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STATEMENT OF

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BEFORE THE

SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL

SCIENTIFIC PLANNING AND ANALYSIS

OF

THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

ON

RESEARCH AND DEVELOPMENT AND THE ECONOMY

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to address this Subcommittee on a most important and timely subject of both national and international concern. I have testified many times before the House Committee on Science and Technology, as well as other committees and subcommittees concerned with science and technology issues. However, this is my first opportunity to address this Subcommittee since you have assumed the broad special oversight function for scientific planning and analysis.

Mr. Chairman, you have asked me to address the subject of the present hearings--"Research and Development and the Economy"--based on completed and ongoing work by the General Accounting Office, as well as on the basis of my personal views developed through many years of involvement in the R&D budget process and other issues involving science and technology.

This subject is extremely broad and complex. I have, therefore, prepared a rather lengthy statement for the record but will present only highlights in my verbal testimony. Included for completeness or emphasis are excerpts of testimony I have presented previously.

INTRODUCTION

Major Issues

My statement is addressed primarily to four major issues. These are:

--To what extent do research and development of the Federal Government and the private sector affect the U.S. economy and its position in the world economy?

--What should be the respective roles of government, especially the Federal Government, and the private sector and how can we establish a better climate for utilizing our nationwide scientific and

technological resources to meet national needs and to insure our international leadership and competitiveness?

--How can we improve the decision process in the Federal Government for establishing policies and priorities for resource allocation and for dealing with issues that transcend the purview of individual agencies and components of the private sector?

--How can the Federal Government foster increased application of science and technology to the solution of State and local government problems?

Emerging Global Perspective

Before discussing these issues, I shall briefly describe the situation or context in which I believe they must be examined.

Peter Drucker, in an address nearly 15 years ago to the annual meeting of the Corporate Associates of the American Institute of Physics on "New Knowledge in Physics and the Economy," stated the proposition that:

> "Scientific research is no longer tangential to the economy; it is at its dynamic core. Conversely, social developments are no longer tangential to scientific research; they are a major determinant."

Carl H. Madden, chief economist of the U.S. Chamber of Commerce, in a recent address to the General Accounting Office on the subject "Changing Roles of Government and Industry," presented an overview of what he calls an "intellectual revolution" that is changing human values and having a profound impact on both industry and Government.

These changing values involve moving from purely economic considerations with respect to technology to greater emphasis on environmental and social impacts. He stated that, in response to the human value changes, the corporation is becoming a social as well as an economic organization.

He further stated that the Government must recognize the evolutionary character of economic activity and, therefore, the need for creative regulation; giving selective incentives to business corporations to produce what people need and not interventionist regulation in an effort to control "something called power."

All of us would agree that never before has it been so essential to integrate science and technology with socio-economic considerations at all levels of policymaking and throughout the broad spectrum of organizational elements involved. The importance of futurity in present day decisions interrelating scientific, technological, economic, sociological, political, and institutional factors cannot

be overestimated. The dominance of the Federal Government and its impact on the elements of the infrastructure is greater than ever before. Finally, both the national and international situations are changing so rapidly that positive action is urgent.

We are experiencing great changes in the role of research and development and the impact of technology innovation in relation to our national goals. As all of us know, our international leadership in science and technology is being challenged at a time of increasing world economic interdependence, especially in energy, food, and critical minerals. By adopting special institutional arrangements between government and industry and by employing special incentives, foreign nations are overtaking our lead in technology innovation and world trade.

At home, there is need for increasing productivity in both public and private sectors. Our national goals and priorities are shifting toward easing the energy crunch, environmental protection, conservation of natural resources, and solving urgent related socioeconomic problems. All of these changes are having a profound effect on the roles of industry and Government, especially the Federal Government, as partners in our nationwide science and technology endeavors.

Industrial investment in R&D and innovative technology is restrained because of uncertainties in the domestic economy,

the impact of inflation on capital requirements, and the uncertainties of Government economic policies. Governments at all levels have established regulations for environmental protection, equal employment opportunities, safety of employees, product safety, and consumer protection. Some of these regulations have stimulated innovative technology; others have increased the costs of doing business and diverted capital that otherwise might have been invested in R&D.

ECONOMIC IMPACT OF RESEARCH AND DEVELOPMENT

Economists and other scholars generally agree that there is a high positive correlation between science and technology and the economy, but there is relatively little agreement concerning precise measurements, the appropriate methodology for establishing these correlations, and the interpretation of various statistical results.

A central problem is the inability to measure the specific productivity of research and development. The recently published "Science Indicators 1974" report by the National Science Board deals primarily with indicators that measure resources--human and financial--for research and development. Compared with assessments presented in the "Science Indicators 1972" report, substantial progress has been made in developing measures of the outcomes or impacts of research and development.

For the most part, however, the statistics cited and the output indicators used had to be sufficiently qualified in validity, methodology, and completeness to support firm conclusions or recommendations.

