and science policy. This latter committee is headed by the Federal Chancelor, although the Minister for Education and Science usually presides. It is composed of the Ministers responsible for programs in the economic, social, educational and scientific areas.

The Federal Ministries most involved with science planning and implementation are: Defense; Economics and Finance; Education and Science; Food, Agriculture and Forestry; Interior; Transport; Post- and Telecommunications; Youth, Family and Health; and the Foreign Office. Coordination is accomplished through the Interministerial Committee for Science and Research (Interministerieller Ausschuss für Wissenschaft und Forschung), and special inter-ministerial committees have been established for space research and oceanography.

The Federal Ministry for Education and Science (Bundesministerium für Bildung und Wissenschaft, BMBW) was established in 1969 and has responsibility for planning and implementing the science programs of national importance. The BMBW provides funding in support of national programs of scientific effort, designated "priority programs." These are related to nuclear energy and space with associated technologies, data processing, marine and advising on special projects. These are formed for the solution of individual problems, and may be ad hoc bodies or advisory groups which function for periods not exceeding two or three years.

Particular attention is presently being given to selecting members of Federal advisory bodies so that qualified younger personnel are included as well as the older, established scientists. The BMBW considers its relationship with its advisors as a "critical partnership." Further, the advisory bodies will now be chaired by one of their own members, rather than the Minister for Education and Science (as was the case in the past).

Many of the recent changes in the advisory system were based on the recognition by the Federal government of the need "to develop methods of political decision-making for research policy." Further statements indicate that priorities expressed in research policy should not only show the importance assigned to science and technological development as a whole, but within each field these priorities should be set with due consideration of social policies. It is believed that science policy should be more subject to the influence of a critical and informed public, hence provisions have been made for explanations to Parliament and the public as to who the advisors are, how they vote, and how their views are taken into consideration when policy is formed. Plans therefore include publication of an annual statement with information about the advisory services, the membership of the major advisory bodies, and the results of their work, including minority votes, together with comments by the BMBW.

Each of the Federal Ministries has similar advisory bodies, some of which serve more than one ministry and, therefore, have representation from each ministry involved. Some also include representatives from the State governments, typically in the areas of health and agriculture.

2. Planning and Advisory Bodies of the State Governments

At the State level, the officials responsible for science-related matters are generally the Ministers of Education and Cultural Affairs. In the Western Sectors of Berlin, there is a Senator for Education and Cultural Affairs, and another Senator for Science and Art. The state of North Rhein-Westphalia has an Office for Scientific Research (Landesamt für Forschung) which reports directly to the Minister President (governor); this office supplements the promotion of scientific research performed by the State Ministry of Education.

4. Federal-State Coordinating Organizations

A number of advising, planning and coordinating organizations have been established to achieve unified goals for the science, research and educational activities of the Federal and State governments. Each of these organizations includes representatives of Federal and State Ministries, together with leading individuals from the private sector.

The Science Council (Wissenschaftsrat, WR), established in 1957 by agreement between the Federal and State governments, is responsible for:

- preparing an overall policy for the promotion of science based on plans prepared by the Federal and State governments within the framework of the responsibilities of the governments;
- coordinating the plans of the Federal and State governments;
- defining areas of special importance which are to be given priority rating and establishing an annual priority program which reflects national needs; and
- making recommendations for the allocation of funds budgeted for the promotion of science by the Federal and State governments.

The WR is composed of representatives of the Federal Ministries, usually of undersecretary rank, the State Ministers for Education and Cultural Affairs, and leading scientists. Some of the latter are appointed by the Federal Chancelor on recommendation of the West German Rectors' Conference and the larger scientific organizations, while others, (for example, leading industrial scientists) are appointed on the joint recommendation of the Federal and State governments. The recommendations of the WR are not legally binding on either the Federal or State governments. However, strong cooperation between the leaders of the scientific community and the responsible governmental authorities has become an effective part of the planning mechanism.

The German Educational Council (Deutscher Bildungsrat, DBR) was established in 1965, also by joint Federal-State agreement. Its members serve as the official advisors to the governments over the full spectrum of educational matters, including adult and vocational training. It does not deal with university matters, however, since these are handled in the WR. Like the of supraregional importance which are involved in the implementation of science. Over 90 percent of the funds available to it are contributed in roughly equal shares by the Federal government, principally through the BMBW, and the State governments. The balance is provided by other associations. The estimated budget for 1972 is about $156 million.

The DFG, mainly concerned with fostering basic research, is currently financing about 70 percent of all research projects performed in university research centers. It does not operate its own research laboratories but supports the operation and expansion of existing facilities or the formation of new research centers. A committee for applied research has recently been established to improve cooperation between basic research institutions and industry.

The Max Planck Society for Advancement of the Sciences (Max-Planck-Gesellschaft zur Förderung der Wissenschaften, MPG) is the largest research organization in the FRG. It maintains and operates 52 research institutes and centers and acts to carry out research in fields which the universities would have difficulty in undertaking, such as those requiring interdisciplinary effort or specially equipped facilities. It also strives to advance new methods and procedures and provide the facilities for highly qualified scientists to work independently.

About 75 percent of the funds available to the MPG come from contributions of the Federal government, principally the BMBW, and the State governments; the balance comes from other associations and contract research. The Federal and State governments generally share the costs equally, with the exception of two Max Planck Institutes performing nuclear research which are funded 90 percent by the Federal government and 10 percent by the government of the state in which they are located. The estimated total 1972 budget of the MPG is about $165 million.

The MPG, like the DFG, fosters an atmosphere of close cooperation between the governmental and scientific sectors. It, too, is deeply involved in basic research, but provides one of the primary mechanisms for bridging the gap between science and industry, particularly through the research efforts of the larger Max Planck Institutes.

An organization closely aligned to DFG and MPG is the Fraunhofer Society for the Advancement of Applied Research (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, FhG), which maintains and operates 20 research institutes and centers. The functions of the FhG are to analyze the needs of industry and determine which

The research supported by the AIF is oriented towards production and is performed in about 150 industrial research institutes. Some of these are independent bodies established by their industries; others are established at universities either by industry or the university.

In addition, the contract research laboratory of the Battelle Institute (Battelle Institut Gemeinnützige Laboratorien für Vertragsforschung) in Frankfurt performs research on a non-profit contract basis for industrial firms and governments, both Federal and State. This laboratory of the American Battelle Memorial Institute was established in 1920.

6. Private Sector Research Funding Organizations

Three other organizations are important in that they provide funds for support of science projects: The Volkswagen Foundation (Stiftung Volkswagenwerk, VW-S), the Fritz Thyssen Foundation (Fritz Thyssen Stiftung, FTS) and the Donors' Association for German Science (Stifterverband für die Deutsche Wissenschaft, SV). The first was formed as a result of the denationalization of the Volkswagen factory, the second is privately endowed, and the third is a joint endeavor of commerce, trade and industry. Combined, these three foundations make available about $58 million per year for the support of science, including education. The bulk of the grants given by VW-S and the FTS go to universities for support of work in the humanities. Each, however, supports some work in the natural sciences. In this area, the FTS provides most of its support for priority programs of the DFG. The funds of the SV are usually given as lump sum grants to the larger scientific organizations, like the DFG and the MPG. These grants are not earmarked for a particular purpose and thus give the recipients a great deal of flexibility in the choice of projects which are to receive support.

7. Organization Interaction

Each of these organizations forms an important link in the structure for planning and implementing science in the FRG. They have been described briefly in sequence to furnish some degree of clarity, which results in an over simplification of the structure as presented. These organizations are closely interwoven, generally by mutual representation or funding, one organization to the other. As has been noted, the Federal and State governments are represented in many of the organizations, and representatives of State governments serve in many of the advisory bodies of the

The quality of past performance by a firm is given heavy consideration. A register is maintained listing firms of all sizes known to government as being highly qualified to perform in specific technological areas. In addition, the entire scientific community (university, industry and government) places strong reliance on the expertise of particular individual scientists, hence a firm may also be considered qualified by virtue of the expertise of an individual within the firm. Support is often directed to qualified firms after goals have been discussed through informal personal contact with respected individuals.

The whole program by the BMBW is based in a small number of large firms which are usually active in the physics-based technologies. Little support is presently provided in the areas of chemistry-based technologies due, in large part, to the already imposing stature of the chemical industry within the FRG.

Government interacts with industry by means of numerous mechanisms, both direct and indirect. Government directly supports industrial research through grants and contract research, with proposals for support initiated by either party. Occasionally, support is provided for parallel projects toward a common goal performed by two firms using different approaches. Joint ventures between firms in R&D, and even production, are permitted, and these, too, may be initiated by industry or by government. Government often encourages (or even strongly suggests) that cooperative effort be undertaken.

There are no government restrictions on the inflow or outflow of industrial technology between industries or foreign firms. The buying and selling of licenses is encouraged, and the State governments encourage foreign and domestic industrial investment within their territories by providing tax advantages, subsidized sites and the infrastructure necessary to attract new industry. There is also widespread use of foreign managerial and technical personnel, which facilitates the flow of technology in its human aspects. At the same time, the outflow of technology is encouraged through various programs which assist industry in establishing foreign facilities.

In addition to these measures in support of industry, the government also provides support in the form of legal and tax measures for corporate expenditures serving R&D, such as accelerated depreciation, tax credits, investment grants and tax allowances for support provided to scientific associations. Donations by individuals in support of general scientific purposes are also permitted as tax allowances.

In general, government-private sector relationships are good although the feelings about government support are somewhat mixed. Where R&D costs are especially high and where government has traditionally provided support, such as in the fields of aerospace and

PART II

MAJOR TECHNOLOGY ENHANCEMENT

PROGRAMS AND MECHANISMS

The implementation of technology enhancement in the FRG does not readily lend itself to analysis of individual, rigorously defined programs. Instead, this appendix will mainly be concerned with the mechanisms and incentives which are universally applied throughout the scientific and technological sectors. Some underlying philosophies which prevade the scientific scene are presented. The importance of the larger organizations and their sub-units, in which S&T policy is implemented, is illustrated in terms of their structure and operation. Indirect incentives are outlined as well as special measures applied in the Western Sectors of Berlin. The application of the mechanisms and incentives by the Federal government, in priority areas of national need, are also described together with the results obtained.

A. Underlying Philosophies

Governmental planning addresses broad areas in which basic and applied research is needed, but decisions by private enterprise (i.e., industrial initiative) are felt to be the all-important steering mechanism. Direct industrial involvement in both planning and implementation is strengthened through personal contacts and by an interchange of personnel between the universities (seat of basic research) and industry. Interactions between the universities and industry further assure that new knowledge and applications constantly flow to industry. Government is emphasizing the importance of industrial attentiveness to new information and assures that industrial initiative is guided toward national goals by supporting selected proposals originated by industry.

Although support is provided to many projects, Government feels no obligation to keep industry viable by this mechanism. Except for contract research, the government rarely furnishes more than 80 percent of the estimated costs. Industry must take the initiative and provide its own contributions for projects it wishes to undertake. An additional part of industrial initiative is the ability and desire to utilize the resulting technology.

Most government support is provided by means of grants, and direct repayment is not expected; project success implies "repayment" through increased corporate taxes paid by the firm. Also required repayment of grants would deny to the government the right to make resulting information and patents available to other industrial firms.

By long-standing tradition, there is strong support for science in Germany, stemming in part from the recognized economic importance of science and from the world-wide prestige attained. This attitude has been enhanced in the recent past by a conscious government effort to publicize scientific activities. There has also been increased emphasis on education generally, and particularly in science, provided at public expense at all levels subject only to academic qualification. However, overcrowded universities are prompting greater attention to educational planning.

The scientific community is accorded a prestigious position in society; in turn, it bestows its own greatest respect on individual scientists noted for their creative ability and expertise. These highly respected individuals become dominant forces for mechanisms which are used for planning, decision-making, coordinating, and implementing scientific activities.

The attitudes described in the foregoing paragraphs constitute an underlying philosophy which permeates all S&T activities in the FRG. It affects the public position with respect to science, the organization

2. Individual Scientists

The respected individual scientist fills another important role. Particularly at the upper echelons of government and in scientific organizations like the MPG and the DFG, as well as research units in industry, personal contacts are paramount. When technological thrust is desired in a particular area, an informal meeting is usually held, say between a government representative and a distinguished scientist, or between the director of an MPG institute and an industrial research director. The discussion would cover the intended project and its relationship to other projects and to the general goal, with an informal request extended for one or more proposals. Evaluation of proposals and selection of the effort to be supported are accomplished by a committee of experts as described below.

At the same time, it should be noted that individuals or firms are free to submit unsolicited proposals to government research institutions or industrial research centers if they feel that technological redirection is in order. For example, the government program in support of data processing and computer technology resulted from a memorandum which was prepared jointly by the two largest electronic firms.

C. Organizations Implementing Science Policy

The committees of experts and individual scientists contribute to the implementation of S&T activities through the organizations which have been established to perform scientific research or planning. A description of one such organization will serve to highlight the salient features of all of them.

The Confederation of Industrial Research Associations is typical in that it interacts directly with industry in the area of production-oriented research. Its organization and operations strongly resemble those of other bodies concerned with implementation of science, such as the DFG, MPG, and FhG; differences will be indicated below.

1. Confederation of Industrial Research Associations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen, AIF)

The AIF is the parent organization of 76 industrial research associations which have been founded and are operated by the industrial sectors they represent (for example, steel forgings, wood, glass, etc.). These industrial sectors are composed of a large number of small firms, many of which lack R&D facilities.

These six groups provide expert opinion in the areas of:

- materials;
- processing techniques;
- energy;
- construction and fastening;
- chemistry; and
- technical physics.

The committees are further subdivided into fourteen special jurisdiction groups (Fachgebietsgruppen) which provide expert opinion in specialized areas. For example, the materials committee has three subgroups for metallic materials, non-metallic organic, and non-metallic inorganic materials. The function of the committees is detailed below.

The Approval Committee consists of the President of the AIF and representatives of the Board of Directors, managing office, Scientific Council, BMWF and the States, together with a permanent advisor representing the DFG. This Committee makes final decision on projects which are to receive support.

a. Project Initiation, Selection and Implementation

Cooperative research projects are initiated at the industrial level or by an individual (such as university professor at a research institute who recognizes the need for research in a particular area), and are generally beyond the capabilities (either due to lack of equipment or funds) of the proponent. The initiator submits his proposal for evaluation by the research council of his research association. The research association may decide to undertake the project with its own funds or may seek assistance from the AIF. For example, support may be sought for a project whose results would benefit other member associations of the AIF. If AIF support is solicited, the proposal is submitted through the Scientific Council for evaluation by one or more cognizant expert committees.

In addition to a technical description of the project, proposals contain hourly rates of all workers on the project, equipment costs, overhead charges and subcontracting fees, together with an estimated completion schedule. Each committee meets semi-annually and evaluates the scientific

Member associations perform research at about 150 industrial research institutes. About one-third of these are owned by the member associations and operated as independent research facilities. The remainder are either research centers of universities and receive part of their support from the State in which they are located, or are at universities and derive their support from the research associations. None of the research institutes of the associations are directly owned or operated by the member companies of those associations.

Each member association usually solicits support for four or five proposals annually. In recent years, about 350 proposals have been evaluated yearly, together with requests for supplemental funding on about 100 previously approved projects. In all, about 2,000 projects have been supported by the AIF since 1954.

The supported projects represent about half of the entire cooperative research effort of the member research associations. However, each association must report to the AIF the total expended on research, wherever the research is performed (i.e., at its own institution, a research center of a university or one located at a university). Cooperative research performed by member associations in 1971 totaled about $47 million, almost $10 million of which was made available by the BMWF. The BMWF share is expected to increase to approximately $14 million by 1974. The public funds are supplied and administered through the mechanism of a contract between the BMWF and the AIF.

Research association recipients are not expected to repay grants, even if the research projects achieve their proposed goals. This is consonant with the general government philosophy that the economy will benefit indirectly through increased productivity and additional revenues gained through corporate taxes.

Furthermore, the BMWF does not feel that support funds should be used simply to maintain the viability of the AIF's member research associations. The research associations must carry on their own programs for promoting cooperative research within their member companies. As a stimulus, more government support is made available through the AIF to those associations which have the most active cooperative research programs. This philosophy accounts importantly for the rejection of proposals on non-technical grounds, as noted earlier.

The approval procedure is essentially the same as that for the AIF; the assessors evaluate proposals, primarily on technical grounds, and the Main Committee makes the final decision. Like the AIF, the DFG makes payments for supported projects "after-the-fact," but every 3 months (rather than 2), distributing public funds directly (rather than through commercial banks).

The same selection process is used for priority procedure grants although the objective here differs from that of the normal procedure grant. This procedure is used for research programs in fields designated by the DFG Senate as priority areas needing emphasis so that the national research effort can reach a particular goal (for example, to bring the FRG research level in a given field up to international standards.) Under this procedure, proposals are generally solicited either from an individual scientist or from a group of scientists. As many as five to ten proposals may be received to attack a particular problem and all scientists submitting proposals are present when the assessors meet. All are free to enter into the discussion of all proposals and assist the assessors in reaching a decision on which proposal to recommend for support.

The DFG administers yet another type of program, established in 1970 on recommendation of the WR, for special areas of research (Sonderforschungsbereiche) at selected universities. The stated objectives are:

- closer cooperation between individual researchers and the various research institutes;
- a rational distribution of specialized research fields throughout the universities;
- increased financial support for research; and
- greater efficiency in the control of research projects.

Through implementation of these objectives, attempts are made to concentrate advanced research in a particular field at the best qualified university and by means of increased support to enhance the research capability at the selected university. Directing support to one university is also intended to discourage duplication of effort at other universities. The emphasis is on increased planning and greater efficiency in controlling the direction of the overall research effort. Another goal is to improve cooperation between the universities and non-university research centers, such as the institutes of the MPG and government research establishments.

members, elects the Senate, which in turn elects the President, the Administrative Council and the chairmen of various committees. The Administrative Council is composed of the usual corporate officers. The Senate, which is the governing body, is composed of the President and other members of the Administrative Council together with two Federal Ministers (or Under Secretaries), three State Ministers nominated by the States, the heads of the sections of the Scientific Council, honorary Senators (who serve as advisors) and between 12 and 32 elected Senators from the scientific, business and public sectors.

