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STATEMENT BY D. ALLAN BROMLEY

Director, Office of Science and Technology Policy
Executive Office of the President

Before the Committee on Budget

United States Senate

February 22, 1990

STATEMENT
by
D. Allan Bromley
Director, Office of Science and Technology Policy
Executive Office of the President
Before the Committee on Budget
United States Senate

Mr. Chairman:

Thank you for giving me the opportunity to present the Administration's views on science priorities and the budget request for science, technology, and space programs. In doing so I will discuss how my office participates in the development of science priorities and how these programs support our national goals.

As most of you are aware, The Office of Science and Technology Policy has undergone a number of changes in the Bush Administration. One important change is my appointment as Assistant to the President for Science and Technology, concurrent with my confirmation as Director of OSTP. This upgraded position for the Science Advisor reflects the increased importance of science and technology in the Bush Administration and has brought an expanded role and responsibilities for myself and the OSTP staff within the Executive Office of the President. These expanded responsibilities include my membership on the Domestic Policy Council, the Economic Policy Council, the Space Council, the Council on Competitiveness, and a close working relationship with the National Security Council and the Office of Management and Budget.

As specified by the National Science and Technology Policy, Organizations, and Priorities Act of 1976 (P.L. 94-282) that created OSTP, a major function of our office is to provide "a source of scientific and technological analysis and judgement for the President with respect to major policies, plans and programs of the federal government." My increased access and direct participation in the policy-making process within the White House has greatly increased OSTP's ability to fulfill this responsibility. I am directly involved in briefing the President on the scientific and technological components of national and international policies.

As a result of these expanded activities, OSTP staff members must cover far more ground than in the past. They interact on a daily basis with other units throughout the Executive Office of the President to ensure that considerations of science and technology are taken into account in policy deliberations. The staff has been upgraded and expanded. For the first time in OSTP's history, the President has nominated for Senate confirmation all four of the Associate Directors called for in P.L. 94-282. These four distinguished individuals will have responsibilities in physical science and engineering, life science, industrial technology, and policy and international science.

As an example of the role that they will play, Dr. James Wyngaarden, OSTP's Associate Director for Life Science, heads the Biotechnology Working Group of the Council on Competitiveness chaired by the Vice-President.

My new responsibilities and the expanded and revitalized role of OSTP mean that issues of science and technology are well represented in the policy-making process of this Administration. In addition, however, the President has recently established a new, high-level advisory group of twelve distinguished scientists and engineers from the private sector that reports directly to him. The President's Council of Advisors on Science and Technology (PCAST), which I have the honor to chair, recently held its first meeting, hosted by the President at Camp David. I anticipate that PCAST will meet once a month and will establish a series of panels to focus on specific problem areas.

In addition to OSTP's roles in participating in the formulation of national policy on issues that involve science and technology, and providing access to authoritative science and technology advice, OSTP is also directed in P.L. 94-282 to coordinate Federal science and technology activities and to resolve science and technology policy issues that affect more than one agency. The primary mechanism for this is the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), which I chair and that I am in the process of restructuring and revitalizing. As part of this restructuring, I intend to reorganize the FCCSET Committees so that they span the spectrum of science and technology in a more appropriate manner.

I anticipate that there will be occasions for interaction between PCAST panels and the reorganized FCCSET Committees, perhaps by holding joint meetings, so that Federal science and technology activities can take advantage of the experience of the private sector. An example of the role that I think FCCSET committees can and should play is provided by the Committee on Earth Sciences, which over the past year has developed a focused, coordinated, multi-agency program of research on global change and to which the President has responded by proposing a budget increase for FY 91 of 57 percent, to over $1 billion.

OSTP/OMB COOPERATION

On budget matters, I have an agreement with Richard Darman that OSTP and the Office of Management and Budget (OMB) will interact closely and at all staff levels in the development of science and technology budgets. Let me describe to you this developing interaction, which I believe is extremely important in the priority-setting process that goes into making up the Federal budget requests. As you know, this year this process has resulted in the President proposing a record total of $71 billion for research and development for FY 91, including a 12 percent increase in civilian R&D, which is impressive in the face of the current austere U.S. budget climate.

The entire outlook of the Bush Administration emphasizes investments in the future while – at the same time – maintaining commitments to the past and present. As an Administration we believe that one of the most effective ways of investing in our future is by supporting research and development in science and technology. Thus, the President has asked that there be a close co-operation between the Office of Science and Technology Policy, the Federal R&D agencies and the Office of Management and Budget in developing this Administration's R&D budget. This should insure that the Administration's proposals to Congress have a sound science and engineering underpinning and represent the most efficient and effective allocation of funds for the support of the Federal R&D enterprise.

The first step in this close interagency co-operation will take place in the FCCSET council working groups. Here agency program officers with the guidance and advice of both OSTP and OMB staff will help co-ordinate the individual agency R&D programs to eliminate duplication and to ensure that all important areas of R&D in specific disciplines are, in fact, supported. The National High Performance Computing program and the U.S. Global Change program are two of the best examples of how this process has the potential to work. In the coming year other areas, such as materials R&D, that are supported by almost all of the R&D agencies will be reviewed in the same manner.

Then, during the summer months when these agencies are preparing their new budget proposals for presentation to the President, both OSTP and OMB staff will be available to the agency heads and their staffs to review the focus and content of individual agency programs required to carry out the agency missions. Finally, in the fall when all of the agency budget proposals are presented to the Administration, as OMB conducts its review, OSTP and OMB staff will jointly evaluate and prioritize the different agency programs in light of urgent national needs and Administration policy. This process was started this past fall and we in OSTP and OMB expect the process to proceed even more smoothly this coming year.

To give you some feeling for the way our two agencies interacted this past year, let me describe briefly a few of the measures we set in place for future budget discussions. Early in the year, OMB surveyed areas of R&D commonly funded by the various R&D agencies, OMB requested that these agencies provide us with the funding levels for each activity identified in these areas. Since this was the first year we carried out this exercise, the data we gathered is not as 'hard' as we would have liked but we expect it to be more well-defined next year. After the data collection, agency personnel met with OMB staff for 'budget hearings' on these programs. OSTP participated in these hearings, as it did in the traditional Fall OMB 'Director's Review'.

At Director's Review, R&D programs and funding levels were examined to determine an optimum allocation of funds across the R&D agency budgets. I participated with Dick Darman in virtually all of the hearings related to science and technology. This latter determination was very tough, since nearly all of the agency budget proposals were excellent and worthy of support. Unfortunately, the available budget resources would not – nor I suspect will they ever – stretch to cover all of these efforts. However, several general, quite simple guiding principles were applied in your final determination.

First, support is required for all programs that address national needs and national security concerns. Examples would be, the Federal environmental clean-up effort, scientific research to address the global climate change issues, a pre-eminence in space and adequate support for the defense technology base. Implicit in this, I might add, we considered the balance of R&D funding for civilian versus defense needs.

The second guiding principle was the adequacy of support for basic research which, really, is the well-spring of all our future scientific and technological progress. In evaluating the agency programs, a concerted effort was made to ensure that 'small science' funding received the highest priority in the final individual agency programs. Finally, we examined the R&D budgets to insure that the level of funding for the scientific infrastructure and facilities in this country will maintain our scientific pre-eminence. Large facilities such as telescopes, synchrotrons, and particle accelerators are necessary for state-of-the-art research to continue. Although many may call these 'mega-projects', once built they service thousands of scientists and make possible a scientific understanding of the world and universe in which we live. They are essential for the health of our R&D enterprise.

The final step in preparing the Administration's budget is a series of meetings with the President. Dick Darman and I with the Cabinet Secretaries and other R&D agency heads sat down with the President to resolve the overall budget priorities in line with available budget resources. The very high priority the President accorded to Science and Technology is reflected in the fact that in his budget proposal to Congress, the chapters on research and development are preceded only by a chapter on increasing the national savings rate.

RECENT OSTP ACCOMPLISHMENTS

In the past year, the Office of Science and Technology Policy has been engaged in a number of activities designed to increase the contribution of science and technology to improved economic competitiveness and a strong national defense. Although many of these activities are being reorganized to reflect ongoing changes in the office, our future efforts will build on what has been done in the past.

The following descriptions touch only on some of the highlights of recent OSTP activities. A more thorough description can be found in the OSTP Budget Justification to Congress: "Summary of Accomplishments in FY 1989 by the Office of Science and Technology Policy."

In the area of international science and technology, OSTP has sought to ensure that science and technology become more integral parts of U.S. foreign relations and that science and technology issues are adequately considered in the development of foreign policy. OSTP has worked closely with the National Security Council, the State Department, and appropriate U.S. government technical agencies, as well as the nation's scientific and engineering communities, to plan, coordinate, and follow up on state visits and summits. In addition, OSTP has sought to encourage international participation in a number of large, world-class science projects currently under development, including the Superconducting Super Collider, Space Station Freedom, and the human genome project. Finally, OSTP has helped to coordinate and has participated in a number of multilateral and bilateral efforts to improve the infrastructure for science and technology around the world and to strengthen science and technology cooperation.

OSTP is also involved in the application of science and technology to support national security. For example, OSTP participates in efforts aimed at resolving critical scientific and technical issues and helps draft position and issue papers for use by the National Security Council, the Office of Management and Budget, and other participating agencies. The Director of OSTP is also assigned the responsibility for managing the nation's telecommunications resources during wartime and non-wartime national crises and emergencies. OSTP also recently assisted the National Security Council in redefining the President's policy on U.S. export controls.

OSTP has been active in several areas affecting industrial competitiveness. For example, OSTP has the responsibility for implementing P.L. 100-418, which created the National Advisory Committee on Semiconductors. After a series of meetings in 1989, the committee released its report A Strategic Industry at Risk. OSTP has also provided active participants in policy forums on advanced imaging technology, high-resolution television, and x-ray lithography.

Through my membership on the Space Council, OSTP plays a major role in reviewing and developing U.S. space policy. In the past, OSTP has also worked closely with NASA and other agencies on developing policies toward the National Aerospace Plane, Space Station Freedom, and NASA's space sciences program.

In the life sciences, OSTP has begun to plan and coordinate government-wide initiatives for the Decade of the Brain, which has been established by Congress and the President to recognize the dramatic increases in knowledge about the brain and its disorders and the formidable challenges of the future. OSTP has also been engaged in activities involving biotechnology and the human genome project.

Last year, it was my pleasure to recommend to the President the awarding of 27 National Medals of Science and Technology for distinguished achievement in mathematics, science, engineering, and technology and 112 Presidential Awards for Excellence in Science and Mathematics Teaching to the nation's top science and mathematics teachers.

Finally, OSTP has been working with the Office of Presidential Personnel to identify highly qualified candidates for a range of top-level science appointments.

FEDERAL R&D BUDGET

"The budget's chief emphasis is on investment in the future," according to President Bush, and that emphasis finds strong affirmation in the Administration's support of science and technology in the President's 1991 budget. Altogether, the budget proposes a healthy increase of 7 percent in the conduct of both civilian and defense R&D by the federal government. Even more encouraging to me is the distribution of that funding. The Administration's proposals would increase civilian R&D 12 percent, from the $23.8 billion that was enacted in FY 1990 to $26.7 billion in FY 1991. Basic research would go up about 8 percent, from $11.4 billion to $12.4 billion. At a time of declining real defense expenditures, proposed defense R&D would rise by 4 percent and defense basic research would go up by 5.9 percent. As evidenced by President Bush's first budget, science and technology are going to be major and ongoing concerns of this Administration.

Altogether, the total conduct of R&D, both civilian and defense, would rise to $68.1 billion. Adding $3.1 billion for the construction, repair, and modernization of R&D facilities brings the total proposed federal support for R&D to $71.2 billion. This amount is 5.1 percent of the total budget for FY 1991 and 1.3 percent of the U.S. gross national product. In FY 1990, the corresponding percentages were 5.0 percent of the total budget and 1.2 percent of GNP.

This year's budget proposals have the effect of changing the proportions of civilian and defense R&D funded by the federal government. During the 1980s, defense R&D rose much faster than civilian R&D, reaching a peak of 69 percent defense and 31 percent civilian in 1986 . Since 1986, the ratio of civilian R&D to defense R&D has been growing steadily, and in FY 1991 civilian R&D is projected to be 39 percent of the total conduct of federal R&D.

PRIORITIES

The Office of Science and Technology Policy is charged with reviewing and coordinating federal R&D that cuts across the missions of more than one federal agency and with providing advice to the President on issues of science and technology policy that affect national and international policy. In light of these responsibilities, OSTP has defined several areas that will receive major emphasis in the coming year.

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Basic Research

Basic research provides a continuing flow of fundamental new knowledge, and federal support for basic research is an essential investment in the nation's scientific and technological future. Our country is unique in the extent to which our universities both conduct the research that expands the base of fundamental scientific knowledge and simultaneously prepare future generations of scientists and engineers to use that knowledge in an innovative and creative fashion.

This university-based, individual-investigator and small group research still constitutes the heart of our science and technology enterprise. Funding for this research must be protected to maintain the diversity and vitality of American science and technology.

A significant problem has arisen, particularly in the National Institutes of Health and the National Science Foundation, where the fraction of excellent, peer-reviewed, new proposals from young investigators just beginning their academic careers has fallen significantly, dropping to below 30 percent for the first time in the postwar period. The discouragement caused by a lack of funding is particularly unfortunate at a time when the nation has a very serious need to recruit more young people into such careers.

The problem results, in substantial measure, from the fact that agencies such as NIH and NSF have responded in the past to urgent and reasonable recommendations that grants be made on a multiyear basis and that individual grants be increased to reflect the rising costs of doing research. The corresponding "outyear mortgages" now limit the number of new proposals that can be approved. A contributing factor is the demographic fact that the number of young scientists competing for such support continues to grow at a rate exceeding that of the available resources.

The federal government also supports basic research through construction of the large, expensive research facilities that are essential to progress in areas ranging from space sciences to particle physics to materials engineering. Large facilities are important not only for academic research but also for industry-oriented research. OSTP will work to ensure that a balance is maintained between the demands of these large facilities and those of individual investigators.

Science and Technology for Economic Growth

Our ability as a nation to commercialize scientific and technological innovations effectively is a major factor in assuring our long-term economic growth, industrial competitiveness, and national security. The United States spends more on research and development than does any other country in the world. We must continually assess the role of government and industry in the technology commercialization process to ensure that we realize the full potential of this public and private investment. Indeed, defining new relationships between the public and private sectors to achieve this goal will be a major challenge of the 1990s.
Specific concerns on which OSTP will focus are:

- Catalyzing state and local activities in industrial competitiveness to obtain maximum leverage for federal funds.

- Improving the technology transfer process from federal laboratories to the private sector.

- Encouraging the development and application by the private sector of critical technologies that exert strong leverage on the U.S. manufacturing sector and other sectors of the U.S. economy.

- Refining our technology policy to establish guidelines for future federal R&D investments.

- Fostering an effective three-way partnership involving industry, academia, and government.

- Working to ensure an adequate flow of well-trained professionals in mathematics, engineering, and science.

A prerequisite for our future national well-being is a strong manufacturing sector. Our national policy toward technology has the primary underlying objective of encouraging this manufacturing base--particularly in the high technology end. In addition, the nation needs a better working relationship between government and industry and an improved climate for the formation of private sector R&D consortia. The sophistication and capital-intensive nature of modern technology require new ways of increasing cooperation between government and industry and of fostering communication on long-term technology goals.

SEMATECH, the consortium of semiconductor companies focusing on precompetitive research and development, is an important example of such government-industry cooperation. The goal in this case is to encourage cooperation among businesses to help bridge the current disconnect between R&D and timely commercialization of semiconductor chips.

OSTP plans to focus attention on several broad areas of advanced technology, including information technology, biotechnology, and materials science and engineering. Such "enabling" technologies, have application in a broad range of commercial sectors; however, no single company may be able to capture sufficient return to justify the required investment to develop the technology independently. This topic will be discussed separately below.

Science, Engineering, and Advanced Technologies

Advanced technologies cover the spectrum from basic research to engineering development in a broad range of fields. For purposes of illustration, the areas of information technology and materials science and engineering will be highlighted.

Information technology covers all aspects of computing, computer networks, and computer-aided design, engineering, and manufacturing. High-performance computing, while still a relatively small component of the overall industry, holds particular promise as a high-leverage technology that could expand dramatically in the future. A national computing network, ultimately linking research institutions, businesses, schools, and homes, will have very strong leverage on the rest of our economy.

Materials include the basic components of our industrial civilization, from ceramics, semiconductors, superconductors, and metals to polymers and composites. Important new insights into the nature of materials and new abilities to create materials, in some cases on an atom-by-atom basis, are ushering in an age of "tailored" materials that will have a wealth of everyday applications. OSTP intends to raise the visibility of this critical area of R&D.

Science and Technology for National Security

America's scientific and technological strength provides the qualitative edge that has long ensured our security and that of our allies. OSTP will continue to interact closely with the Department of Defense in providing advice to further advances in defense technology.

Particularly in times of international uncertainty and change, as noted above, a strong research and technology base is critical to promote investigation into promising new technologies and to guard against technological surprise from potential adversaries. OSTP is keenly interested in ensuring healthy levels of investment in critical and cutting-edge technologies central to tomorrow's defense.

Many of these technologies also have commercial applications. For example, they are integral to the development of the National Aerospace Plane, an aircraft designed to take off and land on a normal runway and fly through the atmosphere and into orbit at hypersonic speeds. The NASP program has also contributed to these technologies, generating important advances in composite materials and fluid dynamics.

The dramatic changes under way in Eastern Europe presage changes in the international environment and in the security needs of the West. The development and application of technology to support changing defense and foreign policy requirements in such areas as arms control verification technologies, intelligence collection, analysis and protection, and command, control, and communication capabilities are key OSTP concerns.

Life Sciences

The life sciences have made enormous progress during the last decade, yet they still represent a frontier with major advances already on the horizon that will dramatically enhance our quality of life. While research into diseases such as AIDS captures much attention, many other areas of investigation will also have a sweeping impact on our population: e.g., efforts to understand and ameliorate the effects of aging.

President Bush has designated the 1990s as the Decade of the Brain to focus needed public and scientific attention on the multidisciplinary efforts required to continue our progress in understanding mental illness, addictive disorders, and treatments for diseases that affect the brain. OSTP will be coordinating the activities of the individual federal agencies responding to this new initiative.

OSTP will also be concentrating on the human genome project and on biotechnology within the life sciences. In the coming year, for example, OSTP plans to examine the federal investment in biotechnology to identify those areas in need of attention. One such area is generic applied research involving technologies, such as scale-up technology, large-scale culture systems, and protein design, that have broad benefits. Another very important issue is the need for training the next generation of biotechnologists.

Global Change

Global change is one of several issues that highlight the increasingly interdisciplinary nature of science. At the federal level, this interconnectedness calls for an increasing number of R&D programs that involve different agencies and scientific specialties. The degree of success of the global change R&D program in predicting atmospheric temperatures, for example, will depend on effective communication between these specialties.

As our depth of knowledge increases, effective communication among scientists in different disciplines becomes ever more critical. OSTP will play an important role in facilitating the necessary cross-fertilization among scientific communities.

The global change area is one where the effectiveness of the FCCSET mechanism has been demonstrated in striking fashion by the activities of FCCSET's Committee on Earth Sciences. This Committee has carefully coordinated and integrated the activities of eight federal agencies into a national research plan aimed at greatly improved understanding of the phenomena underlying global change.

Because this is truly an international matter demanding international resolution, and because the President has made it clear that in this area--as in all others -- U.S. national policy must be based on sound science and sound economics, he will host an international White House Conference here in Washington on April 17-18 of this year that will bring together the three senior government officials in science, economics, and the environment of each of the participating countries. The goals of the conference will include sensitizing these three communities to each other's activities, focusing on the gaps and uncertainties in current scientific and economic understanding, improving the analytic tools and data required to address problems of global change, and developing at least an initial framework for international research that draws on the resources, expertise, and data of all of the participating countries (this framework will parallel, in part, the national plan developed by the Committee on Earth Sciences).

