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Science and Technology: From Eisenhower to Bush

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It was very appropriate that the Center for the Study of the Presidency asked me to speak at its October 1990 Austin 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 fullest expression in the Bush Administration today. It took many years to lay the groundwork for these mechanisms, as science and technology became ever more important, after World War II, in the affairs of the federal government. But when the position was established, it was in fact established very quickly, and the reason was 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, succinctly, "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 (a 1950 creation based on the recommendation of William T. Golden) to ask them how he should respond to the crisis. Columbia University Professor of Physics I. I. Rabi was chairman of the committee at that time. He had been a friend from the years 1948-52 when Eisenhower had been President of Columbia 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, the President of Massachusetts Institute of Technology (MIT) 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. (This period of a few weeks is important; I shall return to it below.) President Eisenhower made 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, the Harvard chemist 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 looked on them as members 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 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. My Yale associates, who well remember that I absolutely refused, for 30 years, to do anything before 9 a.m., were appropriately impressed. 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 that I have survived 30 years of Ivy League faculty meetings.

Another distinguishing feature of my office is that 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 such experienced and competent individuals to join me in OSTP, because working with them has been one of the most rewarding parts of my job.

The Ups and Downs of White House Science Advice

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 President Nixon trusted them even less. The situation came to a head in the early 1970s, when several former members of PSAC and one current member testified against the Nixon Administration's positions on antiballistic missile plans and the supersonic transport, even though they had participated in confidential discussions on these topics. 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 obviously 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 Gerald 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 Assistants 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 very much like having 20 Ph.D. oral examinations over the period of a year. I shall be a kinder and gentler examiner when I return to my Yale professorship.

The President's Council of Advisors on Science and Technology

P.L. 94-282 also made provision 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 Presidential 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 the mission responsibilities and health of the federal laboratories, the health of the nation's colleges and universities, the control of U.S. air space, and matters of 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, with the possible exception of Eisenhower, 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 two years 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, for example, 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 co-chaired 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 science and technology topics that have come to the President's attention during the past year: 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 (which William Golden and Gordon Hoxie had also recommended) of reestablishing an entity comparable to PSAC. However, in contrast to the few weeks required by Eisenhower to establish his PSAC, it took seven months of legal and organizational activity before President Bush could sit down with a comparable body. 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 participated actively in a portion of all of those meetings, as have other individuals within the senior White House staff, and there is clear evidence that they have found PCAST's deliberations to be extremely valuable. The members of PCAST, with

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backgrounds ranging across industry, academia, and government, bring some of the best minds in the country to bear on questions of great national and international importance, and the discussions are as free-wheeling and as provocative as any I've known.

Since the demise of PSAC, concern has been expressed that 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 in place to look at high performance computing and communications, and the group is establishing panels in such areas as competitiveness, education, biotechnology, biodiversity, and materials science. These panels will be a valuable source of input not only for Presidential decision-making but also for 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 working with the Office of Management and Budget (OMB) 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 almost \$70 billion, so if we divide the responsibility equally, each of us would be looking at something like \$2 billion of research and development.

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 Senate report accompanying the FY 1991 OSTP appropriations bill requested no fewer than nine separate new reports from OSTP, with due dates ranging from next month to early next year. Individually, these reports are all generally reasonable requirements and are just the sort of thing that the science advisor should properly devote time and resources to doing. However, producing them at the level of quality that I would like and that the topics deserve represents a significant amount of work.

I have not even mentioned the brush fires that inevitably need to be dealt with. Let me give an historical example: when George Kistiakowsky, who was a distinguished chemist, came to Washington, he expected to be involved 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 no small portion of my time and the time of OSTP's staff.

Given these competing demands, we must constantly work to 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 helps us perform one of our most important responsibilities: that of helping to coordinate and integrate the federal government's science and technology activities. That mechanism is the Federal Coordinating Council for Science, Engineering, and Technology, which has the rather unfortunate acronym FCCSET (pronounced "fix-it"). FCCSET brings together representatives from the various federal agencies that are involved with science and technology to work out ways to mesh interagency efforts most effectively and to ensure that the maximum science and technology results are obtained at whatever investment level Congressional action makes possible. 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. One of the reasons, I discovered, was that the representatives to FCCSET were at too low a level. When FCCSET made a decision, that decision could be—and frequently was—overruled by the heads of specific agencies, because those individuals did not consider themselves beholden to or involved with FCCSET. I set out 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 includes in its membership the Cabinet Secretaries and Administrators of the agencies and independent agencies, respectively, involved with science and technology, together with Assistant Secretaries from the agencies involved with science and technology, together with Assistant Secretaries from the agencies involved with science and technology less directly. Now FCCSET decisions have major impact, and the Council is making major strides toward achieving the goals set forth in its founding legislation.

Seven umbrella committees have been formed under FCCSET in specific areas of science and technology, and these committees, together 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 integrating the efforts of the nine agencies involved in the program.

This year, two other committees are working on similar cross-cut analyses in mathematics and science education and in high performance computing and communications. These activities are carried out in close collaboration with the Office of Management and Budget, which has the ultimate responsibility for developing the annual Presidential budget submission. Next year, FCCSET hopes to do cross-cut

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analyses 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. Furthermore, once a cross-cut process has been established in a given area, we plan to update the analysis on an annual basis. This will provide both the President and the Congress with a coherent overview of the entire federal activity in each of the study areas.

Although a substantial part of FCCSET's activity does involve budget-related matters, it is important to emphasize FCCSET's broader mandate. As a current example, a FCCSET committee is now undertaking a broad interagency examination of risk assessment. The intention is not to focus on the details of any particular assessment but to reach consensus on the assumptions and general principles that should undergird all federal risk assessment activities.

The focus of FCCSET is primarily on matters internal to science and technology, but broader policy issues frequently emerge from FCCSET as well. Those that are internal to science and technology are typically resolved within FCCSET, while those that involve broader issues—such as international considerations, economic policy, national security, or politics—are taken as science and technology input, through a working group that I chair, to the broader policy-making process of the Economic Policy Council or the Domestic Policy Council, and from there, if necessary, to the President for a final decision.

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 the President and to Cabinet and White House decision-making processes. Any one of these components can draw upon the others 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 variations of 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.”

In the area of science and technology, and specifically in the matter of Presidential advice in these matters—as in so many other areas—Eisenhower rarely receives the credit that he deserves for the depth and scope of his insight or for the mechanisms that he developed to improve the effective functioning of the federal government.