In the section on "Returns from R&D and Innovation," the report states:

> "The contribution of R&D and innovation to the economy and society is presently understood in broad and general terms only. Existing knowledge of the subject is fragmented and tenuous, to an extent which prohibits the development of indicators of the kind presented elsewhere in this report."

Nevertheless, several tentative conclusions were stated qualitatively. Four of these are:

--The contribution of R&D to economic growth and productivity is "positive, significant, and high."

--Investment in R&D and innovation yields a rate of return as high--and often higher--than the return from other investments.

--Industry may underinvest in R&D and innovation with respect to the probable returns to the firm and the benefits to society.

--Standard indices of economic performance reflect only part of the contribution which R&D and innovation make to the economy and society.

In view of such conclusions about the economic impact of R&D, it is important to note some conclusions reported in Science Indicators and elsewhere about trends in the allocation of resources to R&D. For example:

--The proportion of the gross national product (GNP) spent for R&D has declined steadily over the last decade in the United States, while growing substantially in Russia, West Germany, and Japan.

--While the United States spends a higher fraction of its GNP on R&D than other non-Communist countries, these expenditures have been devoted more heavily to defense and space than those in other countries. The United States has invested a much smaller fraction of its R&D budget for civilian industrial purposes than has its economic competitors.

--Industrially funded R&D measured in deflated (constant) dollars rose by a total of only 7 percent from 1969 to 1973, and declined during both 1974 and 1975 by a total of 2.3 percent. A small increase is forecast for 1976.

--The Fiscal Year 1977 Federal Budget for R&D Expenditures reverses the previous declines for basic research and for defense and space, but in constant dollars the increase in expenditures for civilian R&D is smaller.

Despite the lack of precise quantitative output measures, we clearly need to focus greater attention on the question of whether the United States may be in danger of losing its world leadership in science and technology and its competitive economic position in international markets.

FEDERAL AND PRIVATE SECTOR ROLES IN R&D

I shall now discuss the second issue--the respective roles of Government and the private sector in research and development. The R&D process spans a wide spectrum of activities, but may be conceptualized generally into two broad categories--basic research and long-term exploratory development--which undergird the technology base, and mission or product-oriented R&D. In proceeding along the steps of the process from exploratory research to product development, risks tend to decline but costs increase. For example, the cost involved in basic research and exploratory development to demonstrate technological

feasibility of an innovation is generally much less than the cost to complete prototype development, tooling for manufacturing, and market development. These characteristics of the R&D process are suggestive of the respective roles of the Federal Government and industry.

Support of Basic Research and Education

For specific missions, such as defense and space, the Federal Government supports all phases from basic research to product development. For technology primarily related to commercial products, the role of the Federal Government, with few exceptions (notably agriculture and nuclear energy), generally has been limited to support of basic science and exploratory development of emerging technologies.

Various efforts have been made to evaluate the impact of basic research, for example, through retrospective studies, such as the Department of Defense "Project Hindsight" and the National Science Foundation "TRACES Program." Although qualitative correlations have been established to show contributions of science from many years ago to technology that is widely accepted today, it is difficult, if not impossible, to establish quantitative economic measures to evaluate basic research.

No one can tell whether, when, and how payoffs may come. Perhaps more important, the sponsor of the research may not be able to capture the full benefits of the investment. The same characteristics apply to funding graduate education.

For these reasons, the private sector generally does not support basic research and graduate education unless it can identify a direct, prompt, and adequate return on its investment. A few exceptions are large corporations and philanthropic foundations. As part of the Federal Government's responsibility, therefore, it must continue to provide major support for basic research and graduate education in both physical and social sciences and the engineering disciplines. A level of support must be provided to assure adequate prospecting for scientific discovery to provide a reservoir of knowledge from which the technology base is derived. This type of research cannot be directed or evaluated in the same way as mission-oriented R&D.

We have not been able to develop any "best" formula for the level of Federal support of basic research--a percentage of the total Federal budget, a percentage of the total R&D budget, a percentage of the gross national product, or the consensus of experts in various disciplines. However, I believe that a rationale can and should be developed and criteria

established to assure continuity and stability of federally sponsored efforts. In other words, I believe we should have a long-term investment plan.

A major portion of basic research is performed in academic institutions, with close correlation between research and graduate education. Recently there has been a tightening of institutional funds and fellowships for academia. Furthermore, cost inflation results in higher overhead costs and less research for each dollar invested. Graduate students are moving into the fields with most financial support of research and graduate student assistantships. Thus, graduate training programs are becoming captive to current research support and are not necessarily consonant with the best educational plan for developing professional talents to meet the future job market.

