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RECENT DEVELOPMENT IN SCIENCE AND TECHNOLOGY: PROGRESS AND CONCERNS

Having received invitations on many occasions in the past to visit Los Alamos when I was serving as Deputy Director of the Budget, I was especially pleased to have your recent invitation to join you here this morning and have an opportunity--however brief--to take a glimpse at the work of this great Laboratory which has played such a major part in the Nation's atomic energy programs.

Thinking back over the years as I prepared my remarks, I recalled that I had had a part in the writing of the Atomic Energy Act of 1946 and had immediate responsibility in the Bureau of the Budget for some time after that for the budgetary review of the financial requirements of the Atomic Energy Commission. I have a special interest in your program. I believe that I am the holder of one of the first "Q" clearances granted outside AEC. As I undertook to develop a small staff which would have responsibility for review of AEC budgetary requirements, my first recruit was Mr. Fred Schuldt, known to many of

you, who served as the able principal staff member for AEC budget programs in the Bureau for more than 25 years.

So much for nostalgia.

At the outset, I want to take note of the important legislation recently enacted to establish an Office of Science and Technology Policy in the Executive Office of the President, reestablishing the mechanism abolished by President Nixon a few years ago. S. 2404 08

This long-overdue legislation--sent to the White House only this past two weeks--can have a major impact on Government policy in the years ahead in establishing national priorities in R&D; in developing more effective relationships between Government and non-Government science and technology organizations; and, through its periodic reports to the Congress, in making all of us aware of the increasing importance of science and technology in our national life.

I am particularly interested in this legislation, having recommended the establishment of the original Office of Science and Technology to President Kennedy and having had a major role in testimony before congressional committees which led to the enactment of legislation establishing that Office.

Both President Ford and the Congress have displayed courage and foresight in recognizing the need to reestablish this Office and I am glad that in doing so they have strengthened its charter.

In setting the stage for what I have to say today, I cannot do better than quote directly from the declaration of policy contained in the new legislation in which the Congress declares that the

"United States shall adhere to a national policy for science and technology which includes the following principles: * * *

"5. The development and maintenance of a solid base for science and technology in the United States, including:

"(A) Strong participation of and cooperative relationships with State and local governments and the private sector;

"(B) The maintenance and strengthening of the diversified scientific and technological capabilities in government, industry, and the universities, and the encouragement of independent initiatives based upon such capabilities, together with elimination of needless barriers to scientific and technological innovation * * *."

This legislation, together with the Baker-Ramo panels recently appointed by the President and the recently completed work of the Federal Commission on Government Procurement, which set forth far reaching recommendations dealing with subjects

ranging from patent policy to Federal support of research and development, augur well for all who have felt the need for a basic reassessment and redetermination of national policies involving Government-industry cooperation in science and technology.

This subject is of paramount importance because viable technology-intensive industries, large and small, are indispensable to our economy and the achievement of specific national goals.

In times of crises, such as World War II and the threat of Soviet preeminence in space technology, our Government mobilized industrial resources--and industry responded well--in a partnership effort to meet specific national goals. Such partnerships continue in defense and aerospace. We have yet to find the solution to the more complex interrelationships necessary to deal effectively with the energy crisis or the problems associated with environmental protection and safety.

Today the Federal Government is playing an increasingly important role in international economic relations by helping to establish better sharing of critical resources and by assuring American competitiveness in the international marketplace.

More and more American companies are entering into world markets, not only through exports but also through investment in foreign subsidiaries. Many companies represented here today

have developed into powerful multinational corporations. Consequently, a whole new dimension of industrial accountability has emerged. This partnership responsibility is highly important in fostering world peace, assisting the developing nations, and sharing critical resources for the benefit of all mankind.

The question, therefore, is how can we improve the communication, understanding, mutual goals, and working relationships between Government and industry, especially technology-intensive industry, in meeting both national domestic needs and international obligations.

FACTORS INHIBITING THE CLIMATE FOR INNOVATION

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 more tangible factors.

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 of the resulting product. In such cases, the question to ask is whether Federal funds are being spent wisely in the public interest, such as to stimulate useful innovation. An example that comes to mind is Federal policy regarding patent licensing.