International Science and Technology

The results of basic research have always been a global resource adding to the knowledge base and ultimately to the economic prosperity of all nations. While the social rate of return on investment in basic research is very high, benefits do not accrue only to sponsoring countries or governments but rather to the world at large. This being the case, where possible, nations need to coordinate planning and support for basic research, as in the above example of global change. Coordination is especially needed for projects that require extraordinary financial commitments, such as the Superconducting Supercollider, Space Station Freedom, and mapping of the human genome, and that involve science and engineering talent from many nations.

OSTP is developing a framework for dealing effectively and comprehensively with the challenges of coordinating science and technology on a global scale. This comprehensive approach will be addressed within the FCCSET structure. Existing bilateral science and technology relations with countries and regions such as Japan and the European Community will play an important role in this effort, as will emerging cooperation with the Soviet Union, Eastern Europe, and developing countries.

Science, Mathematics, and Engineering Education

Education at all levels needs to be revitalized. This revitalization involves not only the training of our scientists, engineers, and technical workforce but also the education of a population sufficiently literate in science and technology to deal with the social issues arising from rapid scientific and technical change.

Achieving such a goal will require a broad-based approach involving businesses, academia, educational organizations, and State and local governments. For example, businesses are playing an increasingly important role in the training and retraining of our workforce. Junior colleges and technical schools provide a means of upgrading the skills of our youth and workforce. And last but not least, the precollege level is where life-long interests in science and mathematics are aroused, if they are to be aroused at all.

Through FCCSET, OSTP is developing a framework for interagency coordination and collaboration for mathematics, science, engineering, and technology education. The goal is to develop an effective and appropriate role for the federal government in support of the states, localities, and universities as they reform science and technology education.

CONCLUSIONS

Though the FY 1991 budget covers a wide range of R&D activities, several underlying themes unify the Administration's science and technology policy:

- **The first is to preserve the initiative, independence, and creativity of American scientists through a stable multiyear pattern of funding for basic research and continued real growth in federal R&D funding.**

- **The second is to foster a more efficient and effective coupling between R&D and commercial production.**

- **The third is to ensure that the best scientific advice is an integral part of all policy decisions on the environment.**

- **The fourth is to contribute to international cooperation through international support of large science projects such as the Superconducting Supercollider and the Space Station, along with international cooperation on a wide range of other scientific endeavors.**

- **Finally, a key goal is to improve national literacy in science and mathematics and meet future requirements for trained people in science and engineering. This is essential for our future economic prosperity in an increasingly technological and competitive world.**

R&D IN THE FEDERAL BUDGET: 1991 AND BEYOND

D. ALLAN BROMLEY
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Executive Office of the President

AAAS Science and Technology Policy Colloquium
Washington, D.C.
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When the President's FY 1991 budget was released on January 29, I held a press conference at which I called it an excellent budget for R&D in what is otherwise a very difficult budget year. I continue to believe this budget to be an excellent one for R&D. The overall increases in the budget -- 7 percent total for federal R&D, with a 12 percent increase in nondefense R&D and an 8 percent increase in basic research -- reflect President Bush's strong belief that research and development are a vital investment in our nation's future.

I am not going to describe in detail the components of the budget, because I know that will be done during much of this colloquium. Rather, I thought I would describe some of the thinking that went in to the formulation of the President's 1991 budget, and that will go into the formulation of future budgets. I will mention some of the problems that this budget tries to address -- and some that will have to be addressed in future budgets. And I will cover some of the long-term priorities for the Office of Science and Technology Policy.

FCCSET AND PCAST

But before that, I thought I would describe some of the institutional changes associated with OSTP that have been going on during the last several months, changes that may have a substantial effect on future R&D budgets. First, and most important, for the first time in the history of OSTP I now have the four Presidentially appointed, Senate-confirmed Associate Directors called for in OSTP's founding legislation.

One of the next most important developments, in my view, is the reorganization and revitalization of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which was established by that same legislation. FCCSET is the interagency group within the Executive Office that is charged with reviewing, integrating, and coordinating the R&D activities of the federal government that cut across the missions of more than one federal agency. As such, FCCSET has the potential to play a substantial role in shaping federal R&D efforts and guiding budget decisions.

There have been two meetings of FCCSET since I came to Washington last summer, and at both meetings we had excellent representation from the agencies, with Cabinet secretaries and heads of independent agencies constituting the majority of those in attendance. In general, we foresee a substantially altered and enhanced role for FCCSET within the White House. For the first time since it was created, FCCSET should be functioning as it was designed to function.

Much of the impetus for FCCSET's revitalization has come from the recent success that several FCCSET committees have had in coordinating cross-cutting areas of science and technology. For example, the Committee on Earth Sciences has taken all of the formerly disparate research being done by federal agencies on the global environment and has organized it into the U.S. Global Change Research Program -- a coherent, government-wide approach to the scientific understanding of global change. This is the kind of coordination I expect FCCSET to bring to many other important areas of science and technology.

FCCSET has recently formed seven new umbrella committees, each chaired by a high-level official of a Federal agency or department, to oversee broad areas of science and technology. Subcommittees and working groups will be active within each of these umbrella committees to examine, coordinate, and integrate federal activities in selected areas of science and technology. The seven umbrella committees are in (1) earth and environmental sciences (chaired by Dallas Peck, Director of the U.S. Geological Survey), (2) education and human resources (chaired by James Watkins, Secretary of the Department of Energy), (3) food, agriculture, and forest research (chaired by Charles Hess, Assistant Secretary for Science and Education of the Department of Agriculture), (4) international science and engineering (chaired by Reginald Bartholomew, Under Secretary for Security Assistance, Science and Technology of the Department of State), (5) life sciences and health (chaired by James Mason, Assistant Secretary of the Department of Health and Human Services), (6) physical, mathematical, and engineering sciences (chaired by Erich Bloch, Director of the National Science Foundation), and (7) technology and industry (chaired by Thomas Murrin, Deputy Secretary of the Department of Commerce).

I expect FCCSET to be a powerful influence in helping to shape and implement federal science and technology policy. The planning and coordination provided by FCCSET will allow for more effective use of the scientific and technological resources of federal agencies. FCCSET will also help to develop and review, in close cooperation with the Office of Management and Budget, annual and long-range federal budget plans in selected cross-cutting areas of science and technology.

Policy matters internal to science and technology will be resolved within FCCSET. Policy input involving science and technology to broader issues with strong political and economic components -- such as global change -- will be channeled to the Domestic Policy Council or the Economic Policy Council for Cabinet-level consideration and eventual presentation to the President through a new Working Group that will report to both Councils and that I chair.

One problem with FCCSET in the past has been that it has had very little input from the private sector. In the future, much greater input will come from the President's Council of Advisors on Science and Technology, a group of 12 distinguished scientists and engineers that the President established in February. PCAST has held two meetings thus far -- the first at Camp David in February, and the second in the White House complex last month. The President and several of his top advisers participated in all or part of both those meetings and were involved in very candid discussions with the PCAST members.

Because I chair both FCCSET and PCAST, I have the opportunity to coordinate their actions so that each benefits from the other's activities. For example, much of the work of PCAST will be carried out through panels chaired by PCAST members and with extensive private sector representation. These panels will in many cases parallel the committee and subcommittee structure of FCCSET, so that the concerns and activities of the private sector can be taken into account in the deliberations of FCCSET committees and so that PCAST can be aware, in detail, of relevant governmental plans and activities.

SETTING PRIORITIES IN THE FEDERAL BUDGET

As in the case of the Committee on Earth Sciences, FCCSET committees can have a very substantial effect on federal R&D budgets. Working through OSTP and through the Office of Management and Budget, FCCSET committees can scrub the components of cross-cutting programs, making it possible to consider the program as a whole, as a coherent national activity rather than a collection of agency programs.

Regarding the interactions between OSTP and OMB, our two offices have established an excellent working relationship. Our respective staffs work together at all levels to review the distribution of federal funds and to ensure that the Administration's proposals to Congress represent the most efficient and effective allocation of those funds. This interaction is also extremely important in the priority-setting process that goes into the development of the Presidential budget requests.

It may be helpful to describe how this priority-setting process worked last fall, because some variant of it will be applied in the future. Last fall Dick Darman and his senior staff reviewed all R&D programs to determine an optimum allocation of funds across the R&D agency budgets. I participated in virtually all of the reviews dealing with science and technology and will continue to do so in future years. It was a very difficult process, since almost all of the agency budget proposals were excellent and worthy of support. Unfortunately, in the reviews that were completed this past fall, the available budget resources would not stretch to cover all agency efforts -- nor, I suspect, will there ever be enough resources to cover all of the proposals.

As a result, this last fall, OMB, with substantial input from OSTP, applied three quite simple guiding principles in prioritizing the agency requests.

1. The first principle is that support is required for certain programs that address national needs and national security concerns. Examples would be scientific research to address global change, a preeminence in space, and adequate support for the defense technology base. Out of these considerations, I might add, comes the division between civilian and defense needs.

2. The second principle is the adequacy of support for basic research. In my view, basic research--and particularly university-based, individual-investigator and small group research--constitutes the heart of our science and technology enterprise. Funding for "small science" must be guaranteed if American science, as a whole, is to flourish. Thus, in evaluating agency programs, a concerted effort was made to ensure that small science received high priority in the agencies' final programs.

3. The third principle is to ensure an adequate level of funding for the scientific infrastructure and facilities in this country, including large facilities. Large facilities, such as the superconducting supercollider, Space Station Freedom, and, in a more distributed sense, the human genome project, are essential if American scientists are have, in future, the facilities and the infrastructure necessary to take them to the research frontiers of their fields. Once these facilities are built, they serve thousands of scientists and make possible a scientific understanding of the world and universe in which we live.

The final step in preparing the Administration's budget was a series of meetings with the President. Dick Darman and I, in each case with the affected Cabinet secretary or R&D agency head, sat down on a case-by-case basis with the President to resolve the budget priorities within the constraints of the available budget resources. The President made the final priority decisions -- as indeed he should. The budget that was presented to the Congress this January was the end result of this process, and the same basic process--with a substantially enhanced FCCSET role--is expected to apply to the R&D component of federal budgets in the future.

PROBLEM AREAS IN THE BUDGET

That process resulted in a good budget for science and technology this year, but there remain several areas of concern.

One very serious problem involves the funding rate for grants at the National Institutes of Health and the National Science Foundation. Despite nearly a decade of funding increases at those two agencies, the money available for new, young investigators is very tight. During fiscal year 1989, for the first time ever, the fraction of excellent, peer-reviewed, new proposals that were actually funded by these two agencies fell below 30 percent. The discouragement caused by a lack of funding is particularly unfortunate at a time when the nation has a very serious need to recruit more young people into scientific careers.

There are several reasons for this state of affairs. One is that the rate of inflation for research in the physical and life sciences is higher than the consumer price index (sophistication inflation), and the nonearmarked dollars available to NIH and NSF have not kept pace.

Members of the scientific community also built part of this problem for ourselves. For years, we argued for multiyear grants and contracts to cut down on the amount of paperwork required to do research. Both NSF and NIH have responded to those requests, and in the process they have built substantial "outyear mortgages" for themselves.

Simple demographics are yet another contributing factor. About 87 percent of all the scientists and engineers who have ever lived and worked are active today, whereas only 4 percent of all the human beings to have lived on this planet are alive today.

Finally, we must also recognize that, to some extent, we are the victims of our own success. It has been a remarkable decade in science. The increased funds devoted to research during the 1980s have produced a wealth of advances, which in turn have created an exponentially increasing number of exciting opportunities throughout the scientific disciplines. The number of high-quality applications is growing steadily. We must find some way of dealing with the remarkable progress that we have made.

Another area of concern for the budget involves how Congress will treat the President's proposals. As you well know, the President proposes, but the Congress disposes. There is a strong base of support on Capitol Hill for science and technology, but the next few years will not necessarily be easy ones for science and technology on Capitol Hill; nor are substantial increases for R&D guaranteed. There are a variety of pressures on the federal budget that will continue to increase, and support for R&D is eminently vulnerable.

First and foremost are the pressures of the deficit. The Gramm-Rudman-Hollings deficit reduction act calls for a deficit target in fiscal year 1991 of $64 billion. In fiscal year 1992 the deficit target drops to $28 billion, and the year after that to zero. Barring a very great reduction in defense spending--and I do not believe that we can count on that at this time--savings will have to be found in current programs.

Science and technology in the federal budget are also in direct competition with programs that have very active and vocal constituencies. For example, funding for the National Science Foundation and for NASA falls under the same Appropriations Subcommittee that supports Veteran Affairs, Housing and Urban Development, and a number of other independent agencies.

A useful way to consider the problem such Subcommittees face is to reflect on the types of programs funded by the federal government. These can be divided into three categories: (1) outlays for obligations made in the past, such as commitments to Veterans or to Social Security (2) current needs, such as health care, the homeless, or the war on drugs, and (3) investments in the future. Thus, in the case of the National Science Foundation and other scientific agencies, the future is in direct competition with current needs and past obligations. In such a situation, it is always tempting to defer investments in the future and to respond to the much more demanding needs of the past and present.

Given these pressures, Congress does remarkably well at supporting science and technology. But Congress cannot do it alone. Research and development must have a constituency that is more commensurate with the importance of science and technology to our nation. I have talked a great deal this spring about developing a constituency for science -- a constituency for the future -- that would support the federal government's efforts to invest our future. Partially, this will depend on developing a level of scientific literacy in the country that enables people to understand, at least in outline, the importance of science and technology in almost every aspect of modern life. But it will also rely on your efforts, as the individuals who are at the interface between science and technology, the federal government, and the public.

Those of you here this morning bear a very special responsibility in helping the Congress to respond to the President's budget requests. It is essential that you make known your concerns about the importance of continuing -- and increasing -- the nation's investment in research and development to your Representatives and Senators. I have been asked repeatedly by members of Congress why, if the problems of funding are as serious as I maintain them to be, these members have not heard directly from their scientist and engineer constituents. This is a fair question.

It is simply no longer possible for the scientific and technology communities of this nation to expect someone else to make the case for science and technology. We need your help so that we can better help you and the nation.

FUTURE INITIATIVES

This problem of funding is, of course, one with which OSTP is continually involved. But there are other areas in which our office has begun to focus, and let me conclude today by mentioning a few of them. They include science and technology for economic growth, global change, science and mathematics education, high performance computing, materials science and engineering, and biotechnology.

SCIENCE, TECHNOLOGY, AND THE ECONOMY In the area of science and technology for economic growth, much has been written about the proper role of the federal government in promoting commercially important technologies. Some people have pointed to the loss of market share in key industries and have advocated that the U.S. government should move to bolster those industries through favorable tax treatment or direct subsidies. But the Bush Administration believes that private industry, not the federal government, knows what is best for private industry. The

Administration will not adopt a policy that has the effect of picking winners and losers in the marketplace.

Nevertheless, the Bush Administration does acknowledge the very important role for the federal government in supporting the development of generic, enabling technologies. These are technologies that are important in a wide variety of commercial applications and to our national security; however, no single company can capture enough of the benefits to justify investing an adequate amount of R&D in them. The rationale for investing in these enabling technologies is essentially the same as that for investing in basic research: individual companies cannot bear the cost and risk of such investments alone given the diffuse nature of the benefits.

In a speech to the American Electronics Association on March 7, President Bush pointed specifically to the importance of these enabling technologies. He said, "This Administration is committed to working with you in the critical precompetitive development stage where the basic discoveries are converted into generic technologies that support both our economic competitiveness and our national security. Here again we can help to level the international playing field on which you compete."

Later in the speech, the President noted that he would charge the Competitiveness Council, which is chaired by the Vice-President, with a new task: "to find ways that American industry can better translate new ideas and technologies into marketable products."

At OSTP, we believe that this is an important function for the Administration. OSTP's Associate Director for Industrial Technology William Phillips, who was confirmed last week, will be working with the President, with the Competitiveness Council, and with the other parts of the Administration to further this work on leveraging technologies.

The FY 1990 Defense Authorization Act requires OSTP to establish a panel to merge the lists of critical technologies prepared by the Departments of Defense and Commerce as of importance to the long-term national security and economic prosperity of the United States. We are now in the process of setting up that panel and beginning the examination of candidate technologies. The panel's first report will be submitted to the President on October 1 of this year and transmitted to Congress

30 days later. This will be an important process within OSTP, and we will devote a considerable amount of time to it this spring and summer.

GLOBAL CHANGE Another area that has occupied much of our time in the last few months has been global change. Next week I will be cochairing, together with Michael Deland of the Council on Environmental Quality and Michael Boskin of the Council of Economic Advisers, an international White House Conference on Science and Economics Research Related to Global Change. The conference will bring together delegations from 18 countries, the Organization for Economic Cooperation and Development, and the European Community for two days of discussions on the key scientific and economic questions surrounding global change. The conference will look at what is known about global change, what is not known, and how long will it be before the remaining uncertainties are reduced. In this way, the conference will complement other ongoing national and international activities that are contributing to the formation of policies on this issue.

A primary function of the conference, which is complementary and supporting the work of the U.N.-sponsored Intergovernmental Panel on Climate Change (IPCC), will be that of emphasizing the importance of economics as the glue that binds scientific understanding of global change phenomena with rational policy making -- both national and international -- in this area. Economic analyses have been conspicuous by their absence in most discussions to date of national and international policies concerning global change.

HIGH PERFORMANCE COMPUTING A third area of emphasis for our office will be high performance computing -- an important example of an enabling technology for industrial, research, and national security applications. Last fall I sent to the Congress a report entitled The Federal High Performance Computing Program, produced by the Computer Research and Applications committee of FCCSET. The program laid out by the report had four distinct parts. The first concerns developing the hardware that will, both with enhanced mainframes and through the use of parallelism, make possible TERAOP computers operating at trillions of operations per second. The second is developing the user friendly software technology and algorithms that will permit full and efficient use of the hardware capabilities that are now and will soon be available. The third is building a national fiber optic network that will increase the accessibility of geographically dispersed users to these supercomputers and reduce the incompatibility that now characterizes many computer networks. One of the major new areas that I see as a target here is that of education --- an area that has been more resistant to technological change than any other in our society. Another is the small business that up to now simply has been denied access to the power of major computer facilities. And the fourth is training the personnel who will extend the tremendous advances that have been made in the past.

To further coordinate and increase high-level attention for high performance computing, and to explore where there exists a basis for extending the Federal program into a national program, I convened a meeting earlier this year of agency heads and their deputy directors for R&D agencies that support high performance computing. A second meeting of this group was held last month and further meetings will be held as necessary. I expect that the result of this effort will be a far more coordinated program and budget submission for FY 1992.

<u>SCIENCE AND MATHEMATICS EDUCATION</u> A fourth area of emphasis within our office is that of science and mathematics education. I do not have time to discuss education in detail, but I want to outline our overall approach. During his State of the Union message, President Bush set down six goals for education, including making American students the best in the world in science and mathematics education. The Administration takes this set of national goals and objectives very seriously. The President and the Governors have agreed to work with Congress, with education groups, and with business to institutionalize a process to oversee the development of ways to measure progress against these goals and report regularly to the nation on whether they are being achieved.

We need to pursue a number of detailed steps to achieve the goals and objectives that the President and Governors have established. We need more magnet schools for science and mathematics that can inspire our most gifted young people. We must focus on the "forgotten middle"--the technicians who will be running the high-technology factories of the future. And we need to encourage more women and minorities to study science and engineering and to pursue technical careers.

MATERIALS SCIENCE AND TECHNOLOGY A fifth area is that of materials science and technology -- in my opinion an orphan area in the federal government because it does not fall neatly into any given agencies or, indeed, into any of the traditional scientific or engineering disciplines. Yet this area is of enormous importance to almost every aspect of our increasingly technological society.

BIOTECHNOLOGY Finally, biotechnology may hold the promise in the coming decades that electronics and other products of the physical sciences did in the postwar decades. While we still hold a commanding lead in the related basic research areas, we are falling behind on international competitiveness in the critical scale-up of laboratory to industrial production facilities.

CONCLUSION

We are committed in OSTP, and indeed throughout the Administration, to strengthening, to the greatest extent possible, the science and technology base on which so much of our national future depends. But hard choices lie ahead: how best to balance large projects in science against funding for individual investigators and small groups, how to produce the steady stream of trained scientists and engineers that industry and universities will require in the 21st century, how to increase cooperation among universities, government, and the private sector.