The Senate also authorizes the formation and discontinuation of research institutes, invites scientists to membership, and selects the directors of the research institutes and centers. It determines the overall direction of the research effort and regulates this direction by control of the funds for the institutes. The elected Senators, representing the scientific community, are drawn from the universities, industry and the institutes of the MPG. In order to assure the infusion of new ideas, attempts are made to limit the number of scientists from the institutes who serve in the Senate, and to have approximately equal numbers of members representing industry, government and science.

The MPG, like the AIF and DFG, has a Scientific Council (of 210 members), composed of the directors and some of the scientists from the research institutes. The Council is further divided into three major sections corresponding to the interests of the institutes, namely biology and medicine; chemical, physical and technical; and the humanities. There is an overall chairman of the Council and a chairman for each section. The scientific work of the institutes is guided by the members of the Scientific Council meeting in the sections, where mutual technical and organizational problems of the institutes are discussed. Recommendations are then made to the Senate in order to guide its deliberations with regard to science policy.

a. Max Planck Institutes

Of the 52 research institutes operated by the MPG, 28 undertake work in the fields of biology and medicine, 15 work in the chemical-physical-technical area and nine work in the humanities. Each Max Planck Institute has a director and a committee of advisors and operates under an annual bidget. A number of administrative and organizational structures are used by the Institutes depending upon the size and field of research. There are about 7,600 employees overall, of which about 2,000 including approximately 600 foreign guest-workers are professionals. The size of the institutes in the chemical-physical-technical areas varies greatly. The largest is the to the BMBW itemizing costs for research work, buildings and equipment. If the BMBW considers the budget too large, the MPG, and not the BMBW, determines where adjustments should be made.

In 1971, the MPG budget was about $147.5 million, of which about $125 million was from public funds. The 1972 budget is $165 million, of which the public share is $143 million.

b. Direct Interaction between Max Planck Institutes and Industry

The Max Planck Institutes provide a strong link between basic research and industry. The advisory committees of the Institutes often include industrial representation; this and other personal contacts foster the undertaking of research projects of direct interest to industry. These projects are usually done under contract after approval by the Director of the Institute. Industry also reviews Institute publications for research results with practical application.

c. Garching Instrument Company for the Industrial Use of Research Results (Garching-Instrumente Gesellschaft zur industriellen Nutzung von Forschungsergebnissen)

The MPG recognizes that many research projects produce process "know-how," results which have industrial application, or patented devices. In order to accelerate the commercial introduction of these processes, results and patents, the MPG in 1970 provided the capital investment (about $156,000) for the Garching Instrument Company for the Industrial Use of Research Results, established as a profit making organization. It is considered that commercial operations are contrary to the purpose of a basic research institute, and that items of commercial importance are often not developed sufficiently nor rapidly enough because they are not fully appreciated. Garching Instrument is therefore kept abreast of new developments within the Institutes; also aware of industrial needs, it brings these new developments to the attention of industry. It also advises Institute scientists on the marketability of results; assists in negotiating satisfactory arrangements for industry's use of developments; and supervises agreements once consummated. The company acts as licensor of patents which result from Institute research. Revenue from licenses is equally divided among Garching Instrument, the MPG and the inventor. Garching Instrument also determines the marketability of new ideas and, for the more promising ones, develops them through model, prototype industry contains proprietary information, agreement may be reached to withhold publication for as long as two years. This time limit is intended, in part, to act as an incentive for rapid application of research results.

In addition to the 20 research Institutes, the FhG also operates several appended bodies whose work relates to applied research and which provide services to industrial organizations.

a. Patent Bureau of German Research (Patentstelle für die Deutsche Forschung)

In order to provide assistance to independent inventors, the Federal and State governments, together with the German Patent Office (Deutsches Patentamt), SV and DFG, established the Patent Bureau for German Research (Patentstelle fur die Deutsche Forschung). The Patent Bureau is administratively a part of the FhG, but its funds are derived from the Federal and State governments.

The Patent Bureau advises researchers and inventors with regard to obtaining, maintaining and utilizing protective rights for inventive activities. It also assists in establishing contacts with third parties who might be interested in utilizing the invention. To the extent that funds are available, these latter services are also extended to independent owners of patents or patent applications.

All services of the Patent Bureau are open to:

- scientists at universities, other institutions of higher learning, or research institutes that are freely able to dispose of inventions;
- independent inventors; and
- employees whose inventions, subject to the Employee's Invention Law, are "free" or have become "free" or are utilized only to a limited degree by the employer.

Since 1955, the Patent Bureau has worked on about 6,000 inventions. However, few have been commercially exploitable.

b. Other FhG Activities

The FhG also operates two documentation centers of importance to industry; one dealing with construction and the other with worth the expense in terms of the capabilities established. In addition, the BMBW is provided with more choice when decisions are required relating to the approach which will best fulfill national needs and which will merit further support.

a. Grant Support

BMBW generally supports projects in the form of four classes of grants, depending upon the percentage of the total (estimated) cost of the project to be supported; (1) greater than 80 percent, (2) 66 2/3 to 80 percent, (3) 50 to 66 2/3 percent, (4) up to 50 percent. The greater the support, the more of the rights which the BMBW reserves to itself for control of the project and its results.

The responsibilities and rights of the grantee are carefully enumerated by the BMBW. Some apply regardless of the level of support, but others depend on the support given.

All proposals must be based on the current state-of-the-art. In addition to describing the work to be performed they must include material lists, drawings, fundamental scientific and technical calculations and detailed descriptions of prototypes including, so far as possible and if applicable, preliminary operating, maintenance and repair instructions. The work program must cover the entire period of support.

If less than 50 percent support is given, the grantee must attempt to incorporate written suggestions and alterations in procedure submitted by the BMBW; with more than 50 percent support, the grantee must take these into consideration at his own expense.

All projects must be kept within estimated cost and time calculations, but grantees are free to make adjustments in either category as long as the scope of the project is unchanged. Greater than 50 percent support requires a grantee to obtain prior approval of the BMBW for redirecting funds allocated for the purchase of special equipment and facilities. The BMBW retains title to all equipment purchased from project funds supported at the 80 percent level, however, the grantee may continue to use equipment after termination of a project until the BMBW has another use for it. Grants greater than 50 percent dictate that subcontracts be placed with qualified small firms or firms located in the Western Sectors of Berlin.

the application fees as well as the employee compensation and assumes ownership of the protective right. The employee's rights extend to partners, subsidiaries and consultants in the service of the grantee for all supported projects.

Regardless of level of support, the grantee must concede to the BMBW the irrevocable and non-exclusive right of utilization, free of charge, for all of the following related to the project: domestic and foreign protective rights; applications for patents; inventions, other innovations and improvements; transferable rights of use; and blueprints, process methods and other documentation. After consultation with the grantee, the BMBW may use the grantee's rights for the following purposes: public commissions; government measures for the promotion of S&T and for the conduct of joint programs with other governments, multi-national and supranational organizations and institutions. The BMBW can also grant non-transferable sub-utilization rights to third parties.

If a project is given more than 50 percent support, the BMBW, after consultation with the grantee, may grant non-exclusive and non-transferable sub-rights of use to a domestic third party for other utilization. This provision is applicable only when the third party can document its inability to obtain direct right of use from the grantee within a reasonable time and under suitable conditions. When dealing with a third party, the grantee, must ascertain that he has continued authority over any domestic or foreign protected rights secured from another third party.

The grantee also concedes his other domestic and foreign protective rights to the BMBW, as long as this is necessary to assure utilization in the interest of promoting S&T, for conducting joint programs with other governments, multi-national and supranational organizations and institutions and other purposes of the BMBW. Transfer of rights are constrained by the conditions by which the BMBW itself is bound, and the grantee must be consulted before sub-rights of use are conceded. The grantee must participate in negotiations, if possible, and the transfer of rights of use to a domestic third party entail renumeration to the grantee by the third party.

Non-domestic transfer of rights of use may prevent guarantee by the BMBW of remuneration. However the BMBW does attempt to secure similar rights of use from the foreign consignee, and such a transfer will not be permitted if the grantee can show that the transfer will jeopardize his competitive position.

6. Trade Associations

Non-profit trade associations are primarily funded by the industries they serve, but do receive some support from the BMWF and, to a lesser degree, from the BMBW. The largest of these bodies is the Association of German Machinery Manufacturers (Verein-Deutscher-Machinenbau-Anstalten, e.V.), which has 500 full-time employees and 3,000 member companies. Membership in the Association is voluntary and represents 93 percent of the machinery manufacturing industry in West Germany. The majority of the member firms (80 percent) employ less than 200 workers. Membership fees are computed on the basis of approximately 25 cents for each $312 of company turnover. Additional funds from the BMWF amounted to about $11 million in 1971. The Association generally provides services related to taxes, legal matters, insurance and information programs (e.g., compilation of annual statistics for the industrial sector). The Association also serves as the standardization forum for the entire industry and sponsors some research, as on noise pollution by machine tools. The Association does not operate laboratories, hence expert teams are assembled to determine what research should be performed and the facility (university or research association) to be utilized.

7. Patent Services Provided by Cities

The cities of Stuttgart and Ludwigshafen have made arrangements with local patent attorneys to provide free advisory services at weekly sessions for independent inventors with limited financial means.

D. Indirect Incentives

Along with organizational structures for implementing science, the Federal government provides a number of indirect incentives to enhance the creative ability of individuals, and encourage scientific activities. These relate to joint ventures in research, cost computation for contract research, protective rights, and taxes, and apply for the entire country; additional special provisions are applied in the Western Sectors of Berlin. These provisions are integrally woven into the operation of the organizations described in the foregoing and complete the picture of mechanisms for implementing science.

1. Joint Ventures

Joint ventures for R&D are allowed by government almost without restriction, except that a competitive atmosphere must exist

Inventions are defined as new and commercially usable devices showing technological advancement and a sufficient level of ingenuity. In the event of two simultaneous applications, the rights fall to the inventor who registers first with the Patent Office. As with all applications, each is made public 18 months after registration and is then available to everyone for licensing.

Patent protection extends for 18 years, but patents must be renewed annually. Since the cost of renewal increases yearly, it is to the owner's advantage to utilize the patent quickly in order to derive a return on his investment. A patent may expire in less than 18 years if the owner desires or if he fails to renew it.

The owner retains exclusive patent rights of production and distribution of the protected item. He may exclude third parties or resort to licensing. When the owner files his application with the Patent Office, he may declare that any licensee can use the patent, in which cases fees are reduced by 50 percent. Under a rarely used provision, a third party may utilize a patent in the public interest should the owner refuse to permit a license. During the 18-year period of protection, patent rights may be sold or inherited provided that renewal fees are paid. Furthermore, the FRG patent laws are valid only within the country; if rights are desired in a foreign country a patent application must be filed in that country.

Most of these features are intended to preclude monopolistic control of patents. In particular, increasing annual fees and automatic reduction in fee for declared non-exclusivity act in this direction.

As an inducement to innovative applications, existing patents can be used in research without obtaining a license. If a new application results, the researcher must, naturally, negotiate with the owner of the patent for the use thereof.

Protective rights deriving from joint venture research are owned jointly by all partners. Rights which stem from research at universities generally are titled to the professor in charge of the project.

Any patents arising from research effort performed at a Max Planck Institute are owned by the MPG. In the case of the FhG, distinction is made by type of project. If an FhG institute performs contract research for industry, any resulting patents belong to the contracting firm; protective rights arising from government-contracted research are owned by the FhG, but government distinction is made between inventions and proposed improvements (which cannot be patented). Suggestions for qualified technical improvements which give the employer a remunerative commercial advantage are given the same consideration as inventions; the employer must pay the employee a just compensation, calculated according to "Guidelines for Compensation of Employee Inventions in Private Industry" issued by the Federal Ministry for Labor and Social Affairs.

In compensating the employees two factors are considered: (1) whether the invention or improvement results from the employee's normal duties and (2) the importance of the invention or improvement in the market. A point system has been established to scale each category and compensation is based on the total number of points awarded. For example, if a machinist working for an electrical component firm invents an electrical relay which dominates the market, he would receive a large number of points in each category: his job is not to design relays and his design is far superior to previous devices. However, an improvement on his lathe, although ruling the market, would accrue fewer points and less compensation.

An employer must also compensate an employee for improvements which do not qualify as inventions or technical improvements (i.e., which do not necessarily give commercial advantage), but which the employer utilizes significantly. The amount of compensation is negotiated.

5. Tax Incentives

Tax advantages and incentives for science and technology in the FRG extend beyond the usual allowances for corporate activities. Some tax allowances are given to individuals for activities which promote science and others are given to inventors as an inducement for creativity.

Donations for scientific purposes may be deducted as special expenses when determining income taxes. This is limited to 10 percent of total individual income or, in the case of legal entities, to 2 percent of the sum of wages, salaries and turnover in a calendar year.

Payments to domestic and legal persons (i.e., natives of the FRG) which serve public purposes directly and exclusively are exempted from inheritance tax. Public purposes include the promotion of science. The transfer of real property from corporations

In addition to tax incentives, the BMWF provides a 10 percent subsidy for investment in industrial R&D facilities. This is available to all firms, but is generally used only by the larger companies.

E. Special Measures Applied in the Western Sectors of Berlin

Berlin had been a center of industry prior to World War II, but over 75 percent of the industrial capacity in the Western Sectors of Berlin (West Berlin) was destroyed. About 25 percent was due to war losses and 50 percent due to Soviet dismantling. The equipment and installations of almost 460 firms in the most important industrial sectors were completely removed. The partition of the city and the blockade further handicapped industrial reconstruction.

Notwithstanding obstacles, West Berlin industry has revived, led by firms specializing in electrical engineering and machine building (including office machines). However, as is true throughout the FRG, these industrial sectors are dominated by a few large firms. For example, in 1970, eight of the electrical engineering firms in West Berlin (4 percent of the industrial sector) employed 75,500 workers (76 percent of those employed in electrical engineering). In the machine building sector, 26 percent of the employees worked for only 3 percent of the firms. These figures indicate the importance of small- and medium-sized industries to the economy of West Berlin. Most of the scientifically-oriented industry in West Berlin is made up of small- to medium-sized "court yard" firms (so-named because the buildings housing them usually have several interior courts) which specialize in high technology fields relying heavily on the technical skill of employees for hand assembly and finishing of small-series production items.

Much of the support for firms in West Berlin is aimed at keeping the small- and medium-sized industries viable and in attracting new industry to the city. This special support, applied in addition to that provided in the remainder of the FRG, and other programs aimed at maintaining West Berlin as a viable city were motivated above all by political reasons.

Directly supporting R&D efforts of small- and medium-sized industries is a program financed by the BMWF and administered by the West Berlin Chamber of Commerce. Prerequisites for this support are the following:

- Firms completely located in West Berlin should, if possible, conduct the research in West Berlin. Research may be performed outside West Berlin (at a university, for example) if the research center best qualified for the effort is located elsewhere in the FRG. ;

Subsidies are also provided for capital investments for R&D. A 25 percent investment grant is available for movable capital goods; a 10 percent subsidy is given for non-residential construction; and a cash subsidy amounting to 30 percent of cost may be given for equipment used exclusively for R&D purposes.

In addition to support given by the BMWF, European Recovery Program (ERP) revolving funds, amounting to about $900,000 per year, are available to provide low-interest loans. These loans are customarily used in support of research projects.

Special provisions are made for indirect support of West Berlin industry, including tax rebates, special depreciation allowances and tax reductions. A turnover tax rebate is given to West Berlin firms based on the net value added in West Berlin: a tax rebate of 4.5 percent is applicable if the value added is between 10 and 50 percent. The tax rebate is increased to 5 percent for value added between 50 and 65 percent, and to 6 percent if it is in excess of 65 percent. As an inducement to purchase goods made in West Berlin, an FRG buyer of such goods receives a turnover tax rebate of 4.2 percent. Services in selected fields (such as engineering, consulting and data processing) are also eligible for the 6 percent turnover tax advantage. Investment goods produced in the West Berlin plant of a firm for installation in an FRG plant of the same firm are also entitled to this tax advantage.

Manufacturing equipment (including buildings) may be depreciated a maximum of 75 percent either in the year of investment or in the following four years. Residential housing is included if at least 80 percent of the units are occupied by employees of the investing firm.

Corporations located and managed in West Berlin are entitled to a 20 percent reduction on corporate taxes and an additional reduction of 3.2 percent on revenue generated in West Berlin. FRG and foreign corporations with production facilities in West Berlin, employing over 25 persons, have the same privileges on revenues derived from West Berlin operations. Self-employed individuals, partnerships and single proprietorships not subject to corporate tax are entitled to a 30 percent reduction on their income tax.

of the State in which they are located. These percentages apply to funding exclusive of that which some centers receive from EURATOM.

The centers perform basic and applied research for breeder reactors using the uranium-plutonium cycle and fast neutron processes; breeder reactors using the thorium-uranium cycle and thermal neutron processes; bio-medical radiation research and studies of deep storage of radioactive waste; nuclear power for ships; nuclear and radiation chemistry, physics and mathematics; high-energy physics; plasma and fusion research; and isotope separation. One center also operates the West German nuclear research vessel "Otto Hahn."

The first two nuclear research programs have accomplished their goals and the research centers perform advanced research on a par with that of other nations. The planning, construction and operation of first-generation nuclear power stations is now accomplished by reactor and utility companies without government guidance. The FRG nuclear industry has received orders for 18 nuclear power plants within the FRG which will, when completed, have a total capacity of almost 14,000 MWe. Two plants have been exported, one to the Netherlands and one to Argentina. Six prototype and demonstration power reactors, operating and/or under construction, are being used to investigate other nuclear power technologies including natural uranium fuel, heavy water moderation, high-temperature gas-cooling and fast breeder reactors.

As the industrial development of first-generation nuclear power stations was being realized, provision was also made during the Second Program for the development of advanced converters and of thermoinic and fast breeder reactors. The Third Program emphasizes development of more economical generation of electric power through construction of prototype plants, including promotion, planning and establishment of experimental reactors and investigations related to the fuel cycle.

For the development of more efficient light-water prototype reactor plants, industry is expected to share costs (usually 50 percent). However, grants are available for plant erection, first fueling and procurement of necessary heavy water. In addition, the Federal government assumes 90 percent of the risk up to a ceiling of about $31 million

Plans for the Fourth Program indicate the following priority areas:

- reactor safety, radiation protection and nuclear environment protection;

- continued development of sodium fast-breeder reactors, high-temperature reactors, and uranium enrichment technology; and

- fusion research and international projects for solution of basic problems in high energy physics (with CERN) and solid-state research (with Grenoble).