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

**COMPETITIVE TECHNOLOGIES
IN THE DEFENSE AND COMMERCIAL SECTORS**

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Executive Office of the President

JASON Spring Meeting
McLean, Virginia
April 24, 1992

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 physical 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
WASHINGTON, D.C. 20506**

SCIENCE, TECHNOLOGY, AND THE INTELLIGENCE COMMUNITY

D. ALLAN BROMLEY

**Assistant to the President for Science and Technology
Executive Office of the President**

**Security Affairs Support Association
Fort Myer Officers Club
Arlington, Virginia
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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

D. ALLAN BROMLEY

Science, Scientists, and the Science Budget

*To influence
R&D funding,
the science and
engineering
community
must learn what
determines priorities.*

Several times over the past 3 1/2 years I have been asked, explicitly by Congress and implicitly by others, to rank the research and development projects supported by the federal government in order of importance. Although those making this request have usually been motivated by good intentions, I have consistently resisted. The science budgets with which I have been involved in the Bush administration emerge from a process far too complicated to be represented by any single linear ranking of R&D projects. The science budget is itself a statement full of priorities, but those priorities exist along a number of dimensions.

This multidimensionality reflects the many different objectives for R&D support in today's society. A partial list of these objectives would include meeting national needs (such as national security, health, industrial productivity, and environmental protection), expanding the frontiers of knowledge, educating students, maintaining the nation's store of scientific

equipment and facilities, ensuring U.S. preeminence in science and technology as well as their effective use in our society, and meeting past commitments. Individual projects inevitably contribute to more than one objective. The largest and most ambitious projects usually

contribute to them all.

The task of arriving at a science budget is further complicated by the complex relationships among these various objectives. For example, certain pairs of objectives are commonly seen as defining the extremes of continuous spectra: basic research versus technology development, small science versus big science, civilian versus defense research, research versus education, and so on. Often these pairs are taken to be opposite and antagonistic, but a closer examination usually reveals quite a different picture. For example, each year the administration must strike a balance between the work that individual investigators wish to do today and the equipment and facilities that those same investigators will need 5 to 10 years from now to define and reach the frontiers of their fields. When posed as little science versus big science, the two goals seem antithetical, but in fact they are complementary and synergistic.

D. Allan Bromley is the assistant to the president for science and technology and director of the Office of Science and Technology Policy.

Because of the synergism among R&D objectives, the challenge is often to achieve balance among goals so as to achieve them all most effectively. In practice, this entails making a cascade of priority decisions throughout the budgetary process. These priorities are conveyed to the Congress in the president's annual budget submission, and the Congress then applies its own priorities to the president's proposals in arriving at final appropriations. From the outside, the system may appear to be chaotic, but more often than not it results in decisions that are remarkably sound.

From the earliest days of his campaign George Bush emphasized the importance of investing in science and technology, and he has maintained that emphasis throughout his first term. At the most immediate level, funding for research and development has increased substantially. If Congress enacts the President's FY 1993 requests for R&D, support for civilian R&D will have gone from \$21.3 billion in FY 1989 to \$30.4 billion, an increase of 43 percent. Basic research funding will have gone from \$10.6 billion to \$14.3 billion, an increase of 35 percent. Even defense R&D has gone up in current dollars, though the total defense budget has fallen.

President Bush has also sought to involve the scientific and engineering communities much more extensively in the federal government's R&D decisionmaking. He established the President's Council of Advisors on Science and Technology (PCAST) so that he and his top aides could receive input on science and technology directly from distinguished representatives of the private sector. He elevated my position within the White House hierarchy and nominated four associate directors for the first time in the history of the Office of Science and Technology Policy (OSTP). He has also given considerable support to the strengthening of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which provides another avenue for private-sector input into federal decisions.

Most recently, after much discussion between the White House and the Congress, the Critical Technologies Institute has been established. It will be administered as a Federally Funded R&D Center by the Rand Corporation under contract with the National Science Foundation. It will be directed by an operating committee consisting of the cabinet secretaries of the R&D-intensive agencies and five senior members of

the Executive Office of the President (EOP). The President has asked me to chair this committee.

The Institute will have a number of functions. It will make possible longer-range strategic planning for technology and its application than is possible in the normal short-response environment of the Executive Office. It will provide support for the ever-increasing number of legislatively mandated studies that are being requested of OSTP and other EOP offices. And it will make possible the much simpler and easier utilization of private-sector expertise in validating and calibrating the activity of governmental bodies.

Despite this increased present and projected access to federal policymaking, many scientists and engineers remain frustrated with science and technology policy at the federal level. I have spoken with more than a few who dismiss the process as narrowly political, as responsive largely to special interests. That has not been my experience. Policymakers need to balance a large number of objectives in arriving at sound policies, only some of which are based purely on scientific and technological criteria. If they are not successful in balancing these objectives, they risk damaging the science and technology enterprise.

I want to lay out some of the objectives that policymakers are trying to achieve in arriving at an R&D budget and to note some of the many points at which the scientific and engineering communities need to contribute to federal decisions. It is absolutely vital that the communities provide this input, even if it cannot be the only influence on a decision. Without this input, policymakers must nevertheless act, but they will be lacking essential guidance.

Bottom-up or top-down

One of the major reasons for the success of U.S. science and technology is the fact that its programs are built largely from the bottom up. In most other countries, a science and technology budget is established at a high level of government and is then divided among different programs. Here, the situation is much more pluralistic. The desires of individual scientists and engineers are reflected in proposals developed by individuals and groups of individuals with shared research goals. These proposals are then filtered by the agencies as they put together their R&D portfolios.

One of the best aspects of this system is that if one agency does not like a particular idea, the chances are

good that another agency will find it appropriate to its mission. More than 20 federal agencies, in addition to private industry and other nongovernmental entities, support U.S. research and development. As a result, good ideas have a high probability of being supported somewhere within the system.

In such a pluralistic system, however, coordination and strategic planning can be difficult. As a result, the Bush administration has greatly increased the role of FCCSET, which is the cabinet-level interagency body within EOP charged with coordinating federal activities in science and technology that cut across the missions of more than one agency. A particularly important activity under FCCSET has been the "crosscut." In a crosscut, an interagency committee begins by developing an inventory of everything that the federal government is doing in a particular high-impact area of science and technology. Drawing on that information, the committee then establishes strategic objectives and priorities for a coordinated federal effort. Existing programs may be restructured or even eliminated to reflect new objectives, and new programs may be started to fill gaps or take advantage of opportunities. The result is an integrated government-wide effort rather than a heterogeneous collection of purely agency programs.

The President's FY 1993 budget included special Presidential Initiatives based on these FCCSET crosscuts in five areas: high-performance computing and communications, global change research, mathematics and science education, advanced materials and processing, and biotechnology research. For the FY 1994 budget, FCCSET has recommended the addition of advanced manufacturing as a new crosscut.

The FCCSET process would seem to embody elements of top-down planning, but in fact it draws its strength from the bottom-up contributions of the individual agencies. Suggestions for crosscuts and other FCCSET activities arise from the agencies and are reviewed and approved by the full FCCSET. If an agency chooses not to cooperate in the process, FCCSET cannot and does not attempt to force it to do

To criticize some megaprojects on the grounds that they do not advance science sufficiently is to fail to recognize their multiple objectives.

so. In this way, the administration has sought to bring the diversity of U.S. science and technology to bear on focused problems of national importance. It has been extremely encouraging to me to see the unprecedented level of cooperation engendered by FCCSET as well as what I might term the peer pressure for quality generated when different agencies compare and integrate their respective programs.