The federal budget will reflect the decisions that are made in these and other areas. But the decisions themselves will come from our vision for the future of science and technology, from our deeper ideas of where we are and where we should be going. The first rule of the budget examiner is that God is in the details, and if I might apply that analogy to science, I would hope that as you delve into the numbers that we have presented this year, you might also spend some time reflecting on the broader import of those numbers.

And let me reiterate my plea for your individual help in building a national constituency for science and technology. In a very real sense, those of you in this morning's audience hold the future of American science and technology in your hands. Working together, we can maintain it as a central part of our national future -- and as perhaps the greatest adventure that is available to members of our species.

(B)

INTERNATIONAL SCIENCE AND TECHNOLOGY

D. ALLAN BROMLEY

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Thank you Dr. Lederberg.

I have often said in the past that the characteristic feature of our age is the unprecedented rate of change in science and technology. Recently, however, it seems that the rate of change in foreign affairs may even be surpassing us. A member of my office, my Assistant Director for National Security Affairs, happened to be in Berlin attending a conference the weekend that the Berlin wall first came down; she brought back some remarkable impressions of a world in the midst of change. That Sunday morning she was standing with a crowd of West Germans at Potsdamer Platz while East German cranes and construction crews worked to cut a new opening in the wall. A group of men standing on a small hill by the wall played French horns, and the West Germans talked quietly in the fog as they waited.

Not long after sunrise, the East German cranes moved a section of the wall away, and the East German border guards ushered their countrymen past the minefields and barbed wire and then through the gap. It was the first time in their lives that many of these people had been in the West, and the West Germans formed a spontaneous reception line, applauding and shaking the hands of the people who passed by.

According to my colleague, three things were sold out in the city of Berlin that weekend: bananas, radios, and champagne. In fact, she says that she has never seen so many empty champagne bottles in a single place. She has described it, aptly, as an intoxicating weekend; to the Germans I am sure that it was intoxicating in ways beyond our comprehension.

I would like to begin by exploring the connection between the rate of change in science and technology and the rate of change in political institutions, because I believe that the two are more closely related than may at first appear. In retrospect, it is relatively easy to discern the great changes in science and technology that have influenced the course of the twentieth century: the development of flight and the jet engine, the dramatic advances in health care and basic biological knowledge, the release of nuclear energy, both controlled and uncontrolled, and the Green Revolution.

But it is more difficult to recognize the ongoing scientific and technological revolutions that are dramatically changing society today. I would like to concentrate on one of the most pervasive and yet subtle of these influences: the information revolution. Actually, in my view there have been four critical technological revolutions in the past two centuries, including the information revolution. The first was the industrial revolution beginning about 1760 in the British midlands. It was over in less than 100 years; no one but a few misguided Luddites recognized that it was under way; it could not have been stopped once it started; and it changed forever the face of society. Next came the nuclear revolution in 1945--the release of nuclear energies--the fires of the atom. This was followed by the Green Revolution, which is much misunderstood but has saved the lives of millions. And no less important is the computer revolution--a revolution that has only begun. It shares many of the features of the Industrial Revolution, and it will have an ever more pervasive and permanent impact on our society. I have remarked elsewhere that the morning you awake to find that your toaster is smarter than you are, your view of society and your place in it may undergo rather dramatic change.

Information is rapidly becoming one of the most important forms of capital in the world. We are moving into an information age in which knowledge will be a key determinant of national and international affairs.

Yet of all forms of capital, information is the most fluid and uncontrollable. It may be possible to control the access of people to food, or to weapons, or to health care. But information exists on in our minds, or in the words on a piece of paper, or increasingly in the memory of a computerized data base. Governments have long sought to control information, but in the onslaught of the information age they are finding that control to be more and more problematic. As Oliver Wendell Holmes wrote, "A mind that is stretched to a new idea never returns to its original dimension."

The information revolution has been spurred on by several new technologies: the computer, communications satellites, in this country the fax machine. During the periods just before and after the June tragedy in Tianenman Square in Beijing, it was the fax machine, used as never before, by Chinese students in the United States to communicate with their compatriots in China that maintained an unbroken linkage with the valiant group leading the prodemocracy movement.

But some of the most important information technologies in the world today are not necessarily the most advanced. The technologies that have had the most dramatic effect in the countries of the Eastern Bloc are the radio, the television, and the VCR.

Those technologies have conveyed information about freedom, about democracy, about the advantages of market economies to people who have had none of those things, and those same technologies have conveyed back to us the result of that knowledge. It will make fertile ground for future scholars, studying the role of the fax machine, of television, and of VCRs in the revolutions of 1989.

In a 1988 article in Foreign Affairs, Walter Wriston wrote that "in the last years of this century, . . . the velocity of change in the world has become so great that there are literally no precedents to guide us. Policymakers are discovering that many of the events that are altering the world come not in response to their actions, but are driven by technologies which they may only dimly understand."

My own position as Assistant to the President for Science and Technology and the enhanced role of the Office of Science and Technology Policy in the Bush Administration attest to the reorganized importance of science and technology in national and international affairs. It has been estimated that nearly half of the bills that are considered in Congress have a substantial component of science and technology. And I can report from my own experience that science and technology are major considerations within the White House as well. It is no longer possible to divorce policy making from the influence of the scientific forces that are remaking our world.

At the same time, science and technology are the most truly international of all human activities. It is frequently the case that scientists and technologists are on more intimate terms with colleagues on the other side of the globe than they are with those on the other side of the hall. What happens in Japan or Germany in biology is often of more interest to a biologist than what happens with neighboring labs.

This international dimension of science finds best expression in the person-to-person and institution-to-institution bonds that are formed through years of education, collaboration, and communication. Education is the first and most important of these unifying forces. In this country, educational exposures work both ways. Students from other countries are educated here in the United States, and American students, postdocs, and mature scientists spend sabbatical years or other periods in foreign institutions.

We in the United States believe in open and equitable access to our education institutions, not only for the students of this country but for the students of any country. Many countries have been eager to take advantage of this access, because it remains a fact that the United States has the best system of graduate education anywhere in the world. As a result, nearly half of the engineering graduate students in this country are foreign citizens. The proportions are about the same for mathematical sciences and computer science, and just a little less for the physical sciences.

These proportions do not imply that there are too many foreign students in the United States. Rather, there are too few American students enrolled in these programs. The United States faces serious shortages of trained personnel in certain areas of engineering and computer science in the 1990s, and the shortages are likely to become worse. Over the last two decades of this century, the population of 18- to 24-year-olds will have declined by 19 percent. At the same time, surveys of college freshmen show that interest in science and engineering has declined substantially. Interest in majoring in science is down by one-third over two decades, and interest in majoring in engineering decreased by one-quarter in seven years. Perhaps most disturbing is the fact that interest in computer science--central to the information revolution--is down by fully two thirds in the past four years!

As it is, without the very large fraction of foreign students who remain following their graduation to take up career positions in the United States, the shortages that we foresee in many of our scientific and technological fields would be vastly worse than is now the case. Already the U.S. economy depends on an influx of bright young people from abroad for its health and vitality.

This trend, of course, has not gone unnoticed abroad, and it is a matter of particular concern in much of the Third World. Leaders of those countries have accused the United States of draining away their most talented young people for the benefit of our economy and quality of life, and in so doing of reducing their potential for development and growth. This is a serious problem for these countries, and I shall return to it again in a moment.

Cooperation Among the Developed Nations

The free flow of students finds a parallel in the free flow of ideas around the world today, particularly when it comes to basic scientific knowledge. Much of the international character of science derives from its universality. Most research results from the United

States, or from Japan, or from the Soviet Union are available almost immediately, and the international language of science--most often a combination of mathematics, jargon, and labored English--ensures that anyone with the proper training will be able to read and comprehend those results.

The United States is firmly committed to the free and open international flow of basic scientific knowledge. We believe that all countries benefit from the dissemination of scientific results. Protectionism is as damaging in science as it is in trade. To quote my friend and predecessor William Graham, "Science is the rising tide that raises all ships."

This philosophy also underlies the U.S. approach to a very important subset of our scientific efforts today--namely, the megaprojects in science, such as the Superconducting Super Collider, the human genome project, Space Station Freedom, global change research, and the compact ignition Tokamak. The results of these projects are a global resource adding to the knowledge base of all countries. Consequently, it is not only desirable but necessary to coordinate the planning and support of these projects. We are moving toward the day when large science projects will be distributed around the world, reflecting the truly international character of modern scientific information.

Our office is currently developing a framework for dealing effectively and comprehensively with the challenges of coordinating science and technology on a global scale. One important input to this framework will be our existing bilateral scientific and technology agreements. In 1988, for example, President Reagan and Prime Minister Takeshita signed a new science and technology agreement based on the principles of equal access to research facilities, equitable contributions to basic research, adequate protection of intellectual property, and protection of security obligations.

This is just one of a very broad range of international science and technology agreements. The State Department estimates that the United States is involved in nearly 600 bilateral science and technology agreements involving more than 20 U.S. agencies and 120 foreign countries. The United States also contributes its support to multilateral organizations across a full range of scientific disciplines.

Given the changes going on in the world today, a greatly expanded focus of our office in the next few years will be new or expanded science and technology cooperation with the countries of the Eastern Bloc. Already, delegations from Czechoslovakia, East Germany, the Soviet Union, and Hungary have visited OSTP to explore the possibility of upgrading or starting new exchanges and cooperative research programs. The East Germans and Czechs, in particular, were quick to point out that their new science ministers are not communists but are, rather, respected scientists who will be putting together national policies. In general, we will be looking for opportunities to integrate science and technology cooperation with the President's broad foreign policy goals to encourage the independence and democratization of Eastern Europe.

With regard to the Soviets, a meeting has been scheduled for the spring of the Joint Commission established under the Basic Sciences Agreement. During that meeting, we are planning to explore expanded areas of cooperation in basic scientific research. Also, in the ministerial-level meetings now going on to prepare for the Bush-Gorbachev summit next July, discussions are under way to develop new initiatives for future cooperation in such areas as environmental protection, manned and unmanned space exploration, and, of course, basic research.

At the same time, we will remain alert to Soviet efforts to acquire Western technologies with military application. We recognize that increased East-West interaction brings expanded opportunities for sensitive technology transfer, even as it brings opportunities for mutual benefit. And we will encourage our allies to be equally vigilant.

International Competition

There are many exciting opportunities for cooperation between the United States and the rest of the world, including the developing world, which I shall discuss in a moment. But there is a flip side to cooperation--competition. It is critically important that we recognize that we are faced with a highly competitive international marketplace. Today, 70 percent of all American-made products compete with imports. Of every dollar we spend, an average of 27 cents nationwide goes to imports. With the unification of the European Community in 1992 and the continued economic expansion of the Pacific Rim countries, that competition is only going to become stronger. The United States has become part of a truly global marketplace, though we have been slow to recognize that fact and modify our institutions accordingly.

The United States still has the strongest science and technology enterprise that the world has ever seen, but we no longer are in a leading position in all fields. By concentrating their resources and focusing their efforts, other nations have succeeded in equaling and in some cases in surpassing us--the Soviets in applied mathematics, the French in optics, the Japanese in electronics.

There is nothing wrong with this. It is a part of the orderly development of other nations and is due at least in part to the help that we have provided to other countries since the end of World War II. But the internationalization of the marketplace has modified the conditions under which research and development are performed. As I mentioned before, international parity in science and technology have greatly increased the opportunities for international cooperation in research designed to produce new knowledge. But when it comes to the application of that knowledge, considerations of competitiveness must take precedence.

I am convinced that competition is not inconsistent with cooperation. The results of fundamental research are, by their very nature, public knowledge. What can and, in some cases, must be protected are the details of a particular application of the results of this fundamental research. This particular know-how is, in the last analysis, our only edge in a world increasingly dominated by aggressive competitors with vastly lower manpower costs, higher productivity, and much more coherent national technological and economic policies than we have.

The competitive stance of the United States is determined by a large number of factors, only some of which involve science and technology. But let me briefly mention, as an example, one factor with which our office is involved: the protection of intellectual property. Adequate and effective protection of intellectual property is of great importance to this Administration and is an integral part of our international science and technology activities. In some cases, disputes over the protection of intellectual property have undermined science and technology relationships. Solutions to these problems, while not out of reach, will require forthright negotiation. We need to assess the precise nature of the problems and develop criteria that the State Department and the other agencies can use to guide negotiation in this area. Otherwise we may lose much of the benefit from these valuable science and technology relationships.

International Collaboration with Newly Developing Countries

Turning for a moment from the developed world, I would like to discuss another area of great opportunity for science and technology agreements. This involves what are often referred to as the Two-and-a-Half World countries: India, Brazil, and China. These three countries all have strong indigenous science and technology enterprises, but all are recognized in many areas as not being at the very frontiers of world science. All three have enormous reservoirs of human talent awaiting training. All have some difficulty in providing attractive opportunities for their trained youth in their domestic infrastructures.

The Reagan Administration recognized the importance of improving our bilateral interactions with these three countries in all areas. However, in the Heads-of-State discussions that focused on these interactions, it soon because clear that the only area in which programs of cooperation and collaboration could be established without what appeared to be insurmountable political barriers was science and technology. I had the privilege of chairing the Presidential panels that negotiated the bilateral agreements for scientific and technological collaboration with India and with Brazil, and I was involved in the negotiations with the Chinese.

There are enormous opportunities for the United States in all three of these countries, but it is essential that we treat these interactions as collaborations between effective equals rather than foreign aid. These are proud countries, and their scientists and politicians are particularly sensitive to any real or imagined condescension on the part of the United States.

In these negotiations, I found it of critical importance to base the selection of areas for cooperation on two simple criteria. First, both countries must have a real record of accomplishment in the selected areas to bring to the cooperation. Second, both countries must have a real need for the results of research in the selected areas. I would add that there is no shortage of areas where these two criteria can be fulfilled in excellent fashion.

Relations with the Third World

The situation changes drastically when you consider U.S. interactions with the Third World. In this area, I can only say that past U.S. efforts have been largely disastrous. Misunderstandings, inadequate preparation, and grossly inflated expectations have marred efforts on both sides.

One major problem is that we in the United States have never been able to sort out fully the rationale for our participation in programs of collaboration with the Third World. As I see it, however, there are several such rationales. The first is purely humanitarian. As people we are interested, from a purely humanitarian point of view, in improving the quality of life of those who are less fortunate than we are.

On a more practical and pragmatic side, we are interested in developing foreign markets for our goods and services. We must do this, in fact, if our balance-of-trade situation is to improve in the long term.

Also, inevitably, as the world becomes more and more a global village, and as even the most remote people are exposed to satellite television and radio, people in the less developed world will realize the profound difference that exists between the quality of their lives and that which we enjoy. Unless we do something to reduce this difference, and unless we are perceived to be doing something in this area, we face a world in turmoil.

There is much talk of technology transfer to the Third World. Much of this talk is far too glib. It assumes that technology can be neatly packaged in the developed world, transported with equal neatness to the Third World, and unwrapped and applied without significant change. Nothing could be farther from the truth.

Nothing can be transferred to people who are hungry, to people who are in the midst of political turmoil, to people who lack the educational background and training to implement the technology, to people who do not have the infrastructure required to retain some fraction of their own most able citizens to provide the midwife function for these new technologies.

What this implies is that our first focus must inevitably be on the development of an indigenous agricultural system that will feed the citizens of the country involved. Then we must help develop the political stability that is essential to effective assistance and development activity. And most important, from the point of view of our present concerns, we must assist these countries to develop adequate educational systems and the indigenous infrastructures that will make it attractive for a significant number of their own best young people to make their careers at home. Only then will it be possible to discuss realistically the kinds of science and technology that will help to improve the quality of life in Third World nations.

Thus, I am convinced that science transfer must precede technology transfer. When attention does turn to technology, we must focus on such fundamental areas as agriculture and health care. We must resist the temptation on our part, and the very real desire on the recipients' part, to focus on the more glamorous, high-technology areas.

Science and Technology in International Affairs

So what can we say about the United States' international science and technology arrangements in general? Obviously, these arrangements differ from one country to another, reflecting the state of that country's development and its past relations with the United States. But there are several broad principles that do apply in all of our science and technology agreements: comparable access, shared responsibilities for both basic and applied research, adequate protection and fair disposition of intellectual property rights, and effective protection of sensitive knowledge. The United

States will continue to pursue these goals in our ongoing negotiations with other countries, as it has in the past.

There is one other broad generalization that can be made about international science and technology in the United States. It will continue to become increasingly important. It is sometimes tempting to think that the great advances of science are behind us, that the rate of change cannot possibly maintain its breathtaking pace. This is nothing new. Lord Kelvin (1824-1907), one of the greatest scientists of his age (but who received his Nobel Prize not for his science but for his realization of the first transatlantic cable) stated unequivocally at the end of the nineteenth century that all that mattered in physical science was already discovered and that nothing remained to be accomplished except cleaning up a few minor details.

That impression is always completely mistaken. Great advances are on the horizon in science, advances that will change society in ways we cannot even imagine.

For example, I am completely convinced that the information revolution is just beginning. Certainly, with the continued development of high-performance computing and broadband digital networks, our access to information will increase by orders of magnitude. At that point, the greatest bottleneck in information handling will be the interface between the machine and the human using it. This puts a major premium on the development of software to take advantage of hardware capabilities, and particularly on the development of the most user-friendly interfaces possible.

Continued progress in basic biomedical research is going to continue to increase not only our knowledge of life but our ability to control it. Biotechnology is already reshaping the way we think about the production of many valuable pharmaceutical and chemical products. This revolution, too, is in its earliest stages. We will soon be able to give microorganisms, plants, and animals characteristics they have never had before, greatly increasing their value to human beings.

The interconnectedness of the earth system, an attribute that found its most succinct expression in the photographs of the earth taken by the Apollo astronauts, has now become a factor in national and international politics. The prospect of environmental change on a global scale is going to force nations to reexamine a wide range of policies in light of our understanding of the earth and its operation.

And soon we will be taking the next steps into space--first through a permanent manned presence in orbit, and then through journeys beyond earth orbit to the Moon and Mars. So far, our presence in space has its parallel in fourteenth-century oceangoing craft. As our ancestors required vastly improved seamanship to survive the unknown, so also do we require vastly improved spacemanship.

I understand that the Board of Directors of the Council of Foreign Relations is now considering an expanded program on the effects of science and technology on international affairs. I highly commend that activity. As it has in the past, the Council will be a central force in defining the foreign policy agenda of a rapidly changing world. Science and technology will be key factors in that world, and they must not be overlooked.

As I have mentioned, I believe that science and technology have a great deal to offer in any such reappraisal of international affairs. Scientists and technologists are used to talking with each other and working together. Agreements in science and technology can lead to agreements in other areas.

I have long maintained that we in the United States do not take advantage of science and technology as integral parts of our foreign relations. I was surprised recently to discover that Sweden had just installed its seventeenth U.S. technology attache in Detroit--for the obvious reason that its automotive industry wanted real-time information on what we were up to in our major automotive industries. In total, Sweden has 147 such attaches worldwide. We in the United States have none. I have also noted with more than passing interest the very effective role that members of French embassies worldwide play in advertising--in the best sense of that word--the capabilities and advantages that French industries and products can offer. Our embassies do not consider this part of their missions.

Indeed, President Reagan, noting that the number of qualified scientists and engineers holding posts in our embassies had dropped precipitously, signed an Executive Order requiring that the State Department actively recruit such persons. To the best of my knowledge, not one has been recruited to date. While I understand the impulse to find positions for Foreign Service Officers lacking such training, I believe that we are neglecting very important potential communication channels.

If I can draw one last parallel with the information revolution, science and technology are in many ways the original information revolution. What is science but knowledge about the universe, and what is technology if not information about how to use that knowledge for human benefit? Thus, in pondering the state of foreign affairs in the 21st century, one might find in science and technology the characteristics of a new, truly international sensibility. For as Louis Pasteur said, "Science knows no country because knowledge belongs to humanity and is the torch which illuminates the world."

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SCIENCE AND TECHNOLOGY IN THE BUSH ADMINISTRATION

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An Address to a George Washington University
Science and Technology Policy Seminar
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Let me begin by extending Allan's deepest apologies for not being able to be here this evening. His personal affairs have kept him away from this and several other events that he very much wanted to attend. He asks for your forbearance and hopes that he will be able to speak to many of you in different forums in the near future.