Many factors, including the high capital cost of facilities in some research areas and the need for long-term stability and maintaining a "critical mass" level of effort with opportunities for full-time career researchers, have caused some to raise the question of whether support for research and graduate education should be decoupled. Perhaps at least a determination should be made of how to assure that graduate and postgraduate training is suited to the future job market and that continuity and stability of essental research programs in both physical and social sciences are maintained.

In funding basic research and graduate education, the Government not only supports industry's R&D efforts by augmenting the science and technology base underlying the innovation process; it also supplies a stable base of scientists and engineers. Basic research should continue to be conducted at Government laboratories, universities, and private institutions, depending on the capabilities of each.

Some reorientation or rethinking of Federal policies and priorities toward funding the science and technology base may be appropriate. This reorientation could be based in part on increased distinctions between R&D policy supporting defense and space on one hand and consumer-oriented technology on the other. Several noneconomic criteria are important in decisions concerning defense and space R&D. While there are "spin-offs" from defense and space R&D to commercial markets, they are not crucial elements in the decision to fund defense and space R&D projects.

Federal financing of applied research and development in support of commercial technology should be considered in the context of potential economic and social benefits to the Nation and in relation to the private sector's ability and motivation to invest its own resources, as well as in relation to other Government initiatives that can influence the climate for private-sector innovation.

GOVERNMENT-INDUSTRY COOPERATION

Many people have attempted to diagnose the barriers to innovation and to offer solutions for improving the climate for Government-industry cooperation. The problems that have been identified generally fall into two broad categories. The first is to a large extent subjective and attitudinal. The second comprises a number of tangible factors.

Viable technology-intensive industries--large and small--are indispensable to our economy and the achievement of specific national goals. We must, therefore, come to grips with issues that tend to create adversary attitudes and find better ways to work together.

Attitudinal Problems

Perhaps the major subjective problem inhibiting Government-industry cooperation is the lack of mutual trust. Many Government officials are suspicious of industrial motives and the potential economic and political power of large corporations, especially those with multinational affiliations. On the other hand, industry is concerned that Government officials do not understand and appreciate the profit motive. Industry also believes there is a lack of understanding by Government officials of the technology innovation process.

Also, the meaning of public accountability is commonly misunderstood. Some Government officials believe that public

accountability means that every Federal dollar spent should be tagged with a program directive, management control, and Government ownership of whatever results.

There are situations in which a broader view of public accountability is appropriate which would not provide for specific direction and management by the Government nor Federal ownership to the resulting product. In such cases, the proper question to ask is whether Federal funds are being spent wisely in the public interest, such as to stimulate useful innovation. Two examples that come to mind are Federal policies with respect to patent licensing and support of basic research and graduate education.

Some Government officials hold the view that patents derived from federally funded R&D must be owned and controlled entirely by the Government. However, in most cases, the public interest may best be served when private industrial contractors, with a few provisos, are granted exclusive licenses for commercial development.

As I have indicated previously, basic research cannot be directed or controlled to the same degree as applied research and development. Also, the wide dissemination and use of scientific information best serves the public interest.

When developing and marketing commercial products, industry naturally prefers to exercise its own discretion independent of

any Government assistance or influence unless it needs help to deal with serious threats from foreign competition or another domestic enterprise which it believes is exercising unfair competition. Industry is particularly concerned about the constraints of Government regulations which tend to divert capital from innovative R&D to R&D and other investments necessary to comply with regulatory requirements. Furthermore, some multinational corporations may not be inclined to share strategic information with the Government, and to plan and conduct their business in such manner as to assure harmony with the international objectives of the United States.

As a final attitudinal concern, there are many in both Government and industry who are unwilling to assume responsibility for what others would judge to be reasonable and necessary risks for investment in exploratory research and development when the payoff is uncertain in time or economic return.

Tangible Problems

Many factors have been identified as real or tangible constraints that tend to cause a decline in technology innovation. Among these are the uncertainty of the economy, the high cost of capital, and slowdown during the last few years in Federal spending for research and development. The myriad of regulations established by both Federal and State Governments affect the cost of doing business and may involve conflicting requirements imposed by different agencies. For example, in Federal

procurement of conventional commercial products, the public would be served better in many cases by best-buy competition based on superior or innovative performance and life-cycle costs, rather than by the prevalent procurement practice which tends to favor the lowest bidder who offers products that meet acceptable quality specifications.

In the larger sense, criticism is levied that we have not established a consistent national policy and strategy for Government-industry relations to balance incentives and constraints and assure a favorable climate for technology innovation by private enterprise. This contrasts sharply to other nations, notably Japan and West Germany, that have both policies and special institutional arrangements to foster industrial technology innovation and improved manufacturing productivity.

Part of this issue is the question of whether our antitrust laws, which were established primarily on a domestic basis, need to be reexamined in an economy which is becoming increasingly world interdependent in market relationships and competition. This question is highlighted by the increasing number and size of multinational corporations and the fact that foreign corporations are growing faster than U.S. corporations.