By law all the members of FCCSET and its committees must be federal employees, but the FCCSET committees have been

very careful to structure the crosscuts in such a way as to catalyze interactions with the private sector. A large number of organizations have helped shape FCCSET initiatives, and the final programs reflect the needs of the private as well as the public sector. For example, the Computer Systems Policy Project, a cooperative effort among computer companies, did a wide-ranging study of the High-Performance Computing and Communications program last year, and many of its recommendations have been incorporated into the HPCC program plans.

PCAST has also reviewed all of the FCCSET initiatives and has provided valuable input to the members of FCCSET committees. In addition, PCAST has formed ad hoc panels in many of the areas being covered by the FCCSET crosscuts to maximize the availability of private-sector input into these activities.

Small science and big science

Another point of emphasis in the Bush administration's R&D budgets has been funding for individual investigators, who continue to constitute the heart and backbone of U.S. science. The budgets of the past two years have each proposed increases of about 10 percent for individual investigator research, and the Congress has responded favorably to these requests. As a result, the federal government now funds more individual investigators, and at a higher total level of support, than it ever has.

However, funding for individual investigators makes up only about 10 percent of the total federal

R&D budget. The remainder goes toward support of a tremendously diverse set of other activities, from user facilities at national laboratories to weapons development projects in industry, from agricultural experiment stations to large science and technology projects serving broad groups of researchers.

These large projects, often referred to as megaprojects, are especially visible, but there are many difficulties inherent in using them to draw any sharp distinctions between big science and small science. Megaprojects include single facilities (the Superconducting Super Collider) as well as coordinated programs of research being done largely by individual investigators and their students and associates (the Human Genome Project). Some large projects (such as telescopes or some accelerators) pursue purely disciplinary research, whereas others (for example, the U.S. Global Change Research Program) are focused on more thematic research.

Some of what are often grouped with the megaprojects in public discussions, including such projects as Space Station Freedom and the Space Exploration Initiative, have never been primarily science projects, although for convenience they are included with R&D in the budget. But they are justified primarily on the basis of considerations such as exploring physical frontiers, increasing appreciation of science and technology, maintaining national leadership in a given area, or taking the initial steps in a great human adventure and only secondarily on their long-term (though quite certain) contributions to scientific and technological progress. To criticize them on the grounds that they do not advance science sufficiently is to fail to recognize their multiple objectives.

Megaprojects that do have substantial basic research components are essential to the future of individual investigator research. They should therefore be seen not as competitors but as enabling projects that serve the current and future needs of broadly based science. They, too, are investments in the future. If the growth of a megaproject were to squeeze out support for individual investigators, that project would be defeating its own purpose. It is the responsibility of each administration—and of the Congress—to ensure that the balance between megaprojects and individual investigator research is maintained.

But although the administration and Congress implement this balance, it is the individual disciplines

that must decide what the balance should be. Only those at the forefront of a field can decide on the proper mix of large projects, individual investigator research, and other organizational arrangements, within given funding projections, that can best advance knowledge in an optimal fashion. Individual disciplines have a responsibility to set these priorities and to convey that information to decisionmakers in a timely and useful way, recognizing, however, that there will necessarily be other inputs to the ultimate decision.

Academic research

The United States places greater demands on its research-intensive universities than does any other nation. We expect them to do much of this country's fundamental research as well as to train the young people who will use the resulting new knowledge in effective, creative ways. The success of our research-intensive universities in meeting these expectations has been a critical component of this nation's science and technology preeminence.

Reflecting this success, funding from all sources for R&D at colleges and universities has gone from \$4 billion to \$17 billion in the past 15 years, a doubling in real terms. Nevertheless, the academic research community is experiencing very real and understandable frustration, despite these funding increases. A number of factors have contributed to this distress. There are a larger number of researchers, and many are submitting multiple proposals and amended proposals, severely stressing the peer review system. The costs of doing increasingly sophisticated research have gone up faster than inflation. New regulations have brought increased administrative costs, which have effectively reduced funds available for the support of research itself.

Most important, academic research has, to some extent, become the victim of its own success. Progress in research has generated an unprecedented number of opportunities, and our success at training academic researchers has produced many young people who are more than ready to grasp and explore these opportunities. Though available levels of funding have increased, the numbers of such opportunities and researchers have increased even faster.

Our national goal of excellence in science and technology requires that our research universities con-

tinue to constitute the heart of our national R&D efforts. Federal agencies and U.S. businesses would be severely limited in trying to achieve their objectives without the participation of faculty and students within our world-class institutions of higher education.

Even as we focus national attention on the sorry state of precollege education in this country, we cannot take our leadership in higher education for granted. We have to ensure that our system of higher education—long the best in the world—remains healthy. To that end, PCAST and FCCSET have begun major and complementary reviews of the health of our research-intensive colleges and universities and of the appropriate nature of the relationship between the research-intensive universities and the federal government in a rapidly changing environment. PCAST has held a number of public meetings around the country to gather input from researchers, administrators, and the members of the public for its study, and the FCCSET committee is gathering data for its analyses. The results of these studies, which will be available in late 1992, should do much to point the way toward a more vigorous and productive partnership between academia and government.

Basic research and technology development

Yet another axis along which the administration works to achieve balance is that between basic research driven by individual curiosity and more applied R&D focused on relatively specific goals. The federal government's rationale for investing in basic research has long been clear: Because no one can predict where, when, or to whom the benefits of that research will flow, no single organization or institution can justify adequate levels of investment.

The Bush administration believes that the same is entirely true with respect to the development of certain generic, precompetitive technologies—technologies that have not yet reached the point where an individual company could decide whether or not a specific one of them can be profitable to it. In these cases, too, no one can predict, *a priori*, where, when, or to whom the benefits of that technology will flow, so society will in-

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and to convey them
to decisionmakers.*

evitably underinvest in those technologies without governmental involvement. In OSTP's 1990 report *U.S. Technology Policy*, we spelled out some of the assumptions and other aspects of this policy.

Clearly, however, this administration does not consider it appropriate to provide federal support for very limited technologies that benefit a specific industry at a specific time. That is what we would expect to result from what

we would define as an industrial policy—one that attempts to pick winners and losers in the marketplace. Nevertheless, we do believe that the federal government has a very important role to play in the spectrum that begins with basic research—where the federal government has in most cases already played a strong role—through to the point where it is possible to assess the commercial applications of a generic technology.

A useful test as to whether a technology is precompetitive is whether a company is willing to spend money on it in a cooperative joint venture with its competitors. The results from precompetitive technology research can be shared by a group of companies without reducing the incentives for any of them to further develop competitive proprietary products based on the results of that cooperation.