Stepping in for your boss on short notice is something that I've been asked to do more than once since coming to Washington 25 years ago. Especially when I worked on the Hill--for Emilio Daddario and Tiger Teague, among others, in the House and for Gordon Allott of Colorado in the Senate--I learned a great deal about the importance of staffs in government. Of course, I was on some very interesting staffs in those days. In Senator Allott's office, George Will was a senior staff member and wrote speeches for the senator. Another senior staffer was Paul Weyrich, who went on to make his own reputation in politics. In any case, I found filling in for the Chairman at affairs like this to be--interesting. As I tell my children, it builds character.

As I look around the room and see so many familiar faces, it's clear that there aren't many more knowledgeable audiences in this town or any other when it comes to science and technology policy. I doubt that you could put together a group with more science policy expertise than the group here tonight. So what I thought I would do, rather than simply stating some of the Administration's positions on issues close to your hearts and mine, is try to focus more on the process by which those positions are established. I'll concentrate on some of the big issues--including the budget, technology development, and global change--since these set the pace for many others. If you have questions about other areas, maybe we can get to them in the question and answer period.

The first thing I should do is discuss some of the changes going on in our office. OSTP is a much different place today than it was a year ago. It will never be a large office, but we are up to about 40 full-time personnel, from a low of around 15 to 20 at the end of the Reagan Administration. We are also about to have, for the first time in OSTP's history, all four of the Presidentially nominated and Senate-confirmed Associate Directors called for in the founding legislation. James Wyngaarden, the Associate Director for Life Sciences, was confirmed last November at the same time as I was. As soon as the Senate returns from its recess, we expect Eugene Wong to be confirmed as Associate Director for Physical Sciences and Engineering and William Phillips to be confirmed as Associate Director for Industrial Technology.

In addition to the four associate directors, we have a number of assistant directors in such areas as the environment, the physical sciences, and national security. In general, we feel that the office is now well structured to deal with the wide range of issues in science and technology that rise to the Presidential level.

The Office of Science and Technology Policy has two important components that play important roles in the science and technology advisory apparatus in the Executive Office of the President. One is the Federal Coordinating Council for Science, Engineering, and Technology, which was created by the same 1976 legislation that created OSTP. FCCSET is charged with reviewing and coordinating science, engineering, and technology activities that affect more than one federal agency.

In the past, several FCCSET committees--such as the Committee on Earth Sciences and the Computer Research and Applications Committee--have demonstrated the great advantages to be derived from effective coordination of cross-cutting issues in science and technology. For example, over the past several years, the Committee on Earth Sciences has organized all of the formerly disparate research on global change into the U.S. Global Change Research Program, which is now a coherent, government-wide approach to the scientific understanding of global change. Such coordination not only cuts down on duplicative research and increases the effectiveness of the research being done; it also gives particular areas of R&D increased visibility that can be used to emphasize important new initiatives in science and technology.

We are now in the process of revitalizing and reorganizing the FCCSET structure. We had the second meeting of the full FCCSET--chaired by Allan--last week. At both that meeting and the first meeting we had excellent representation from the agencies, with Cabinet secretaries and heads of independent agencies constituting the majority of those in attendance. In general, we foresee a substantially altered and enhanced role for FCCSET within the White House. For the first time since the FCCSET was created, it should be functioning as it was designed to function.

FCCSET is now in the process of establishing and populating several umbrella committees in such areas as health and the life sciences, the physical, mathematical, and engineering sciences, and education and human resources. Various subcommittees will be formed under these committees in such areas as high-performance computing, the social and behavioral sciences, and materials science and engineering. Our intention is to cover the broad range of issues in science and technology that need Presidential attention. In turn, FCCSET will provide input into the other White House Councils, such as the Domestic Policy Council and the Economic Policy Council, on major issues that contain substantial elements of science and technology.

Another important source of science advice is the President's Council of Advisors on Science and Technology, which the President announced at the beginning of February. PCAST held its first meeting at Camp David last month, and for over three hours, while a torrential rain fell outside, the Council, the President, and several of his top advisors discussed key issues in science and technology. The Council is a very forthright, as well as a very distinguished group, and I think you we can be assured that the President will be well-informed about both the promise and the problems of science and technology.

Allan is the chairman of both PCAST and FCCSET, besides being the head of OSTP. As such, he is able to coordinate the activities of all these entities. For example, he is considering the prospects of setting up committees under PCAST that would parallel some of the committees under FCCSET. This would allow input to the FCCSET committees from the private sector to a degree that has not been possible before.

Finally, Allan's elevation to the position of Assistant to the President has inevitably changed the role of science and technology advice within the White House.

He is a full member of the Economic Policy Council, the Domestic Policy Council, and the National Space Council, and he works closely with the National Security Council and the Competitiveness Council. When combined with the interest that Dick Darman and John Sununu have in science and technology, it is obvious that science and technology are much closer to the center of White House thinking than they have been in the past.

SCIENCE AND TECHNOLOGY IN THE FEDERAL BUDGET

One of the best reflections of the status of science and technology in the Bush Administration can be seen in the 1991 budget. As I.F. Stone has noted, in Washington "the budget is the message." I don't know how many of you have read through parts of the budget--which this year, by the way, is a quite lively and enjoyable document--but the two chapters on research and development are preceded only by a chapter on increasing savings. To the extent that you can read priorities from a table of contents, science and technology have done quite well.

The budget calls for a record $71.2 billion for research and development, a healthy 7 percent increase in what is otherwise a tight budget year. But our office is even more encouraged by some of the trends within that total. Civilian R&D would go up 12 percent, from the $23.8 billion that was enacted in FY 1990 to $26.7 billion in FY 1991. Basic research would rise $1 billion, from $11.4 billion to $12.4 billion, an increase of 8 percent. At a time of declining real defense expenditures, basic research by the Defense Department would go up by about 6 percent.

Many of you are probably familiar with the particular programs slated for increases within the President's budget, so I won't go into them here. Rather, I thought I would talk about the process by which some of these budget numbers are produced. Specifically, I thought I would talk about the roles and interactions of OSTP, the agencies, and the Office of Management and Budget.

Allan has an agreement with Dick Darman that OSTP and OMB will interact closely at all staff levels in the development of the federal R&D budget. This interaction is designed to ensure that the Administration's proposals to Congress represent the most efficient and effective allocation of funds. It is also extremely important in the priority-setting process that goes into making federal budget requests.

The first step in this close cooperation takes place in the year preceding the submission of a budget. The FCCSET committees meet regularly to discuss R&D areas funded by a variety of federal agencies. Some of these committees and their working groups in the past have given attention to developing a national R&D budget for their areas--the Committee on Earth Sciences is the best example. Under a revitalized FCCSET, we expect this to be the norm rather than the exception.

Both OSTP and OMB staff are available to agency heads and to their staffs to review the focus and content of the programs of individual agencies. In the fall, when all of the agency budget proposals are presented to the Administration, OSTP and OMB staff have jointly evaluated and prioritized the agency programs in light of urgent national needs and Administration policy.

At this point, Dick Darman reviews all of these R&D programs to determine an optimum allocation of funds across the R&D agency budgets. During this last fall, Allan participated in virtually all of the reviews dealing with science and technology, and he will continue to do so in future years. It was a very difficult process, since nearly all of the agency budget proposals were excellent and worthy of support. And, unfortunately, in the reviews that were completed this fall, the available budget resources would not stretch to cover all agency efforts--nor, I suspect, will there ever be enough resources to cover all of the proposals.

As a result, this last fall, OMB, with input from OSTP, applied three quite simple guiding principles to prioritize the agency requests. The first principle is that support is required for certain programs that address national needs and national security concerns.

The second is the adequacy of support for basic research. In Allen's view, basic research--and particularly university-based, individual-investigator and small group research--constitutes the heart of our science and technology enterprise.

The third guiding principle is to ensure an adequate level of funding for the scientific infrastructure and facilities in this country, including large facilities. Allan has discussed these principles in more detail in recent Congressional testimony.

The final step in preparing the Administration's budget was a series of meetings with the President. Allan and Dick Darman, along with the affected Cabinet secretaries and other R&D agency heads, sat down on a case-by-case basis with the President to resolve the budget priorities in line with available budget resources. The budget that was presented to the Congress this year was the end result of this process, and the same basic process--with a substantially enhanced FCCSET role--is expected to apply to the R&D component of federal budgets in the future.

GLOBAL CHANGE

In addition to our work on the budget, an issue on which we have done a great deal of work is global change. As you know, some people have accused the Bush Administration of moving too slowly on this issue and doing less than other countries. But an examination of the facts, as opposed to the rhetoric, gives quite another impression. If you judge a nation's commitment in this area by its budget numbers, no other country comes close to the United States.

A comprehensive process now under way is establishing U.S. policy on global change. That process, combined with the ongoing research program developed by the Committee on Earth Sciences, provides a responsible approach to dealing with global environmental change.

First of all, Allan chairs a Working Group on Global Change under the Domestic Policy Council. The Working Group provides a Cabinet-level coordinating mechanism on global change and is an important source of advice for the President.

The President feels strongly that domestic policy on global change should be based on the soundest scientific and economic information available. To acquire this information, the Working Group, as one of its first tasks, called for studies on the economic costs of global change and responses to it; the concerns and activities of the private sector regarding global change; and legal precedents for international agreements and conventions on the environment. In addition, the Working Group has set up a number of briefings by top experts on the scientific, economic, environmental, and industrial aspects of global change.

The next step in the process is a conference that Allan, Michael Boskin, and Michael Deland will be cochairing on the seventeenth and eighteenth of next month here in Washington. The conference will bring together the three senior officials in science, economics, and the environment from a number of countries to look at the tools and data needed to deal with global environmental problems.

Meanwhile, the U.S. government is continuing to support the work of the Intergovernmental Panel on Climate Change, or IPCC, which is sponsored by the United Nations and the World Meteorological Organization. The three working groups of the IPCC met here in Washington last month in plenary session. That is where the President delivered his speech on global change that was so much in the news.

The IPCC process is designed to provide input to an International Framework Convention on global warming to take place next year. At the Malta summit last December, President Bush proposed that the United States be the location for the first negotiating session for a Framework Convention, and he reiterated that offer to the IPCC last month.

The issue of global change is of great importance to this nation and to the planet. We must make sure that decisions are made on the basis of the best information available, and the Administration is now in the process of gathering that information and making those decisions.

THE MEGAPROJECTS AND INTERNATIONAL COOPERATION

I would like to discuss in somewhat greater detail one area that particularly affects my work at OSTP: that of the large facilities, or megaprojects, in science. These projects, such as the Superconducting Super Collider, the human genome project, Space Station Freedom, global change research, and the compact ignition Tokamak, are both expensive and of great interest worldwide. The results they produce will be a global resource adding to the knowledge base of all countries. Consequently, it is not only desirable but--increasingly--necessary to coordinate the planning and support of these projects.

The outlines of international cooperation on many of these projects are already becoming clear. For example, the European Space Agency, Japan, and Canada are contributing laboratory modules and other hardware valued at more than $7 billion for Space Station Freedom. On the Superconducting Super Collider, the Department of State has been working closely with the Department of Energy and other agencies, including OSTP, to develop a plan for involving other countries in planning, building, using, and managing the SSC.

In the past, because of shifting commitments by the U.S. government, we have developed a reputation as a somewhat unreliable partner in certain cooperative science projects. Part of the reason for this is a difference in how we make policy in the United States. Other nations make commitments for a number of years into the future on large projects. In contrast, we reevaluate our funding budgets every year and allow for the possibility of changing priorities.

OSTP is now beginning a study of how to develop a framework that will allow international cooperation on the megaprojects in science to move forward without international disagreements over commitments. It might be desirable, in this effort, to look at the megaprojects not one at a time but all at once. It might, for example, be easier to develop equitable funding arrangements and satisfactory geographical distribution if we average these considerations over a number of different megaprojects.

We also need to develop more stable and credible agreements to cover the megaprojects. At some point, we may even consider new treaty agreements to accomplish this end. OSTP is not yet ready to make recommendations in this area, but we are working within the Administration and with Congress on this subject.

SCIENCE AND TECHNOLOGY FOR ECONOMIC GROWTH

One last area that has consumed a great deal of our time is the proper role of the federal government in promoting commercially important technologies. Some people have pointed to the loss of market share in key industries and have advocated that the U.S. government should move to bolster those industries through favorable tax treatment or direct subsidies. But the Bush Administration believes that private industry, not the federal government, knows what is best for private industry. The Administration will not adopt a policy that has the effect of picking winners and losers in the marketplace.

But the options available to the federal government do not necessarily fall into the stark categories of massive government subsidies of favored industries on the one hand and a total "hands-off" approach by the federal government on the other. At OSTP, we strongly believe that the real choices lie in another direction, and we have been working within the Administration to promote some of these options.

First of all, it is obviously the responsibility of the federal government to create the macroeconomic conditions that are conducive to investments in research and development by private industry. President Bush has outlined a number of actions designed to establish such conditions, such as making the R&E tax credit permanent, cutting the capital gains rate, and reducing the deficit.

Secondly, the government has an important effect on competitiveness through its regulatory policy making. Government regulation can shape not only a company's domestic markets but its international markets, through the degree of harmonization between regulations here and abroad.

Third, the government must try to eliminate both real and perceived disincentives to industrial collaboration. These collaborations, from R&D through joint precompetitive ventures, provide a means for companies to share risk and pool resources, and they are common in other countries. Ironically, they are also common between U.S. firms and foreign firms. But this country has been slow in adjusting to the new reality that we are now competing in a global marketplace, and new mechanisms need to be found that allow companies and the federal government to work together to better meet this competition.

Finally, the government has a very important role to play in supporting the development of generic, enabling technologies. These are technologies that are important in a wide variety of commercial applications; however, no single company can capture enough of the benefits to justify investing an adequate amount of R&D in them. The rationale for investing in these enabling technologies is essentially the same as that for investing in basic research: individual companies cannot bear the cost and risk of such investments alone given the diffuse nature of the benefits.

In a speech to the American Electronics Association on March 7, President Bush pointed specifically to the importance of these enabling technologies. He said, "This Administration is committed to working with you in the critical precompetitive development stage where the basic discoveries are converted into generic technologies that support both our economic competitiveness and our national security. Here again we can help to level the international playing field on which you compete."

Later in the speech, the President said that he was going to charge the Competitiveness Council, which is chaired by the Vice-President, with a new task: "to find ways that American industry can better translate new ideas and technologies into marketable products."

At OSTP, we believe that this is an important function for the Administration. We will be working with the President, with the Competitiveness Council, and with the other parts of the Administration to further this work on leveraging technologies.

The FY 1990 Defense Authorization Act requires OSTP to set up a panel to identify critical technologies of importance to the long-term national security and economic prosperity of the United States. We are now in the process of setting up that panel and beginning the examination of candidate technologies. The panel's first report will be submitted to the President on October 1 of this year and transmitted to Congress 30 days later. This will be an important process within OSTP, and we are planning to devote a considerable amount of time to it this spring and summer.

CONCLUSION

In closing, let me say that science and technology are playing a very important role in the Bush Administration. The most important reasons for this are the President's recognition of the influence of science and technology on national and international policy and the President's receptivity, and the receptivity of his top officials, for the best information and advice in this area.

I also like to think that the competence, industry, and leadership of Allan Bromley, together with the assistance of the staff and advisors he has assembled, contribute to the current state of affairs. Allan is one of the best possible people we could have as science advisor, and I'm finding it a great joy, as well as a great challenge, to be a part of his staff.

SCIENCE AND TECHNOLOGY: FROM EISENHOWER TO BUSH

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Twenty-First Annual Leadership Conference
Center for the Study of the Presidency
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It is very appropriate that you would ask me to speak to you at this conference honoring the Eisenhower presidency, because it was President Eisenhower who first established the position I now hold within the White House, and it was Eisenhower who established the basic mechanisms for science advice that have achieved their fullest expression in the Bush Administration today. I wish I could say that Eisenhower's actions were the result of long, careful deliberations. It is true that they were the result of a long history of science advising within the White House, during which much of the groundwork for my position was laid. Still, it took a precipitating event for Eisenhower to take the step of naming a science advisor, an event that marked a watershed in both science and politics -- the launching of Sputnik on October 4, 1957.

It is easy to forget the almost hysterical response in this country to the launching of Sputnik. Edward Teller was quoted as saying that this country had "lost a battle more important and greater than Pearl Harbor." On another occasion, when asked what one might find if they were to travel to the Moon, Teller answered, "Russians." Newspapers editorialized about a national emergency, and many people worried about whether the Soviet Union had leapfrogged ahead of the United States in science and technology.

Eleven days after the launch, Eisenhower met with the Science Advisory Committee of the Office of Defense Mobilization to ask them how he should respond to the crisis. I. I. Rabi was chairman of the committee at that time, and he answered with his usual frankness. He said that the President needed a man who could work with him in the White House, someone the President liked, to clarify the scientific and technological dimensions of major decisions. James Killian then spoke up and said that the President should also have a science advisory committee that reported directly to him rather than through the Office of Defense Mobilization, which was the case for the existing Science Advisory Committee.

A few weeks later, Eisenhower took both of these steps. He appointed James Killian his Special Assistant for Science and Technology, and the Science Advisory

Committee became PSAC, the President's Science Advisory Committee.

From the outset, the chemistry between PSAC and Eisenhower was extremely good. Eisenhower referred to the group as "my scientists," and he later recalled that some of his happiest times in the White House were those he spent with PSAC. PSAC took on a number of very important and difficult issues, including the establishment of NASA, the management of scientific information, the limitation of nuclear tests, and curriculum reform in education. In his memoirs, Eisenhower wrote, "Without such distinguished help, any President in our time would be, to a certain extent, disabled."

The Characteristics of a Science Adviser

The relationship between Killian and the President was also very good, as was the relationship between Eisenhower and George Kistiakowsky, who became science adviser in 1959. Both of these men had many of the characteristics that have marked effective science advisors. They both had very well developed political antennae, partially because of their long experience in Washington. They also were very careful to work with other individuals in the White House, even though both of them had access to the President any time they wanted it. In doing so, they developed a number of allies within the White House, and the inner circle of the White House believed that they were part of the team and were prepared to work with them.

The scientific community often looks on the science advisor as its representative in the White House without recognizing his overriding need to both be, and be viewed as, a member of the President's political team. If he is viewed as a representative of the scientific community by the staff of the White House, his effectiveness can go to zero with blinding speed. Of course, part of the science advisor's job is to maintain the strength of the scientific and technological enterprise, so in that respect, his interests and those of the scientific community coincide. But the science advisor has responsibilities that extend beyond arguing the case for science and technology.

The most important of those responsibilities is to inject science and technology into the major policy decisions where it plays a part. This requires, of course, that the science advisor has access to these discussions in the first place, a requirement that has not always been met in the past. I am extremely fortunate in this respect, in that President Bush has elevated my position to that of Assistant to the President. (I might note, by the way, that Gordon Hoxie, the President of the Center for the Study of the Presidency, made this recommendation quite forcefully not long before George Bush's election.)

This action has made it possible for me to be a member of the Economic Policy Council, the Domestic Policy Council, and the National Space Council, and it has enabled me to work very closely with the National Security Council and with the Vice President's Competitiveness Council. It has also made it possible for me to attend the 7:30 staff meetings of the 13 assistants to the President where the events of the day are discussed. Much of the discussion at these meetings is necessarily political, and I know that some people within the White House have considered science advisors to be rank amateurs in this area. But they forget the many hours of practice that we've had honing our skills at university faculty meetings.

Another distinguishing feature of my office is the the President has appointed, and the Senate has confirmed, all four of the Associate Directors called for in the founding legislation, for the first time in the history of OSTP. I have sought to maintain a very collegial atmosphere among the Associate Directors and myself, so that issues that come to our attention are passed back and forth among us and worked on collectively. I have also been extremely fortunate in persuading OSTP's Associate Directors to join me in government, because working with them has been one of the most rewarding parts of my job.