2. Space Research Program

The FRG space program was initiated in 1962 based on the achievements of the U.S. and USSR and the realization of the importance of space technology to national economic and scientific growth. The objective was to establish an infrastructure for the peaceful use of space in both a national and an international framework. Due to financial and material limitations, much of the promotion of space research has been directed toward European programs and cooperation with NASA.

From mid-1962 until the end of 1968, about $250 million were expended in annually increasing allotments. About 56 percent of this was spent for joint European space research, and the balance for national programs. The necessary base has been created, enabling a large number of FRG scientific institutions (including the universities) to increase their participation in projects sponsored by the European Space Research Organization (ESRO), and to undertake experiments jointly with the U.S. and other countries in space research using sounding rockets and satellites. Scientific, technical and organizational capabilities were developed and have permitted participation in more sophisticated space projects, initially through assistance to a number of industrial firms and the establishment of ground installations for the development, testing and operation of technically complex space flight instruments. Where industrial participation is indicated, the firms generally provided some (usually half) of the support.

Toward the end of this period, space efforts were increasingly directed toward specific R&D projects. These

The Heinrich Hertz Institute for Oscillation Research (Heinrich-Hertz-Institut für Schwingungsforschung, HHI) is located in West Berlin and works closely with the Berlin Technical University. Its research program emphasizes micro-wave technology and it performs research on problems related to electronic equipment of satellites, electronic transmission procedures and ground station installations. The Federal government provides most of the operating funds. Some funds are supplied by the FRG Postal Service (an autonomous organization which has its own budget).

The space programs have been successful in that the FRG is a major participant in international space activities. As a result of the establishment of the infrastructure, including both industrial capability and trained personnel, a number of satellites have been orbited with successful FRG experiments on board. These have included AZUR (in cooperation with the U.S.) and DIAL (with France) satellites for research on the earth's atmosphere. The ESRO A-1 satellite (Highly Elliptical Orbit Satellite, HEOS) also carried successful FRG experiments. In addition, over 200 experiments with space probes have been conducted through ESRO.

Current priorities are assigned to the following activities:

- development of the French-FRG experimental communications satellite "Symphonie;"
- establishment of two ground radio stations;
- development of aeronomy satellites in the AEROS series;
- development of solar probes in the HELIOS series;
- participation in several ESRO satellites; and
- participation in the development and production programs of the third stage of the EUROPA II launcher under ELDO.

3. Civil Aviation

The Federal government promotes R&D in the field of civil aviation, contributing significantly to increasing the scientific and technological potential in the industrial sector of this field. Aviation technology has been brought from one State government. It performs studies on the effective utilization of data processing systems for public administration, trains specialists for the Federal government and scientific institutions, and performs basic research. It is the main advisory body to the Federal government in the data processing field.

About $113 million was expended by the Federal government on the First Program. Additional funds were appropriated by the State governments and industry, but the extent is unknown. Industrial capability has successfully been brought up to international levels in a number of areas, particularly in the development of medium-sized computer installations (including process control computers), some electronic components, and small programmable keyboard computers. Partial success was achieved in the development of one large computer system. A more balanced competitive position was achieved for FRG computer firms within their domestic market; whereas the market was dominated by foreign manufacturers in the early 60's, by 1970 about 20 percent (in value) of the medium-sized computer installations and 40 percent of the small computers in use in the FRG were of domestic origin. Only slight inroads (7 percent) were made by domestic manufacturers in the large computer area.

As the First Program drew to a close, it was recognized that a number of factors would hamper increased applications. The objectives of the Second Program (1971 to 1975) are directed to overcome shortages of qualified personnel, a lack of standardized software and program packages, and a lack of technical prerequisites for extended application in science, society and industry. Joint support is provided by four Federal Ministries, indicating the importance of the new program. In addition to the BMBW, the BMWF, the Ministry for Labor and Social Affairs and the Ministry of the Interior are involved.

An estimated Federal expenditure of $757 million is planned for the Second Program, with emphasis shifting from industrial R&D (which will now receive only 29 percent of the total funds). About 31 percent of the funds are earmarked for universities (including the acquisition of computers), and 23 percent for application of data processing methods.

Education in computer science at universities and professional education centers is to be stressed in order to meet the increasing demand for data processing specialists development. Use of these centers will be available to universities and other scientific institutions. Six centers are planned and of these, four are currently operational at Stuttgart, Munich, West Berlin and Hamburg.

Other activities corroborate the emphasis on data processing. The German Postal Service in concert with Siemens and AEG-Telefunken has formed a joint data processing and data transmission company, Deutsche DATEL. The company rents time-sharing services, including terminals, and provides programming and application advice to small- and medium-sized businesses.

The BMBW, as a part of the reorganization of its advisory system, has established a "Special Committee for Data Processing and Documentation" to assure that full and efficient utilization is made of this modern technological tool.

5. Oceanography

Oceanography was selected as an emphasized program area in 1969, partially as a less expensive substitute for particular phases of space research. The technological challenges of overcoming a hostile environment apply to oceanography, and immediate benefits for society are realizable.

The promotion of marine research started as a priority program of the DFG and was supplemented by the work of a number of marine research institutions. The BMBW then took over the support of these programs. The initial BMBW program was for the period 1969 to 1973, but a newer version is now being formulated for the period 1972 to 1975. Priorities for oceanographic R&D have been established, with the following objectives:

- prevention and control of ocean pollution;
- investigation of the origin of mineral deposits and the development of exploration techniques so that mineral resources of the ocean floor and its foundation can be utilized;
- utilization of marine food resources;
- recognition and control of natural phenomena related to the shore and coastal areas; and

extremely important in the future was initiated by the BMBW in 1969. Fields to be stressed in the program are judged by three criteria:

- the value of the development for the solution of problems of modern society, including the preservation of a competitive position on the international scene;

- the potential already available for development in the field; and

- the continued long-term technological importance of the field.

Within the program, priority is given to projects directed toward such broad goals as:

- securing better living conditions and health for the people;

- establishment of a sound infrastructure, such as transportation, communications, energy systems, and raw material resources;

- the preservation and improvement of technological capabilities in international competition; and

- measures to safeguard internal and external security.

In order to fulfill these goals, projects in this program are divided into three main categories, each having several major subdivisions:

- technological R&D for industrial innovation, including

  --physics- and chemistry-based technologies

  --energy technology (non-nuclear)

  --materials and production technologies

  --observation and investigation of scientific and technical fields from which important technologies may emanate.

transformation and the transmission and storage of energy are representative of projects supported as energy technology. Support has been given for the establishment of prototype installations and the promotion of demonstration projects in such areas as the biotechnical production of high-value proteins from micro-organisms, the production and storage of helium, new traffic systems and super-conducting cables for energy transmission.

In the category of public administration, major projects are being carried out in the long distance-high speed ground transportation area. These projects are particularly related to the creation of a system using magnetic suspension and a linear induction drive. Prototypes of this type of system have reached speeds of 93 miles per hour (150 kilometers per hour) on a six-tenths of a mile track. Ultimately, speeds are expected to exceed 300 miles per hour (500 kilometers per hour). Since, in time, any system in use in the FRG would be incorporated into a European system, a parallel effort is being directed toward projects using air-cushion suspension and linear induction drive. Each of these developments has been supported 80 percent by government and 20 percent by industry. About $2.8 million have been spent on each system to date. The choice of suspension system to be used will be made in the fall of 1972, at which time the government will assume full funding of the demonstration project, expending about $12 million in 1973.

The environmental projects fall into the same category. Support is provided for projects related to living space and land utilization (basic ecological research), waste removal and treatment (including environmentally-oriented packaging materials and procedures for re-utilization or non-injurious removal of waste, improved sewage treatment, and reprocessing and safe storage of radioactive wastes), environmental chemicals and biocides, and high-sea and coastal-water problems. The solutions to water, air and noise pollution problems are also receiving support. Examples include the improvement and development of procedures for treatment of waste water, especially industrial and toxic waste. Air pollution studies include procedures for desulfurizing fuels, improvement of internal combustion engines, the development of new propulsion systems and the reduction of radioactive emissions from nuclear installations.

In addition to support of New Technologies Projects by the BMBW, the BMWF is providing support (about $2 million

BIBLIOGRAPHY

Arbeitsgemeinschaft Industrieller Forschungsvereinigungen e.V., AIF Jahrbuch 1970 der Arbeitsgemeinschaft Industrieller Forschungsvereinigungen, Köln, 1971.

______________, Geschäftsbericht 1971, Köln, 1971.

Brose, John and Kerr, Kathleen, In Brief-Berlin (English edition) Presse- und Informationsamt des Landes Berlin, Berlin, 1969.

Büro für Entwicklungsförderung bei der Industrie- und Handelskammer zu Berlin, Gewährung einer Zuwendung für Entwicklungsarbeiten, Berlin, (undated).

______________, Merkblatt, Berlin (undated).

______________, Übersicht über die veranschlagten/entstandenen Entwicklungskosten, Berlin, (undated).

Der Bundesminister für Bildung and Wissenschaft (BMBW), Leistungsplan: Datenverarbeitung (DV), Bonn, 1971.

______________, Zweites Datenverarbeitungsprogramm der Bundesregierung, Bonn, 1971.

Der Bundesminister für Wirtschaft (BMWi), Bewilligungsbedingungen des Bundesministers für Wirtschaft (BMWi) für die Gewährung von Zuwendungen zur Förderung von Entwicklungsvorhaben in der Berliner Industrie, Bonn, 1969.

______________, Technologie und Wirtschaft, Bonn, 1970.

Der Bundesminister für Wirtschaft und Finanzen (BMWF), Bewirtschaftungsgrundsätze des Bundesministers für Wirtschaft und Finanzen (BMWF) für die Gewährung von Zuwendugen zur Förderung von Erstinnovationen und der hierzu erfonderlichen Entwicklung, Bonn, 1971.

Haertel, Dr. Kurt, One Year Deferred Examination as Viewed by the German Patent Office, International Review of Industrial Property and Copyright Law, Vol. 1, No. 1, Weinheim, 1970, pp. 4-18.

Karbowski, Dr. J., Untersuchung über die personellen Voraussetzungen bei den Berliner mittelständischen Industrieunternehmen, Forschungs- und Entwicklungsergebnisse praxisnahe anzuweden, Rationalisierungs-Kuratorium der Deutsche Wirtschaft - Zweigstelle Berlin, 1970.

Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., Verzeichnis der Organe und Institute nach dem Stand vom 1. Januar 1971, München, 1971.

Messerschmitt-Bölkow-Blohm, System '72, München-Ottobrunn, 1972.

Organization for Economic Co-operation and Development, Reviews of National Science Policy - United Kingdom and Germany, Paris, 1967.

Press and Information Office of the Federal Government, The German Federal Government, Hamburg, (undated).

"Projektstudien zur Entwicklung von Hochleistungsschnellbahnen in der Bundesrepublik," Transport Management, Dezember 1971/Januar 1972, München, 1972, pp. 7-9.

Schwandt, H.M., Berlin's Manufacturing Industries 1970, United States Mission in Berlin, Berlin, 1971.

UNIVAC, Stellungnahme zum 2. Datenverarbeitungsprogramm der Bundesregierung, Frankfurt/Main, 1971.

United States Department of State, Background Notes - Federal Republic of Germany, Washington, D.C., 1970.

United States Mission in Berlin, Law for the Promotion of the Berlin Economy, reprint of United States Department of State Airgram No. 533, Berlin, 1970.

APPENDIX FOUR

ANALYSIS OF PROGRAMS AND MECHANISMS

IN JAPAN

TABLE OF CONTENTS

LIST OF CHARTS AND TABLES

LIST OF ATTACHMENTS

LIST OF ABBREVIATIONS

AEC	Atomic Energy Bureau
AIST	Agency of Industrial Science and Technology
ASME	Agency for Small and Medium Enterprises
CST	Council for Science and Technology
EA	Environmental Agency
FILP	Fiscal Investment and Loans Program
IAEA	International Atomic Energy Agency
IPCR	Institute of Physical and Chemical Research
ISAS	Institute for Space and Aeronautical Sciences
JAERI	Japan Atomic Energy Research Institute
JDB	Japan Development Bank
JECC	Japan Electronic Computer Corporation
JRDC	Research and Development Corporation of Japan
JT&TC	Japanese Telephone and Telegraph Company
MITI	Ministry of International Trade and Industry
MOF	Ministry of Finance
NIRS	National Institute of Radiological Sciences
NSDA	Nuclear Ship Development Agency
OURDC	Overseas Uranium Resources Development Corporation
PNC	Power Reactor and Nuclear Fuel Development Corporation
SAC	Space Activities Commission
STA	Science and Technology Agency

PART I

THE ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Part I of this appendix discusses the environment within which science and technology policy is developed and implemented. The discussion is presented in three sections as follows: Government Involvement in Science and Technology; Government Organization for Science and Technology Policy Development and Implementation; and Government-Private Sector Relationship and Interaction.

A. Government Involvement in Science and Technology

Science and technology (S&T) and, in particular, the application of S&T findings to industrial uses, have been key elements in modernization and economic development of Japan, begun nearly a century ago when the Japanese government first announced a national goal of modernizing Japanese society and industry through the introduction of scientific knowledge and technology from abroad. This basic philosophy has not been substantially altered even though there have been many innovations of local origin.

At the conclusion of World War II, Japan lay devastated and demoralized, and the government was confronted with what seemed to be an insuperable task. Not only had much of the nation's capital wealth been destroyed and its production facilities damaged, but the country also faced serious deficiencies in food and raw materials and had been cut off from its sources of technology imports. The road to economic recovery appeared to be long and hard, necessitating very careful planning.

After much deliberation and consultation with the private sector, the government decided on a course of action which, at the time, sounded more visionary than realistic. The government would try to advance the country's industrial structure, striving to "catch up" with the latest industrial technological developments in western nations as rapidly as practicable. This would entail rehabilitation and advancement of existing industries, and then establishment of technology-intensive industries through heavy reliance on government subsidies and on technology imports from abroad. The government felt that this plan would not only quicken economic growth and relieve unemployment, but would also elevate the technological base of the country, raise the standard of living, and increase Japan's competitiveness in world markets, although this was regarded as a longer-range objective.

It may be observed that competing in international markets offered Japan its only means to regain stature and prestige as a world power; this implied establishment of industrial production facilities on a par with those of the most advanced nations, and not just facilities as substitutes for imports. Thus, immediately following the end of World War II, science and technology were inextricably interwoven with reconstruction, economic recovery, economic growth programs, and national pride.

Japan into third place in the world economy, after the U.S. and the U.S.S.R.

Japan's phenomenal economic resurgence in only 25 postwar years derives from many factors, the most noteworthy being imports of foreign technology, abetted by the dedicated determination of the Japanese people and a highly cooperative relationship between government and industry. Other important factors include: the negligible share of national resources devoted to defense or to space exploration; stable labor-management relations; high debt-to-equity ratios (ranging as high as 6 and 8 to 1) for all major Japanese corporations; the protectionist policies of the government; and a favorable exchange rate, which stimulated the sale of Japanese products abroad. However, assessment of the significance and contribution only of technology imports lies within the scope of this study.

The Japanese government estimates that since the end of the war, it has paid nearly $3.0 billion for foreign technology imports, most of which came from the United States. These imports, which from the very beginning were subject to strict control by the government, have had a pervasive influence on the economy of Japan. Not only have they contributed to industrial growth, but, by raising the level of technological sophistication, have enabled Japanese scientists and engineers to conduct independent R&D activities and transfer technological expertise from one industry to another. In recent years, Japanese technological expertise and know-how has begun to be exported to other countries.

According to one source, the Japanese Ministry of International Trade and Industry (MITI) exercises considerable authority over technology imports. With the enactment of the Foreign Investment Law in May 1950, the government was given the right to screen licensing agreements and direct foreign investments in Japan. Under this authority, MITI controlled applications from domestic companies for technological assistance contracts with foreign firms, the type and flow of foreign technologies into the country, and selection of recipients of tax and other incentives for channeling technology investment and applications to designated industries in the national interest. According to one source, MITI "had kept a pervasive authority to directly intervene in economic activities under the Law Concerning Temporary Control of Demand and Supply of various goods. This law was abolished in 1952, but MITI kept the power to control export and import of capital, technology of the manufacturing industries was estimated to be 20.6 percent in 1967 as against 33.6 percent in 1961.[3] The largest contributions were made to chemical, machinery, iron and steel, and electric industries.[4]

The Japanese government has in recent years established a complicated system of interlocking agencies, quasi-public corporations, and mandates, and has participated in the launching of a large number of technology enhancement programs. These are intended to help accelerate the importation and assimilation of new technologies, establish domestic priorities, provide overall planning for industrial expansion and coordinate the country's S&T activities. Moreover, the ultimate goal of nearly all these programs (other than the few related to space and defense) has from the start been the application of newly-developed technologies to civilian and industrial needs. The Japanese government, therefore, maintains a broad system of tax and other incentives designed to encourage R&D investment in and utilization of new technologies. (The S&T organizational structure and the major S&T programs in Japan are discussed in detail in subsequence sections of this appendix.)

Japan's spectacular economic growth rate has continued unabated into the early 1970's without showing signs of slowing down. However, there have been early signs of trends and conditions, inherent in the very rapid rate of industrial expansion, which could have adverse effects if not countered. For example, in the fervor of trying to build up industrial capacity and foreign trade potential as fast as possible, the government has neglected commensurate investments in social capital, such as the construction of adequate housing facilities, modern highways, and solid waste disposal systems. There has also been developing popular awareness of potential ill effects from environmental pollution, caused primarily by the enormously increased quantities of smoke emissions and effluents of industrial plants and the exhaust systems of myriad motor vehicles. A third concern is the much lower percentage of total R&D activities financed by the government compared with the situation in all highly industrialized countries in the world.