One way in which the government can support the development of these generic technologies is directly through the federal budget, but many other forms of leverage are also available. In some cases, the government needs only to act as a catalyst for the formation of partnerships or consortia among companies, universities, and federal laboratories. A very large number of these partnerships have been established, and more are being created at an accelerating pace. For example, the Department of Defense (DOD) has helped support Sematech, a consortium of companies working to leapfrog an entire generation of semiconductor manufacturing processes so that the United States can regain its traditional preeminence and market share in this area. Consortia are working on batteries for electric automobiles, on high-temperature superconductivity, on new composites for automobiles, on plant biotechnology, and in many other areas.

We are also working very aggressively to benefit from the enormous investments we have already made over the years in our more than 700 federal laboratories and to make the laboratories more responsive to national needs. An important step here is to have the peer review panels of experts from government, the private sector, and academia, which now evaluate the quality of completed research, participate much earlier in the R&D process—in the selection and design of projects. In this way, the private sector would be much more involved in the development of the laboratories' research programs and would be more prepared to participate actively in the work and make greater use of the results.

Civilian and defense R&D

The ratio between civilian and defense R&D is an often-cited measure of an administration's intentions toward science and technology, but in fact the two numbers measure quite different things. Over 90 percent of defense R&D is aimed largely at the development, testing, and evaluation of new and improved weapons and support systems. The vast majority of defense R&D is therefore judged by criteria quite different from those applied to civilian R&D.

Nevertheless, there are important commonalities between defense and civilian R&D. Defense R&D has always had major commercial benefits in addition to its primary goals, and those benefits remain strong today. But in contrast to the past, when frontier technologies developed in the defense sector diffused in large numbers into the civilian sector, today the trend is in the opposite direction: Advances in defense capabilities have increasingly benefited from technological innovation in the civilian sector. As a result, many key government R&D programs, such as the National Aerospace Plane, find joint sponsorship in the Pentagon and in nondefense agencies.

Because of this convergence, we must increase the two-way linkages between defense and civilian R&D and draw upon commercial endeavors for defense purposes as we support technology transfer from government laboratories to the private sector. The FCCSET process offers some insight into how this convergence is occurring. The Department of Defense is involved in all five of the FCCSET crosscuts, often as a leader of individual initiatives. DOD's involvement grew out of a need to more effectively fulfill its mission, yet this in-

volvement has other major implications throughout the defense and civilian sectors.

As Operation Desert Storm reminded us, America's tremendous scientific and technological strength provides the qualitative edge that has long helped preserve peace. Despite the end of the Cold War, continued uncertainties require that a robust science and technology program be maintained as the foundation for future defense capability. Above all, support for defense R&D must be maintained as total defense spending is reduced if we are to protect ourselves against technological surprise.

National versus international

The national and international components of R&D form another axis along which governments try to achieve a balance. Of course, science has always been one of the most international of human activities. But today knowledge has truly become a global commodity; it rapidly flows around the world to those who can use it most effectively.

Because of the increasing economic importance of this knowledge, some have called for tighter controls on the international flow of scientific and technological information—for example, through the restriction of foreign acquisitions or limitations on the outflow of U.S. technologies. But I believe that most such restrictions would ultimately be counterproductive. Rather, what we need to do is become much better negotiators, in the private as well as the public sector, when striking international agreements involving science and technology. When the United States provides increased access to some aspect of its science and technology, we should see to it that we get comparable benefits in return. The development and use of technology can and should be a positive sum game in which all parties can benefit.

There is one component of science and technology where international cooperation is essential—namely, megaprojects that have become too expensive for any one nation to afford. If such projects are to proceed, they must draw on the shared contributions of many countries.

In the case of international megaprojects, however, the differences among governmental institutions and their procedures can sometimes cause difficulties. In particular, the U.S. approach to these megaprojects tends to differ from that of other nations. In most other

countries, when a project is approved, all of the required funding is appropriated at the outset. When the U.S. Congress, during its annual budget cycle, questions a project that was already approved, our collaborators sometimes find it difficult to understand why we are reconsidering something that they thought was already decided and final.

Because of such episodes, and because in a few cases we have been less than sensitive to the needs of our collaborators for timely communication about changes in projects, the United States has gained a reputation as something of an unreliable partner in international cooperation. This has led us to discuss alternative approaches to international cooperation in the case of megaprojects. One element in such an approach would be the initiation of international discussions well before a specific project ever got started. The question at issue, instrumental characteristics, location, funding, schedule, and involvement of various countries in an ensemble of megaprojects could be discussed in advance, so that collaboration can be made more effective from the very beginning.

Basically, what we need to do in each particular area of science and technology is to come together as an international community and ask ourselves: What are the next questions that need answering to push forward our common frontiers? We could then develop expert advice as to what we need in the way of facilities and instrumentation, where we are going to put them, how we will fund them, and how we can take advantage of the best possible international expertise available.

The subject of megaprojects in science was the leading agenda item at a meeting of the science ministers from all of the Organization for Economic Cooperation and Development (OECD) nations held in early 1992. At that meeting, the science ministers agreed to establish a forum that would facilitate such exchange of information about potential megaprojects at an early conceptual stage. The participants at the forum would be the senior scientists, senior instrumentation specialists, and senior political officials

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who could speak authoritatively on the science, the instrumentation, and the policy and planning involved in the projects. The first meeting of the forum was held in July 1992 to determine the priorities, methodologies, and arrangements for the forum's future work.

The role of scientists

In all of the cases discussed above, the ultimate balance between complementary objectives can only be struck through the political process—by weighing the needs of different groups and working

toward consensus. But in each and every case, input from the scientific and engineering communities is essential. If this input is not forthcoming, decisions will still be made, but they will be made on the basis of incomplete and inadequate information.

In some cases, technical criteria should be the most influential basis for government action. This is particularly the case for merit review of competing projects, but it also applies more broadly. In recent years, a number of disciplines such as astronomy/astrophysics and high-energy physics have undertaken priority-setting exercises to arrive at a broadly agreed-upon list of activities and projects that should be pursued. Although these disciplines have not gotten everything that they requested, they have been much more successful in shaping governmental decisions than have those disciplines that have not set priorities.

At the same time, it bears emphasis that priorities depend critically on their environment, which can change rapidly and dramatically. But if the criteria upon which the original priorities were developed are rational and consistent ones, then they are entirely adequate to the development of priorities appropriate to new situations. As a result, the criteria have much greater longevity and stability than do priorities, and we need to focus just as much attention and effort on the evolution of national criteria for the establishment of priorities in science and technology as on the priorities themselves.

Scientists and engineers influence government decisionmaking in a number of other ways. They participate in professional societies and associations that

seek to influence policy. They serve on advisory committees and panels that interact directly with federal officials. And they are political constituents with an expertise that commands the respect of policymakers. As such, when they avoid special pleading, they can influence decisions in areas that are not directly related to R&D, as they have in arms control.