Some Government officials believe 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.

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 a 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 terms of 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 the 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 meeting acceptable quality or minimal specifications.

In the larger sense, criticism is levied that the Government has 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 with other nations, notably Japan and West Germany, that have 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, 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.

Improved productivity and advances in science and technology cannot take place separately from other aspects of national policy; advances made in the laboratory and on the testing grounds require adequate financial support obviously. However, these advances can be similarly flawed if such support does not go hand-in-hand with policies developed which will make it possible to use and develop these innovations. The Internal Revenue Service, Securities and Exchange Commission, Justice Department, and Department of Commerce all must play a part. Too frequently, these organizations go their individual ways for their own reasons and possibly for even socially desirable purposes. This does not mean, however, that their actions will coincide with adequate accounting as to their impact and consequences for risk-taking and technological innovation.

There is currently no organized systematic procedure for measuring the effect of these Government decisions on science and technology; thus, industrial risk-takers lean toward hedging and zero-risk decisions. Innovation under these conditions can

be, at best, incremental. Hopefully, the new Office of Science and Technology Policy will recognize that innovation must come as the result of total Government policy--not the more frequently narrowly construed concept of science and technology.

There are encouraging signs that the Council on Environmental Quality and the Environmental Protection Agency is taking a more realistic view in assessing the trade-off between costs and benefits of environmental regulations. There are also increasing signs that the Federal courts are restive in the increasing role in which they are being cast of making technical judgments in cases where legislation or regulations are not precise and where provision has not been made for the necessary trade-off considerations. Perhaps we need to be thinking in terms of an administrative court with adequate technical backup staff unless more systematic procedures for relating costs and benefits can be developed by such agencies as the Environmental Protection Agency and the Food and Drug Administration.

Economic Impact of Research and Development

There is agreement that there is (1) a high positive correlation among science, technology, and economic growth and (2) relatively little agreement concerning precise measurements,

appropriate methodology for establishing these correlations, and interpreting 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.

Several tentative conclusions were that:

--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.

The report also states that the proportion of the gross national product spent for R&D has declined steadily over the last decade in the United States, while growing substantially in Russia, West Germany, and Japan; also that the United States

has invested a much smaller fraction of its R&D budget for non-defense, nonspace 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 need to develop better productivity measures for R&D is urgent. If technological innovation is declining in this country, part of the reason may be that we are not investing the necessary resources in R&D, but it may also mean that we are investing them in the wrong places. Evaluating the economic and social impacts of R&D programs will help to answer these questions and will support more investment in R&D in those areas where accurate measures demonstrate meaningful contributions to society.

Major Essential
Commercial Ventures

There are controversial views concerning the Federal Government's role in mobilizing combined nationwide scientific and technological resources required to develop major commercial products needed to meet national goals. For example, although the Energy Research and Development Administration, 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 the energy area.

The basic argument is whether the Government should finance and manage such programs directly or attempt to 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 time frames and magnitude of capital investment, require that the Federal Government be involved. The question is: To what extent and how?

Two case studies, which shed some light on this question, are presented in the General Accounting Office reports dealing with the Liquid Metal Fast Breeder Reactor Program and the Federal Coal Research Program. These reports are available and I commend them to anyone interested in a fuller appreciation of the complexities involved in accomplishing national energy objectives. Regarding the Breeder Reactor Program, the delicate question of judgment is at what point will the technology--largely Government financed--be sufficiently reliable, economic, and safe as to make it a viable commercial enterprise and how will the transition from major Federal involvement to commercial implementation by the private sector be accomplished.

Similar questions are involved in developing the means to convert coal to synthetic gas or liquid fuel, a problem made more complicated because of the environmental concerns associated with mining and developing coal as an energy resource and the fact that much of our coal reserves are located in areas which will require large-scale construction of public facilities, such as hospitals, schools, and roads.

These are only two of a number of examples which could be cited to illustrate the point that we have not yet established a consistent policy concerning the respective roles of Government and industry in developing 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 studying of policy alternatives should be continued in an effort to establish a general policy and criteria for guidance in determining the Government's role in each situation of this type.