The government is currently preparing elaborate plans for substantial investments in social capital during the rest of the decade, and is also seriously considering various alternatives for tackling the problem of environmental pollution. It is contemplating a measurable increase of its contribution to R&D activities, which would certainly contribute to strengthened

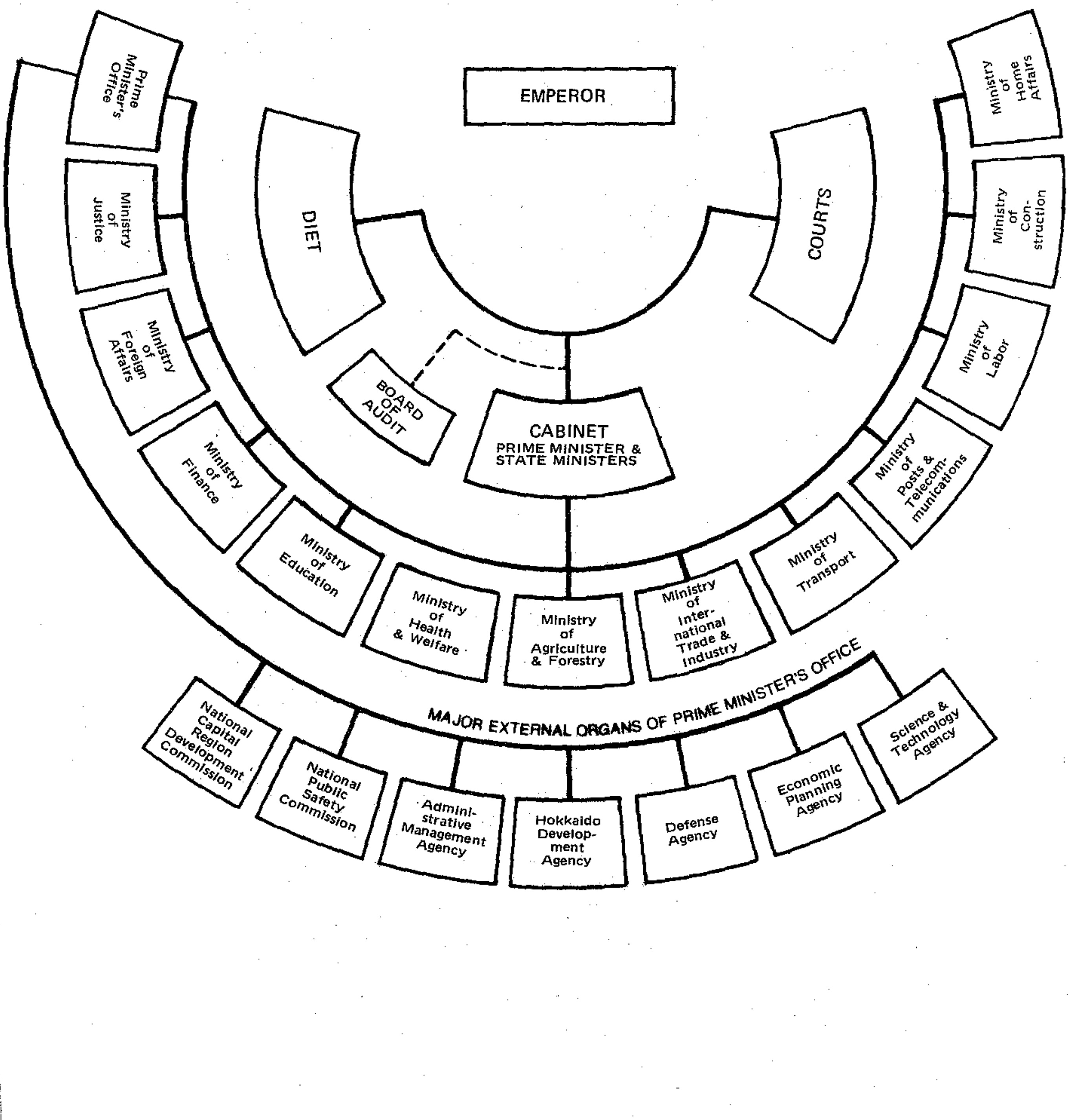
---

[3] Keichi Oschima, "Science and Technology and Economic Growth in Japan;" Testimony before U.S. Congressional Subcommittee, April 1972, p.3.

[4] Ibid.

FIGURE 1

Government of Japan



countries for the study of particular areas, such as disaster prevention, research management and environmental protection.

2. Science and Technology Agency (STA)

The Science and Technology Agency was established in June 1956, when the former Scientific and Technical Administration Committee, founded in 1949, the Atomic Energy Commission, created in January 1956, and a number of other organizations were combined to improve overall coordination and administration of government programs in the area of science and technology "key pillars of national prosperity."[6/]

STA is headed by a Minister of State for Science and Technology, a member of the Cabinet and, by custom, also head of the Atomic Energy Commission and the Space Activities Commission. It is composed of an Administrative Secretariat and four Bureaus (namely Planning, Research Coordination, Promotion, and Atomic Energy), as shown in Figure 2.

The Agency acts as the secretariat for the CST and the other four advisory bodies to the Prime Minister (see footnote 5), and is the point of contact between the administration and the Science Council of Japan. It is also assigned administrative authority over a number of "Corporations under Special Charter," including the Research Development Corporation of Japan (JRDC), and a number of national laboratories which carry out research in fields which cross ministerial boundaries. Currently, there are six government laboratories and seven quasi-governmental corporations.

The principal functions of STA are:

a. Formulation of basic national policies for science and technology, based on recommendations made by the advisory bodies which report directly to the Prime Minister and by those reporting to the Minister of State for Science and Technology (i.e., the Electronics, Inventions Promotion, Resources, Aeronautical, and Consulting Engineer Councils).

[6/] Science and Technology Agency, Science and Technology Agency An Outline; Prime Minister's Office, Tokyo, Japan, 1970, p.1.

b. Overall coordination:

- in areas in which inter-ministerial research cooperation is essential (e.g., space development, disaster prevention, and atomic energy development). This includes participation in formulating research budgets for the ministries involved in research programs;

- in matters which are not related to research, but which are common to all aspects of science and technology (e.g., training of personnel, science information, etc.), including tax incentives for R&D, conducted by industry;

- in matters involving international cooperation (e.g., OECD, UNESCO, ECAFE, etc.) and bilateral cooperative programs; and

- in matters concerning atomic energy and space development, both of which are administered exclusively by STA.

c. Participation in budget formulation for scientific activities of ministries (i.e., anticipated research programs, construction of large scale facilities, etc.).

- Ministries submit budget estimates on scientific activities to the Ministry of Finance on the basis of an overall framework of budget policy formulated by STA for the fiscal year. The Agency reviews the plans and recommends priorities to the Ministry of Finance.

- In special cases, whenever several ministries are involved in a given S&T program (e.g., training of government R&D workers), the budget is allocated to STA en bloc; in turn STA allocates funds to the ministries. This scheme is used in connection with atomic research and other important research programs. In such cases, the ministries submit estimates to STA.

- STA has discretionary authority in the disposal of a "Special Fund for Promoting Multi-Ministerial

Energy" covering a period of 20 years to 1985, with emphasis on the decade beginning in 1967. The goal was nuclear power capacity totaling 6 million kw by 1975, and 30-40 million kw by 1985. These targets have since been revised upward.

- Coordination of government efforts in atomic energy development. The AEB coordinates the work among ministries and agencies concerned with major atomic energy projects, as well as the general use and development of nuclear-related technologies and materials.

- Regulation of nuclear reactors and other facilities. It establishes standards and regulatory legislation for safety, and handles preventive measures for safety control.

- Operation and supervision of related establishments. The AEB operates the National Institute of Radiological Science and supervises several semigovernmental establishments, among them the Japan Atomic Energy Research Institute, the Japan Nuclear Ship Development Agency and the Power Reactor and Nuclear Fuel Development Corporation.

- Promotion of international cooperation. The AEB actively participates in international organizations, such as the International Atomic Energy Agency (IAEA) and others.

4. Research Development Corporation of Japan (JRDC)

The Research Development Corporation of Japan, established in 1961 and patterned after the United Kingdom's National Research Development Corporation (NRDC), is one of the quasi-government "Corporations under Special Charter" over which STA has administrative authority. JRDC has a mandate to encourage invention and innovation. It selects high-risk scientific projects with a good potential for commercial application, brings them to the attention of industrial circles, and underwrites the cost of development. (A full discussion of the JRDC is in Part II of this appendix.)

5. Ministry of International Trade and Industry (MITI)

The Ministry of International Trade and Industry, one of the two top agencies in the Japanese government (the a compromise; if not successful, it will take responsibility for decision in accordance with provisions of the Foreign Investment Law. Similar procedures are followed in other sections. In case a compromise must be found between the chemical and, say, the petroleum industries, the first attempt will take place between both associations; if not successful, between both MITI sections; if again unsuccessful, the matter is then turned over to the Ministerial Secretariat for action. When required, these agreements and decisions are conveyed to other pertinent government agencies, Parliament and foreign governments."[8]

MITI's broad functions are reflected in its organizational structure, shown in Figure 3, indicating a large number of bureaus. Some of these bureaus are concerned with specific industrial sectors (such as heavy industry, textile industry, public utilities industry), while the activities of others cut across industries (e.g., as safety techniques, weights and measures, patents, trade development, foreign trade, small and medium size enterprises, and industrial science and technology). Most of MITI's functions do not fall within the scope of this study.

MITI functions exclusively related to science and technology are shown in Figure 4 and Attachment 1. They are represented by those of the Patent Agency, the Agency for Small and Medium Enterprises, and the Agency for Industrial Science and Technology. The last-mentioned is the most important of the three for the purposes of this study, and is discussed below. The Agency for Small and Medium Enterprises is also discussed because of the special tax and other considerations accorded to small and medium size enterprises, as described in Part II of this appendix.

6. Agency of Industrial Science and Technology (AIST)

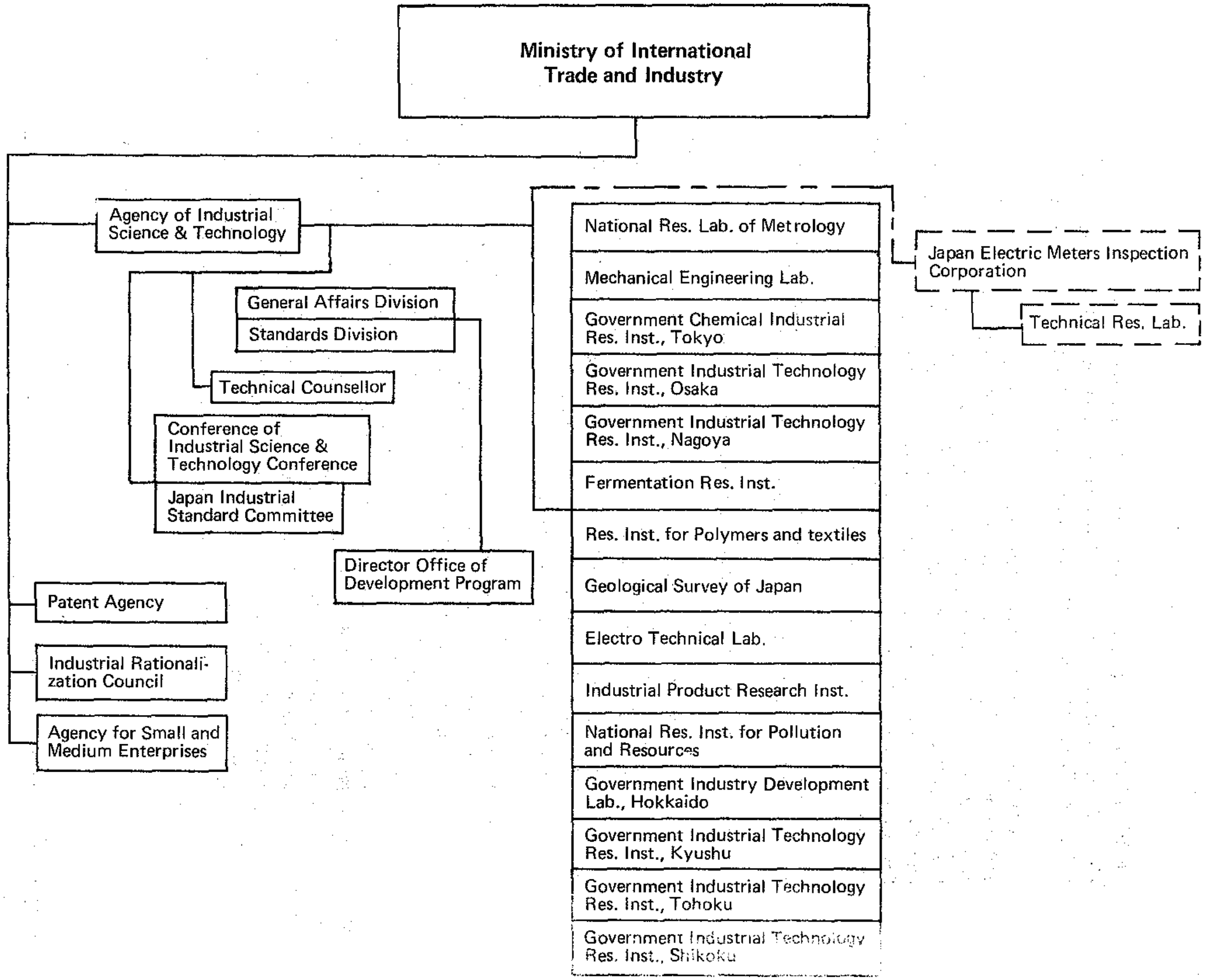
The Agency of Industrial Science and Technology, which began as an extraministerial office of MITI to administer mining and industrial technology in 1948, was later incorporated into MITI and subsequently assigned administration

---

[8]Naohiro Amaya, The Ministry of International Trade and Industry (MITI); Sophia University Socio-Economic Institute, Bulleton No. 24, Tokyo, Japan, 1970, p. 7.

FIGURE 4

MITI's Functions Related to Science and Technology



Title of Project	Project Period	Budget Billion yen (Million dollars)
(1) Magneto-Hydrodynamic Generator	1966-1972	5.5 (15)
(2) Super-High-Performance Electronic Computer Systems	1966-1971	10.0 (28)
(3) Desulfurization Process: (1) sulfur removal from stack gas (2) sulfur removal from fuel oil	1966-1971	2.6 (7)
(4) New Process for Olefin Products	1967-1973	3.9 (11)
(5) Sea Water Desalting and By-Product Recovery	1969-1975	5.0 (14)
(6) Remotely-Controlled Undersea Oil Drilling Rig, 1st phase	1970-1974	5.1 (14)
(7) Electric Car	1971-1975	5.0 (14)
(8) Pattern Information Processing System	1971-1978	35.0 (97)
(9) Turbofan Engine for Aircraft 1st phase	1971-1975	6.7 (19)

Except for project (8), these are relatively low-budgeted programs, most of which will be discussed in more detail in Part II of this appendix.

c. Promotion of R&D work in mining and manufacturing industries. As will be discussed later, AIST has encouraged R&D by the private sector through subsidies, special depreciation allowances for the actual utilization of new technologies, long term loans at favorable terms, and the formation of research associations for the conduct of joint R&D work.

d. Promotion of industrial standardization. The Japanese Industrial Standards system promotes the improvement of mining and industrial products and the modernization of production processes.

Not all of the R&D work performed by the AIST institutes and laboratories is of direct interest for this study, although a good deal of it is connected with developing technologies designed to enhance the mining and manufacturing potentials of whole regions within Japan. However, many of the R&D projects (other than those cited above) are clearly national in scope and involve the development of advanced technologies, namely:[10]

- automobile safety engineering
- protection techniques against automobile exhaust gas
- protection techniques from machine noise and vibration
- techniques of plastics wastes treatment
- plastics processing techniques
- manufacture of fire-proof construction materials
- high-purity materials for use in electronics
- removal of oil spills from sea and waterway surfaces
- fuel cell and high-energy-density battery for electric vehicles
- optical system for a satellite tracking camera
- biological treatment of industrial waste water
- degradable plastics
- conversion and transport of electric energy
- ocean electronics
- propulsion of electronmagnetic jet
- nuclear fusion reaction

10/Ibid, pp. 14-41

According to ASME's definition, small and medium-sized enterprises are those with no more than 300 employees; manufacturing companies with no more than ¥50 million ($162,340) capitalization; and business and service industries with no more than ¥10 million ($32,470) capitalization.

Major ASME policies directed at smaller enterprises include:

a. promotion of cooperatives for the purpose of developing joint activities;

b. improvement of technological and managerial capabilities through technological consulting and educational services and the use of public experimental and research laboratories of various kinds in the prefectures;

c. assistance through financing, particulary when needed for the purpose of modernizing production facilities or to engage in a joint or collective undertaking;

d. promotion of modernization through the use of a number of fiscal incentives and public finance assistance, the latter through the specialized institutions; and

e. assistance in labor recruitment through an authorized vocational training system and a prefectural employee reference service.

The efficiency of ASME's efforts in improving the economic standing of smaller enterprises will be discussed in a later section in connection with tax and other incentives given to such enterprises.

8. Ministry of Finance (MOF)

Under their broad mandates, STA and MITI have considerable authority over S&T programs carried out in the organizations under their tutelage, but neither one has unchallenged authority over the funds allocated. Virtually all their activities entail disbursement of large amounts of public funds for such purposes as the establishment of new corporations or research institutes, the construction of S&T facilities and the granting of incentives. A third government agency, the Ministry of Finance, therefore, plays a very significant role, largely through the well-known "consensus process" which has been so elements for the promotion of science and technology. The private sector also has a strong influence which, as will be discussed later, is exercised primarily through the powerful industrial conglomerates and Keidanren, a Federation of Economic Organizations.

Keidanren was established in August 1946 as a merger of several economic organizations which had been in existence since before the war. At the end of 1969, Keidanren's membership included 105 industrial, commercial, and financial associations and 731 firms, representing all of the leading Japanese business concerned with manufacturing, mining, foreign trade, commerce, maritime and land transportation, banking, securities, construction, insurance and so forth. This is indicated for some industries in Figure 6.

The Federation's stated objectives are:

> "The maintaining of close liaison among all industries, conducting studies on and investigations of various domestic and international problems facing the Japanese business community, presenting concerted impartial views and recommendations to the Diet and various governmental agencies concerned, and working out practical solutions of problems through implementation of its view, thus contributing to the sound development of the Japanese economy."[11]

Keidanren is organized into several standing and ad hoc committees, each of which is assigned a specific problem area or a current economic issue for analysis and recommendations for practical solutions. The committees draw on the information and resources available and hold discussion meetings and conferences. There were 34 committees in operation as of February 1970, studying a broad range of issues including industrial policy, industrial technology, marine transportation, energy, liberalization of capital movements, information processing, and fiscal and monetary policies. A list of these committees is provided in Attachment 2 of this appendix.

Keidanren maintains close contact with other national organizations, such as Japan Federation of Employers' Associations, Japan Committee for Economic Development, and

---

[11] Keidanren, Keidanren Federation of Economic Organizations and Activities 1970, Tokyo, Japan, 1970, p. 5.