The desired roles require a high degree of what I might term scientific statesmanship. By tradition, scientists and engineers have been much better at representing their own interests than they have been at placing those interests within a broader context. But today, science and technology face new kinds of pressures. As the discretionary part of the federal budget has become more and more a zero-sum game, science and technology are viewed as being in direct competition with many programs that have very vocal and powerful constituencies. As such, the investments represented by science and technology are increasingly susceptible to being squeezed out by what are presented as more pressing needs.

In this context, nothing is more counterproductive than for various parts of the scientific and engineering community to cannibalize one another in public or in the budget process. The assumption behind this behavior tends to be that if funding does not go to your project, then it will go to mine. But Washington simply does not work that way. If it chooses to cut support for R&D, Congress is much more likely to spend the funds on immediate consumption than on other investments in the future. For better or worse, all forms of R&D are viewed in much the same light by policymakers, and they will tend to rise and fall together.

The public debate over Space Station Freedom provides an excellent example. Although the station is not primarily a science project, space activities have helped to build support for other forms of investment in the future. If Congress were to cancel the station, it is highly unlikely that those funds would flow to other parts of the R&D budget. Indeed, when the Congress threatened to cut funding for the Space Station in 1991 and the Superconducting Super Collider in 1992, it was clear that very little of the liberated funding would have gone to support of R&D. That is why I believe that scientists and engineers must come together to

promote *all* research and development, and not just particular areas, to the public and its elected representatives.

It is true that scientists and engineers who become involved in policymaking run the risk of being perceived as just another special-interest group. But science and technology differ from many of the concerns pressed upon the federal government in that their benefits to society far outweigh the benefits to any specific group. Nevertheless, the risk of appearing excessively self-interested argues for a very broad-based approach to public outreach, in which informing and influencing policymakers is just one of many objectives. After all, in a congressional hearing, an industrialist's mention of how important trained researchers are to a company can have more impact than the entreaties of 10 scientists.

According to the National Science Foundation, there are more than 5 million scientists and engineers in the United States—three times the number of U.S. lawyers and physicians combined. But effective advocacy by scientists and engineers requires a fundamental shift in attitudes. Scientists and engineers can no longer ignore the political process and trust that someone in Washington will eventually realize how important their work is to the future of the nation. There are too many groups with what may well appear to be more immediate needs than those represented by the long-term investments required for science and technology. Scientists and engineers need to recognize the terms of the debate, the criteria applied in decisions, and the perceptions of policymakers and the general public.

Both the administration and Congress have been extremely foresighted in funding science and technology, and many members of Congress agree with the administration that this nation is seriously underinvesting in research and development. But the executive branch and Congress are under intense pressure from a large number of groups, and in the tight budget climate of the next few years they will necessarily make particularly difficult decisions. Scientists and engineers must make their voices heard if the promise of U.S. science and technology is to continue to be realized.

Dana FYI

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release

July 30, 1992

The Bush Administration's Policies for an
American Technological Revolution

FACT SHEET

The President today met with the scientists, management and workers at the world's largest science and engineering project, the Superconducting Super Collider (SSC). He reaffirmed his continuing strong support of the federal investment in this unprecedented scientific undertaking which will provide broad societal benefits.

The Problem

Technological innovation is essential to sustained economic growth. Those nations that innovate most successfully will compete best in an increasingly integrated global economy.

International competitiveness requires needed investments in basic research and efficiently commercializing the results of that research. It involves a technology policy that recognizes the important role of entrepreneurs, and the need for flexibility in deploying resources to their most efficient uses.

The Bush Administration Principles

Since 1989, President Bush has aggressively pushed a strong science and technology agenda, and he has proposed devoting an unprecedented level of resources to R&D.

The President's science and technology agenda relies on six basic principles:

- The private sector must be free to determine its own research priorities.
- The Federal government must promote sound tax policies that stimulate private sector investment in R&D and technological innovation.
- The Federal government must assure that its regulations do not impede firms from developing products or from bringing safe, new products to market.

- The Federal government must support a strong program of basic and applied R&D, which provides broad societal benefits.
- The Federal government must work cooperatively with the private sector in the development of generic or enabling technologies.
- Federally-funded technology must be transferred swiftly and effectively to the private sector for commercialization.

The President has taken these six principles and developed a comprehensive strategy for enhancing America's technology prowess and competitiveness. It includes:

- Opening Up Foreign Markets to U.S. Goods;
- Accelerating Technology Transfer;
- Investing in the Future: Strengthening Our Knowledge Base and Increasing Federal Support for Emerging Technologies;
- Educating Our Students for a World of Technology;
- Coordinating with the Private Sector in Consortia and Other Arrangements to Develop Generic or Enabling Technologies;
- Stimulating Private Sector R&D Through Sound Tax Policies; and
- Promoting Technology Through a Sound Regulatory System.

Opening Up Foreign Markets to U.S. Goods

The U.S. remains the world leader in the export of scientific and technological knowledge. Our high tech exports have increased by two-thirds since 1987, and we enjoy a \$37 billion trade surplus of high tech exports with the rest of the world. The President is determined to maintain this position by opening new foreign markets, and by protecting the intellectual property rights of those on the leading edge of scientific and technological innovation.

1. Bilateral Agreements with Japan. The Administration has opened Japanese markets to U.S. high tech goods through trade agreements covering supercomputers, satellites, semiconductors, and amorphous metals.

2. Intellectual Property Rights in the Uruguay Round. The Administration is currently negotiating to ensure that the U.S. science and engineering base is protected from foreign pirating of technology.
3. North American Free Trade Agreement (NAFTA). The Administration is completing the negotiations on the NAFTA which will open new opportunities for American exporters and the free flow of investment capital into the technologically intensive fields of the environment, medicine, agriculture, electronics and telecommunications.
4. U.S./Asia Environmental Partnership. This unprecedented coalition of U.S. and Asian government units, businesses, and community groups is working together to enhance Asia's environment. This will result in the greater export of American technological know-how and equipment.

Accelerating Technology Transfer

The Federal government has invested billions of dollars in creating the world's finest, most advanced research laboratories. This valuable national resource can assist civilian research efforts to investigate and develop commercially viable technologies.

- Technology Transfer. The FY 1993 Budget proposes a significant increase in technology transfer activities, including almost 1,500 Cooperative Research and Development Agreements (CRADAs) between government laboratories and private industry, an increase of 60 percent over the past two years; approximately 4,500 new invention disclosures; 2,000 patent applications; and almost 300 technology licenses awarded.

The Administration's National Technology Initiative. Ten conferences have been held across the country, and five more are scheduled between now and December 1, 1992. These conferences act as catalysts for creating new partnerships among government, universities and American companies to better translate new technologies into marketable goods and services. A list of the conferences is attached.