An organizational step which we think would make the development of such a policy easier would be to move toward consolidation of agencies concerned with energy policy and energy research and development. In recent testimony before the Senate Government Operations Committee, I proposed the establishment of a National Energy Administration which would combine the Federal Energy Administration and the Energy Research

and Development Administration and the establishment of an independent data collection and analysis unit within the new agency, while transferring FEA regulatory activities elsewhere--possibly to the Federal Power Commission. This latter move we believe is important to remove the "conflict of roles" of the FEA which presently is both a regulatory and a policy agency, a principle which Congress found unsatisfactory at the time it established the Nuclear Regulatory Commission and a separate ERDA. In the long run, we believe the Congress will have to establish a Department of Energy and Natural Resources and a National Energy Council if we are to effectively deal with the Nation's long-run energy problems.

Manufacturing Productivity

Improving productivity in both public and private sectors has been generally recognized 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.

In addition, we have 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. It is not well diffused throughout medium- and small-sized companies.

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.

In addition to improving traditional manufacturing methods, computers and numerically controlled machines are

changing both the management and the engineering technology of manufacturing.

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. 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 have involved joint public and private efforts. The United States has no comparable national program, although several Federal agencies are interested in this subject. A new organization has been created which could provide the central focus and leadership. This agency is the National Center for Productivity and Quality of Working Life, established by the Congress in November 1975.

We have recommended that the Center 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 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 expertise of the Center and of the Department of Commerce and their close coordination with other public and private organizations can 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.

WHAT CAN WE DO?

Attitudes

What can we do to improve the climate for Government-industry cooperation? Well, we may be inclined to empathize with Snoopy. A few weeks ago in the Peanuts comic strip he soliloquized,

"My body blames my foot for not being able to go places. My foot says it was my head's fault, and my head blames my eyes. My eyes say my feet are clumsy, and my right foot says not to blame him for what my left foot did. I don't say anything because I don't want to get involved."

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 improve understanding. An excellent example is the July 9, 1975, report by Robert Gilpin, "Technology, Economic Growth, and International Competitiveness," report prepared for use of the Subcommittee on Economic Growth of the Joint Economic Committee. Another good example is the 1973 report, "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 IRI and Arthur D. Little.

Discussion and debate in 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 hearings also are useful for improving understanding and perspective. For example, the Subcommittee on Domestic and International Scientific Planning and Analysis of the House Committee on Science and Technology has just completed hearings on "R&D and the Economy."

Tangible Issues--Government Initiatives

With regard to the more tangible issues, I believe several initiatives can be or are being taken.

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 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.

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 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.

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.

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 reorienting 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.

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 legislation--previously referred to--establishing an Office of Science and Technology Policy 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.

As part of a planned GAO study on the impact of various Federal policies on industrial capital formation, we will review the interrelations among Federal R&D activity, private R&D activity, and industrial capital formation. This study will consider the direct impact 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 will be investigated. More specifically, we will 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 analyze the impact of the level and composition of Federal R&D expenditures on industrial R&D expenditures and industrial capital formation. In this effort, we will attempt to develop more effective methods for allocating Federal R&D expenditures.

Tangible Issues--Industrial Initiatives

One way in which cooperative Government-industry relations on the international scene could be improved is for industry

to disclose voluntarily to the Government, subject to protection of proprietary data, sufficient information about its international agreements so that our Government is not disadvantaged in dealing with foreign governments which are privy to such information.

Presently the executive branch has no authority to require the submission of private sector-Communist government technology exchange agreements for review and approval. Recommendations for improving the Government's role in monitoring and controlling technology transfer in East-West trade are contained in a recent GAO report on this subject.

Encouraging as the recent initiatives designed to improve Government-industry cooperation in science and technology may be, we still have, as a Nation, much to do. We need to learn more about how industry and Government can pool their efforts; it is clear that neither can go it alone either domestically or internationally. Perhaps we can learn from our experience in defense procurement and our space program how these relationships can be made more effective. For, if we are to resolve our energy problems and problems of controlling our environment and the public technology required to deal with the concerns of our cities, there must be close and productive relationships. If these relationships are to be developed, the first step is to recognize this need.