Japan Chamber of Commerce. It also maintains cooperative relationships with many government agencies presenting its views on economic and other issues and trying to influence their planning and implementation policies. Keidanren's impact derives from the fact that it presents a unified position representing the private sector. The Federation also affects ministerial policy planning and implementation more directly through Keidanren representatives appointed to advisory councils and committees and in response to requests from government agencies for counsel or for the views of the business community on specific problems. Needless to say, not all the recommendations made by Keidanren are followed by the government, as will be discussed further in the next section.

Keidanren has taken a position with respect to several national and international economic issues which are very important to (albeit indirectly related to) science and technology. The Federation has come out in favor of liberalization of capital transactions and curtailment of residual import restrictions. To enhance the competitiveness of Japanese enterprises in world markets, Keidanren recommends the promotion of science and technology with greater financial participation on the part of the government than heretofore, development of the information industry, study of the anti-monopoly policy under new conditions of internationalization of the economy, ocean and space development, and cooperative arrangements with foreign countries for the tapping of metallic resources abroad.

C. Government-Private Sector Relationship and Interaction

As pointed out earlier, there has been substantial government-industry cooperation since the end of World War II. Certainly by American standards, government guidance and direction of the economy has been unmistakable. As Eugene J. Kaplan of the Department of Commerce points out in a recent publication,

> "What makes government-business interaction in Japan different from what takes place in other countries is the extent and scale of such interaction."[12/]

12/Eugene J. Kaplan, Japan The Government-Business Relationship A Guide for the American Businessman, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D. C. 20240, February 1972, p. 70.

normally rotated among several agencies in order to increase their breadth of vision. The contacts they thereby establish and the knowledge they acquire about government operations prove very valuable later on if the erstwhile civil servants decide to work for private industry, as most of them do.

- Easy access and effective channels of communication between government agencies and the private sector allow constant interaction, exchange of ideas, consultations, and suggestions, so that by the time program implementation is considered, many potential difficulties have already been resolved.

- There is mutual need for support and assistance. The government needs the goodwill and cooperation of the private sector to accomplish its goals and implement its plans. The government therefore ensures that the private sector has the necessary resources to achieve the agreed-upon goals. In turn, the private sector relies on government funds primarily in the form of loans at favorable terms which provide business firms with working capital and investment funds for high priority and developmental projects. This is important in view of the high debt-equity ratio (now averaging 80-20) which now obtains for all major companies. The private sector also needs the government's assistance in times of falling demand and strong international competition, and to sanction cooperative or joint undertakings by private firms.

- The granting of a large variety of tax concessions, depreciation write-offs and allowances, grants, and subsidies act as important "lubricants," which private enterprises welcome to enhance their cash position.

- Government granting of contracts to and participation in joint ventures with the private sector is fair and beneficent. The business community is generally satisfied that the government has fairly "selected" firms to implement various development projects. The awarding of contracts is made on the basis of identifiable areas of technological expertise, thereby eliminating much of the competition which would otherwise prevail among firms in trying to obtain a government contract. Private firms feel that if they miss out on one opportunity, they probably will not on the next one.

- Discussions between government officials and the private sector are conducted with mutual trust and confidence. It is accepted that both sides are basically interested in the same goal, economic advancement of the country,and that all will benefit from achieving it.

PART II

MAJOR TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS

Part II is divided into three main sections, the first of which describes recent trends in Japan's overall R&D policy to provide an appropriate context for ensuing descriptions. The second section describes a set of fully-subsidized R&D projects of national scope; a set of projects financed jointly by the government and the private sector; and a program designed to stimulate invention and innovation. The third major section discusses the tax and other incentives used by Japan to enhance technology development and application; the special tax and other incentives offered to small and medium-sized companies for R&D performance; and the availability of development loans through the Japan Development Bank, currently only partially subsidized by the Japanese Government.

A. Recent Trends in R&D Policy

As discussed earlier, Japan's quick economic recovery and growth after World War II was mainly accomplished through heavy imports of foreign technology. The raising of the country's technological base stimulated R&D activity and led to invention, innovation, and the establishment of new, high-technological industries. However, significant investment in research and development did not begin in Japan until the 1960's. Starting with a rather low base, the growth in combined government-private sector R&D expenditures paralleled the growth in economic output.

During the 1960's R&D expenditures increased at an average annual rate of nearly 25 percent, which by the end of the decade had multiplied the country's R&D investment more than six times. In FY 1970, R&D expenditures exceeded the ¥ 1 trillion mark ($3.77 billion) for the first time, a remarkable increase of 27.5 percent over the previous year ($2.99 billion). This placed Japan at about the same level of spending as France, Germany, and the United Kingdom, but still far below that of the United States and the U.S.S.R.

1. Government vs. Industry-Financed Research and Development

In contrast to other technologically advanced countries, industrial R&D activities in Japan are financed primarily by the private sector. The portion of total R&D expenditures financed by the government reached a peak of 33.7 percent in FY 1966-67, and had declined to 27.3 percent by FY 1970-71.

Keidanren, the private sector, and many university scholars have urged the government to invest more in R&D activities, not only to expand the environment for invention and innovation, but to alleviate serious national problems in the public sector. The government has since allocated $1.23 billion for R&D activities for FY 1972, a record 25.4 percent increase over FY 1971. Yet, even this larger amount represents only about 3.3 percent of the General Account Budget, a ratio which has remained virtually unchanged in the past seven years as Figure 7 shows.

It is expected that government R&D funds for research and development will continue to rise, although perhaps not at the same high rate. Coupled with a predicted slight decline in the private sector R&D investment, the government's portion of total R&D expenditures in the nation will undoubtedly increase.

2. Allocation of Government R&D Funds by Program Area

By far the largest portion of government R&D funds is allocated to national universities in which nearly all of the country's basic research is carried out. These funds, which accounted for almost one-half of the government's R&D budget for FY 1968 and FY 1969 (see Figure 7), have declined to around 39.5 percent in FY 1972, although the overall amount increased by more than 60 percent between FY 1968 and FY 1972.

R&D funds for the three "big science" program areas (atomic energy, space research, and ocean research) account for most of the remainder of the government's R&D budget. These funds tripled (from $96 million to $289 million) between FY 1968 and FY 1972. The increase has averaged 28.8 percent, 37.8 percent, and 49.1 percent annually in atomic energy, space, and ocean research and development, respectively, as Figure 8 indicates.

Increased R&D funding for the atomic energy program reflects Japan's concern about its dependence on overseas sources for enriched uranium as installation of nuclear generating plants proceeds at a rapid pace. Similar concern applies to reliance on U.S. technology and hardware for Japan's space program. Finally, Japan's recent drive toward seabed exploration and exploitation, especially petroleum, as a means of raising its share of ownership in petroleum production, has prompted additional R&D expenditures in the ocean program area. Major projects in each of the aforementioned program areas are discussed below in more detail.

3. Environmental Pollution Abatement and Control

The issue of environmental pollution did not receive any attention in Japan until about the mid-sixties; a basic environmental law was enacted in 1967, but its provisions were not enforced. A series of smog incidents in the Tokyo metropolitan area in 1970 caused the issue to resurface, whereupon greater public awareness, abetted by the media and the scientific community, quickly turned the issue into a major political problem. The government responded to the clamor for environmental protection by allocating $5 million for pollution control in its FY 1970 (April) R&D budget. In the same year, one of AIST's laboratories, the Government Resources Research Institute, was renamed the Environmental Pollution and Resources Research Institute and charged, inter alia, with conducting research on industrial pollution control. The government also created the Environmental Pollution and Safety Bureau to operate under MITI as a regulatory agency for industrial pollution and safety. In addition, several ministries and the STA reorganized or established new agencies to focus on anti-pollution activities.

Late in 1970, the Ministry of Finance issued a policy statement on pollution to establish priorities for budget allocations for FY 1971, incorporating the following four major points:

- emphasis on control of air and water pollution;
- payment of pollution control costs by identificable individual polluters;
- local governments sharing pollution control costs when polluters cannot be individually identified; and
- national funds to be appropriated primarily for basic research and experimentation.

The FY 1971 government R&D appropriation for pollution control was only $8 million, and contrary to the policy statement, about one-third of government loan funds for pollution control were used to aid industry in controlling pollution; less than 3 percent of the funds were used for basic research and experimentation.

Continued political pressure and public demand led to the establishment of a ministerial-level Environmental Agency (EA) in July 1971. The new agency was patterned after the Environmental Protection Agency (EPA) of the United States, and was given responsibility for most government environmental policy formulation and administration, including coordination of pollution-related budgets of other ministries.

Government R&D funds proposed for pollution control in FY 1972 were $16.2 million, about double those for FY 1971. Of this, the Environmental Agency received $4.26 million for such major items as overall research promotion expenses ($1.14 million) and nature conservation ($429,000). Items which EA administers but shares with other government agencies totaled $6.00 million, including the construction of a hydraulic model of the Seto Island Sea ($3.11 million), air pollution research ($1.18 million) and water pollution research ($1.24 million). Additional R&D funds were directly allotted to other government agencies, including subsidies for general pollution research projects to MITI ($5.97 million); development of a "closed system" model of an industrial plant to MITI ($1.14 million); and pollution research funds to STA ($146,000), the Ministry of Education ($341.000), the Ministry of Agriculture and Fisheries ($529,000), and the Ministry of Transportation ($81,000).

Total government R&D funding for pollution abatement and control has been minimal when measured against either the magnitude of Japan's pollution problem or the size of the country's GNP.

with a large segment of the domestic industry, and even less so in foreign countries. In 1968, MITI decontrolled all imports of foreign technology except in the seven critical areas of aircraft, weapons, explosives, atomic energy, space development, electronic computers, and petro-chemicals for which the country had not yet developed sufficiently to be able to compete in international markets. Since then pressure has increased from both the private sector and academic circles to remove controls in the remaining areas in that they are inconsistent with Japan's efforts to "rationalize" its industry and "internationalize" its economy.

In February 1972, the Ministry of Finance decided on complete liberalization of technology imports after July 1972. The MOF decision was expected to precipitate heated discussions with MITI expecially with regard to electronic computers and petrochemicals, for which liberalization runs counter to MITI's policy of domestic industrial development. In the other five areas there are fewer objections to liberalization, since all related imports can be classified as defense imports, and can therefore be controlled under OECD rules. In May 1972, MITI announced that it had decided to liberalize technology imports in the petrochemicals area in October 1972 and in the electronic computers area in August 1974.

6. Technology Exports

Japan's exceptional ability to adapt and assimilate foreign technology enables it to export increasing amounts of Japanese technology to other countries. Such exports amounted to $46 million in FY 1969 and $59 million in FY 1970, representing increases of 35 and 27.7 percent, respectively, over the preceding year.

The ratio of Japancese exports to imports of technology has increased substantially from 1961 to 1970 (from 2.4 percent to 13.6 percent), but still compares unfavorably with France (63 percent) and West Germany (38 percent). Figure 9 shows the exports/imports ratio in technology trade for Japan and four other leading nations between 1963 and 1970. It is interesting to note that the ratio has been increasing for Japan and the United States, has remained about the same for West Germany, but has declined for France and for the United Kingdom. Japan's ratio (0.13) for FY 1969 and 0.136 for FY 1970) indicates that for every dollar's worth of technology exports, Japan spends eight dollars on imports. Over 50 percent of Japanese technology exports have been going to high technology countries, testifying to the advanced status of such exports. A breakdown of destinations indicates that one-third of the exports are purchased by the United States, approximately another one-third by Asian countries, about one-fifth by West European nations, and the remainder by other nations around the world.

7. Special Account Budget

The R&D budget appropriations cited above should be regarded more as indicators of priorities and direction of R&D activities than as measures of government investment in research and development since neither the overall amounts nor the expenditures for individual R&D activities reflect disbursements made out of the "Special Account Budget." Government disbursements for R&D activities derive from two sources: the "General Account Budget," which is made up of tax revenues, is submitted to the Diet for approval, and is made public; and the "Special Account Budget," which is based on postal savings and various trust accounts, is not submitted to the Diet for approval, and is not made public.

Money provided STA for its "Special Fund for Promoting Multi-Ministerial Projects" over which the agency has discretionary authority, comes out of the "Special Account Budget."[16/] The same is true of a large portion of R&D activities which are financed directly by government ministries through various loan funds, and of funds made available to the Japan Development Bank for long-term, low-interest loans. The beneficiaries of such loans are not generally known outside a very limited circle coordinated through the Ministry of Finance.

Given these circumstances, it is very difficult, if indeed possible, to estimate the amount of funds included in the "Special Account Budget" as well as the amount made available for various R&D activities. One estimate has it that the contribution of the "Special Account" to government spending is slightly more than half as large as the General Account Budget, and that a large portion of it is used to finance R&D projects.

B. Financing and Implementation Mechanisms for Government-Sponsored Technology Enhancement Programs

The period of reconstruction and industrial development in Japan was followed by what might rightfully be called a period of large scale technology enhancement programs through active support and participation by the central government. The Research Development Corporation of Japan (JRDC) was established in 1961 for the purpose of stimulating invention and innovation. In 1966 the National Research and Development Program was instituted; it currently comprises nine national R&D projects administered by MITI's AIST. The first seven projects under this program were selected after the Council for Science and Technology designated 121 R&D fields to be sufficiently important to warrant development under the auspices

---

16/ See pp. 211-212.

The strong influence exerted by Japanese industry on the formulation of S&T policy and programs pervades the S&T activities of STA, MITI, and those other ministries, institutes and special corporations under their administrative authority, and is greatly enhanced by the "consensus" process described earlier. This is true whether initiatives for new programs originate with the government or the private sector, including Keidanren: the ultimate product always represents a common ground between the government and the private sector.

2. Initiation of Projects

The initiation mechanism depends on the size and complexity of a new project and appears to be deceptively simple. Large-scale projects (e.g., those in the National R&D Program and those in the atomic energy, space, and ocean development programs) are normally originated by the government, which invites a number of "appropriate" companies to submit proposals. Invitations are generally extended to companies (often the large Japanese conglomerates) with which the government prefers to deal owing to their expertise in particular R&D areas. (More often than not, work related to the definition and dimension of the project is accomplished informally between government and industry representatives prior to solicitation of proposals.) All major companies in Japan are somewhat loosely "classified" as being competent to engage in designated areas of research and development, sometimes narrowly defined.

Following announcement of the project, there is a period of intense negotiations during which all details of implementation are worked out, from research and manpower requirements to subcontracting, construction of new facilities and financing. The government names the prime contractor and, at this point, competitive bidding reaches its peak, for companies do not always accept the government's designation or selection of their R&D specialty and bid in areas reserved to the prime contractor. The participating companies ultimately accept the decision, convinced that, in the long run, each will receive an equitable share of government contracts. It is normal, then, for several companies to conduct R&D on different aspects of each project. The desulfurization R&D project (discussed below) is the only current large-scale project on which two companies - Hitachi and Mitsubishi - are working on the entire project.

Smaller-scale technology projects may be said to "evolve" out of the government's day-to-day contact with the private through the Japan Development Bank, which is partially subsidized by the government, unless the project itself was fully subsidized by the government. Other project participants during the development period may also be given concessions commensurate with the extent of their participation.

4. Government Requirements and Cost/Time Overruns

The government demands strict adherence to project specifications, performance, and especially time and cost schedules, although participating companies often complain that the regulations and estimates are unrealistic. The small number of competitors for government contracts and the meticulous pre-contract negotiations greatly reduce the risk of time and cost overruns, which have, in fact, been infrequent. When they do occur, however, the companies must make up the difference unless they can justify events to the full satisfaction of the government, which then provides the additional funds.

5. Patent Policy

Patents which result from R&D work performed for the government or in government-owned and operated institutes and laboratories belong to the sponsoring agency. As a result, several government agencies, particularly MITI's AIST, have accumulated a large number of patents. Patents owned by AIST may, as a rule, be licensed to any company on a non-exclusive basis, with royalties going to the government. An exception is made in the case of patents obtained under projects which are part of the National R&D Program. The government may retain a few of those patents and some of the rights; the remaining patents are licensed to the participating companies on an exclusive basis for a period of one to two years, after which the patents may be freely licensed to any company. Patents held by STA's Japan Atomic Energy Research Institute (JAERI) may be issued to participating companies, generally on a royalty-free basis, but companies may sometimes, be required to pay a small fee dependent on the extent of the company's participation in the project.

There is no special government mechanism for notifying the private sector of government-held patents available for licensing. To facilitate the transfer process, particularly for the large number of patents held by AIST, the private sector has established an Industrial Technology Promotion Association, a nonprofit body which acts as a broker. Government agencies select patents which can be licensed to private companies and submits them to the Association which through

So far, MITI appears to be pleased with the progress and prospects of these projects and plans to continue its support. There have been no significant cost or time overruns to date. All of the major Japanese industrial firms are involved in one or more of these projects and are cooperating fully with the government. Contingent on successful completion and commercialization, the government will likely increase its support of the National R&D Program, including initiation of new projects. The current National R&D Projects are:

1. Magneto-Hydrodynamic Generator

Although abundant rainfall and special geographic features enable Japan to exploit its water resources for the generation of electric power, ranking fourth world-wide (behind the U.S., Canada, and the U.S.S.R.) in hydroelectric power, increasing demand, coupled with the difficulty of finding new sites for hydroelectric plants, has forced Japan to rely more on thermal power and nuclear energy as sources of electricity. (This latter source is discussed in the next section.) The development of a magneto-hydrodynamic generator (MHD) was undertaken by AIST in 1966, and the government has allocated $15 million for the project. Scheduled to be completed in 1972, this will help enhance the country's ability to produce electric power.

Much of the R&D work for the MHD generator is being carried out in AIST's Electrotechnical Laboratory, the leading governmental research organization specializing in electricity and electronics. Closely allied R&D work is being conducted in the Government Industrial Research Institute in Osaka, on hot-pressed oxides and non-oxides for use as electroconductive refractory materials for MHD power generation.

2. Super-High-Performance Electronic Computer Systems

The development of a super-high-performance electronic computer and pattern information processing system (described later), are best understood if discussed within the context of the development of the electronic computer industry in Japan, briefly discussed below. 18/

18/ Most of the material in this section on the development of a computer industry in Japan is taken from two excellent sources to which the reader is referred for greater detail: Eugene J. Kaplan, Japan the Government-Business Relationship a Guide for the American Businessman, op.cit., and Japan Computer Usage Development Institute, Computer White Paper 1971 edition, the Asahi Evening News Company Ltd., Tokyo, Japan.