- Expanding the Role of the National Laboratories. The FY 1993 Budget proposes that National Laboratories play a greater role in high priority areas of civilian applied R&D by helping to form R&D consortia and other collaborative arrangements led by industry and academia.

- Improving Linkages Between Federal and Industry R&D. Presidential initiatives proposed in the FY 1993 Budget call for increased private sector roles in setting directions for federally funded R&D in critical areas such as high performance computing, advanced materials and biotechnology.
- Fostering Entrepreneurial Activity in Small High Technology Businesses. The Administration has removed impediments to the success and growth of small high technology businesses that are responsible for a disproportionate share of new jobs and innovations.

Investing in the Future: Strengthening Our Knowledge Base and Increasing Federal Support for Emerging Technologies

The Administration remains committed to funding basic and applied research, and to working with industry to develop generic technologies but believes that the market competition is best able to identify winners and losers.

- The President's FY 1993 budget proposes \$76.6 billion in research and development. This represents an increase of nearly \$2 billion, or 3 percent. Federal civilian R&D would increase by 7 percent. The budget proposes over \$14 billion for basic research, an increase of 8 percent, and over \$17 billion for civilian applied research and development, an increase of 6 percent.
- A. Initiatives in Basic Research
 - Superconducting Super Collider (SSC). The FY 1993 Budget proposes \$650 million to support continued prototype superconducting magnet development, and construction of support facilities and a test tunnel segment. The budget maintains the 10-year project schedule approved last year.
 - Doubling the National Science Foundation (NSF) Budget by 1994. The budget proposes an increase of 18 percent for NSF, including a 21 percent increase for basic research.
 - Increasing Support for Individual Investigators. The budget proposes roughly \$8 billion, an increase of 9 percent, for individual investigators funded by the Departments of Health and Human Services and Energy and the National Science Foundation.
 - U.S. Global Change Research Program (USGCRP). The budget proposes \$1.4 billion, an increase of 24 percent, for this initiative to understand more fully the Earth's climate system and to develop sound policies concerning issues such as ozone depletion and global warming.

- Astronomy and Astrophysics. The budget proposes a total of \$890 million for these programs. This proposal is consistent with the recommendations of a recent report of the National Research Council.
 - Agricultural National Research Initiative (NRI). The budget proposes a 51 percent increase to fund six areas of research: natural resources and the environment; nutrition, food quality and health; plant systems; animal systems; markets and trade policy; and processes antecedent to adding value and developing new products.
 - Biotechnology Research. The budget proposes \$4 billion, an increase of \$271 million or 7 percent, for a new coordinated Presidential initiative in biotechnology involving 12 Federal agencies.
- B. Applied Research and Development
- High Performance Computing and Communications (HPCC). The budget proposes \$803 million, an increase of 23 percent, for the second year of the President's High Performance Computing Initiative.
 - Advanced Material and Processing. The budget proposes \$1.8 billion, an increase of 10 percent, for a new Presidential initiative intended to improve the manufacture and performance of materials.
 - Advanced Manufacturing R&D. The budget proposes a total of over \$1 billion, including \$321 million for nondefense-related manufacturing R&D.
 - Energy Technology R&D. The budget proposes \$914 million, an 18 percent increase, for targeted energy technologies. These investments, guided by the National Energy Strategy, will increase energy efficiency, and generate advances in new electricity technologies.
 - Fusion R&D. The budget proposes a 7 percent increase for the development of energy from nuclear fusion. This initiative maintains the U.S. commitment to the International Thermonuclear Experimental Reactor (ITER) engineering design.
 - Transportation R&D. The budget proposes nearly \$1.4 billion, an increase of 17 percent, for transportation research and development in the fields of high-speed rail, aviation and aeronautics technologies. This proposal includes \$260 million for the National Aerospace Plane (NASP) program.

- Space Research and Technology. The budget proposes \$305 million, a 12 percent increase, for NASA space technology development.
- Protecting the Public Health. The budget proposes \$4.8 billion for applied research and development at the Department of Health and Human Services, including over \$1.2 billion for research on Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (AIDS) and an 80 percent increase for the Women's Health Initiative.
- C. Expanding the Geographical Frontier of Space
 - Space Station Freedom. The budget proposes \$2.2 billion, an 11 percent increase, for fabrication and testing of critical components in preparation for first element launch in 1996.
 - Improving Access to Space. The budget proposes \$5.4 billion for civil space transportation, including the Space Shuttle, commercial expendable launch vehicle services, and other initiatives such as the SpaceHab module for microgravity research.
 - New Launch System. NASA and the Department of Defense will propose \$250 million for joint development of a new, more flexible and powerful launch system.
 - Space Exploration. The budget proposes a total of \$586 million for space exploration programs, including the planned mission to Saturn, two new robotic missions to explore the moon, and advancing key technologies needed for future missions to Mars.

Educating Our Students for a World of Technology

Our education system must produce American workers able to compete with any in the world. The National Education Goals call for U.S. students to be first in the world in science and mathematics by the year 2000.

- The President has proposed to Congress \$2.09 billion for science and mathematics education programs, an increase of 7 percent over 1992.
- To enhance teacher training, the President has proposed federally-funded math and science training for 770,000 U.S. teachers, almost half of the total number of teachers in those fields.
- The President's budget proposes a series of

demonstration projects using electronic communications technologies to enhance math/science curricula.

Cooperating with the Private Sector in Consortia and Other Arrangements to Develop Generic or Enabling Technologies

It has long been recognized that it is not possible to predict where, when or to whom the benefits of basic research will flow so that no single institution can justify the necessary investment. The same argument applies to the development of generic or enabling technologies. Examples of Federal support for cooperative activity with the private sector in the development of generic technologies include:

- Sematech, a consortium in which the Federal government and the computer industry cooperate to develop technologies for semiconductor chip manufacture that will leapfrog the next generation and allow U.S. industry to recapture a substantial share of the international market for these chips.
- The Battery Consortium, involving the Federal government, major automobile manufacturers and a number of electrical battery companies, is working towards the development of storage batteries for electric automobiles.
- The Automotive Composites Consortium, involving the Federal government (through the National Institute for Standards and Technology) and major automobile manufacturers, is developing and testing composite substitutes for large metal automotive components (e.g. front-end assemblies) that will result in more fuel efficient but still safe automobiles, and technology with much wider industrial application.

Stimulating Private Sector R&D Through Sound Tax Policies

Fostering technological innovation requires tax policies that encourage research, investment, and risk-taking.