Most of the other industrialized nations have developed closer relationships between government and the private sector

on capital formation and R&D directed to the private economy. This is an area in which we perhaps should explore new perspectives for Government-private sector interaction within the framework of American institutions.

Several factors need to be recognized and dealt with to improve the effectiveness of these relationships. Many of these are self-evident; however, it is worth recapitulating some contrasting characteristics that distinguish the roles of DOD and NASA from those of some nondefense, nonregulatory agencies--particularly as they relate to partnerships with private industry. DOD and NASA are characterized by:

--well defined missions and recognized priorities;

--firm national commitments;

--federally controlled destiny, i.e., independent strategy not contingent upon other jurisdictions; and

--selective support of R&D and purchase of resulting products and services, i.e., closed-loop missions and markets.

Civilian agencies, such as the Urban Mass Transportation Agency, the Office of Water Research and Technology, the Bureau of Mines, and the Law Enforcement Assistance Agency, are to a large extent characterized by:

--broader public service goals and less definitive priorities,

--missions comprising nationwide collections of local problems having some commonality of national significance,

--leadership roles limited by jurisdictional prerogatives of State and local governments--responsibility for coordination but no control authority, and

--sponsorship of technology innovation but without purchase of resulting products and services.

The characteristics of the Energy Research and Development Administration are mixed but, with the exception of the nuclear energy and weapons programs, are more like the other nondefense agencies.

Now let us look at the situation as viewed by private industry seeking to develop viable markets for its technology-intensive products and services. There are four fairly distinct types of markets potentially available.

--Closed-loop Government defense-type markets in which industry assumes low risks, obtains direct support for R&D, and has a ready-made customer for resulting products.

--Strictly commercial competitive enterprise involving magnitude of investment and timescale

within such limits that industry assumes the risks, develops its strategy, and competes for known markets.

--Important commercial ventures to meet urgent national needs that involve magnitude of investment, timescale, and risks too great for the private sector to handle without Government assistance.

--The public technology market, i.e., State and local governments, and other public-service institutions which comprise a latent, non-standardized, and fragmented market in need of Federal leadership to alleviate barriers to market aggregation.

In the last two situations, the Government's role and its relationship to industry is a different ball game. We still are in the learning process of when, how, and to what extent the Federal Government should provide leadership, intervention, or assistance in these situations.

Major Essential Commercial Ventures

There are controversial views concerning the Federal Government's role in the mobilization of combined nationwide

scientific and technological resources required to develop major commercial products needed to meet national goals. For example, although ERDA, in combination with industrial firms, is investing heavily in nuclear power development, some experts question what the specific role of the Government should be in this enterprise.

The basic argument is whether the Government should finance and manage such programs directly or provide the right climate and incentives for innovation by the private sector, as well as insurance against the risks, with oversight sufficient to assure adequate public protection from potential hazards and monopolistic advantage or excessive prices.

The energy problem involves extensive industrial participation and its products ultimately will be commercially delivered to public utilities and other users. The technological and market uncertainties, combined with the long timeframes and the magnitude of capital investment, require that the Federal Government be involved. The question is: To what extent and how?

GAO has reported to the Congress on the ERDA Liquid Metal Fast Breeder Reactor--a high-priority energy research and development program. The program objective is to develop a broad technological and engineering base with extensive utility and

industrial involvement which will lead to a strong competitive commercial breeder industry. We addressed issues relevant to key questions facing the breeder program decisionmakers, such as need and program timing, benefits, costs, risks, and options.

We concluded that the program should be continued with substantial support from the Federal Government with a clear recognition that it is still a research and development program. We believe there has been premature concern and emphasis on commercializing the reactor at a time when the Nation is years from demonstrating its reliability, economy, and safety. When and if the research and development efforts succeed and technological and economic feasibility are demonstrated, there will be issues yet to be resolved regarding the transition from major Federal involvement to commercial implementation by the private sector.

In February 1975, we issued a report to the Congress entitled "Federal Coal Research--Status and Problems to be Resolved." We found that for coal to play an important role in meeting energy demands, three developments are essential.

--Research must demonstrate the commercial feasibility of converting coal to synthetic gas or liquid fuel.

--The coal industry must be willing to finance and be capable of supplying increasing quantities of coal.

--Environmental problems associated with coal supply and use must be resolved rationally.

We suggested matters for consideration by the Congress, including Federal incentives that may be needed to overcome the problems which could delay the transition from the research phase to the commercial production phase for coal conversion processes. Incentives may be needed in the areas of development of costly specialized equipment, obtaining plantsite locations, and capitalization of new conversion industries. Federal action and funding may be needed for improving mine technology, increasing manpower, new transportation systems, resolving environmental considerations, and incentives to attract private investment.

Another GAO study recently completed was a review of NASA's land satellite experimental program. The satellite is being developed to determine the feasibility of using remote-sensing technology to assist in achieving more intelligent management of our environmental and natural resources to help relieve the global energy, mineral, and food shortages.