In 1961 MITI urged the seven domestic producers to establish a joint venture, the Japan Electronic Computer Corporation (JECC), to handle rentals of domestic computers. Since 80 percent of installed units in Japan are rented, JECC acted to consolidate rental operations, purchasing domestic computers directly from manufacturers and leasing them to customers. JECC is funded through loans from the Japan Development Bank in the amount of nearly $78 million in 1970 and around $94 million in 1971. In addition, domestic computer manufacturers may set aside 15 percent of the value of their sales to JECC in a tax-free fund as a hedge against capital losses resulting from the repurchase of obsolete computers.

IBM's introduction of third generation computers (i.e., 360 series) in 1964, coupled with General Electric's purchase of the largest French computer manufacturer, Machines Bull, in the same year "triggered a wide-spread reassessment of the Japanese position and led to major changes in strategy."[20/] The Japanese realized that the technology gap between Japanese and American producers had been increasing, that further advances and improvements in computer technology and performance were proceeding rapidly, and that domestic producers, because of their small scale production and technological disadvantage, were quite vulnerable. The importance and potential of the computer was for the first time appreciated by government and the business sector, and the development of the computer industry reached the highest priority. In 1966 the Electronics Industry Deliberation Council produced a report which confirmed the computer industry's key role for Japan's future development and recommended several programs, among them a joint project to build a new large computer.

The National R&D Project to develop a super-high-performance electronic computer system, also known as the National Computer Development Project, got under way in 1966 under the auspices of AIST, which allocated a total of $28 million for its completion in 1971. The hardware phase, similar to IBM's 360 series, was completed in 1970, and the implementation of the software phase and testing in 1971. According to the Japan Computer Usage Development Institute[21/]

20/ Kaplan, op.cit. p. 89.

21/ Japan Computer Usage Development Institute, Computer White Paper; op.cit., p.22.

of about 10 percent annually. A severe water shortage is expected in the early 1980's, and the Ministry of Construction estimates that by 1985 the annual water shortage will be around 5.5 billion cubic meters if remedial action is not taken.

Desalting of seawater was designated as a National R&D Project in 1969 and MITI allocated $15 million for implementation by 1975. The R&D is being carried out in AIST's Government Chemical Industrial Research Institute in Tokyo. The project is concerned with desalination of seawater, utilization of by-products, and engineering and materials research for a multi-stage flash process recovery of potassium as a by-product.

Progress has not been as fast as desired, leading one of Japan's opposition parties to introduce a bill in 1972 for the promotion of seawater desalination. The bill proposes that the Government promulgate a basic plan and that a special agency be formed to develop the necessary technology and to provide appropriate facilities.

6. Remote-Controlled Undersea Oil Drilling Rig

Japan is highly dependent on foreign sources for oil to meet the ever-increasing needs of its industrial structure. The present domestic output of petroleum covers less than one percent of the nation's demand.[22/] Moreover, "domestic oil deposits were estimated at only 800 thousand tons in 1969, accounting for less than 0.01 percent of total world deposits."[23/] The petroleum industry is based on supplying crude oil to petroleum-related enterprises, rather than on exploration and development of oil desposits. Furthermore, approximately 95 percent of the investment in petroleum facilities is in foreign hands.

In 1968 MITI's AIST launched a broad program of marine (ocean) research and development, described elsewhere in this chapter. An important aspect of that program is seabed petroleum development, which should increase Japanese ownership of oil from 5 percent to 30 percent by 1975. Toward this end, development of a remote-controlled undersea oil drilling rig, along with offshore platforms and seabed machinery, is by far the most important project. AIST has allocated a total of $14 million for this project since FY 1975. Several corporations are working to develop underwater

---

22/ Ministry of Foreign Affairs, The Japan of Today, Tokyo, Japan, 1970, p.50.

23/ Ibid. p. 50

engine of gas-powered motor vehicles, noise and air pollution problems are not likely to be wholly eliminated as long as they are used as sources of power. Steam engines and the gas turbine have received attention as possible alternative sources of power for motor vehicles, but these, too, are unlikely to alleviate pollution. The Japanese Government has decided to test the technological feasibility of developing an electric car by 1975 since such a car would not exhaust gas and would generate less noise than a gasoline engine. The performance of an electric car would be less than that of a gasoline-powered car, but probably adequate for city driving, hence the AIST is supporting development of an electric car for city-bound transportation.

AIST has allocated nearly $14 million for the period FY 1971 - FY 1975, calling for the development by 1973 of prototypes for five model cars with performance characteristics as shown in Figure 10.[27/] The initial effort (1971-73) is concentrated on research related to the development of an overall structure suitable for an electric car, improvement of the performance of component parts, and establishment of safety features. This includes research on the feasibility of replacing conventional body materials with plastics, development of a new body material amenable to mass production, development of a long-life battery with a high density of energy, and development of a battery recharge system.

In addition to reducing air and noise pollution, electric cars may produce side benefits. For example, electric cars require no clutch, thereby making driving much simpler, hence traffic accidents are likely to be reduced. Perhaps of greater significance, new technologies, such as compactness and high energy output of the storage battery, light weight of the motor, and control mechanism of power and opeation, should have broad applicability in other industries. Furthermore, introduction of automated transportation systems will undoubtedly rely on electric cars for electrically-guided and automated roadways. All in all, Japan is determined to maintain its position as a car producer second only to the United States.

27/ Ministry of International Trade and Industry, Agency of Industrial Science and Technology, Development Program of Electric Car in Japan, April 1971, Tokyo, Japan, pp. 8-9.

8. Pattern Information Processing System

Interest in an information industry for Japan followed the introduction of IBM's 360 series computer in 1964. As early as 1967 MITI had persuaded the six computer manufacturers and JECC to form the Japan Information Processing Development Center, which established regional data processing centers throughout Japan and demonstrated the benefits inherent in developing an information industry for Japan. In 1969, MITI launched a major study to define programs and map out a course of action. The report, endorsed by the government and the private sector, recommended, inter alia, the development of software and time-sharing. MITI then created the Information Technology Promotion Agency, a joint venture between government and six computer manufacturers to undertake the urgent development of the software industry. According to Kaplan "...the government invested a 50 percent share. The majority of the venture's funds underwrite internal software development while the remainder become guarantee deposits at large private long term credit banks to secure loans to private software companies. This overcomes the inability to borrow of new software houses, whose only assets are cerebral."[28]

Development of time-sharing proved more difficult, for it involved the use of the cable network of the Japan Telephone and Telegraph Corporation (JT&TC) to transmit data processing information to end-users, a service which JT&TC wanted for itself. The problem was finally resolved in May 1971 with passage of an amendment to the Public Electric Communication Law freeing the use of communication circuits for time-sharing purposes. The new law, effective September 1972, is expected to lead to rapid spread of information processing.

The construction of a domestic super-high-performance electronic computer in 1971 intensified discussions about possible commercial applications of the computer. As a result, MITI, through AIST, launched an 8-year project to develop a Pattern Information Processing System, which some people have called "a fourth generation" computer. AIST has allocated $97 million, considerably more than for any other project under the National R&D Program. Completion of the project is scheduled in 1978.

---

[28] Kaplan, op. cit., p. 96.

Joint venture programs and projects, particularly those involving large national technological development, are normally carried out under quasi-government "Corporations under Special Charter," established especially for this purpose. Each corporation is first funded by the government plus the contribution from the private sector, remains under government control for the duration of the program, and eventually qualifies for special development loans from the Japan Development Bank. During the course of the projects, private companies often increase their financial interest in the corporations through annual contributions intended to enhance their participation "rights" when the projects are completed. Proportionately more joint-venture projects are carried out under contract by industry than are projects under the National R&D Program.

1. Atomic Energy Program

Government R&D activities in atomic energy are carried out through the Japan Atomic Energy Research Institute (JAERI) the Power Reactor and Nuclear Fuel Development Corporation (PNC), and the Nuclear Ship Development Agency (NSDA), all government-owned, government-controlled corporations chartered to permit the use of private funds. 29/ The current technology projects of these establishments will be described below. The National Institute of Radiological Sciences (NIRS), a government-owned corporation, and the Institute of Physical and Chemical Research (IPCR), a research laboratory responsible to the Prime Minister, are related, but not directly relevant to this report.30/

29/ For better perspective the reader is referred to pp. 212-213 which describes the functions and operations of AEB which is responsible for the operation and supervision of these establishments. As mentioned in that section, the AEB also acts as the Secretariat of the Japanese Atomic Energy Commission (JAEC) which is an advisory organ in the Prime Minister's office. JAEC was established in 1955 to plan, deliberate and decide on matters concerning atomic energy utilization policy, long-range planning, safety and regulation, and any other matter about atomic energy that the Prime Minister may indicate.

30/ NIRS research programs are directed toward public health, both preventive and remedial. Its budget for FY 1971 was $4.1 million, a major portion of which is for the purchase of a cyclotron for cancer research. IPCR, which receives half of its funds from private sources, has been successfully conducting research on gaseous diffusion barrier development. However, the major diffusion work was transferred to JAERI in FY 1971.

PNC is a government corporation established in 1967 to promote the development of nuclear power reactors and, after taking over the activities of the former Atomic Fuel Corporation, the development of nuclear fuels, the reprocessing of spent fuel, isotopic enrichment, and uranium ore prospecting and mining. PNC operates as an independent corporation although 90 percent or more of its funds are provided by the government. (The remaining funds are contributed by large manufacturers and public utilities.)

As late as 1970 nuclear power generation in Japan was still very small and consisted of the output of the Tokai Power Station, which uses a modified Calder Hall type reactor, 166,000 kw. capacity, and the Tsuruga Power Station, which uses a boiling water reactor, 357,000 kw. capacity. The first station has been in operation since 1967 and the second since March 1970. Both stations are owned and operated by the Japan Atomic Power Company. Five others are currently operative and fifteen more stations are currently on order or under construction. PNC's FY 1971 budget for all projects was $76 million with an additional $61 million obligational authority for future year construction, almost all of which is for reactor development facilities. For FY 1972, PNC was given $123 million out of the total of $182 million allocated for R&D activities in the atomic energy program area. PNC's principal programs are discussed below.

c. Development of Power Reactors

Current government policy calls for purchase of conventional reactors from abroad and adapting them to local requirements, and then turning to home manufacture. The policy is designed to increase Japan's nuclear generating capacity as soon as possible. Since FY 1971 the electric utility industry has been rapidly installing nuclear generating plants of the light water reactor (LWR) type. The initial unit of each size or type needed was purchased from a U.S. firm, and subsequent units from its Japanese licensee.

PNC is concurrently engaged in a long-range program to develop an Experimental Fast Reactor (EFR) "JOYO", a prototype Fast Breeder Reactor (FBR) "MONJŪ", and an Advanced Thermal Reactor (ATR) "FUGEN", in accordance with the timetable in Figure 11. PNC has contracted with five nuclear industrial groups in Japan for the implementation of these projects.

The Experimental Fast Breeder Reactor is a 50 MWE sodium-cooled reactor which will later be increased to 100 MWE. Construction was started in March 1970 at PNC's O-Arai Engineering Center, about 100 km. northeast of Tokyo; the reactor will be operational in 1973. PNC has the obligational authority for most of the construction cost, expected to exceed $100 million.

A second preliminary design for the Fast Breeder Reactor being prepared by the five atomic industry groups was scheduled for completion in May 1972 with work on the final design to begin in the summer of 1972. Individual contractors are to be selected to design each major component, with one of them designated to assist PNC on overall plant coordination. Construction of the FBR is scheduled to begin in 1974, but the prototype will not be ready until 1979. The FBR is also a sodium-cooled reactor with an approximate electric output of 300 MWE. Its cost is estimated to exceed $100 million.

The Advanced Thermal Reactor will be heavy-water-moderated and boiling-light-water-cooled with a thermal output of 557 MWT and an electrical output of 165 MWE (maximum 200 MWE). Construction started in December 1970 at Tsuruga site, 75 miles north of Osaka, and the reactor is expected to become operational in 1975. Construction costs are estimated at $170 million, with additional funds for the R&D work.

Many facilities for testing and experimentation for the engineering development of the EFR, FBR, and ATR have already been constructed at the O-Arai Engineering Center, several of which have been in operation since 1970. A heavy water critical assembly went into operation in December 1969.

Much of the power reactor R&D is being done by industry under contract with the remainder at national universities, laboratories and institutes. PNC underwrites nearly the entire development cost, although participating private companies contribute some of the required personnel. In addition, the companies annually invest some of their own funds which are accumulated by the PNC. Results of component design and testing will be made available to all and, upon completion of the projects, the prototype reactors and pilot plants will be turned over to private industry. Any additional reactors and plants needed later will be financed entirely by the private sector.

have been developed, resulting in the discovery of approximately 8000 metric tons of U_3O_8 equivalent in more than 100 locations throughout Japan.

Currently, Japan obtains its uranium ore from Canada, the United States, and South Africa, mostly under long term contracts. In its search for other uranium resources overseas, the Japanese Government has since 1967 participated in jointly-funded explorations in Canada, the United States, Australia, Niger (with France), Somalia (with Italy), Mexico, Argentine, and Brazil. Explorations have been carried out under the auspices of the Overseas Uranium Resources Development Company (OURDC), a private corporation created at the behest of PNC and fully supported by Japanese engineering and mining companies.

PNC's participation in uranium ore exploration is limited to the preliminary prospecting. PNC designates surveys and does all R&D required for locating or converting ore deposits. It obtains any needed license rights to conduct site explorations. If successful, subsequent project operations are turned over to a private company, or to the OURDC for overseas explorations. PNC's budget for uranium ore prospecting has been only $500,000 in each of FY 1971 and FY 1972. OURDC's budget has also been rather limited, averaging around $2 million annually in the recent past.

PNC's and OURDC's prospecting operations have been only moderately successful. The joint-venture with Australia is not doing as well as anticipated, and the OURDC recently waived its right of participation in the joint exploration venture in Bur, Somalia owing to unpromising ore processing tests and prospecting results.

f. Reprocessing of Spent Fuel

Detailed drawings for the construction of the first spent fuel reprocessing plant in Japan were completed by Saint-Gobain Techniques Nouvelles (France) in March 1969. Construction of the pilot plant at Tokai has already started and the plant is expected to go into operation in 1974. The plant will have a capacity of 700 kg. of metallic uranium of spent fuel a day (with 300 operating days a year), and will produce about 670 kg. of uranium trioxide and about 7.5 kg. of plutonium nitrate a day. The plant cost of $70 million is borne entirely by PNC. Private companies, primarily electric utilities, will underwrite the building of any additional reprocessing plants required in the future.

series of rockets produced in Japan and to active participation during the International Geophysical Year (IGY) in 1957-1958, space observations for the International Quiet Sun Year (IQSY) in 1964-1965, and space research during the International Active Sun Year (IASY) from 1968 to 1971. A milestone in space technology was achieved in February 1970 when Japan became the world's fourth space power, successfully orbiting a satellite around the earth; in September 1971, ISAS launched its first scientific satellite, "Shinsei".

In 1969, NASDA was created and a U.S./Japan Space Cooperation Agreement was signed. During the same year, SAC issued a report outlining a comprehensive space development program for Japan. It was designed to almost exclusively use domestic resources and technology but was drastically revised in late 1970 to take advantage of U.S. assistance and technological expertise made available through the Space Agreement. Japan discontinued development of a solid-fueled "Q" rocket in favor of a more powerful liquid-fueled "N" rocket and also delayed the initial satellite launches by approximately three years. The revised program assigned the development of scientific satellites and the "Mu" rocket to ISAS, leaving the development of applications satellites and the larger launch vehicles required for them to NASDA. The space program has been proceeding satisfactorily, relying increasingly on U.S. assistance for both applications satellites and launcher development.

Japan has appropriated $77.9 million for rocket and satellite development programs for FY 1972, nearly 59 percent more than FY 1971. Of this amount, $59.4 million (75 percent) was allocated to NASDA, primarily for work related to the manufacture of the first and second stages of the N-vehicle ($33.1 million), for satellite development ($5.19 million), and for further development of the Tanegashima Space Center facilities and the construction of a test and control center in the Tsukuba area north of Tokyo ($13.3 million). The government also allocated $10.7 million (50 percent more than in the previous year) to ISAS for launching scientific satellites, beginning work on two new rockets which will be equippped with improved attitude control devices, and the development of one scientific satellite (CORSA) for cosmic radiation studies.

3. Ocean Development Program

In 1969 the Council for Ocean Science and Technology in the Prime Minister's Office submitted a long-term appears to be directed toward ocean applications. Development of seawater desalting technology and of a remote-controlled underwater oil drilling rig were considered sufficiently important to be implemented under the National R&D Program (as discussed earlier). An extensive geological and mineralogical sea bottom survey program of the entire continental shelf was initiated by the government in FY 1971, and a program to develop technology for building marine structures was started in FY 1972. Other important projects include: establishment of a Marine Science and Technolgoy Center, embodying research, large-scale experimental facilities and education of marine technicians; an underwater habitat designed to train personnel to work effectively on the continental shelf; and a large-scale hydraulic model of the Seto Island Sea. In addition, $1,315,000 has been set aside to construct Japan's first geological survey vessel by 1973. It will have a capacity of about 1800 tons, be capable of surveying the ocean floor 8000 to 12,000 meters deep, and be used to explore ocean resources close to Japan.

These projects have been under way for only a short time, but continued support by the government and the private sector (which is actually spearheading the R&D work in ocean science and technology) indicates satisfactory progress. The large variety of projects suggests a greater financial commitment by government than is actually the case: appropriations for FY 1972 for the entire ocean development program, including projects under STA, MITI, the Ministry of Agriculture and Forestry, the Ministry of Transport, and the Ministry of Construction, was only $29.2 million, although still nearly 32 percent more than in FY 1971.

E. Stimulation of Invention and Innovation

The Research Development Corporation of Japan (JRDC) was established in 1961 as a government mechanism to stimulate invention and innovation and the development of new technologies through selection and implementation of high-risk scientific projects with industrial application potential, and promotion of effective exploitation of such projects by bringing them to the attention of the private sector. It had been noted that many domestic R&D projects with a high potential for commercial or industrial exploitation were not carried through development due to lack of sufficient funds, high risk, or inability to assess the practical applications of research findings. JRDC is intended to bridge gaps between government, the research community and the private sector, projects can usually move quickly to industrial production. They are usually product-or-process-oriented and, because of cost, risk, or long development time involved, would not be undertaken by private companies on their own.