The Ups and Downs of White House Science Advice

Like myself, James Killian and George Kistiakowsky were assistants to the President, but unfortunately the good relationships that Eisenhower had with his science advisers and with PSAC were not to last. President Johnson did not trust scientists much, and Nixon trusted them even less. Furthermore, Nixon had good reason not to trust them. In 1973, the members of PSAC received confidential information on both the Supersonic Transport and on antiballistic missile plans. One of the members did not agree with the Administration's decisions on these issues, and he went public, including giving testimony to Congress that opposed the President. Not surprisingly, Nixon concluded, "Who needs this?" and wiped out both PSAC and the position of science adviser.

This emphasizes a crucial aspect of presidential advisory committees. If, after having presented arguments on a particular topic, the committee or the President decide to go in a different direction, a member must quietly accept the decision or resign. A member does not have to support a course of action that he does not think is wise, but he does have a responsibility not to go public in opposition while retaining his membership on the advisory board involved.

When Ford came into office he acted very quickly, working closely with the Congress, to reestablish a White House science advisory apparatus. This was done through P.L. 94-282, which established today's Office of Science and Technology Policy. This involvement of Congress answered to the desire of Congress to have direct access to the nation's senior advisor in science and technology. But it does cause certain complications. I am the only one of the President's advisors who wears two hats, as both an assistant to the President and as the Presidentially appointed and Senate-confirmed Director of OSTP. As a result, whenever Congress wants to know the position of the White House on an issue involving science and technology -- or when they just want to beat up on the President a little -- they call me to testify. Since I was sworn in a little over a year ago, I've testified before Congress over 20 times, which is something like having 20 Ph.D. orals over the period of a year.

The President's Council of Advisors on Science and Technology

P.L. 94-282 also made provisions for establishing a new PSAC, but neither Ford nor Carter took this step. President Reagan, when he was elected, went halfway by establishing the White House Science Council, on which I was a member. This council had many of the functions of the old PSAC, but it also had some critical differences. PSAC reported directly to the President; the White House Science Council reported to the Science Advisor. The council also was not nearly as involved in detailed military matters as was PSAC.

Nevertheless, the White House Science Council set its own agenda, just as PSAC did. It responded to requests, but it also was quite free to raise issues that it saw boiling up to the Presidential level. During the council's existence, it accomplished much good work in areas such as federal laboratories, the health of the nation's universities, U.S. air space, and industrial competitiveness.

Nevertheless, while he was Vice-President, I believe that President Bush recognized at least some of the limitations of the White House Science Council, so that by the time of his campaign he was already thinking in terms of a higher-level body. In my opinion, President Bush, perhaps better than any other President since Jefferson, recognizes not only the importance of science and technology in our daily lives but the ability of science and technology to contribute to the basic national goals.

Certainly the events of the President's first 21 months in office have demonstrated both of those aspects of science and technology. Of the six national education goals established by the President and the nation's governors, no fewer than three involve science and technology, including the most ambitious of the six, that American students be first in the world in science and mathematics by the year 2000. Scientific input has also proven to be crucial to Presidential decision-making on questions of the environment, and particularly global change, which has risen to the top of the political agenda throughout the world. The President was committed to the formulation of a National Energy Strategy well before Iraq's invasion of Kuwait, and

I cochaired several meetings with Jim Watkins on the scientific and technological dimensions of that strategy. Let me just give you a quick listing of some of the other topics that have come to the President: AIDS research, SDI technology, space exploration policy, the fate of the U.S. semiconductor industry, the burgeoning costs of medical care, and the list goes on from there.

Recognizing the accelerating pace of scientific and technological change, the President, last February, took the long-awaited step of reestablishing an entity comparable to PSAC. It is known as the President's Council of Advisors on Science and Technology, and if that phraseology seems a bit stilted, you only have to consider the advantages of the acronym PCAST over PCSTA. PCAST's first meeting was held in February at Camp David with the President and his top advisors, and it has been meeting monthly since then. The President has sat in on a portion of all of those meetings, as have other individuals within the White House, and I believe I can say that they have found PCAST's deliberations to be extremely valuable. These are some of the best minds in the country, with backgrounds ranging across industry, academia, and government, and the discussions are as free-wheeling and as provocative as any I've known.

Since the demise of PSAC, concern has been expressed the freedom of information legislation passed in 1972 would destroy the effectiveness of presidential science advisory bodies. Some argued that letting the public in on PCAST discussions would mean that little of value would ever be discussed. This has turned out to be entirely erroneous. PCAST operates in full conformity with freedom of information legislation. We have open sessions at every meeting, but we also have closed ones, and freedom of information has not been a problem.

PCAST has also been able to follow in the tradition of PSAC in setting up panels of private-sector representatives to look at specific issues. A panel is now being formed on high performance computing and communications, and the group is considering panels in such areas as biotechnology and materials science. These panels will be a valuable source of input not only Presidential decision-making but into the broad range of federal activities in science and technology.

Coordination of Federal Science and Technology

This input will be especially welcome in the Office of Science and Technology Policy. The legislation that established OSTP gave it the responsibility of helping to coordinate the research and development programs of the federal government. However, OSTP has a staff of about 35 full-time employees, and the federal government's R&D budget is about $70 billion, so if we divide the responsibility equally, each of us would be in charge of a cool $2 billion.

In addition, there are many other demands on our time. The members of Congress understandably feel that our office has a responsibility to them, so they often add formal duties to our slate. The OSTP appropriations bill that was passed several weeks ago requested no fewer than nine separate reports from OSTP, with due dates ranging from next month to early next year. Individually, these reports are all perfectly reasonable and are just the sort of thing that the science advisor would be happy to accept. But even if we do nothing else in OSTP, it will not be possible to complete all of those reports.

I haven't even mentioned the brush fires that inevitably need to be put out. Just to give you an historical example: when George Kistiakowsky, who was a distinguished bomb chemist, came to Washington, he expected to cope with international science policy at the highest level. What he actually did for his first several months in Washington was to cope with a major threat to the cranberry market resulting from a pesticide scare! This sort of thing continues to take up a substantial portion of my time and the time of OSTP's staff.

Given these competing demands, we must constantly avoid the danger of not being able to fulfill our primary mission: that of advising the President. Fortunately, the legislation establishing OSTP also sets up a mechanism that help us perform one of our most important responsibilities: that of coordinating the federal government's science and technology activities. That mechanism is the Federal Coordinating Council for Science, Engineering, and Technology, which goes by the rather unfortunate acronym of FCCSET. FCCSET brings together representatives from the various federal agencies that are involved with science and technology to work out ways to mesh interagency efforts. It is the modern equivalent of the Federal Council for Science and Technology, which was established by PSAC during the Eisenhower Administration to perform a similar function, but which never managed to have much of an impact.

Unfortunately, when I arrived in Washington, FCCSET was also not having much of an impact. The reason, I discovered, was that the representatives to FCCSET were at too low a level. When FCCSET made a decision, that decision could be overruled by the heads of specific agencies, because those individuals did not consider themselves beholden to FCCSET. So I set out trying to elevate the level of representation on FCCSET, and as people recognized the value of an interagency White House council on science and technology, they were eager to take part. Today FCCSET consists of the heads of the technical agencies and independent agencies along with the Assistant Secretaries of the agencies that are involved in a less direct way with science and technology. Now FCCSET decisions mean something, and the council is making major strides.

Seven umbrella committees have been formed under FCCSET in specific areas of science and technology, and those committees, along with their subcommittees and working groups, have undertaken a variety of new activities. Many of these committees are using as a model a FCCSET activity that has had great success in the past few years. In 1988, the Committee on Earth and Environmental Sciences began putting together a coordinated, interagency program on the issues surrounding global change. Today, the resulting U.S. Global Change Research Program has become the centerpiece of the United States' approach to this issue. The President's 1991 budget requested a 57 percent increase for the program, to a total of over $1 billion. At least part of this request reflects the work of the Committee on Earth and Environmental Sciences and its subcommittees in eliminating overlap and meshing the efforts of the nine agencies involved in the program.

This year, two other committees are working on similar programs in mathematics and science education and high performance computing and communications. Next year, FCCSET hopes to do the same thing in biotechnology and in materials science and engineering. Eventually, our goal is to cover many of the most important areas in science and technology that extend across the missions of more than one federal agency.

Conclusion

Thus, as I see it, the ingredients for an effective science advisory apparatus are all in place: an interagency body that can coordinate the efforts of the federal government, a council of advisors that reports directly to the President, and a science advisor and associate directors who have access to White House decision making. Any one of these components can draw upon the other two for help. For example, PCAST can provide a valuable source of private sector input to the work of FCCSET, and the staff of OSTP can draw upon the deliberations of FCCSET bodies in preparing policy guidance within the White House.

The remarkable thing to me is that all of these entities already existed in the Eisenhower Administration, though some of them have only come to fruition during the past few years. Eisenhower recognized the importance of getting good advice on science and technology, and he was knowledgeable enough about the ways of government to know how to go about getting that advice.

In the speech that announced Killian's appointment and the formation of PSAC, Eisenhower commented on these needs. He said, "I have made sure that the very best thought and advice that the scientific community can supply, heretofore provided to me on an informal basis, will now be fully organized and formalized so that no gap can occur. The purpose is to make it possible for me, personally, whenever there appears to be any unnecessary delay in our development system, to act promptly and decisively."

And later in that same speech, Eisenhower noted the importance of this endeavor, an importance that if anything has grown since then. He said, "In conclusion, although I am now stressing the influence of science on defense, I am not forgetting that there is much more to science than its function in strengthening our defense. . . . The peaceful contributions of science -- to healing, to enriching life, to freeing the spirit -- these are the most important products of the conquest of nature's secrets. And as to our security, the spiritual powers of a nation -- its underlying religious faith, its self-reliance, its capacity for intelligent sacrifice -- these are the most important stones in any defense."

U.S. TECHNOLOGY POLICY AND THE PATH TO COMPETITIVENESS

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Executive Office of the President

Technology 2000
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It is a great honor and a great pleasure for me to be the first keynote speaker at the first of this new series of conferences for NASA. These are the kinds of events that must become increasingly common in the coming years. They give representatives of the federal government and of the private sector an opportunity to interact on a person-to-person level, and there is no substitute for that personal interaction. They also allow us to build the new partnerships that will be necessary to meet the competitive challenges of the 1990s, partnerships that have been all too rare in the past but that offer our best hope for the future.

I'm also here to bring you a message from the Bush Administration, and that is that this Administration is vitally interested in the prospects of this country's high-technology industries. The companies you represent define the leading edge of our national economy. If you were to falter or drop behind the international frontiers, the rest of the economy would be sure to follow.

We know that the stakes are high. They are high not only for your companies, for your employees, and for your suppliers and customers. They are also high for the federal government and for the nation, because if our private industry cannot compete in the global marketplace, we will be unable to achieve our goals in other areas of national concern -- in defense, in education, in health care, in the protection of the environment. The strength of the nation's economy is the foundation on which national policy is built, and ensuring the strength of that foundation must be a paramount concern.

Today, more than ever before, one of the key determinants of the strength of our economy is the proficiency of our technology. Other factors are also important, and I'll be talking about some of those later this morning. But you know better than anyone that the difference between success and failure in the marketplace often comes down to who has the better technology. If this country is going to remain an economic leader, we must retain our lead in technology.

I do not believe that we have lost that lead. On the contrary, the United

States continues to have the strongest science and technology base in the world, largely because of the generous support provided by the federal government, and ultimately by the American taxpayer, for research and development since World War II. However, a number of countries, by focusing their resources in particular areas, have moved up to equal -- and in a few cases surpass -- the position of the United States.

That is not necessarily bad. In fact, it was to be expected as other countries recovered from World War II and began to follow the United States' lead. What we must now do is ensure that, in all areas of science and technology where our activities do not define the frontier, they are close enough to those frontiers so that we can exploit, without delay, new developments whenever and wherever they occur.

An excellent example of our continued preeminence in science and technology is provided by NASA. There is no doubt that NASA remains far ahead of any other country's space program. It is a federal activity for which we can continue to feel admiration and pride. It has had a dramatic economic impact on this country through the technology that it has injected into the private sector. And, even more important, it has changed the way we think about ourselves, both as Americans and as human beings. That is the most enduring impact of the space program, and it is an impact that cannot be measured in dollars and cents.

Let me mention a few other strengths of American science and technology, because it will be important to keep these in mind in considering technology transfer and technology development. First, this country continues to have the strongest research university system in the world. At the undergraduate level on the average, and most especially at the graduate level, our universities continue to set world standards and typically attract the brightest young people from around the world. These research universities also provide a double dividend. They generate the new knowledge that drives both science and technology, and at the same time they produce the young minds trained to use that knowledge in new and more productive ways. In no other country does this process work as effectively.

The United States also continues to have a business climate that encourages the formation of new companies and allows successful companies to grow quickly into major businesses. The rapid growth of the biotechnology industry is one example -- with over 400 firms founded in biotechnology in the 1980s -- but there are other examples throughout American business. These small and medium-sized firms generate many of the most important new ideas in our economy, and they continue to generate most of the new jobs in this country. So long as adequate investment capital remains available for new start-ups, these companies will continue to contribute a dynamic quality to the U.S. economy that is not evident elsewhere.

Finally, the United States remains an open and restless society that prizes and rewards innovation. Our world is today changing at accelerating speed -- largely because of advances in science and technology -- and those companies that remain flexible and innovative are going to be the ones best able to take advantage of those changes. Brute force and size are no longer enough for success in American business. In the future, the spoils are going to go to the quick, to the smart, and to the tenacious. The massive production lines for which the United States has become famous can no longer be looked on as the paradigm, though the advantages of scale will continue to be important. We need greater flexibility and agility in changing our production capabilities, both to reflect technological changes and to match customer demand. And we must develop much greater sensitivity to that demand, particularly in the international marketplace.

U.S. Technology Policy

The strengths that I have just listed are all important factors in considering the proper role of the federal government in technology development. They indicate the directions that will be most fruitful, where federal programs can leverage the underlying strengths of our institutions. They also give an indication of what has worked best in the past, providing lessons that we can draw upon today, although not necessarily replicate.

We have recently been giving much thought to these issues in my office, the Office of Science and Technology Policy, because we take the name of the office seriously, and it has been my intention since coming to Washington to emphasize the "T" in OSTP. We took an important step in this regard a few months ago when we released a report entitled "U.S. Technology Policy." That report looks at the many facets of the federal government's current technology policy and shows how they fit together into a comprehensive framework. As such, it serves as a baseline for future dialog within the government and between the government and private industry.

The report points out that the federal government already supports a substantial amount of technology development. President Bush's 1991 budget proposed spending over $15 billion on applied research and development just on the civilian side, with even more than that proposed for defense applied research and development. Furthermore, well over a billion dollars of this money is focused on specific dual-use generic technologies, such as robotics, high-performance computing, semiconductors, superconductivity, and advanced imaging technologies.

Historically, the federal government has supported this work for two reasons: to meet its own needs in such areas as defense and space, and to meet broader national needs that can be seen as "public goods," such as better health care, the clean-up of pollution, or a stronger transportation or communications infrastructure. However, this R&D has also resulted, over time, in major advances in the private sector. Particular examples come immediately to mind: the development of commercial aircraft, the creation and growth of the computer industry, the strength of American agriculture. But in fact the impact is much more pervasive, because federal R&D has helped to establish the science and technology base from which industry has been able to draw in developing commercial products and processes.

The influence of federal R&D on private industry continues to be strongly felt today. Your attendance at this conference is one measure of that influence, as are the many spinoffs that continue to emerge from research supported by NASA. We must work to ensure, both within the federal government and within private industry, that this positive influence remains as large as possible. Where barriers to the transfer of knowledge and technology from the federal government to private industry exist, those barriers must be lowered.

NASA's Technology Utilization Program provides many valuable examples of how this can be accomplished. The Technology Utilization Officers at NASA's field centers are charged specifically with transferring technology to private industry, and we owe many of the spinoffs that are emerging from NASA's R&D work to them. The ten Industrial Applications Centers that NASA has set up across the country, together with their state-sponsored affiliates, also offer a direct means of transferring technology to private industry. The federal government can learn much from these policy innovations, even as it continues to build on these pioneering efforts.

Technology Transfer and the Federal Laboratories

Technology transfer from NASA's facilities is just part of a much larger picture. The federal government supports about 725 federal laboratories at a total cost of over $20 billion -- about a third of the total federal R&D budget. These laboratories embrace an astonishing breadth and depth of science and technology, including some of the best science and technology to be found. They are truly one of this country's most valuable assets.

However, a technology base is unlike many other assets: it must be put to use to be valuable. Several steps taken by Congress and the Reagan Administration in the 1980s provide the mechanisms needed for us to tap the expertise available in our federal laboratories and put it at the disposal of our industrial producers. For example, it is now the responsibility of every federal manager -- defense or civilian -- to consider the commercial ramifications of the work they are supporting and to encourage its commercial application. We must continue to promote these mechanisms so that they become business as usual rather than an additional layer of responsibility imposed on many others. In general, they must receive a much higher priority that has often been the case in the past.

We must also think about the missions and organization of the federal laboratories and make sure that the country is receiving the best possible return on its investments. For example, potential commercial applications should in many cases be considered not only in the conduct of R&D but in its planning. Furthermore, both the planning and the conduct of R&D should be guided by input from potential users. This will require that new alliances be established among federal laboratories, businesses, and universities so that the transfer of technology is maximized.

As you are well aware, this technology transfer is not easy. It is hard to transfer technology even within a large organization, much less between organizations, especially when there are large bureaucratic obstacles or cultural differences to overcome. In these instances, leadership, commitment, and vision at the very top of the organizations are essential to overcoming these barriers.

In addition, the term "technology transfer" is itself often misunderstood. It seems to imply that technology can be neatly identified, wrapped up, and transported with equal neatness to another organization, where it can be unwrapped and applied without significant change. Nothing could be farther from the truth.

In fact, there is only one way in which technology can be effectively transferred, and that is in the minds of people. The "transfer" that must take place is between two or more individuals in separate organizations. So the first and most important step in technology transfer is that the potential providers and potential users of technology must be brought together. We must make it much easier, for example, for federal scientists and engineers to work in the private sector, and vice versa, so that individuals with technologies firmly planted in their brains can move from one institution to another. Far too many needless restrictions and red-tape inhibit that exchange today, and we must reduce those barriers.

We must also foster the new partnerships that I mentioned at the beginning of my talk. Consortia and collaborative arrangements like SEMATECH make it possible to pool resources and specialize on problems, so that each firm does not have to reinvent the technological wheel. We must all work together -- businesses, governments, and universities -- to encourage these collaborations, while keeping in mind that their ultimate objective is to increase competitiveness, both domestically and internationally.

Critical Technologies Now and in the Future

So far I've talked mostly about using our existing assets more effectively. But many people want to go beyond that. They ask, "In addition to supporting dual-use technologies, shouldn't the federal government also support technologies designed to benefit private industry? To the extent that they increase American competitiveness, those technologies would also seem to qualify as a public good."

Despite what you might think -- and despite what you might have read in the press -- the Bush Administration believes that the answer to that question is yes. This Administration has made a clear commitment to support the development of generic, precompetitive technologies that are important in both the public and the private sectors.

In a speech to the winners of the National Medals of Science and National Medals of Technology two weeks ago, the President reiterated this commitment. He said, "Today, our government must help carry that [basic] research forward and contribute to the development of generic technologies that build on basic discoveries. If America is to maintain and strengthen our competitive position, we must continue not only to create new technologies, but learn to more effectively translate those technologies into commercial products. In this way, we can help leverage the R&D of the private sector, helping whole industries advance in an increasingly competitive global market."

Many questions have been raised about the meaning of the terms "generic" and "precompetitive," but in fact they have been defined quite precisely. A generic technology is simply one that has the potential to be applied to a wide variety of products and processes extending across many industries. A generic technology is typically not something that is commercially sold. Rather, it requires subsequent research and development, generally by the private sector, to result in commercial applications.

Precompetitive refers to a particular part of the innovation process. It applies to activities before the point at which a company can tell whether a specific technology has commercial potential. It would not apply, for example, to the development of application-specific commercial prototypes. With precompetitive R&D, results can be shared by a group of companies without reducing the incentives that any of those firms would have to develop products or processes based on that work.