One of the issues yet to be resolved is the establishment of a long-range plan, including the question of the Federal

Government's role in supporting satellite-based remote-sensing technology. The technological and market uncertainties, combined with long timeframes and the magnitude of capital investment, discourage private-sector support. The question again is: To what extent and how should the Federal Government support the emerging technology?

These examples illustrate the point that we have not yet established a consistent policy concerning the respective roles of Government and industry in the development of major long-term commercial ventures to meet national needs. It is unlikely that a formula for general application can be devised, but I believe that further study of policy alternatives should be continued in an effort to establish a general policy and establish criteria for guidance in determining the Government's role in each situation of this type.

Manufacturing Productivity

Improving productivity in both public and private sectors has been recognized generally as one of the most effective means to stimulate economic growth.

Since 1970 the General Accounting Office, in cooperation with executive branch agencies, has been fostering efforts to measure and enhance the productivity of Federal activities. Under the Joint Financial Management Improvement Program, a report is submitted annually to the President and the Congress

on identifiable causes of productivity gains and losses and recommended actions to foster improved productivity.

The U.S. Government, with over $50 billion annually in purchases of goods from the American economy, has a direct interest in reducing these procurement costs through improving manufacturing technology and thus increasing productivity. Domestic supplies of raw materials are diminishing, and there will be a need to increase our raw material imports with the probability of continually paying higher unit prices. It will be necessary to expand our exports to pay for the increased imports of raw materials.

In recent years, there has been a significant rate of increase in the imports of high-technology products which have consistently been among our major exports. Furthermore, the U.S. rate of improvement in manufacturing productivity is among the lowest in the world.

GAO has recently completed a comparison of programs in the United States and other countries concerned with advancing the state-of-the-art of manufacturing technology, particularly in the manufacturing of parts and components produced in medium and small lots--with special attention to the potential for further application of computers to the design and manufacturing process.

We concluded that the United States generally uses more advanced manufacturing technology than other countries in the

world. The U.S. total output and output per employed person is higher than any other nation's. However, our advanced technology is concentrated in a few high-technology and/or capital-intensive firms, such as in aerospace, electronics, and other industries producing defense-related products. It is not well diffused throughout the civil U.S. industrial base. Our study also suggests that, without some added impetus, the advanced technology will not expand or diffuse widely to small- or medium-sized firms through 1985.

In terms of "best practice," however, our study indicates that the United States no longer has a technological advantage. In general, the level of technical capability in all industrial nations seems about equal, although industrial firms in some countries seem to have higher levels of sophistication in certain aspects of advanced manufacturing technology than firms in other countries.

Our international competitors are capturing increasing shares of foreign markets and are increasingly penetrating U.S. markets. It is significant that they are competing in those markets with U.S. high-technology manufacturers. The principal U.S. exports for the future appear to be essentially the same as at present, i.e., primarily agricultural products, aircraft and components, electronics (principally computers), and nonelectrical machinery.

Unlike the United States, our principal foreign competitors have well-developed government-directed programs and special institutional structures for overcoming barriers to diffusion of existing manufacturing technology, and for advancing the state-of-the-art through coordinated research and development programs. At least inferentially as a result of such programs, these countries have shown better results than the United States in such areas as rate of increases in productivity, international trade, modernization of facilities, and capital investment in modern technology.

In addition to improvements in traditional manufacturing methods, computers and numerically controlled machines are changing both the management and the engineering technology of manufacturing. There are indications that manufacturing methods are about to change--not incrementally but radically. The changes are already taking place in the foreign countries where the productivity-improving institutions and mechanism were created to recover from the adverse effects of war.

Such institutions exploit, develop, and diffuse the new computer-integrated manufacturing systems and are well designed to continue development of their nations' manufacturing productive capabilities faster than that of the United States.

Their success is evidenced by their increasing share of the international markets--in some cases, at the expense of our own manufacturers.

But our principal concern is for the future. We need to foster international competition which stimulates each country toward the common goal of improving worldwide living standards. To insure our ability to compete, however, we must take positive measures to strengthen our own manufacturing productivity.

Significant short-term benefits are possible through improved diffusion of the available technology. For long-term, sustained productivity increases, research and development is necessary to find new methods and to refine existing technology so that it can be economically used outside the few highly capitalized, high-technology firms.

In the most successful foreign countries, both programs and institutional models involve joint public and private efforts. The United States has no comparable national program, although several Federal agencies are interested in this subject, and a new institution has been created which could provide the central focus and administration for it. This agency is the National Center for Productivity and Quality of Working Life established by Congress in November of last year.