2. Selection of "Commissioned" Firms.

For each project selected, JRDC develops performance specifications, obtains the necessary license from the researcher, and then, through government and other media, solicits bids from interested firms. A company is then selected based on its competence and financial soundness to undertake the development of the project, becoming a "commissioned" firm.

3. Negotiation of terms of "Commission".

The commissioned firm and the JRDC negotiate details concerning financial assistance to be advanced by JRDC, performance specifications, conditions under which the project may be terminated before completion, criteria of success, royalties to be paid and method of payment, licensing and other protective measures. JRDC does not normally fully underwrite a project, but expects commissioned companies to supply 20 to 40 percent of the cost, nor does JRDC provide funds for purchase of land or construction of permanent buildings. Project duration is usually between 2 and 3 years, but extensions are possible, and costs range from a few thousand to more than a million dollars. Negotiated terms are in a contract which both the JRDC Council and STA must approve, after which and for the duration of the project JRDC acts as coordinator between the "commissioned" firm and the research group and monitor of progress.

4. Evaluation of Development Work.

JRDC evaluates the results of each completed project according to the criteria set forth in its contract, but particularly to determine whether it should be judged a success or failure in terms of its industrial application. This is considered carefully from both the economic and technological points of view.

5. Commercial Exploitation and Repayment.

If a project is judged to be a failure, the commissioned firm ceases work and the JRDC investment is written off as a total loss. No repayment is expected, but the

JRDC's concept of success is repayment of the obligation to the Corporation, rather than contribution to employment, GNP, or exports or other measure of the relative impact of the investment. Although it would be difficult to obtain data and assess such measures, they would be much more meaningful. At present, the decision about repayment is made after completion of the project and before exploitation of findings. Successfulness of impact might better be measured by the accumulated royalties over a period of time (provided that the royalties are based on volume of sales or units produced) and by the ratios of total and JRDC royalties received to total cost and JRDC investment. These measures would also indicate the extent of diffusion of the newly-developed product or technology.

Corporation officials admit using stringent criteria in the selection of commissioned projects, that they concentrate on projects with a relatively high potential for quick commercial success, and that many R&D projects of "merit" are rejected because a lack of funds. Apparently, potential success bears more heavily with the Corporation than merit; high-risk projects may be avoided even though their economic impact may be high; and the government may not be taking full advantage of all inventions and innovations generated in the country. However, many inventors with R&D projects which JRDC confirms as having a commercial potential, but which it is unable to finance, are thereby enabled to obtain funds from private sources.

F. Government Incentives for Enhancement of Technology

STA's National R&D Program and AIST's Special Charter Corporations (Atomic Energy, Space, and Ocean Development), described above, are the two basic mechanisms used by the Japanese Government for the enhancement of technology. In essence, however, these and similar programs carried out by other Ministries are the largest government subsidy programs, for the objective of each project is to develop a prototype wholly or partially paid for by the government. Furthermore, in most instances the prototype plant or piece of equipment is turned over to the private sector at no cost. Such subsidy is regarded as "investment" in the country's future growth on the premise that new technologies thereby developed will repay in government revenues many times the original investment.

The aforementioned "subsidies" are direct and under the control of the agencies which grant them. There are a large variety of other, less direct incentives to technology enhancement, ranging from special tax rates for the conduct of research to use a newly-developed technology must first apply for a certificate of approval, issued jointly by MITI and MOF. MITI and MOF each examine every application and issue a certificate of approval if the new technology is deemed to be in the national interest, will promote economic growth, has good market potential, or meets other, similar criteria. If an application is approved, the company is allowed a first year accelerated depreciation equivalent to not more than one-third of the acquisition cost of the necessary machinery, equipment, and facilities, including the cost of new buildings but excluding the cost of land. This allowance is in addition to the regular depreciation allowance which applies generally.

c. Tax Deduction on Newly-Acquired Fixed Assets

In addition to the special first-year depreciation allowance, companies which are issued a certificate of approval by MITI and MOF are permitted a 50 percent tax deduction on newly-acquired fixed assets, including new buildings but excluding land, during the first three years following the purchase of those assets.

d. Special Amortization

Full amortization of expenditures is allowed associations for technological research in mining and manufacturing if: (1) the expenditures are incurred in connection with the establishment of an association or a cooperative (used to encourage joint R&D ventures by several companies through the association medium); and (2) the expenditures were incurred by an already established association to purchase new equipment and machinery or to build a new plant facility. To date 15 such associations (or cooperatives) have been established, but only four are currently in operation conducting R&D work (in areas such as pollution control and abatement and motor vehicle safety). These associations cease to operate when the joint R&D work is completed, but it is not clear whether they actually go out of existence while waiting for the next joint project to come along. At any rate, the procedure suggests that mining and manufacturing companies (i.e., all companies except those in the service sector) are encouraged to combine, that is, to enter into joint ventures for the purpose of conducting special R&D work.

- Exemption from specified local taxes

- Subsidy given to prefectural and local authorities to provide technical and managerial training services exclusively to personnel of small enterprises.

b. Financing Assistance

Three financial institutions provide financing services exclusively to smaller enterprises:

- Small and Medium Enterprise Finance Corporation, for comparatively large loans of up to about $260,000 (¥ 80 million).

- Peoples Finance Corporation, for smaller loans of up to $3,250 (¥ 1 million).

- Central Banking Corporation, for loans to commercial and manufacturing Associations.

Funding for the first two corporations is provided through an annual government appropriation, in addition to the original capital funds. The maximum amount for each corporation is designated by the Ministry of Finance. Funding for the third corporation is provided about two-thirds by industrial associations and one-third by the government. The total amount of government funds made available to all three corporations was $1,818 million (¥ 690 billion) in FY 1972. The appropriation has increased by an average of 18 percent annually in the last three years.

Loans to smaller enterprises through these institutions are for general purposes. However, special financing for industrialization (e.g., to apply a new technology) is available only through the Small and Medium Enterprise Finance Corporation. Small companies prefer to deal with these institutions because they grant: favorable terms, a lower interest rate than commercial banks; longer term for repayment, (averaging five years or, for some special loans, more than ten years); and a longer grace period, which may be one to two years.

The various programs, tax incentives, and other advantages provided by the government exclusively to smaller enterprises have been quite successful in domestically was revoked, but it was permitted to float foreign currency bonds, a privilege which JDB exercised six times between 1961 and 1970 for a total amount of $111 million.

A portion of the funds allocated annually to government financial institutions is now provided for in the Ministry of Finance Fiscal Investment and Loans Program (FILP), prepared each year independently from the Government General Budget. Other funds come from the General Account Budget itself. The FILP is financed predominantly through borrowings from MOF's Trust Fund Bureau, which manages such special accounts as the Postal Savings Fund, the Welfare Annuity Fund, and the National Annuity Fund. Although JDB has been allocated less than 7 percent of these funds, the amount has been increasing at an average rate of 14 percent in recent years.

JDBS lending operations are generally aimed at promoting a balanced economic growth within broad policy guidelines decided each year by the Cabinet for the coming fiscal year. It has fulfilled a crucial function by providing development financing (the final stage of R&D) for practically every aspect of development sponsored or supported by the government: industrial, technological, regional. In recent years JDB has concentrated its operations in

- promoting urban redevelopment and a balanced regional development through loans for urban transit networks, the prevention of environmental pollution, and the modernization of the distribution system, including facilities for wholesale centers and cooperatives, and for economic development projects in four regions in Japan;37/

- strengthening key industries through loans to the electric power industry for the construction of nuclear power plants and coal-fired thermal power plants; to the petroleum industry for oil storage facilities, gas stations, gasoline transport trucks, and refineries aimed at promoting integration of

---

37/ In FY 1970, JDB loans for urban redevelopment, including modernization of the distribution system and environmental protection, amounted to $175.1 million, and for regional economic development, $168.8 million.

In promoting the introduction and utilization of new technologies, JDB provides:

- financing for new technology industrialization (e.g., to companies in petrochemicals);

- financing for the first use of heavy, complicated machinery which both manufacturers and users are reluctant to consider because of the high risk involved. The funds are given to the user (of, say, a new machine tool), not to the manufacturer, although both are jointly responsible for repayment of the loan; in effect, the manufacturer guarantees repayment of JDB's loan to the user. A machine which is found to be defective will be returned to the manufacturer, and he alone will then be responsible for repaying the loan. The types of machinery which are open to this kind of loan support are specified annually under laws by MITI and MOF;

- financing for the commercialization of new technologies, for example, to a manufacturer who is not confident that a new machine will be readily accepted. The manufacturer is permitted to produce three or four units at his own expense, placing them with selected users for testing. These machines are treated as fixed assets for the manufacturer; the bank regards them as equipment investment and on this basis it approves a loan to the manufacturer.

Loans granted by JDB are concessional loans usually at an interest rate of about 6-1/2 percent which is lower than that of private commercial banks. The repayment of loans is determined by the JDB, as are the other terms, on the basis of the importance of the technology involved, the duration of the project, the financial strength of the applicant and other criteria.

Since 1971, JDB has had to comply with a new additional requirement (namely, technological assessment) in processing applications for technology development loans. JDB must consider both the positive and negative effects of each project, that is, the technology involved must be examined with respect to its likely impact not only on production, but on the environment as well.

The technology assessment requirement has raised two important problems within JDB, the first being the manner in which technology assessment should be handled in each

ATTACHMENT 1

Administrative Structure for Science and Technology in Japan

(enclosed in pocket at the end of report)

BIBLIOGRAPHY

_______________, Agency of Industrial Science and Technology, MITI, Tokyo, Japan, 1971.

Amaya, Naohiro, The Ministry of International Trade and Industry (MITI), Sophia University Socio-Economic Institute, Bulletin No. 24, Tokyo, Japan, 1970.

Bureau of Statistics, Statistical Handbook of Japan 1971, Bureau of Statistics, Office of the Prime Minister, Tokyo, Japan, June, 1971.

Japan Computer Usage Development Institute, Computer White Paper, 1971 edition, The Asahi Evening News Company Ltd., Tokyo, Japan, 1971.

Japan Development Bank, Functions and Activities, Japan Development Bank, 20th Anniversary, 1971, Daito Art Printing Company Ltd., June, 1971.

Kaplan, Eugene J., Japan The Government-Business Relationship A Guide for the American Businessman, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D. C. 20240, February, 1972.

Keidanren, Economic Picture of Japan 1970-1971, Keidanren, Tokyo, Japan.

Keidanren, Keidanren Federation of Economic Organizations Organization and Activities 1970, Tokyo, Japan, 1970.

_______________, Marine Technology Research and Development Plans, SR-1002.

Ministry of Foreign Affairs, The Japan of Today, Tokyo, Japan, 1970.

Ministry of International Trade and Industry, Smaller Business of Japan, March, 1971.

APPENDIX FIVE

ANALYSIS OF PROGRAMS AND MECHANISMS IN THE UNITED KINGDOM

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ACTP	Advanced Computer Technology Project
APACE	Application of Computers to Engineering
CADC	Computer Aided Design Center
DCS	Development Contracts Scheme
DSIR	Department of Scientific and Industrial Research
DTI	Department of Trade and Industry
ICL	International Computers Ltd.
IRC	Industrial Reorganization Corporation
MinTech	Ministry of Technology
NCC	National Computing Center
NEL	National Engineering Laboratory
NPL	National Physical Laboratory
NRDC	National Research Development Corporation
WSL	Warren Spring Laboratory

PART I

THE ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Part I of this appendix discusses the environment within which science and technology policy is developed and implemented. The discussion is presented in three sections as follows: Government Involvement in Science and Technology; Organization for Science and Technology Policy Development and Implementation; and Government-Private Sector Relationship and Interaction.

A. Government Involvement in Science and Technology

The United Kingdom, with a large population and limited natural resources, relies heavily on imports. This reliance is counterbalanced mainly through the export of products resulting from its high technology industrial effort. Both government and industry are, in consequence, constantly striving for improvement of productivity, promotion of economic growth and maintenance of a competitive posture for British products in world markets. This requires a continuing and considerable investment in new technology and a large-scale expenditure for applied research and development. In fact, about 2.7 percent of the GNP is currently being spent for that purpose.

The British government is deeply involved in providing funds for applied science and technology. Although the philosophy underlying such support has varied with changes of government, the fundamental policy has always been present. The government now provides about half of the total funds devoted to R&D on a nationwide basis; private industry is also a substantial contributor, accounting for approximately 38 percent of the total in the recent past. (The total amount for R&D has been running over $2.5 billion annually.) With respect to purely civilian R&D, private industry provides about 58 percent of the funding, with government providing about 34 percent. Additional funding derives from public corporations, research associates, independent trusts, foundations, learned societies and foreign sources.

Industry in the United Kingdom originated with the development of numerous small, craft-type independent units. The industrial complex, even today, is comprised of many small, fragmented industries. By virtue of this fragmentation, the infusion of R&D and the introduction of new technologies, become difficult. It should be noted, however, that since at least 1960, there has been a trend which is still continuing toward mergers and takeovers in many industries, resulting in the formation of much larger firms. Outstanding examples are the aircraft, computer and electronics industries. Added to this has been a major effort in 1971-1972 by both the government and private firms in the high technology area to establish relationships with competing European firms in an effort to share the ever increasing cost of developing major new products. These efforts have had no significat success in the computer field and limited success in aero engines and airframes.

and process plant, civil and military aircraft and aircraft engines, and shipbuilding. The Royal Aircraft Establishment, the Royal Radar Establishment, the National Physical Laboratory and the National Engineering Laboratory, together with 15 other government research establishments, were placed under its aegis, together with the Research Associations, National Research Development Corporation, and the Atomic Energy Authority.

The Conservative Party returned to power in 1970, and in October of that year another reorganization took place. MinTech was dismantled and the Department of Trade and Industry (DTI) was formed, combining the functions of the Board of Trade with many of the functions of MinTech and the Ministry of Aviation Supply. Responsibility for government research establishments was transferred to the mission-oriented departments: eight to the Ministry of Aviation Supply and four to the Department of Environment, leaving only five under the responsibility of DTI in May 1971. The Ministry of Defense took over responsibility for the establishments which had earlier been transferred to the Ministry of Aviation Supply.

Until 1970, the Advisory Council on Technology, chaired by the Minister of Technology, advised on the application of advanced technology in British industry. There was a deputy chairman and ten other members representing scientific, economic, trade union and industrial interests. This Council was abolished at the same time as the Office of Minister of Technology. Since 1970 when the Conservative Party returned to power, two policy trends have become evident: the decentralization of government support for R&D, with control reverting to "mission" agencies; and a change from an "activist" role, with government seeking to lead, control and stimulate R&D in industry, to a "hands-off" attitude. The quasi-governmental Industrial Reorganization Corporation (IRC), which had been one of the primary mechanisms for government direction of industry, was abolished in May 1971. It has since been found necessary, however, for some assistance to be rendered by government, to many small(and some large, e.g., computers and aircraft) industries if they are to remain viable. Other programs have been instituted to promote and sustain faster economic growth, to secure the expansion and modernization of industry, to alleviate problems of regional imbalance, and to assist industry to meet the challenge of the European Economic Community (Common Market). These programs are designed to perform many of the same objectives as the IRC without direct intervention by government, hence there appears to be some softening of the "hands-off" policy.

It may be noted in passing that some assistance such as that to the aluminum industry in order to improve its export posture or reduce imports, was initiated with a view toward increasing productivity. However, assistance to the cotton and allied textile industries, through loans for modernization and re-equipping small and medium-sized firms was intended to improve competitive position, both at home and abroad.

For the most part, these programs are less concerned with national prestige and social problems than they are with practical and commercial exploitation. For example, many of the space programs are concerned with communication satellites, sounding rockets, and satellite launchers. About half of the expenditure on space programs constitutes Britain's contributions to the European Space Research Organization (ESRO) and the European Space Vehicle Launcher Development Organization (ELDO). Funded efforts have also been directed toward developing radio ground tracking stations for satellites and for a satellite prediction center, one of three World Data Centers for space research.

The R&D resources and expertise of the Atomic Energy Authority are being used on an increasing scale for industries other than the nuclear industry. The main objective appears to be the selection of areas which are likely to provide a high national economic contribution. Examples of major problems are: desalination, non-destructive testing, carbon fiber application technology, radio-isotope applications, industrial advisory and R&D service and industrial applications of radiation.

In October 1970, the former Ministries of Public Buildings and Works, Housing and Local Government, and Transport were merged to form the Department of the Environment. Some pollution control programs, mainly located at the Water Pollution Research Laboratory, one of the Industrial Research Establishments, is now under this new department. Additional pollution control research or consulting services are provided through the Atomic Energy Authority and the Research Associations. The Warren Spring Laboratory, one of the Industrial Research Establishments under DTI, performs research work on air pollution as a part of its mission. This research service is provided to the Department of the Environment and to local authorities to assist in the administration of clean air legislation and to assess its effectiveness. The long-term aim is to build up a body of knowledge which can be applied in town planning in order to restrict air pollution to acceptable levels.

with regard to employment, advisory and information services, standards and quality assurance, export promotion services and industrial design assistance. Some programs of assistance provided by the former Industrial Reorganization Corporation (IRC) have been redirected by the Conservative Government. The Investment Grants program, in operation under the Labor Government, has been reoriented through the Industrial and Regional Development Program to provide tax allowances rather than grants in support of capital investment for plant and financial aid for industrial research. Examples are assistance to the shipbuilding, computer, aluminum electronic, instrument and machine tool industries. Technical and research services are provided by the government's industrial research establishments and the Atomic Energy Authority research programs. Financial support is implemented in part by means of the Financial Support for R&D in Industry Program, the Preproduction Order Support Program, and the activities of the National Research Development Corporation and the industrial research associations. (See Part II for detailed descriptions of these programs.)

All of the programs which implement government policy are under the responsibility of the Department of Trade and Industry.

The National Research Development Corporation is the major quasi-government organization involved with technology enhancement programs.

C. Government-Private Sector Relationship and Interaction

Development of S&T policy in the United Kingdom has been directed by government for the most part. There has been some input from industry representatives, but not to any great extent. The government's attitude has, in effect, been that it has known best what was good for industrial S&T, hence, it did not rely heavily on the industrial sector when formulating policy. At the present time, the degree of industry participation in policy development is not known. The subject is currently under review by such bodies as the Central Policy Review Staff, a purely governmental body, but it appears that interaction with industry has been reduced considerably under the Conservative Government.