These definitions are closely tied up with an important activity going on within my office -- the work of the National Critical Technologies Panel. This is a private sector-public sector panel that was set up under the auspices of OSTP by the 1990 Defense Authorization Bill. The panel has 13 members -- six from the private sector, and seven from the federal government, including the panel's chairman, Bill Phillips, who is my Associate Director for Industrial Technology within OSTP.

The panel's immediate task has been to merge two lists of technologies developed by the Department of Commerce and the Department of Defense into a single list of no more than 30 technologies that will be critical to our nation's future economic prosperity and national security. More broadly, the panel has been examining the pace of technological development in this country and in other countries and has been assessing the implications for international competitiveness.

The panel has had four meetings so far, during which it has developed a taxonomy of technologies and a set of criteria to determine which of those technologies are critical. It is now in the process of putting together a report to the President and to Congress, which will be released early next year.

Most recently, the 1991 Defense Authorization Bill has called on OSTP to follow-up the panel's work by setting up a Critical Technologies Institute. This institute would give OSTP an analytical arm for developing strategies to promote critical technologies. It would look at what governments are doing -- both at the federal and state levels -- and at what they should be doing. It would also evaluate programs that are already in place -- again at both the federal and state levels -- to see which programs are most effective.

Within OSTP, we are still considering how best to respond to this initiative. The institute is funded at $5 million, which is 50 percent larger than OSTP's current budget. But the Institute's funding currently extends for only one year, whereas any such effort would require a multiyear commitment. There are also many organizational questions to be answered before we can move forward to establish such an institute.

Role of the Department of Commerce

The legislation places the Critical Technologies Institute within the Executive Office of the President, but it is clear that any such Institute would necessarily work very closely with the Department of Commerce, the Department of Defense, NASA, the Department of Energy, and the other agencies involved in research and development. To take the Commerce Department as an example, we have already been working closely with Deputy Secretary Thomas Murrin and with Deputy Under Secretary for Technology Robert White and the Technology Administration of Commerce. It has been a very fruitful partnership, and we expect it to become even more so.

There are a number of programs going on within Commerce that, like the programs within NASA, serve as valuable models for technology transfer. Let me mention just two of them. One is the program to establish regional Manufacturing Technology Centers around the country, of which there are now three with several more in the planning stages. These centers are designed to disseminate new manufacturing technologies to industry -- particularly to medium-sized and small businesses -- and, according to a recent evaluation of the program, they have been a tremendous success.

I visited one of the manufacturing centers last spring, and it is easy to see why they have had such a dramatic effect. They bring together all of the individuals involved in technology transfer -- university researchers, scientists and engineers from private industry, representatives of federal laboratories -- and set them to work cooperatively on problems of direct commercial importance. If you spend a few hours in such a place, you can feel the excitement of new ideas bubbling up all over the place.

Another promising approach is the Advanced Technology Program, which is aimed at assisting businesses in developing precompetitive, generic technologies that will widely benefit the private sector. This program is designed to help support joint ventures and other research arrangements that have been developed by industry. So far, Commerce has received over 200 proposals, which is far more than the program can support. But if these initial proposals meet with the success that I and my colleagues believe that they will, I expect that the program will be substantially expanded. I look on it, in essence, as a pilot program.

The Advanced Technology Program also reveals several important features of technology development. First, it gives us an operational definition of precompetitive technologies. If a company is willing to spend its own money on cooperative joint efforts with its competitors, then we can assume that the proposed R&D is precompetitive. If a company is proposing to do such R&D on its own, then it must be willing to transfer the results to potential competitors if it is to qualify for government support.

Finally, the Advanced Technology Program emphasizes that technology development should be guided by the potential users. The federal government has a relatively poor track record where it has invested in civilian technology without close involvement at the outset from potential users. If U.S. industry wants government assistance and is willing to coinvest, there is some hope for success. But if industry does not perceive the need or is not interested, there is little point in the government's engaging in technology push.

I might mention, parenthetically, that in the White House we frequently meet with representatives of many U.S. industrial groups. Many consider that they are in some trouble in terms of remaining competitive; many would like to see some form of direct federal assistance. But all too few are prepared to lay out a strategic plan that demonstrates how such assistance would, in fact, put them on a new trajectory that in five or more years would leave them competitive and not in need of an additional transfusion.

This Administration is prepared to be helpful and indeed looks on competitiveness as one of the nation's most pressing challenges -- as I stated previously. But we do not believe that we in government are as well-qualified to make these strategic plans and decisions for industry as is industry itself. Nor do we believe that economic transfusions in the absence of such strategic plans are any answer at all.

Beyond Technology Policy

So far I've limited my comments to technology, because that is an area where OSTP has focused. But as you well know, technology is not always enough. The United States' strength in technology has not prevented a steady erosion in our market share in many industries. Other factors also determine a company's success, including economic factors, trade factors, legal and regulatory factors, and even cultural factors. Technology may be a necessary precondition for success, but it is not a sufficient precondition.

The Bush Administration is taking a wide variety of other steps to address these issues. On the economic front, it has been working to reduce the cost of capital by controlling the federal budget deficit and by making the research and experimentation tax credit permanent. On trade, it is working through the current round of GATT talks to reduce trade barriers and better protect intellectual property. It is reforming product liability laws to restore balance to the tort system and is working to eliminate unwarranted regulation. And, perhaps most important of all, it is focusing substantial effort on the education of our young people, and particularly on the mathematics and science education that will be crucial to our nation's future.

The Bush Administration is taking all of these steps to increase the competitiveness of American industry. But just as a strong technology policy is not by itself enough, so the actions of the federal government alone cannot dictate economic health. The private sector must also contribute, and it must contribute in ways that it has not in the past.

In the area of technology, the private sector must identify and aggressively pursue commercial applications for technologies developed outside its own laboratories, whether by university laboratories, by federal laboratories, by other companies, or by other countries. Regarding its capital stock, it must increase quality, output, and productivity by undertaking the necessary investments in equipment and facilities. Finally, it must improve the skills and abilities of its own workforce and participate cooperatively in improving the quality of U.S. education.

The federal government can establish incentives for private industry to take such actions. An excellent example is the Malcolm Baldridge National Quality Award established by Congress and President Reagan in 1987. This award recognizes the overall quality of a company's performance, from the commitment of its leaders to the satisfaction of its customers. It is based on a self-examination procedure that incorporates seven major criteria for quality. This self-examination procedure has itself proven to be a major source for quality improvement: many applicants have undergone productivity gains of 20 to 30 percent in the process of competing for the award. In fact, one of the first winners of the Award, Motorola, was so impressed by the process that it has required its thousands of suppliers to also compete for the award.

Personally, I would like to see all businesses above some minimum size prepare to compete for the Baldridge Award. The effects on both our domestic economy and on our standing in the global marketplace could be extremely dramatic.

This is the kind of direction in which both the federal government and private industry must go. It is a direction that emphasizes increasing our investments in the future, even at the risk of current consumption. The federal government and private industry are both far too easily captivated by the demands of the present -- what my colleague Richard Darman calls "now-now-ism." But if we lose sight of the future, these demands will become worse, not better.

The Bush Administration is committed to increasing this nation's investments in the future -- through R&D, through increasing rates of investment, through education. I call upon you to join us in this commitment, because it means a better future for all of us. There is a story about the great French Marshal Lyautey, who once asked his gardener to plant a tree on the following day. The gardener said, "But it won't bear fruit for a hundred years." "In that case," Lyautey answered, "plant it this afternoon." That is how I feel about the job before us. But let there be no misunderstanding: I expect results on a vastly shorter time scale.

SCIENCE, TECHNOLOGY, AND THE U.S. AIR FORCE

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Executive Office of the President

Air Force Scientific Advisory Board
Fort McNair Officers' Club
October 24, 1990

It is a great honor and a privilege for me to be able to present the U.S. Air Force Basic Research Award to Dr. Joseph Horner of the Rome Air Development Center at Hanscom Air Force Base, Massachusetts. The committee of the Science Advisory Board that judged this year's nominations expressed the conviction that the entries this year were competitive with research going on anywhere in the nation. This award is thus a mark of great distinction, as are the four honorable mentions and seven runners-up who were also cited. I congratulate all of the individuals so honored.

Dr. Horner has been singled out for his work on the optical processing for pattern recognition, which coincidentally has long been an interest of mine. Studies show that 75 percent of the fraction of your brain that is actually functioning is always engaged in processing visual information. Humans have a remarkable ability to sense patterns and form hypotheses on the basis of visual information, and learning how to perform these functions with computers is one of the challenging and important tasks facing computer science. The potential returns on this research are incalculable -- not only in defense but in education, in manufacturing, in basic research -- really throughout the range of science and technology. I commend both the board and Dr. Horner for your far-sighted recognition of the importance of this research.

The title you have been given for my talk today is "Science in America," and in a moment I plan to at least touch upon this rather all-encompassing theme. But first I wanted to talk more specifically about science in the Department of Defense. For decades following World War II, the Department of Defense was the dominant supporter of both fundamental and applied research in this country, and it originated mechanisms for federal support of academic research that remain the envy of the world.

Other federal agencies now support a proportionately much larger portion of federal R&D, but defense research continues to be crucial to not only our national security but our national prosperity. There are very few technologies developed for the military that do not have some sort of civilian application. Prior to coming to Washington, I used to think that international competitiveness could be separated from national security. I no longer think that to be the case. There are so many dual-use technologies and such close links between the defense and commercial applications of technologies that we must consider economic competitiveness and national security as two aspects of a single problem. The challenge, as I'll be describing in a moment, is to find ways of transferring science and technology developed in within the Defense Department, including within the Air Force, into the private sector as quickly and as effectively as possible.

During the next few years, the United States is going to be restructuring and rethinking the goals of its armed forces. I am convinced that defense research and development -- and particularly basic and applied research -- will be a critical part of this process. The Greek historian Thucydides once said, "A nation that draws too broad a difference between its scholars and its warriors will have its thinking done by cowards and its fighting by fools." This nation cannot afford either of those possibilities.

During the last month or so, several members of the President's Council of Advisors on Science and Technology, which was established by President Bush last February, have begun to do an informal analysis of defense R&D expenditures, and some of the issues they have been focusing on are quite interesting ones. Just to consider the overall numbers for a moment, the point is often made that federal defense R&D exceeds federal civilian R&D, and in absolute terms it does. But a closer examination reveals a number of special considerations. The defense R&D budget actually includes research, development, and demonstration -- with the lion's share of the money in development and demonstration of specific weapons systems. Only about $1 billion of the Defense Department's $38 billion R&D budget proposed for FY 1991 is in basic research or 6.1 account; only about $2.5 billion is in the exploratory development or 6.2 account; and only about $2 billion is in the advanced technology development or 6.3A account.

The rest of the federal R&D budget goes predominantly to test and evaluation activities, including technology demonstrations; engineering development of defense systems; management and support; and the development, testing, and evaluation of operation systems. Some portion of this money contributes to the technology base of this country, but it is undoubtedly a smaller proportion than is the case for research and exploratory development.

I might say, by the way, that this is one of the things that distinguishes my current position from my previous one. I used to talk in terms of millions of dollars; now I talk in terms of billions. Eventually, you get fairly nonchalant about discussing that kind of money. It reminds me of the story I've heard about David Bell, who was John F. Kennedy's budget director. One time before a Senate Appropriations Committee, he gave an estimate for a particular set of outlays totaling $366 billion. But a week later the subcommittee called him back and said that his estimate was in error and that it should have been $350 billion. Bell replied, "Well, give or take $10 or $15 billion, I was substantially correct."

Funding for the research and exploratory development, therefore, does not even fall within Mr. Bell's margin of error. Furthermore, that portion of the Defense Department's R&D budget has been shrinking over the years. In constant dollars, the 6.1 and 6.2 accounts were over twice what they are now in the middle-1960s. As a percentage of total defense R&D, basic research and exploratory development were over twice what they are now throughout the 1960s and 1970s.

In my view, this country will need to place more emphasis on these portions of defense R&D if we are to preserve a decisive edge in our military capabilities. These activities will also be essential to strengthen the interface between defense and civilian technologies.

I am glad to say that the President and the leaders of the Defense Department fully agree with me on this point. The President's 1991 budget called for military research and development to rise about 4 percent, compared with a 1.7 percent increase for total funding within the Defense Department. Even more important, basic research for defense was slated for a 6 percent increase.

Particularly at a time of lessened tension, it is important to maintain and strengthen research to avoid technological surprise and being blindsided. Perhaps there will be less development and testing of specific weapons systems. But support for the basic and applied research on which the weapons systems of the future will be based should increase.

If basic research and exploratory development were increased, it would serve an additional, very important purpose. Such increases would help rebuild some of the bridges between the Defense Department and academic community that were present in the immediate postwar decades. These bridges were important for both sides: they brought the Defense Department into contact with some of the best research and brightest minds in the country, and they supported the development of new knowledge and the training of young minds that were able to use that knowledge creatively in the universities. The task before us today is that of reintegrating our national security enterprise into the civilian research and educational system -- to the benefit of both.

There is another reason for looking to the Defense Department for an increased emphasis on basic and exploratory research and development. The budgetary agreement that is now making its way through Congress is very likely to hold discretionary spending by the federal government at a constant level, in real terms, for the next five years. That discretionary spending includes all of civilian research and development, and, needless to say, the competition for that money is going to be intense. Increased basic research within the Defense Department can help compensate for the limits placed on the expansion of civilian R&D.

Several years ago, I. I. Rabi said that the military "is the most important source that we have of new inventions, new applications, new science. And the reason is a simple one: the military ask for the impossible, [and] they can pay for it." Today, I think that both of those assertions might have to be qualified somewhat. But Rabi's point is well taken: military R&D remains a key determinant of our technological future.

Technology Development by the Defense Department

As such, the portion of defense R&D aimed at technology development warrants particular attention. This last summer the Defense Science Board conducted a summer study on the Defense Department's technology strategy, and I addressed a meeting of that study. As I pointed out to that group, a significant portion of the government's R&D budget, both civilian and defense, goes for technology development. For example, the budget points out that over $1.5 billion of civilian and defense R&D is allocated to developing such advanced technologies as robotics, high-performance computing, and semiconductor technologies.

Furthermore, the Bush Administration has made a commitment to continue to support the development of generic, precompetitive technologies that are important in both the public and private sectors. In a speech to the American Electronics Association on March 7, President Bush pointed specifically to the importance of these precompetitive technologies. He said, "This Administration is committed to working with you in the critical precompetitive development stage where the basic discoveries are converted into generic technologies that support both our economic competitiveness and our national security. Here again we can help to level the international playing field on which you operate."

My office is now engaged in a major effort to identify and prioritize a set of these generic technologies. The FY 1990 Defense Authorization Act directed OSTP to set up a National Critical Technologies Panel, which is chaired by OSTP's Associate Director for Industry Technology, Bill Phillips. This is a panel of six government officials, plus Bill, and six private sector representatives. Their immediate task is to merge two lists of critical technologies developed by the Departments of Commerce and Defense into a single list of no more than 30 technologies that will be critical to our nation's future economic prosperity and national security. More broadly, the panel will be examining the pace of technological development in this country and in other countries and assessing the implications for international competitiveness. The Panel has so far held two meet

In addition to directly funding the development of technologies, the federal government can make it easier for industry to develop commercial technologies. One way to do this is by catalyzing the formation of consortia or networks of industries, with or without government funding. SEMATECH is an example of the former; the large number of joint R&D ventures catalyzed by the 1984 National Cooperative Research Act are examples of the latter. Particularly for small and medium-sized businesses, such consortia make it possible to pool resources and specialize on problems, so that each individual firm does not have to reinvent the technological wheel.

Finally, the hundreds of laboratories funded by the federal government -- including those of the Air Force -- embrace an astonishing breadth and depth of the best science and technology to be found. This base of knowledge represents one of our most valuable national assets. Federal laws and policies now in place make it the responsibility of every federal technology manager -- defense or civilian -- to consider the commercial ramifications of the work they are supporting and to try to encourage its commercial potential. We in the Administration will be building on these previous laws and policies to develop mechanisms that will expedite the diffusion of the results of federally supported R&D to industry. These mechanisms include active licensing of inventions and further removal of barriers to commercial development.

Precollege Education

There is one last topic that I would like to discuss today that may seem less directly related to the matter at hand but is equally important -- and that is the education of our youth. After leading the world for decades in the quality and scope of the education provided to our youth, we are now falling far behind the rest of the developed world. The state of our precollege education can only be considered as scandalous. At the college level, despite wide variations in quality, we remain -- on average -- competitive. At the graduate level, we continue to set the standard for world activity; in fact, the graduate students we train who then return to their homes abroad represent one of our most valuable exports.

You might ask how we can maintain this paradoxical progression, from a precollege system that is scandalous to a graduate system that is worldclass. The answer, at least for science and technology, is that we are willing to drop a very large fraction of our young people along the way, particularly minorities and women. This is a loss that this country can no longer afford.

The demographic trends for the future of science and technology in this country are one cause for concern. The numbers of 22-year-olds in this country have been dropping for almost ten years, and they will continue to do so well into the 1990s. Furthermore, students have been exhibiting less and less interest in science and engineering, both because they see other professions as more lucrative and because of the decrepit state of precollege education in this country.

The Bush Administration has made precollege education a cornerstone of its domestic policy efforts, and within that area it has given special attention to science and mathematics education. Of the six national goals in education that the President announced last January, no fewer than three deal in some way with science and mathematics, including the most ambitious of the six, that American students will be first in the world in science and mathematics by the year 2000.

Because a very large fraction of scientists and engineers make their career decisions during and before high school -- much earlier than is typical for other professions -- it is essential that we refocus our corrective efforts on a much earlier phase of the educational enterprise than in the past. Currently, at these important precollege levels, the quality of mathematics and science teaching is often too low to attract other than the most dedicated student. For these dedicated few, in many cases, both the quality and quantity of mathematics and science exposure are too low to prepare them adequately for careers in these fields. These problems are increasingly recognized, and a number of states have made important strides toward improvement in their K-12 programs. But much remains to be done.

As one of the largest training organizations in the country, one of the largest producers of new technologies, and one of the largest employers of scientifically and technically trained citizens, the Defense Department is increasingly dependent on the same shrinking pool of young people that supplies both scientific and engineering talent and skilled technicians of every kind. The Department of Defense therefore needs to be equally concerned about the failings of our precollege educational system and needs to join in the national effort to reform that system.

MANAGING SCIENTIFIC AND TECHNICAL INFORMATION IN THE 1990'S

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An address to the Forum on Federal Information Policies of the
Federal Library and Information Center Committee
Library of Congress
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Unlike the atomic age or the space age, it is hard to pinpoint exactly the beginning of the Information Age. Nonetheless the explosion of information is undeniable. Whenever I have any doubt of this I merely have to look at my in-basket.

The free flow of information is central to the democratic ideals on which this nation was founded. Thomas Jefferson wrote, "If a Nation expects to be ignorant and free . . . it expects what never was and never will be." A modern corollary is that information plays a vital role in maintaining our national economic competitiveness. Derek Bok, the President of Harvard, summed up this connection well when he said, "If you think that knowledge is expensive, try ignorance."

It is appropriate that this Forum takes place in the Library of Congress, the modern-day equivalent of the Greek library of Alexandria. I am reminded of the definition of a library that was popular with Yale undergraduates some years ago: that a library is a book, followed by a book, followed by a book. These days, however, in view of the growing importance of digital information, one might need to modify that definition somewhat: a library is a byte, followed by a byte, followed by a byte.

Several years ago I did a brief analysis of the information contained in the Library of Congress and how it could be stored electronically. If you assume that there are 20 million volumes in the library, each on the average containing some 300 pages and 450,000 letters, the library then contains about 9 trillion letters, or about 9 trillion bytes--or 9 terabytes--of information. At that time, it would therefore have required about 20 IBM 3850 mass storage units to handle the entire library and provide almost random access to its contents.

What is more important, however, is that memory capacity has been increasingly at a remarkably constant 35 percent per year for the past two decades. Even if we arbitrarily reduce this to 20 percent averaged over the coming century, we find that the same investment that would provide the 20 IBM 3850s to hold the contents of the Library of Congress would comfortably provide the equivalent of that entire system for each and every one of the world's citizens--up to a total population of 15 billion!