On the basis of the GAO analysis of manufacturing technology, we have concluded that there is a need to establish manufacturing productivity as a national priority and to create a national focal point to assist U.S. industry in reaching for the most advanced manufacturing technology and diffusing this technology throughout the private sector. Obviously one center could not do everything that needs to be done; however, a single center can perform a leadership, coordinating, and catalytic function.

We have recommended that the National Center for Productivity and Quality of Working Life take the lead in developing a national policy and appropriate means for achieving balanced productivity growth in the industrial manufacturing base. Further, we propose that the National Center, in carrying out this recommendation, seek the cooperation and assistance of the Department of Commerce and other agencies. The expertise within the Department of Commerce, particularly in the National Bureau of Standards and the National Technical Information Service, would allow that Department to play a major role in providing technological leadership and support.

The combination of the expertise of the National Center and the Department of Commerce and their close coordination

with other public and private organizations would provide the much needed focal point to coordinate all the disparate Government and private work in developing, standardizing, and diffusing manufacturing technology, and assist the emerging State and regional productivity organizations to advance manufacturing technology.

A number of specific functions should be embraced by this central focus and leadership. Three of the major ones are to

--collect and evaluate manufacturing technology information from all available sources and establish means for disseminating state-of-the-art knowledge to potential users;

--foster the development and acquisition of new technology in various ways; and

--analyze public policy options and formulate recommendations that will improve Government-industry cooperation in stimulating productivity improvement.

Technology Transfer and International Trade

GAO recently issued a report entitled "The Government's Role in East-West Trade--Problems and Issues." This report included certain findings and recommendations associated with administering and monitoring exports to and technology exchanges with Communist countries. Although this work centered

on trade with Communist countries, many of these conclusions and recommendations apply to such exports to all countries.

A major observation of our report is that the implementation of export control policy and procedures has resulted in a continuous series of ad hoc decisions and fragmented consideration of strategic export controls. We noted an absence of agreement on criteria and standards for determining which goods and technology should be controlled and whether foreign policy, commercial, or defense considerations should dominate export control policy. We concluded that lack of agreement reflects fundamental interagency and international differences regarding licensing standards and procedures to be followed in controlling exports.

Present export controls predominantly involve national security concerns and are directed to monitoring trade with Communist countries. Access to technological know-how is often of greater strategic importance than is possession of the products of the technology. Effective regulation of technology exports is probably the most complex export control problem because of the difficulties of pinpointing areas of technology which should be controlled and of establishing effective controls.

There is limited monitoring and assessment of technology exports for strategic or other national interests. Existing

control regulations for the transfer of technology are ineffective for various reasons. Most important is the need to improve executive branch understanding of the many ways technology can be transferred and the effects of these transfers on national security and domestic economy.

Although the Government is directly involved with technology development through such efforts as R&D, it has no mechanism nor any clearly defined authority for monitoring the export of technology to assess its impact on such economic national interests as employment, balance-of-trade, etc. Even for strategic reasons, no reporting system exists through which the Government would be informed of the many technology transfers private industry makes. For example, the executive branch has no authority to require the submission of private sector-Communist government technology exchange agreements for review and approval.

Our East-West trade report made a series of recommendations to the executive branch which were intended to improve the administration of national and international export controls. Specifically, (1) the role of the Department of Commerce should be expanded, (2) approval for exception cases should be more carefully assessed against U.S. national security interests, and (3) the understanding of international technology transfers should be increased to permit assessment of their effects on security and other national interests.

Our report also identified several important matters for consideration by the Congress. The administration of export controls and technology exchanges has important implications for many national interests. Efforts to examine the need for amending the Export Administration Act should include consideration of national policy goals for relationships with Communist countries. Such consideration requires coordinated attention by various congressional groups involved with specific political, economic, or strategic issues of this relationship. The formation of export control policy and its relationship to national goals also requires the joint effort of the legislative and executive branches of our Government. The responsibilities of private interests in the policy formation and implementation process should be considered, as well as the Government's need for information about private sector activities. Some companies, on their own initiative, have established policies for exchanging technology in-kind rather than licensing a foreign enterprise for direct financial considerations. Perhaps more of this practice should be encouraged, but the Government should be kept apprised of such arrangements.

DECISION PROCESS FOR R&D POLICIES AND PRIORITIES

Now I shall discuss the third issue--improving the decision process for R&D policies and priorities. Some recent initiatives

by the Federal Government, both within the executive branch and by the Congress are aimed toward establishing more definitive and enlightened policies and priorities for resource allocation and for dealing with issues that transcend the purview of individual agencies and the private sector. Among these are

--the pending legislation, now passed by both the Senate and the House, to establish a Science and Technology Policy Advisory Office in the White House;

--the Office of Technology Assessment comprehensive study of National R&D Policies and Priorities;

--the National Science Foundation R&D Assessment Program;

--the National Bureau of Standards Experimental Technology Incentives Program; and

--the GAO effort to introduce an improved classification structure for the Federal R&D budget.