- Research and Experimentation Tax Credit. Since taking office, the President has urged the Congress to make permanent the current 20 percent research and experimentation tax credit.
- R&D Allocation Rules. The President has called on the Congress to extend the so-called section 861 R&D Allocation Rules, which foster R&D activities in U.S. labs. When Congress failed to act, the President used his administra-

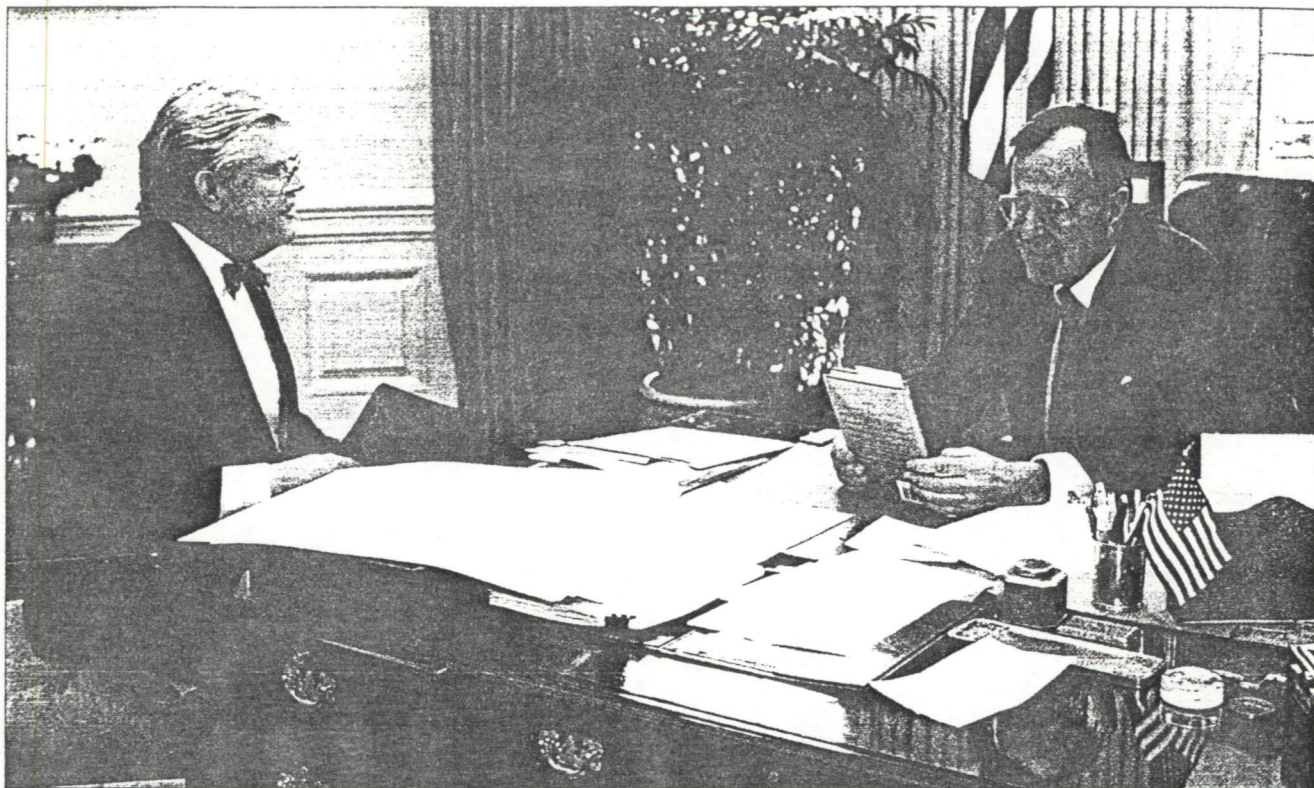
tive powers to extend this important incentive for 18 months.

- Capital Gains Tax Cut. Since taking office, the President has repeatedly urged the Congress to cut the capital gains tax, which raises both the cost of developing new technologies and the cost of purchasing high tech goods.

Promoting Technology Through A Sound Regulatory System

Federal regulatory policy should protect health and safety and promote competition. Where possible, the Federal government should eliminate unnecessary regulatory burdens that stifle technological innovation and product development.

- Biotechnology. The U.S. is the world leader in biotechnology. This \$2 billion domestic industry is expected to increase to \$50 billion by the end of the decade. Some of the most promising advances will be in new drugs and gene therapies to treat existing diseases. Biotechnology will also produce healthier foods, safer pesticides, additional energy resources, and innovative environmental clean-up technologies.
- Drug Approval Process. On April 9, 1992, the Administration announced four actions to speed up the availability of new drugs and dramatically reduce unnecessary burdens in the drug development process: accelerated approval for "breakthrough" drugs for patients with life-threatening or serious illnesses; a new "parallel track" system under which promising new drugs for treating AIDS and other HIV-related diseases will be made widely available as early as possible; external review of some categories of new drug applications by qualified non-government experts; and, streamlined animal testing to reduce the testing time of new human drugs in animals.
- Extending the National Cooperative Research Act (NCRA). The NCRA of 1984 permitted firms to join forces on research projects without the fear of per se antitrust violations. The Administration supports legislation to expand the NCRA to permit firms to jointly produce goods.
- Advanced Television. The FCC is moving to promulgate new rules on a standard for high definition television. This standard will likely embrace the digital technologies pioneered by U.S. private sector firms, which has leap-frogged the analog technologies of foreign competitors.



During D. Allan Bromley's tenure at the Office of Science and Technology Policy, situated within the Executive Office of the President, the government's R&D support increased 13 percent overall. (Photo courtesy of OSTP)

White House Science Office Has President's Ear

Low-profile science advisor influences executive decisions on technology issues, policies and programs.

Few people outside the arcane worlds of science and technology have heard of him, but White House science advisor D. Allan Bromley's decisions can change the way Americans live for generations to come. As special assistant to the President and director of the White House Office of Science and Technology Policy (OSTP), Bromley presides over a tiny domain compared to such multi-billion dollar giants of the federal bureaucracy as the Department of Defense or the Department of Health and Human Services.

When viewed in terms of the potential impact of his somewhat behind-the-scenes role in federal policy-making, however, there is hardly an area of daily life that Bromley does not influence, if only indirectly.

By Mark Tapscott

That Bromley, a respected physicist before joining the Bush administration in 1989, has succeeded in one of the most controversial but least understood jobs in the nation's capitol, while maintaining a nearly invisible public profile, is a measure of the inherent challenges that come with the task of advising the Chief Executive on science and technology issues, policies and programs.

The OSTP Network

As assistant to the President, Bromley is a senior member of the White House staff, equal on the organization chart with national security advisor Brent Scowcroft, economic advisor Michael Boskin and other top presi-

dential aides. As head of OSTP, and with a staff of about 65 people, Bromley is also chairman of several key advisory and coordinating committees that increasingly are setting the tone and coordinating the direction of the federal government's massive basic and advanced science and technology initiatives.