STI IN THE INFORMATION AGE

The Information Age has resulted from the confluence of several technologies, including electronics, computers, and optical data storage and transmission. As such, we are still very much in its infancy. These forcing technologies are evolving at an accelerating pace and will create truly remarkable opportunities that, as a nation, we cannot afford to let pass by.

In retrospect, the rate of change of these technologies is truly astonishing. It is sometimes difficult to remember that, a hundred years ago, electricity itself was little understood. Although Maxwell had predicted electromagnetic waves in his 1873 treatise, it was not until 1887 that Hertz first demonstrated their existence.

It was just a little over 50 years ago that Aiken performed his pioneering work on the Mark I digital computer at Harvard. Only a little more than 20 years have passed since the first fully commercial commications satellite, Intelsat I, was launched. Yet today the world is bound together in a global communications network, and information has become one of our most important media of exchange.

Today I am going to be focusing on a particularly important type of information--namely, that arising from science and technology. Scientific and technical information (STI) has several unique characteristics. First is the character of the information, comprising three broad types--traditional bibliographic information, numeric data such as that arising from physical measurements or computations, and graphic images such as those produced by space-based observing systems. All of these types generally have distinct sources, separate formats, and often completely separate processing systems, but the trend is clearly toward electronic or optical systems that will store and transmit all three types.

A second distinguishing characteristic of STI is its audience. Scientific and technical information is used primarily by specialists. Relatively little STI is directly of interest to a broad audience, although summary conclusions or findings based on that information may be. Thus the patterns of dissemination and the issues and needs regarding access to STI are rather different than those arising with, for example, census data.

A third distinguishing characteristic of STI is its sheer volume and growth rate. STI is the primary product of a major Federal activity--research and development--in which the government invests about $70 billion per year. As a result, the Federal government is the world's most prolific generator of STI.

The magnitude of science and technology information is generally unappreciated. According to a recent report by the Office of Technology Assessment, the bibliographic Federal S&T information base includes an estimated 4 million technical reports, a volume that is expanding at the rate of 200,000 new technical documents per year. Added to that are rapidly proliferating databases containing, in the earth sciences area alone, about 100 terabytes of numeric and graphic data--or over 10 times as much data as in the entire Library of Congress.

By comparison, the database of the Social Security Administration, one of the largest non-technical databases in the nation, comprises just 1.3 terabytes, or somewhat over 10 percent of the total information in the Library of Congress. The U.S. Bureau of the Census estimates its 1986 digital database at 2.6 terabytes. Thus the volume of STI is already one to two orders of magnitude larger than the volume of other kinds of archived materials.

Moreover, this staggering amount of information is a mere trickle compared to the flood of STI that is expected in the 1990's. Between now and 1998, a key NOAA database is expected to add some 200 additional terabytes of STI. Space-based systems are expected to send NASA ground stations more than 5,300 terabytes of STI. Overall, STI is expected to increase by two orders of magnitude--a hundredfold--during the 1990's.

Present STI budgets and technology do not even allow for such a quantity of data to be stored, much less efficiently managed or made available to intended users. Coping with a flow of such unprecedented volumes of information is clearly a monumental task.

Furthermore, managing science and technology information flows and storage is not enough. A number of additional issues deserve our attention.

Access and Dissemination

First of all, the existence of information does not guarantee its use. Data that are not accessible to scientists who need it or who are not even aware of its existence are of little value. Technologies cannot be transferred from national laboratories to private industry if companies--especially small companies--cannot discovery its existence.

Some have pointed out the need for a national directory of directories of very large databases, a kind of electronic card catalogue comparable to the card catalogue of the Library of Congress. Also, the relative roles of Federal and private entities in disseminating STI remain to be sorted out.

Information Literacy

As more and more STI information is stored in digital systems on very large databases, the ability to search these systems becomes critical. Unfortunately, even many of our educators, scientists, and engineers are not literate in today's information technology and thus cannot exploit the results of our large national investment in research and development.

Also, the development of software has fallen far behind the development of hardware and is now the bottleneck to more extensive and effective uses of computer technology. Here again, we have seen only the beginning of the tremendous advances on the horizon in the area of user-friendly software. As I have noted elsewhere, the morning when you awake to find that your toaster is smarter than you are will have deep psychological implications.

Infrastructure and Standards

In the area of database standards, it is important to note that there are over 1,700 separate entities around the world that maintain at least one, and often many, data bases. But because of the lack of any agreed-upon standards, these data bases span a wide variety of systems, services, command languages, protocols, and terminologies. In effect, we are building an electronic Tower of Babel that will sharply limit the utility of these resources.

Foreign STI

Finally, the U.S. is not making effective use of foreign science and technology to enhance our economic competitiveness. Current efforts by Federal agencies to collect and assess foreign STI are fragmented, with no central clearinghouse and no ready means for industry to access much of this information. The Japanese Technical Literature Program in the Department of Commerce is a valuable example of the efforts needed to remedy this problem, but not enough researchers take advantage of this service.

These are among the issues we must address if we are to gain the full value from STI and the greatest return from the Federal investment in research and development. That return is vitally important. In an increasingly competitive world, our economic fortunes as a nation are closely tied to our success in translating new knowledge promptly into new products and services. To survive in the Information Age, we must learn to be information efficient, both in generating new information and in disseminating and using it.

THE ROLE OF OSTP

If STI is to used to maximum advantage, the means and the institutional structures for handling STI within the Federal government must be examined and a more coordinated approach must be derived. Traditional methods and arrangements may be ill-adapted to the need. The Office of Science and Technology Policy is now considering how such an examination might be put into effect.

One of the principal responsibilities of the Office of Science and Technology Policy (OSTP) is to review and coordinate Federal R&D that cuts across the missions of more than one Federal agency. Since the effectiveness of that R&D may depend on scientific and technical information, there is clearly a role for OSTP in helping draw attention to and coordinate Federal STI efforts. Indeed, the Office of Management and Budget, which has overall responsibility for Federal information policy, has indicated a willingness to work with us in considering the special needs and circumstances of STI within the context of national information policy. So I thought it might be useful today to give you an overview of the role of OSTP in this Administration and to indicate some of what we are doing in areas related to STI.

One of the primary ways in which OSTP carries out its mission to review and coordinate Federal R&D is through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which was created by the same 1976 legislation that created OSTP. FCCSET is charged with reviewing and coordinating science, engineering, and technology activities that affect more than one federal agency, with STI a particularly notable example.

In the past, several FCCSET committees--such as the Committee on Earth Sciences and the Computer Research and Applications Committee--have demonstrated the great advantages to be derived from effective coordination of cross-cutting issues in science and technology. For example, over the past several years, the Committee on Earth Sciences has organized all of the formerly disparate research on global change into the U.S. Global Change Research Program, which is now a coherent, government-wide approach to the scientific understanding of global change. Such coordination not only cuts down on duplicative research and increases the effectiveness of the research being done; it also gives particular areas of R&D increased visibility that can be used to emphasize important new initiatives in science and technology.

We are now in the process of revitalizing and reorganizing the FCCSET structure. We had the second meeting of the full FCCSET last week. At both that meeting and the first meeting we had excellent representation from the agencies, with Cabinet secretaries and heads of independent agencies constituting the majority of those in attendance. In general, we foresee a substantially altered and enhanced role for FCCSET within the White House. For the first time since the FCCSET was created, it should be functioning as it was designed to function.

FCCSET is now in the process of establishing and populating several umbrella committees in such areas as health and the life sciences and the physical, mathematical, and engineering sciences. Various subcommittees will be formed under these committees in such areas as and materials science and engineering and, in particular, high performance computing.

High performance computing will also be a particular focus of the President's Council of Advisors on Science and Technology, which the President announced at the beginning of February. PCAST held its first meeting at Camp David last month--at which high performance computing was one of the main topices under discussion--and the second meeting of the group is being held tomorrow and Friday. The Council is a very forthright, as well as a very distinguished group, and I think you we can be assured that the President will be well-informed about both the promise and the problems of science and technology.

I am the chairman of both PCAST and FCCSET, which gives me an opportunity to coordinate the activities of these entities. For example, we are now considering the prospects of setting up committees associated with PCAST that would parallel some of the committees under FCCSET. This would allow input to the FCCSET committees from the private sector to a degree that has not been possible before.

For example, OSTP is in the process of appointing an academic-industry panel on high performance computing with a chairman who is a member of PCAST. This panel will provide OSTP with an independent, private sector assessment of the progress of the program and advice on the integration of these technologies into the mainstream of U.S. science and industry.

HIGH PERFORMANCE COMPUTING

OSTP has the opportunity to get involved in a wide variety of issues. Its priorities will change as opportunities and problems present themselves. At present, however, we are focusing on four main themes: education, economic competitiveness, global change, and high performance computing.

You will note that virtually all of these issues involve STI issues in one form or another. I have already indicated that one of our key competitiveness issues is how to transfer newly created scientific knowledge into new products and services more rapidly and effectively. A major thrust of the Global Change Research Program is to gain a better understanding of how Earth's climate system functions through expanded monitoring and modelling efforts--and these efforts will contribute in a major way to the huge projected growth in numeric and graphic data that I described earlier. As you may be aware, the FCCSET Committee on Earth Sciences has endorsed the work of the Interagency Working Group on Data Management for Global Change, which has dealt directly with STI issues that affect earth sciences. High performance computing will also generate large amounts of modelling data; but more important, this initiative will be critical to our ability to analyze, process, and communicate massive amounts of scientific and technical information. For this reason, it is perhaps the most directly related to STI issues and deserves some further discussion here.

As most of you probably know, last fall I sent to the Congress a report entitled The Federal High Performance Computing Program, produced by the Computer Research and Applications committee of FCCSET. The program laid out by the report consists of four distinct parts. The first is developing the hardware that will, through the use of parallelism, make possible TERAOP computers operating at trillions of operations per second. The second is developing the software technology and algorithms that will permit full and efficient use of the hardware capabilities that are now and will soon be available. The third is building a National Research and Education Network (NREN) that will increase the accessibility of geographically dispersed users to supercomputers and reduce the incompatibility that now characterizes many computer networks. And the fourth is training the personnel who will extend the tremendous advances that have been made in the past.

To further coordinate and increase high-level attention for high performance computing, and to explore where there exists a basis for extending the Federal program into a national program, I convened a meeting earlier this year of agency heads and their deputy directors for R&D agencies that support high performance computing. A second meeting of this group was held earlier this month and further meetings will be held as necessary. I expect that the result of this effort will be a far more coordinated program and budget submission for FY 1992.

As part of the restructuring of FCCSET mentioned earlier, I am broadening the charter of the Computer Research and Applications Committee to include all aspects of information science and technology. I am presently considering whether this charter should also include STI issues, many of which--such as questions of standardization and the planning and management of very large databases--are closely related. An alternative approach might be to expand the interagency group known as CENDI (for Commerce, Energy, NASA, NLM, Defense Information) into a full FCCSET committee. But whether through this mechanism or another, I believe that we must begin to address the issues posed by the special character and explosive growth of Federal scientific and technical information. If we do not, we risk failing to reap the benefits of the emerging Information Age.

PROBLEMS AND POSSIBILITIES

I indicated earlier that the emerging Information Age and the explosive growth of the underlying technologies is forcing rapid change, both for STI and in a wider context as well. Already, for example, sales of print and microfiche documents from the National Technical Information Service have declined 50 percent since 1980, while sales of computer products and online searching of the NTIS database via private vendors are growing. These changes will bring new problems, but will also offer a number of new opportunities. At present, for example, demand among U.S. scientists for time on supercomputers is so high that time has to be closely rationed and many important investigations have to be postponed or curtailed. The absence of a high speed data network capable of rapidly transmitting the volumes of information produced by supercomputers adds to the frustration. Clearly, we are limiting the productivity of our scientists and undercutting what ought to a strong competitive edge for the United States.

Yet this situation is also an opportunity, if we can move rapidly to take advantage of it. According to a recent NTIS report, scientists in Japan who use supercomputers typically have access to at least an order of magnitude more time--a tenfold advantage over U.S. scientists. But relatively few Japanese scientists and engineers seek to use supercomputers in their work. We have shortages because far more of our scientists can and do use the power of supercomputers in their work.

In addition, we still lead in the design and development not only of supercomputers--which are increasingly critical to virtually every field of science and engineering--but also of powerful work stations and parallel processing computers. Exploiting that lead through programs such as the High Performance Computing Program is one of the ways to keep our R&D effort at the frontiers of science.

Research is not the only activity that could be transformed. Imagine how precollege science and math education might change if every child had access to a powerful but inexpensive work station and a large database of text and graphic information and educational programs, so that teachers could begin to customize the education of each child to suit his or her needs and automatically track their progress. Such an approach is technically feasible now and might well become economically feasible within the decade of the 1990's.

Imagine how publishing might change when periodicals can be customized for each subscriber to reflect his or her specific interests and delivered electronically, to be printed, if desired in that form, in the home or office of the recipient. Imagine how the role of libraries will change when most American homes are connected to them over local networks via a wide-bandwidth channel such as an optical fiber or a cable TV conduit. Individuals would be able to search their local library or other repositories electronically to select and retrieve text and pictures, rent and view a movie, or research specific needs from recipies to home remodeling projects. Again, all of these are technically feasible today.

Imagine how much more efficient the Federal STI efforts might be if data were archived on optical disks and could be searched and shared among agencies over a high-speed digital network using a common format. Imagine how professional work patterns might change when telecommuting, teleconferencing, and telecollaboration become even easier and cheaper than they are at present.

In this period of rapid change, the management of scientific and technical information must keep pace. We must vigorously explore the emerging new technologies and reexamine our institutional structures for STI. We must increase our flexibility to respond to new needs and new opportunities. We must give adequate support to the planning and maintainence of our critical data repositories. And, finally, we must seek to improve access to STI wherever possible.

A new phase of the industrial revolution is now in under way, a phase that depends not so much on machines as on information. Our job is to see that the benefits of that revolution are spread as widely as possible.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

COMPETITIVE TECHNOLOGIES IN THE DEFENSE AND COMMERCIAL SECTORS

D. ALLAN BROMLEY
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JASON Spring Meeting
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I thought it would interest this group to know that over the past three years several reporters have called me to ask if, because of the rapid development of the life sciences, the age of the physicists as advisors to the government has come to an end. My answer, to paraphrase Mark Twain, has been that reports of our demise are greatly exaggerated.

It is true that the influence of the life sciences is coming to rival -- and someday may even exceed -- that of the physicial sciences. But there will always be a role for physics in probing the fundamental properties of nature, and there will always be a role for physicists in advising the government on the implications of knowledge generated by fundamental physics research.

Victor Weiskopf has written about these subjects in his book "The Privilege of Being a Physicist." He writes that the real privilege of being a physicist is that

> he is in the midst of things; his work is deeply involved in what happens in our time. . . . In most instances, he cannot avoid being drawn in one form or another into the decision-making process regarding the applications of science, be it on the military or on the industrial scene. . . . This burden makes our lives difficult and complicated and puts us in the midst of social and political life and strife.
>
> But there are compensations. We are all working for a common and well-defined aim: to get more insight into the workings of nature. It is a constructive endeavor; where we build upon the achievements of the past; we improve but never destroy the ideas of our predecessors.

Viki was speaking in this case of results of fundamental research, but his comments apply more broadly to the subject I would like to discuss today -- the technologies that are derived from fundamental research. These technologies have truly become the defining characteristic of our age. Today most Americans take for granted a standard of technological sophistication -- of warmth, cleanliness, food, medical care, and entertainment -- that was undreamt of 150, or even 50, years ago. Almost every company in the United States today -- and therefore almost every job -- is in some way affected by changing technology. This is true not only of high-technology jobs but of jobs that are seemingly low-tech as well -- jobs in textiles or metalworking or even in many service areas.

And of course the technologies derived from fundamental research are also critically important in the defense sector. The success of many, though not all, of the technologies deployed during the Gulf War demonstrated again the importance of technological superiority to maintaining U.S. national security. And the list of critical technologies developed by the Department of Defense shows how dependent defense systems are on forefront research. I shall return to this subject of critical technologies later, because it has major implications for the civilian sector as well as the defense sector.

The Office of Science and Technology Policy

As you know, my office is the Office of Science and Technology Policy, and since coming to Washington I have sought, with the full support of President Bush, to emphasize the "T" in OSTP. One of the first things I did was to select an Associate Director for Industrial Technology within my office -- one of four Presidentially appointed and Senate-confirmed such positions, which for the first time have all been filled with outstanding scientists and engineers. I created this position for two reasons: First, because I believe that technology is extremely important for U.S. economic competitiveness and national security, and second, because I wanted to send a very explicit message to the industrial community that the Bush Administration is serious about working with it to advance the rate of technological progress.

Under the leadership of OSTP's Associate Director for Industrial Technology, OSTP issued, in September 1990, the first statement ever produced of the United States' policies regarding technology development. That document, entitled U.S. Technology

Policy, has been extremely valuable in that it had the support of everyone in the White House and has provided a common base for discussion and the implementation of new technology initiatives.

The document describes the many ways in which the government influences the development and deployment of technology, from its fiscal policies to the regulatory environment to the education and training of the workforce. What is perhaps most remarkable about these policies is how broad-based they are. Indeed, there are few government policies that do not in some way interact with technology.

That document also lays out the rationale for the government's support of technology. Essentially, the argument is the same as for basic research. With precompetitive, generic technologies -- those sufficiently removed from the marketplace that firms cannot yet use them to produce commercial products -- it is impossible to predict where, when, or to whom their benefits will flow, just as it is impossible to make those kinds of predictions for basic research. The government therefore has a role in supporting the development of those technologies up to the point where private firms can decide how, or if, those technologies can benefit them.

The Bush Administration terms this approach a technology policy rather than an industrial policy. The focus is on the underlying technical capabilities rather than on specific firms or industrial sectors. The Bush Administration does not believe that it is appropriate for the federal government to select winners or losers in the marketplace. We are not as well equipped or as well informed as the private sector is to make decisions as to which companies should succeed or fail.

Nevertheless, we do believe that the federal government has a very important role to play in the period from basic research -- where the federal government has in most cases already played a strong role -- through the point where it is possible to assess the commercial applications of a technology. The Bush Administration has been committed throughout its tenure to work with the private sector to develop the technologies that will ensure our future prosperity and security.

National Critical Technologies Panel

Since the release of the "U.S. Technology Policy," my office has been involved in a number of other technology-related initiatives. One has been the preparation and release of the first biennial report of the National Critical Technologies Panel, which was chaired by OSTP's Associate Director for Industrial Technology.

That report surveyed 22 technologies that the panel considered essential for the United States' long-term security and economic prosperity. These 22 technologies encompass a very large portion of the nation's industrial base. For example, microelectronics and optoelectronics, simulation and modeling, and materials and manufacturing are essential to the continuing development of virtually all other advanced technologies -- and many seemingly low-technology products and processes as well.

The technologies included in our list are very similar to those included in the Department of Defense and the Department of Commerce. Indeed, they are very similar to the technologies included in lists generated in other countries. The next stage in the process involves not the refinement of future lists but determining the approaches that will ensure preeminence in specific technologies.

Critical Technologies Institute

That issue will be one of the first to be taken up by the Critical Technologies Institute, which is now being formed through my office and through the National Science Foundation as a nonprofit federally funded research and development center. The NSF issued a request for proposals in December 1991, calling for the proposals to be submitted to NSF by January 31, 1992. The NSF is currently evaluating these proposals, and an announcement of the awardee is expected in the very near future.

The CTI will undertake strategic studies and analyses that can assist federal agencies in determining whether increased investments in particular technologies will serve both agency mission needs and broader national needs. The institute will be governed by an Operating Committee consisting of the seven members specified in the founding legislation and four additional members: the Secretary of the Treasury, the Director of the Office of Management and Budget, the Chairman of the Council of Economic Advisers, and the Assistant to the President for National Security Affairs. I have been designated by the President as the chairman of this committee, and its first meeting was held two weeks ago.

National Technology Initiative

Another important effort undertaken by the Bush Administration has been the National Technology Initiative, a series of regional meetings intended to spur U.S. competitiveness by promoting a better understanding of the opportunities for industry to commercialize new technology advances. The NTI has been organized by the Departments of Commerce, Energy, and Transportation and by NASA. However, government participants and speakers have come from all parts of the federal government concerned with technology, including the Department of Defense and the White House.