With regard to this last task, it has been recognized for some time that the "Special Analyses, Budget of the Government--Federal Research and Development Programs," submitted annually along with the executive branch presentation to the Congress, has not been adequate to serve the needs of the Congress. This analysis presents the total Federal commitment to research and development and to research and development facilities. Amounts are shown in three categories--defense, space, and

civilian (other than space). Beyond the amounts for these three categories, the special analysis also includes the research and development programs of the larger Federal agencies. However, there is no interagency comparability because the agency presentations are in terms peculiar to the agencies.

As an outgrowth of GAO's work in assessing and developing improvements in the information requirements of selected subcommittees of the Committees on Appropriations and at the encouragement of staff members of the House Committee on Science and Technology, GAO has developed a unified-objective oriented classification structure for use in presenting Federal R&D budget and funding data. The structure was transmitted to the Office of Management and Budget in September 1975 requesting that it be used in a supplementary budget presentation along with submission of the President's budget for fiscal year 1977. OMB implemented a part of the structure by collecting and presenting R&D funding data from 14 departments and agencies. GAO is continuing to work with OMB to achieve full implementation of the structure.

The concept underlying the GAO-developed structure is to provide a unified framework for viewing Federal research and development among Federal agencies in terms of the level of effort directed toward accomplishing similar national objectives or finding solutions to similar national problems. The

executive branch does not presently provide the Congress a picture of Federal R&D which is sufficiently clear, comprehensive, and timely to enable meaningful comparisons. Such comparative information is needed to allow the Congress the opportunity to consider the total Federal R&D budget and the relative mix of R&D programs with respect to national priorities. With the new timetables for budget authorization and appropriation actions, as established by the Congressional Budget Act of 1974, the schedule for providing such information to the Congress each year is critical.

I shall suggest one example of the kind of analysis that would be especially useful to this Subcommittee in its broad R&D oversight function. Even though this Subcommittee's oversight is limited to nondefense R&D, it should have the benefit of knowing the total Government R&D expenditures in areas such as transportation, energy, energy conservation, materials, environment, food and nutrition, health and biomedicine, human resources, communications, electronics, and astronautics. Of the projected fiscal year 1977 defense budget of approximately $11 billion for research, development, test, and evaluation, probably as much as $1.5 to $2.0 billion is for technology base R&D in areas that are not only related to the defense mission but also are synergistic with nondefense R&D programs. Breakouts of DOD expenditures by functional categories in which civil agencies are also involved would enable comparisons and

evaluations of overall Federal expenditures by fields of endeavor and would supplement the Special Analyses of individual agencies' R&D programs.

We believe that executive branch implementation of the GAO-developed unified-objective oriented classification structure for Federal R&D will greatly assist the Congress in establishing Federal R&D funding priorities, as well as the most desirable mix of Federal R&D programs.

FEDERAL ROLE IN PUBLIC TECHNOLOGY INNOVATION

The fourth and last issue I shall discuss today is how can the Federal leadership be improved in assisting State and local governments to adopt innovative technology. Much attention has been given to policies and priorities for the Federal allocation of resources for research and development and toward examining the incentives and disincentives that affect private investment in R&D. A closely related issue which, in my view, has not been given adequate attention is the application and utilization of technology in the public domain, particularly the respective partnership roles of the Federal, State, and local Governments and the private sector in public technology innovation to improve the quality and efficiency of public services.

Industrial productivity and the economy can be stimulated by special tax incentives, enlightened patent policy, selective relaxation of adverse Government regulations, and in many other ways. Such assistance is important when market forces

are inadequate or when externalities or high risk preclude adequate private investment. But such stimuli alone generally will not motivate industry to invest its own resources to meet the technological needs of public institutions. This is especially true when the public market for technological products and services is latent, fragmented, or intractable because of political, parochial, and jurisdictional constraints. These factors, as well as economic limitations, greatly impede the acceptance of technological innovations by public institutions.

The primary role of Federal civil agencies in technological innovation, therefore, can be to provide leadership and incentives to others, including private industry. The Federal role involves

--identifying problems and potential solutions, especially those with nationwide commonality;

--adapting existing technology or sponsoring R&D;

--demonstrating the feasibility of technological improvements;

--establishing performance standards;

--removing barriers to acceptance at State and local levels;

--employing regulatory authority; and

--subsidizing or providing special incentives for the transition until the potential for aggregated markets and economies of scale motivate the private sector to invest its own capital.

To be most effective, Federal agencies must establish better partnerships with State and local governments and the private sector. Since industrial resources are needed to produce goods for public institutions to use in improving their services, industrial contractors should be involved in the early phases of R&D, adaptive engineering, and demonstration.

Recent Studies and Experiments in Technology Innovation

Much more needs to be learned about public technology innovation--the process of not only generating technological options, but also fostering the selective adaptation, transfer, and use to benefit both the economy and the quality of life. Even so, we have certainly learned enough to realize that the Federal Government's leadership role in the technology delivery system needs to be improved.