Industry assumes a much more active role in the implementation of technology enhancement programs, and cooperation with the government is much more evident than in the policy development process. Important examples of these programs are given below.

Government procurement is used as an incentive to apply new machine tools to a particular process by means of the Preproduction Order Support Program. In this program, a new type of machine tool, for example, is loaned to a firm without cost to aid in evaluating how it enhances a particular process. The program also assists the machine tool industry by assuring orders for promising new machines, thus reducing the time taken to introduce a new tool to industry.

Additional details on these programs are provided in Part II.

PART II

MAJOR TECHNOLOGY ENHANCEMENT PROGRAMS AND MECHANISMS

Part II of this appendix describes eight major government-sponsored programs and mechanisms that are designed to stimulate innovation and invention, encourage their development and application, foster increased industrial productivity and competitiveness, or enhance technology in general.

A. <u>The National Research Development Corporation Program</u>

The National Research Development Corporation (NRDC) is an independent public corporation for which the Department of Trade and Industry has statutory responsibility. It is a major force in the sphere of technology enhancement, with the following principal objectives:

- to develop and exploit inventions resulting from publicly financed research

- to develop and exploit other inventions which are not being sufficiently developed or exploited

- to support research which is likely to lead to an invention

- to acquire, hold, dispose of, and grant rights in connection with inventions resulting from public research and from other sources when in the public interest.

The NRDC acts commercially in pursuing these objectives, expecting its investment back, with a profit, if a venture is successful.

The NRDC was formed in 1949 under the Development of Inventions Act of 1948, amended in 1954, 1958 and 1965. The 1954 Act allowed the NRDC to support research likely leading to an invention; the 1958 Act enlarged NRDC's borrowing powers as did the 1965 Act, which also extended its activities. The Development of Inventions Act of 1967 consolidated the former Acts.

Because the NRDC has recently become a profitable undertaking, the level of government funding has steadily decreased each year and is now practically nil. NRDC's level of expenditure is about $18.6 million per year, while its borrowings from DTI were less than $8 million for 1970-1971. The cumulative net borrowing now amounts to $65 million out of the $132.5 million provided for by the Act of 1967.

The NRDC borrows from a capital fund provided by government and supplemented by relief-from-interest payments on loans, by income from patent royalties, and the return on investments in projects which are now commercially successful investments. The NRDC is involved in a variety of projects with different terms and arrangements as negotiated. The most common methods of countries include Australia, Canada, France, India, Japan, New Zealand and South Africa. A high official of the NRDC considers that success has been due to three major factors:

- the time element, in that sufficient time is necessary for a program of this sort to "bear fruit"
- the structure, in that NRDC is not in the Civil Service
- the selection of the portfolio of projects to be sponsored.

A wide variety of projects has been initiated or supported by NRDC, covering almost every aspect of technology and applied science. About 10 percent of the projects have been exploratory, i.e., leading to inventions. About 75 percent have led to developments of inventions, and the remainder to production of commercial products. Projects have included development of the hovercraft, computers, fuel cells, flexible barges (Dracones), pharmaceuticals, cryogenic engineering, diesel engines, variable speed gears, potato harvesters, automatic foundry equipment, photo-typesetting, electrochemistry, plastics, computer time-sharing systems, stored program telecommunications control, printed circuits and many more.

The benefits accrued to industry are numerous, including: development of new technologies and products; increased competitiveness in world and domestic markets; increased productivity, employment, production, sales and exports. NRDC estimates that about $265 million worth of manufacture in the United Kingdom would not have taken place, but for the NRDC activities, either by way of technology transfer or of seeding development.

The government, in turn, has benefitted from repayments and royalties. In consequence, it has been able to reduce its support to the NRDC at the same time that the Corporation has been expanding its own support to industry.

B. Preproduction Order Support Program

The objective of this program is to accelerate the adoption of technologically advanced equipment (especially machine tools) by helping to reduce the period between development of a new machine and its commercial acceptance. Historically, there has

Approximately 85 percent of the machines under evaluation have been purchased by the users, an excellent indicator of success. (In fact, many of those machines that were returned unpurchased were returned because of declining economic conditions and altered manufacturing schedules rather than technological reasons.) Moreover, many users have purchased additional machines at full market cost. It appears that this program has succeeded in reducing the introductory period, but the data are not conclusive. Finally, as with the NRDC experience, other major industrial countries (e.g., France) have recently copied and implemented a form of this program, reinforcing the assessment of success.

Both the machine tool industry and the user industries have benefitted. The former has been able to develop and incorporate new technologies into machine tools more readily (for example, numerical control) and had thereby increased its competitive position to some extent. Reducing delays in introducing new equipment has also improved their cash flow situation to some degree. The user industries have shown definite increases in productivity after accepting advanced machines. This has led to increased competitiveness in world and domestic markets and, in some cases, to increased production, sales and exports.

C. Investment Grant Program

The Investment Grant Program was a part of an effort by the British government to increase the long-term rate of growth in the economy. It offered an incentive for increased capital investment in machinery and plant related to specific qualifying industrial processes and for investments in computers, ships and hovercraft. Universities and other educational institutions were not eligible for these grants nor were the nationalized industries except for computer acquisition. The government provided free grants to qualifying industries, i.e., repayments were neither expected nor effected unless the ownership or use of the capital equipment changed during the first three years after the grant was made.

The Investment Grant Program was established as a part of the Industrial Development Act of 1966. The first grants under the Act were made early in 1967. In the period from April 1967 through March 1971, about $5.3 billion was expended by the Government on Investment Grants. In the last year of operation of the program, over $1.5 billion was paid in grants.

While the Investment Grant Program, during the four years of its operation, induced capital expenditure of $21.6 billion by firms qualifying for grants, it is not known whether these expenditures would have been made if the grants had not been available, nor is the amount of expenditure for qualifying scientific research and prototype development known.

The present government has expressed the feeling that the program involved high public expenditure and did not achieve the intended objectives. The program benefitted firms whether or not they were profitable, and discriminated against service industries, which make important contributions toward economic growth and the balance of payments. Furthermore, the discriminatory nature of the program and the detailed information required to support claims for grants imposed a considerable administrative burden and cost on industries. In addition, administration of the program required a government staff of about 1,000 at an annual cost of over $5.3 million. These considerations led to a government decision to replace the program with tax allowances and reductions.

Industry participation in the program is indicated by the number of applications for grants received. In the last year of full operation of the program, there were in excess of 140,000 applications. Furthermore, when termination of the program was announced, firms which intended to apply for a grant on an expenditure occurring after the termination date, but under a contract made before that date, were instructed to send contract details to the government; over 200,000 such contracts were registered.

Thus, it appears that the degree of industrial participation was good, but the amount of capital investment induced is not known. It seems certain that some of this investment would have been made regardless of the existence of this program. Nevertheless, definite benefits to industry have been made as a result of this program. The major question which persists is whether these benefits were worth the large sums of money expended by the government.

D. Financial Support for R&D in Industry

This government program offers support of R&D in order to further the practical application of the results of scientific research. This type of support is generally provided to relatively small firms (i.e., other than the very large ones)

As indicated above, this program usually covers 100 percent of the cost of the R&D for research associations and universities. Levies are not imposed in these cases, but the government reserves patent rights and royalties. These cases are usually turned over to the NRDC for exploitation.

Despite the benefits (as discussed below) which have accrued to industry after more than ten years of operation, this program has not yet become a financial success. Some revenues have been derived by the government from levies, but these amount only to 10 percent (approximately) of the government's investment. For example, out of 200 proposals for support, in the machine tool industry, some 40 contracts have been granted. Of 33 which have been completed, about five have been profitable to date. It may be noted, however, that many of the best proposals were withdrawn after evaluation and acceptance by DTI. The firms which had submitted the proposal would then use the DTI "stamp of approval" as justification for financing the projects on their own.

Many manufacturing firms and user firms (i.e., firms using the machinery developed under this program) have benefitted from this scheme. The manufacturing firms have developed many new products and techniques with financial support from the government. User firms have, perhaps, benefitted even more, although the cost benefits are difficult to determine. Users have been able to produce products more quickly, better and more cheaply as a result of machinery developed under this program. Both types of industry have experienced increased competitiveness and productivity as a result of the program.

E. Research Associations

Research associations have been formed by companies with compatible technical interests, such as making similar products or utilizing common processes or raw materials. A mechanism is thus provided for cooperative R&D effort designed to raise the levels of technical skills and efficiency throughout the particular industry. To that end, the research associations have endeavored to:

- encourage R&D cooperation among the members of the association
- make the industry research-conscious

which, because of their long-term or speculative nature, could not be carried out under the usual grant conditions. However, the "earmarked" grants were discontinued in 1968, largely as an economy measure.

In order to encourage the research associations to derive an increasing proportion of their support from industry, a general grant "stiffening" policy has been in effect since 1951. When renegotiating five-year grants with individual associations, the government attempted to reduce its rate relative to the income from industry. In 1968, a ceiling of £4 million (over $10 million) was placed on the total value of all such revenue grants. Under the same policy, fewer special purpose and non-recurrent grants are being awarded. Grants totaled approximately $10.7 million in 1970, including about $380,000 in special grants.

The major source of funds of the research associations is subscription by member firms, generally based on company size. In some cases, industrial support derives from a levy imposed on each firm in the entire industry, even though some firms do not avail themselves of the association's services. Using subscription funds, cooperative work is undertaken in the interest of the entire membership, and results of the work are freely available and publicized to members.

Another source of funds is for "repayment" or contract work which is performed by an association at the specific request of an individual member and for which a specific charge is made. Results of such activity are communicated only to the member who contracted for the work. Funds may also result from "group projects" which arise in response to a specific request for technical assistance from a group of members with a common interest in a particular problem. The group of members pays for the effort at a negotiated fee, and the results of the work are freely available to all members either immediately or possibly after a limited period of confidentiality. For this reason, government usually permits income raised for group projects to be included, along with the subscription income, in the industrially supported income on which the grant is based.

The incomes of the research associations vary widely. In 1970, they ranged from less than $50,000 for the smallest to more than $4.5 million for the largest. The average income is close to $1 million; biased upwards by the larger associations the median income is about $800,000.

have generally failed in this area. Since each governing Council tends to be dominated by representatives of the larger member firms, the smaller firms feel that, in many cases, the general program takes little heed of their real needs, and that the results obtained are of little direct relevance to them. Also, since specific items of work which might be of value to them are often not undertaken, many smaller firms feel that they get less relative value from their subscriptions than do larger firms.

However, it is also alleged that the smaller firms often do not avail themselves of the general program research which is applicable to their product or process. The lack of application may be due to financial reasons or perhaps, to a reluctance to use new technology.

- Larger firms tend to maintain membership in research associations even though they may be technically self-sufficient. Such companies regard withdrawal from membership as a significant step which they would be reluctant to take, even though the return from their membership subscription may be considered to be inadequate. However, the larger firms having greater influence on the councils, can steer the general research program more toward their needs. With more funds at their disposal, they benefit from contract or group project R&D specifically directed to their own technical problems.

Generally, the members of research associations, both large and small, feel that the work of the association is beneficial, and that government grants should be continued. Even those for which the grant represents only a small portion of their income tend to feel that the magnitude of the grant is important to the profitable operation of the association. As a result of the grant "stiffening" policy, however, a number of research associations have been broadening their services. For example, they accept more contract and group project work as well as membership subscriptions from firms outside the United Kingdom, as a means of increasing their income. Some anticipating a future without grants, are beginning to tailor their operations in this direction. It does not now appear that government support will be totally withdrawn, since it has traditionally been given, but there is some indication that consideration is being given to the formulation of a more specific government however, the fraction was 70 percent (75 percent, up to $82 million for the "stretched RB-211"). As a result, the amount of launching aid is not increased if the actual costs exceed the estimate.

In return for this aid, the government receives, by levy on sales, a share of the estimated margin based on the proposed selling price and the estimated manufacturing costs. The estimated margin and the government share are usually fixed at the beginning of the project, but may be subject to later modification in some cases.

It is intended that the manufacturer will bear the risks involved in production as well as any cost overruns on development. For example, if manufacturing costs exceed estimates to an extent that the actual margin is reduced, the manufacturer is still responsible to the government for the assessed levy. Presumably, the inherent risk and the profit motive would continue to serve as commercial incentives for the manufacturer.

The project has contributed funding toward the successful development of a number of aircraft (viz. the Trident 1 and 3B, the VC10 and Super VC10, the BAC1-11 Series, the Islander and the Jetstream, the Spey engine and possibly the RB-211 engine). The total earnings of foreign exchange from these projects has been $1.87 billion, and the combined total of foreign exchange earnings and import savings is expected to reach $3.34 billion.

Although firms assisted by Launching Aid have produced a number of types of aircraft and engines which have been successful in the domestic and world markets, the program has not been considered successful by government. The merits of the program have recently been debated, and even though the program is still in existence,an alternative form of support is being sought. With the exception of the Spey engine series (and possibly the RB-211), made by Rolls-Royce, none of the supported projects has returned the government's investment nor is any of them projected to become financially successful. The main difficulty seems to lie in the management of new, very expensive and technically complex development efforts. Rolls Royce Ltd. management decisions regarding initial and subsequent cost estimates for the RB-211 engine are generally believed to be the primary cause of the bankruptcy of that firm, although other factors were also present.

is verbatim. DTI also reserves the right to publish results deemed to be in the public interest after consultation with the contractor.

If the work is performed on a confidential basis for the contractor, publication takes place only after a mutually agreed upon period of time. Patents which result from contract work may be vested with the contractor or with the DTI, depending in part upon the nature of the discovery and its relationship to national needs; each case is considered on its own merits. If the contract is of a confidential nature, general licensing rights may be withheld for a mutually acceptable period of time. In addition, the industrial research establishments may share the cost of work with a contractor if the research is in the national interest. The DTI then retains all rights over the results arising from the work and the subsequent exploitation of them. Patents resulting from such research are handled similarly.

The industrial research establishments concentrate their resources on R&D which is in the national interest and which cannot reasonably be done elsewhere. They contribute to the efficiency of industry as a whole through their work in such areas as measurement methods, properties of materials, numerical control, and materials handling, to mention just a few. They are generally staffed by highly competent personnel who, in many instances, rank with world leaders in their fields of expertise.

The industrial sectors benefit in several ways from the R&D carried on within the government-supported industrial research establishments. DTI has a number of Research Advisory Committees (made up of representatives of government, science, industry, and the academic communities) which provide advice for specific fields or industries. These committees function at the Department level and determine what R&D programs are needed for the realization of potential benefits to the nation whether economic or social. Depending upon the R&D required, the research is then performed in one or more of the research establishments. These advisory committees are now being phased out and may be replaced by Requirement Boards with much the same function, although the exact mechanism is as yet undecided. Furthermore, through contracts for reimbursable research, industry can utilize the expertise and facilities of these well-equipped establishments for the solution of problems of immediate and direct interest.

International Computers and Tabulators, Ltd. with the English Electric Company (which was itself created by a merger of several companies sometime earlier), the government provided ICL with a $36 million grant for R&D work. The grant was to be provided in annual payments over a four-year period beginning in 1968. In addition, the government purchased a 10.5 percent equity interest in the company for $9.3 million, which has not yet been fully paid. (These shares were purchased at par value, somewhat below the market value at the time.)

It is generally acknowledged that ICL will require substantial further assistance for some time. Coincidently it appears that the level of support for the computer industry as a whole may be increased in the near future. In a lengthy and persuasive report compiled over a two-year period, the Commons Select Committee for Science and Technology recommended in October 1971, a minimum level of government support for the British computer industry (mostly ICL) of $130 million per year. Since this recommendation, a number of government policy statements on the computer industry have offered nothing approaching $130 million per year.

b. The Development Contracts Scheme

Through this program, the Department of Trade and Industry affords financial assistance to firms with development contracts for novel computer developments and systems. DTI provided 50 percent of the development cost while working closely with the computer firm (usually ICL) and the user during the project. A levy is sought by DTI when the venture becomes profitable. The program is funded at $2 million annually.

c. The Advanced Computer Technology Project

Funded at $1.3 million per year, this program is designed to encourage investments in advanced computer R&D. DTI will share in the cost of the R&D (usually 50 percent), and if the company makes a profit which is the result of the government investment, DTI seeks

On the whole, these programs have been moderately successful thus far. Most of the firms in these three industries have shown profits recently, but it is doubtful whether many of them would have been profitable without government support. The major question which remains unanswered is whether these industries can remain viable without continued R&D support from government. This concern does not necessarily stem from a government reluctance to provide assistance. A general reluctance to seek government support has been noted on the part of many of the smaller firms in these industries. This is most likely due to the more aggressive and risk-taking nature of the firms in these industries compared to others. Also, the terms of most government R&D support have been becoming rather unattractive to these industries. For example, the amounts of the levies which firms in these industries must pay to the government have been about 9 to 10 percent on a discounted cash flow basis. Under the same or similar programs, firms in other industries usually pay only 4 to 5 percent, and as low as 2.5 percent for the ship-building industry. Thus, many firms engaged in manufacturing computers, electronics, and telecommunications equipment would rather assume their own risks.

BIBLIOGRAPHY

Central Office of Information, Industrial Research and Development in Britain, RF.P. 5820/68, March 1968.

Centre for the Study of Industrial Innovation, Aspects of Spin-off, October 1971.

Centre for the Study of Industrial Innovation, On the Shelf, July 1971.

Centre for the Study of Industrial Innovation, Research Associations: the Changing Pattern, March 1972.

Centre for the Study of Industrial Innovation, Success and Failure in Industrial Innovation, Report on Project Sappho by the Science Policy Research Unit, University of Sussex, February 1972.

Department of Trade and Industry, Britain and the EEC, A Series Reprinted from Trade and Industry, 1971.

Department of Trade and Industry, Industrial and Regional Development, March 1972, Her Majesty's Stationery Office.

Department of Trade and Industry, Investment Grants Annual Report by the Secretary of State for Trade and Industry under the Industrial Development Act 1966, 1st April 1970 - 31st March 1971, Her Majesty's Stationery Office.

Department of Trade and Industry, Technical Services for Industry, 1970.

Expenditure Committee (Trade and Industry Sub-Committee), Minutes of Evidence Tuesday, 23rd March 1971, Her Majesty's Stationery Office.

Innovating Industry Project (Centre for Study of Industrial Innovation), Innovation in Industry - A Factor for Growth, June 1969.

Minister for Industrial Development, "Industrial Development Executive," Trade and Industry, 20 April 1972, Vol. 7 No. 3.