One of the major themes of the NTI is the need to foster a much greater array of partnerships among all of the institutions involved in our national competitiveness: our businesses, our universities, our national laboratories, our various levels of government. The initiative is designed to act as a catalyst to combine the very real strengths apparent in each component of our R&D enterprise.

These partnerships can take many different forms: consortia such as SEMATECH or the U.S. Advanced Battery Consortium, university-industry agreements, cooperative research and development agreements between federal laboratories and the private sector, and so on. Many of the institutional barriers to establishing these partnerships were removed during the 1980s. Now we face the much more difficult task of changing the cultural barriers within these institutions so that we can take advantage of new ways of thinking.

One focus of this effort must be the personnel, expertise, and infrastructure resident in our over 700 federal laboratories. The federal government invests over $20 billion a year in these laboratories. They embrace an astonishing breadth and depth of science and technology, including some of the best science and technology to be found anywhere in the world.

Many of these laboratories were established in the immediate post-World War II period, and they originally had very specific missions and objectives. Many of these original missions were satisfied years ago, so that the laboratories are adjusting their programs to remain in close touch with evolving national needs.

One change that I have been advocating is the involvement of potential partners early in the process of planning federal laboratory activities. Many of the labs have panels of distinguished academics and industrialists who review the scientific merit and applicability of R&D done at the lab. But these reviews usually occur after the work has been planned or undertaken. The involvement of these panels from the beginning, as the programs of the lab are being planned, would be much more effective in tying the work of the laboratories to the needs of potential users.

Bush Administration Policies Toward Technology

As you can tell from the initiatives I have been describing, the Bush Administration has been taking a very broad-based approach to science and technology. This approach has also made itself felt in the federal budget. Since George Bush became President, federal support for nondefense R&D has gone up by a third in current dollars. Basic research funding has gone up by a quarter. Defense research and development has also risen, although the defense budget has decreased over that time.

A particular focus of President Bush's budgets has been increased support for individual investigators in our nation's colleges and universities. These investigators are

the heart and backbone of American science, and they must remain productive if American science and technology is to remain productive. This year the budget proposes an increase of 9 percent for individual investigators funded by the National Institutes of Health, the Department of Energy, and the National Science Foundation. Support for university research overall would rise 5 percent, led by a 20 percent increase at the National Science Foundation.

The budget this year also contains a number of special Presidential Initiatives in high-impact areas of science and technology that were developed by committees under the Federal Coordinating Council for Science, Engineering, and Technology, which is known as FCCSET. FCCSET brings together representatives from the various federal agencies that are involved with science and technology to work out ways to integrate interagency efforts most effectively and to ensure that the maximum science and technology results are obtained at whatever investment level Congressional action makes possible.

Three of these special Presidential Initiatives focus specifically on the development of technology: those in high performance computing and communications, advanced materials and processing, and biotechnology research. The budget also includes crosscuts on global change research and on mathematics and science education, and for next year FCCSET has recommended the addition of a crosscut on 21st-century manufacturing.

Let me take the High Performance Computing and Communications Program as an example to demonstrate the potential of the FCCSET process. The FY 1993 budget calls for a 23 percent increase in funding for the second year of a program designed to sustain and extend U.S. leadership in all advanced areas of computing and networking. With the involvement of nine federal agencies, the HPCC program focuses on the underlying research and academic training needed to accelerate significantly the availability of the next generation of high performance computing systems and digital communications networks. In my opinion, there is no other single initiative that will have as large and as widespread an impact on business, education, government, and society in general.

Strictly in terms of funding, the Department of Defense, at $275 million requested for FY 1993, is the largest of the nine agencies participating in the HPCC program. Within the Department of Defense, the Defense Advanced Research Programs Agency (DARPA) has the leadership responsibility for the HPCC program.

DARPA's leadership has been a major factor behind several new high performance systems that have been delivered over the past year. These scalable massively parallel systems already go much of the way toward the five-year goal, established just last year, of creating high performance computing systems operating at speeds of one trillion operations per second.

The Department of Defense is also involved in the two other technology-based initiatives. With $432 million requested for FY 93, the Department of Defense has the largest agency share in the 10-agency Advanced Materials and Processing Program (excluding major national user facilities construction and operating costs). In biotechnology, all three of the services have programs in such areas as environmental restoration, biomaterials, and health research.

The Defense Role in Technology Development

The integral role of the Department of Defense in these three technology-based crosscuts reflects a crucial shift in the relationship of defense to civilian research. In the past, frontier technologies developed in the defense sector diffused in large numbers into the civilian sector. In recent years the trend has been more in the opposite direction -- advances in defense capabilities have increasingly benefitted from technological innovation by the civilian sector.

Because of the interaction between defense and civilian technology, some have urged that commercial considerations be given a more prominent role in defense R&D and procurement decisions. For example, several different groups have recommending that DARPA be converted to a National Advanced Research Projects Agency -- NARPA -- to foster high-technology commercial industry.

But I believe that such an approach carries substantial risks. DARPA's tremendous successes have depended in a critical way on the fact that it has had a single customer, the military. This has allowed it to establish specific objectives, which in turn have provided a means of assessment for program managers. A less specific objective for DARPA, such as a mandate to support commercial technologies, may well have dissipated its efforts across a broad range of less productive endeavors.

I would propose an alternate way of approaching these issues. Today it makes more sense to think of a common industrial base providing technologies for both defense and civilian uses. Government programs that support civilian technologies also support defense technology needs, as evidenced by the involvement of the Department of Defense in all three of the technology-based initiatives. Indeed, the defense and commercial applications of technologies are today so tightly linked that we must consider the technological dimensions of economic competitiveness and national security as two aspects of a single problem.

This can be seen most directly in the lists of critical technologies that I have already mentioned. The overlap between the list generated by the Defense Department, the Commerce Department, and the National Critical Technologies Panel is extensive. What this demonstrates to me is that government agencies, by working to meet their missions, will contribute in substantial ways to commercial technologies as well. This applies not only to the Department of Defense but also to the civilian agencies. Government agencies are now working at the very forefront of technology to meet national needs. These technologies can also produce valuable spinoffs for the commercial sector so long as the government's R&D programs are organized so as to foster that exchange.

This view of the challenge before us also highlights several actions the Bush Administration wants to avoid. Congress has passed legislation requiring that the Executive Branch develop roadmaps for how critical technologies should contribute to competitive industries. We would propose that instead of pursuing this technology push approach, we develop a consensus as to what are the nation's critical needs and opportunities and how can technology be brought to bear on those concerns. This approach would allow specific needs and opportunities to pull technology development, greatly increasing the efficiency and effectiveness of the process.

Conclusion

The policies that I have been discussing are just some of many that the government is pursuing to foster the productive application of technology. I haven't even mentioned international science and technology, trade policies, legal reform, health and environmental regulations, or the linkages between defense and civilian technologies.

But I think that the policies I have mentioned are enough to demonstrate the Bush Administration's commitment to technology, and the importance of science and technology to our economy and well being. It remains the case that the United States has the strongest science and technology enterprise the world has ever seen. We spend more on research and development than do Japan, West Germany, France, and the United Kingdom combined. We award more first academic degrees in natural science and engineering than do those four countries combined. We still have the best research universities in the world; about a third of all the students throughout the world who travel abroad to study come to the United States.

It is true that other countries, by focusing their efforts in particular salients, have been able to equal -- and in a few cases exceed -- U.S. achievements in science and technology. But that has not been an unexpected -- or even particularly unwelcome -- development. Rather, it emphasizes the importance of maintaining open lines of communication and cooperation among countries, so that all may take advantage of advances of knowledge no matter where they occur. It also emphasizes the importance of the United States remaining close enough to the frontiers in each field so that we are ready to take advantage of those advances whenever and wherever they do occur.

I believe that there is a role for the JASONs in the issues I have been discussing today, just as there has been a role for me in the White House. You sit at the

intersection of science, technology, and national needs. Your perspective is one that government cannot get in any other way.

Your recent work on environmental monitoring points in the directions I've been discussing. We must find ways of creatively using technologies in both the public and private sector and in both the defense and civilian sectors. The payoffs to this work could be very high, and I know that the JASONs could make substantial contributions to this important cause.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
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SCIENCE, TECHNOLOGY, AND THE INTELLIGENCE COMMUNITY

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I am sure that you are all familiar with the Chinese curse that you shall be damned to live in interesting times. Well, I would have to take exception with that rule, because professionally the last three years of my life -- since I came to Washington -- have been the most exciting and challenging of my life. And for the United States, as well as the world, the times have been nothing if not interesting.

Think of the events that have occurred in that relatively short period of human history. The Soviet Union has crumbled and the nations of Eastern Europe have been released from decades of tyranny. Through its successes in the Gulf War, the United States has, in the President's words, finally put the Vietnam syndrome behind us. Democracy is spreading in many parts of the world, and here at home the principles of freedom continue to be strengthened.

There have also been negative changes during that time. The United States has suffered through a prolonged recession, though this recession has been milder than most since World War II. In various locations around the world, militant nationalism threatens newfound freedoms. The continued threat of nuclear proliferation gives all nations cause for alarm. Each of these developments requires careful consideration and well-thought-out responses.

My own field -- science and technology -- has also been undergoing changes that reflect the broader changes taking place in our nation and our world. Tonight I would like to talk about the changes going on both in defense science and technology and in civilian science and technology. Finally, I shall conclude with a few observations about how science and technology interact with the intelligence community and how the intelligence community can help support science and technology.

Defense Science and Technology

Turning first to the area of defense, as I am sure you are aware, tremendous pressure is being exerted to reduce the size of the defense budget. Because research and development makes up about one-seventh of total defense spending by the federal government, the pressure to downsize is also felt very strongly there.

To some extent, reductions in certain areas of defense R&D are inevitable. As the military threat from the former Soviet Union continues to decline, the emphasis in defense R&D is likely to shift. Rather than focusing exclusively on the stockpiling of weapons, we can focus as well on the stockpiling of ideas and people who can rapidly convert those ideas into reality if the need arises.

The matter of maintaining a strong technology base is especially important. For decades after World War II, the Department of Defense was the dominant supporter of both fundamental and applied research in this country, and it originated mechanisms for federal support of academic research that remain the envy of the world.

In time of international uncertainty, it is now particularly important to strengthen basic and applied research to avoid being blindsided by potential adversaries. By continuing to increase basic and applied research, an additional, very important purpose will be served. Such increases will help to rebuild some of the bridges between the Defense Department and academic community that were present in the immediate postwar decades. These bridges were important for both sides: they brought the Defense Department into contact with some of the best research and brightest minds in the country, and they supported the development of new knowledge and the training of young minds that were able to use that knowledge creatively in the universities.

During the 1960s and 1970s these links between the defense community and the academic community were gradually broken, largely because of the influence of the Vietnam War. The time to rebuild these bridges is long overdue. As the Greek historian Thucydides wrote, "A nation that draws too broad a difference between its scholars and its warriors will have its thinking done by cowards and its fighting by fools."

Civilian Science and Technology

The budget that President Bush sent to Congress last week also continues a very important shift in civilian R&D. Even though overall defense R&D was up only 1 percent, civilian R&D was up 7 percent -- to over $30 billion. This is in the context of a budget in which spending authority was frozen, meaning that every dollar for increases in research and development had to be taken from other programs, often ones with very strong constituencies.

An important feature of the R&D budget this year is the work that has been done by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). FCCSET is an interagency body that was created to coordinate areas of science and technology that cut across the missions of more than one federal agency. By bringing together representatives from the various federal agencies involved in a particular area of science and technology, FCCSET works to ensure that the maximum science and technology results are obtained at whatever investment level Congressional action makes possible.

Last year, FCCSET carried out crosscutting interagency initiatives -- what we refer to as "crosscuts" -- in three areas: high performance computing and communications, global climate change, and mathematics and science education. This year two new areas have been added to the original three: biotechnology and materials science and processing. Next year, advanced manufacturing will very probably be a strong candidate for addition to this list.

In high performance computing and communications, FCCSET's Committee on Physical, Mathematical, and Engineering Sciences has brought together nine agencies in a program designed to sustain and extend U.S. leadership in all advanced areas of computing and networking. In my opinion, there is no other single initiative that will have as large and as widespread an impact on business, education, government, and society in general.

Last fall Congress appropriated a 27 percent increase for the program and passed the President's High Performance Computing Act of 1991 (P.L. 102-194), which

the President signed on December 9. For FY 1993 the budget proposes a further increase of 23 percent for the program, to a total of $803 million.

In advanced materials and processing, representatives from ten different federal agencies under FCCSET's Committee on Industry and Technology have organized a coordinated effort to exploit opportunities in materials R&D to meet significant national goals and extend U.S. leadership in the materials area. As I have said on other occasions, we are entering the age of tailored materials, and an unprecedented number and range of opportunities await today's researchers.

The FY 1993 budget launches this Presidential Initiative with funding of over $1.8 billion in support of materials R&D. This total includes only those federal programs that are not classified, meaning that the government-wide materials R&D is substantially higher. The $1.8 billion is an increase of over 10 percent from the R&D levels of FY 1992.

In biotechnology, FCCSET's Committee on Life Sciences and Health has developed, a national Biotechnology Research Initiative to assure the nation of a vigorous base of science and engineering for biotechnology. This initiative will maintain the United States' lead in health-related biotechnology research and will expand research in other critical areas, such as agriculture, energy, and the environment, where applications of biotechnology research promise significant breakthroughs.

The National Institutes of Health has been the largest supporter of biotechnology research, but 11 other agencies are also involved in this Initiative, reflecting the breadth of biotechnology's applications. The FY 1993 budget proposes that biotechnology research funded by these 12 agencies increase by 7 percent, to over $4 billion.

In addition to these three crosscuts, a number of other areas of civilian R&D have been emphasized in the budget this year, including energy research, biomedical research, transportation, space technologies, and a host of other areas. In general, the Bush Administration is convinced that these activities will be an essential ingredient in improving U.S. productivity and enhancing long-term economic growth.

The Links Between Defense and Civilian Research

Some might conclude, in looking at this budget, that the federal government has decided to emphasize civilian R&D and deemphasize defense R&D. I see that as a completely mistaken view. By emphasizing civilian R&D, the government cannot help but emphasize defense R&D, because of the steadily increasing number of linkages between the two.

Prior to coming to Washington, I used to think that international competitiveness could be separated from national security. I no longer think that to be the case. There are so many dual-use technologies -- and such close links between the defense and commercial applications of technologies -- that we must consider economic competitiveness and national security as two aspects of a single problem.

Furthermore, changes in the relationship between defense and civilian R&D have been increasing the linkages between them. In the past, frontier technologies developed in the defense sector diffused in large numbers into the civilian sector, and such spinoffs continue to occur today. In recent years, however, advances in defense capabilities have benefitted to an even greater degree from technological innovation by the civilian sector.

One striking demonstration of this linkage involves the crosscuts I mentioned earlier. The Department of Defense is a major contributor to all three of the technology-based initiatives. In high performance computing and communications, DARPA is aggressively pursuing the hardware and software advances needed to achieve the program's goals. In materials, the DOD Materials Science and Technology Program is sponsoring work across the entire range of materials science and engineering. In biotechnology, all three of the services have programs in such areas as environmental restoration, biomaterials, and health research. All of this work is focused on military needs and capabilities, but a very significant fraction of that work also has important commercial applications.

Science and Technology for Intelligence

These changes in science and technology that I have been describing have kept me and everyone in my office extremely busy. The number of issues that involve science and technology continues to grow as science and technology exert an ever greater influence on our lives. And the international character of science and technology requires that we track not only domestic trends but developments abroad as well.

One of the things that has made this last aspect of my job feasible has been the support that the intelligence community has provided me. The DCI has assigned a liaison officer to OSTP who ensures that my staff and I receive timely and relevant intelligence support across a broad range of issues. This assistance has been critical to my ability to support the President as his Assistant for Science and Technology.

When I am asked to describe the work of my office, I often break it down into two broad categories: science and technology for policy, and policy for science and technology. It is useful, I believe, to break up the topic of science and technology and intelligence along similar lines: the impact of science and technology on the work of intelligence, and the role of intelligence in support of science and technology policymaking.

Science and technology have long played a central role in intelligence collection and analysis, but today the ground rules are undergoing major changes. In the past, the intelligence community often had the best science and technology in the world. You were way out in front of the rest of the United States, and way out in front of the world.

But today, in many respects, the commercial world has caught up with you. Research and technology that was once the exclusive province of the intelligence community has become widely available. One example is the enormous expansion in the commercial electronics industries. Another example is the range of collection devices -- sensors, communication gear, satellite imagers -- that will soon be available to the private sector.

Today, you don't have to be a great power to acquire sophisticated collection devices and counter-collection devices. The proliferation of these technologies will pose new challenges to U.S. intelligence collection and security.

Another ongoing change involves the use of science and technology to support intelligence analysis. We have spent a fortune on technology to support collection, but relatively little on the processing and analysis of that information. If you believe that meaning rather than volume is the measure of effectiveness, this is a curious imbalance. We need to support technology to analyze information just as much as we have supported technology to gather it.

I have been impressed by some of the pilot projects I have seen at the CIA and elsewhere for data management (for example, CATALYST). But I have also been surprised and concerned to see how far behind most of the community is in exploiting information systems technologies. Here is an area where the intelligence community can profit greatly from the advances being made in the commercial sector.

Throughout our lifetimes, the United States has relied on our science and technology to give us an edge and ensure our leadership in the world. With the Cold War over, we are entering a new epoch in our nation's history and the mission of intelligence in this world. We need to ensure that the next 30 years will be as creative and as productive a period in science and technology applied to intelligence collection and analysis as the previous 30 years have been.

Intelligence for Science and Technology Policy

What, then, is the role of intelligence in support of science and technology policymaking?

Since one of the main objectives of intelligence is to illuminate the forces at work in our world today, I believe that the intelligence community has a unique contribution to make in meeting the needs of policymakers in both economic matters and science and technology. Collection and analysis of intelligence concerning foreign competition in critical technologies, for example, is vital to our efforts.

I would not suggest, however, that the intelligence community should be expected to assume the sole responsibility for collecting economic information on foreign companies and countries for the U.S. government. Most of the information the government needs to make economic policy decisions is not intelligence per se but open information that is collected by a variety of departments and agencies.

Nevertheless, to the extent that the intelligence community can provide select parts of this critical information -- that which is secret and germane to policymakers' needs -- it should sharpen its skills to do so. Recently, the President directed policy departments and agencies to submit their intelligence requirements through the year 2005 to serve as a blueprint for allocating intelligence resources into the future. OSTP has been working with the NSC staff to ensure that science and technology requirements are thoroughly and thoughtfully represented in that study.

Finally, I would turn my attention to the issue of intelligence support to U.S. industry. As all of you are aware, foreign governments are using a variety of mechanisms to gain access to U.S. research and technology. The vast majority of these activities are open and direct and legal, but some are not.

Under our system of government and our society, there are numerous impediments to the U.S. government providing commercially useful intelligence directly to industry. These range from protecting sources and methods to preserving liaison relationships with our allies to a variety of serious legal and ethical complications. As Director Gates has affirmed, the U.S. government is not in the business of industrial espionage, and we will not go into that business.

But I believe that the resources of the intelligence community could be brought to bear on identifying the collection targets of foreign competitors, with briefings given to U.S. industry. This would allow U.S. businesses to better understand their vulnerabilities and the threats against them and to take steps to protect that information they deem of value. My office is working with the intelligence community to explore the practical steps that might be undertaken to enable a government-industry partnership of this sort to move forward.

Conclusion

To conclude, both of our communities -- that of intelligence, and that of science and technology -- face major changes in the years ahead. The world has become, simultaneously, a smaller and much more complicated place. The challenge to both policymakers and the intelligence community is to try to keep pace with rapidly changing conditions.

This challenge may require, in fact, that we hone particular skills. Let me leave you with a story about Winston Churchill, who was once asked to name the most desirable qualification for a young person wishing to become a politician. He replied, "It is the ability to foretell what is going to happen tomorrow, next week, next month, and next year. And to have the ability afterward to explain why it didn't happen." That is a lesson all of us should bear in mind.

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I apologize for the delay in sending this to you. I hope it's still useful. When you're done with the transcript, I would be very interested in seeing a copy for my own files. Steve Olson