In recent years, a number of studies and experiments from which lessons are being learned about the process have been performed or sponsored by Federal agencies. Notable examples, in addition to the previously mentioned R&D Assessment and Experimental Technology Incentives Programs, are the NASA Technology Utilization Program and the National Science Foundation Intergovernmental Science Program. These efforts include experiments in active technology transfer methods and institutional arrangements, Federal procurement leverage, and aggregation of

markets common to a number of cities. Experience gained by the Federal Laboratory Consortium for Technology Transfer is also relevant. This consortium was initiated by a group of defense laboratories but has now expanded to include representatives from other agencies, coordinated through the National Science Foundation.

CONCLUSION

In conclusion, I believe major attention should be directed toward three issues:

--Improving the measurement and analysis of the impact of R&D on both the domestic and international scenes;

--Improving the climate for Government-industry cooperation to stimulate technology innovation and enhance productivity; and

--Improving Federal leadership in the application of technology to State and local government problems.

In seeking better measurements of the economic impact of R&D, more work is needed in developing science indicators with emphasis on output measures. I also believe that more microeconomic analysis of specific R&D efforts should be pursued.

What can we do to improve the climate for Government-industry cooperation? I have no panacea to alleviate the

attitudinal constraints that continue to retard the development of a more constructive partnership between Government and industry.

It behooves all of us--individually and collectively--to make extraordinary efforts to achieve better communication and mutual understanding of our respective needs and interrelated goals in the context of our total responsibilities and obligations. Continued studies and publication of resulting reports clarifying the issues and alternatives should help to improve understanding.

An excellent example is the July 9, 1975, report by Robert Gilpin entitled "Technology, Economic Growth, and International Competitiveness." This is a report prepared for use of the Subcommittee on Economic Growth of the Joint Economic Committee. Another good example is the 1973 report, entitled "Barriers to Innovation in Industry: Opportunities for Public Policy Changes," based on a study sponsored by the National Science Foundation and performed as a joint effort by the Industrial Research Institute and Arthur D. Little.

Also, continued discussion and debate in open forums and panel meetings, such as those sponsored by the National Science Foundation, the National Bureau of Standards, professional societies, and trade associations can help; especially when all interested parties or sectors, including labor and consumer groups, are represented. Congressional committee hearings,

such as your Subcommittee is now conducting and the extensive hearings held by the House Committee on Science and Technology on science and technology policy and organization during the last three years, are extremely useful for improving understanding and perspective.

With respect to the more tangible issues, it is clear that the Federal Government needs to stabilize its economic and regulatory policies to reduce uncertainties affecting private investment in technology innovation. A comprehensive evaluation of the effect of Federal regulations is needed to assess the individual and collective effect on the climate for private-sector R&D, as well as to determine cost effectiveness and ascertain whether appropriate shares of the costs are being borne by the primary beneficiaries.

In addition, more policy analysis is needed to develop general guidelines and criteria for determining when, how, and to what extent the Federal Government should be directly involved or should alleviate some of the existing constraints and provide special incentives for commercial ventures in technology-intensive industry. Particular attention needs to be given to determining the respective roles of Government and industry in major commercial ventures needed to achieve national goals and also to assess the impact of Federal policies and regulations on the environment for spawning new enterprises and fostering the growth of small innovative companies.

On the international scene, means must be established for sharing of strategic information between industry and Government to assure that international agreements consummated by industry are consonant with Government objectives. Important lessons can be learned from the special arrangements between government and industry in the foreign industrial nations even though they may not be directly adaptable to our system.

Planned GAO Work Related to R&D and the Economy

As part of a planned GAO study on the impact of various Federal policies on industrial capital formation (the accumulation of plant and equipment), we plan to consider the interrelations among Federal R&D activity, private R&D activity, and industrial capital formation. R&D activities and capital formation are major sources of economic growth. Furthermore, industrial capital formation oftentimes incorporates the results of successful R&D activities.

This study will consider the direct impacts of Federal tax, patent, and regulatory policies on private R&D expenditures. In addition, the impact of various Federal policies on the business environment and the effect of this environment on industrial R&D expenditures would be investigated. In particular, we would analyze the effects of Federal regulatory and economic stabilization policies on how businessmen

perceive the riskiness of their environment and how changes in these perceptions affect the level and allocation of their R&D expenditures.

We also plan to consider the impact of the level and composition of Federal R&D expenditures on industrial R&D expenditures and industrial capital formation. Effort would be devoted to developing methods which could provide an assessment of the effective allocation of Federal R&D expenditures.

In general, this study would identify the effects of Federal R&D activities on the economy and how Federal policies affect the R&D efforts in the private sector of the economy.

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Mr. Chairman, this concludes my statement. I shall be pleased to answer any questions.