Among the committees under Bromley's purview are the Federal Coordinating Council on Science, Engineering and Technology and the President's Council of Advisors on Science and Technology. Within the Bush administration, Bromley is also chairman of the science and technology working group of the White House policy coordination group, a member of the White House National Space Council and a participant in the deliberations of the National Security



As head of OSTP, Bromley is also chairman of several key advisory and coordinating committees that increasingly are setting the tone and coordinating the direction of the federal government's basic and advanced science and technology initiatives. (Photo courtesy of OSTP)

Council headed by Scrowcroft and the Competitiveness Council under Vice President Dan Quayle.

Bromley's staff works closely with those of the Office of Management and Budget and with more than 20 federal departments and agencies that have significant scientific, economic and environmental policy and program duties.

Bromley recently described his and OSTP's duties as serving two basic purposes. "The first is to provide science and technology for policy. That is, we try to make sure that the President and other senior members of the administration have the best possible science and technology input to decisions where science and technology may be important considerations but where, in many cases, they are by no means dominant ones," he said.

"In this role, it is also critically important for this office to convey some sense of how reliable a given piece of information may be. In the past, there have been many cases of policy being based on very shaky science that was presented as scientific fact without any error bars. It is very important to provide a relevant measure of certainty as well.

"The second major role of OSTP is policy for science and technology, that

is, those actions needed to ensure that the science and technology enterprise in the United States remains healthy, vital and productive.

"Issues within science and technology we try to resolve within OSTP. With issues that involve broader policy questions, we work with other offices in the White House, particularly with the National Security Council and the Council of Economic Advisers, with the Cabinet secretaries, and, ultimately, with the President himself to seek successful outcomes."

Real-World Achievements

Within the dry recitation of organizational duties and lines of authority, however, there lacks a real-world appreciation of how far OSTP has come under Bromley's leadership since 1989. Interviews with OSTP, congressional and private sector officials and authorities suggest that Bromley's major achievements include:

- marshalling Bush administration and congressional support for significant increases in federally funded science and technology research, including a commitment to double the budget of the National Science Foundation (NSF) by 1994.

- recasting and reinvigorating OSTP's role as central coordinator of the federal government's numerous research and development efforts and policies, and in restoring, via the President's Council of Advisors on Science and Technology, a means of getting undiluted advice from the science and technology private sector directly to the president without intervening political and bureaucratic considerations.

- formulating a coherent federal science and technology policy process while successfully navigating the shark-infested political waters in the

White House, on Capitol Hill and among the various science and technology community factions on the controversial issues invoked by mention of the term "industrial policy," and in the debate on maintaining U.S. economic and technological competitiveness in world markets. Of Bromley's first achievement, the budget statistics tell the basic story: overall, the United States devotes about \$150 billion annually to research and development, almost three percent of the nation's total gross national product.

Slightly less than half the total is funded by Uncle Sam; the rest by the private sector. Of the federal government's R&D funds, about 60 percent go to defense purposes and the rest to civilian endeavors.

The key fact here is that during Bromley's tenure at OSTP, the government's R&D support increased 13 percent overall. "Obviously, we had a lot to do with that," observed a Bush administration official who requested anonymity.

Bromley himself observes, accurately, that "what makes these increases particularly remarkable is that they occurred when real growth in the U.S. domestic discretionary budget has been essentially limited to inflation as a result of the budget agreement between the President and Congress.

"Increases for research and development have therefore had to come at the expense of other domestic programs with very strong and vocal constituencies," Bromley said. "And since research and development make up one seventh of our domestic discretionary budget, and about an equal percentage of the defense budget, they form very large and tempting targets."

Massive Coordination Effort

Of the second achievement, Bromley gains widespread praise among OSTP critics and supporters alike for his success in elevating the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) to a key role in coordinating the thousands of science and technology research projects funded by numerous federal departments and agencies and covering a bewildering variety of often intensely controversial issues.

At Bromley's initiative, FCCSET serves as a central coordinator of federal research and development funding and policy priorities. Bromley is FCCSET's chairman, and the council's members include 13 Cabinet-level departments and agencies, and the assistant to the President for national security affairs, as well as the heads of the Nuclear Regulatory Commission, General Services Administration, the Office of Management and Budget, NASA and NSF.

"What FCCSET does — and Bromley has led this effort — is examine all of the science and technology R&D activity, then make recommendations to Bush about areas and initiatives that the federal government can undertake to break new ground," said the Bush administration official.

"These are called 'cross-cuts' and what that means is that we get everybody together in one room and look at everything all the agencies are doing on a particular problem, then we say 'okay, folks, let's get our budgets and our activities together in a coordinated fashion,'" the official said.

Among the problem areas that have received FCCSET cross-cuts, or will in the near future, are high performance computing and communications, global climate change, biotechnology, math and science education, advanced manufacturing and advanced materials. "Here the best example is the initiative on high performance computing and communications," the official said. Prior to FCCSET's involvement, several departments and agencies were separately working on massively parallel computer technology, much of it in duplicative ways. Bromley managed to bring a much-needed focus to the effort via FCCSET.

According to the official, several goals were set, including production of a scalable, massively parallel, tera-op computer system and a computer network that will allow gigabit transmission to achieve a thousand-fold improvement in computing speed and a hundred-fold improvement in the transmission rate of data networks.

"Our contention is that five years ago, this stuff could be imagined, but there was no clear-cut plan to produce

Advisory Role Falls From Grace

Not so long ago, an enraged president kicked his science advisor right out of the big house on Pennsylvania Avenue. The year was 1973 and President Richard Nixon, riding high on the wave of a then-historic re-election victory against Sen. George McGovern of South Dakota in November 1972, demanded pro forma resignations of all his major first term appointees.

Most of the appointees were returned for the second Nixon term, but the resignations of White House science advisor Edward David and members of the President's Science Advisory Committee (PSAC) were accepted by Nixon, who still seethed over criticism from the science community of his policies on the Anti-Ballistic Missile and Supersonic Transport during his first term.

For the next three years, nobody was appointed in David's

place, nor those of the PSAC members, and the advisory functions they had fulfilled were moved entirely out of the White House to the National Science Foundation.

"It was a bleak moment for those inside and outside of government who believed that the nation needed the advice of scientists at the presidential level," observed Bruce L.R. Smith, a senior staff member of the Brookings Center for Public Policy Education and author of "The Advisors," which chronicles the role of scientists in the federal policy process in the modern era.

The long road back for OSTP culminated in many respects in 1989 when President George Bush appointed Bromley as director of the office and elevated him to the position of assistant to the president for science and technology.

—M.T.

such a system. We now believe that we are about two years away from doing it," he said.

"The good thing (about the cross-cut) high performance computing work is that there was a recognition that agencies would each try to do everything, when in fact, each has strengths that ought to be emphasized," observed a senior aide advising the Senate majority on science and technology issues who requested anonymity.

In addition, FCCSET's reinvigoration illustrates Bromley's success in moving it to the forefront, according to the American Federation of Scientists' John Pike. "We have a national security council, a council of economic advisors and so forth, and FCCSET has sort of become the science council."

Of the revival by President Bush at Bromley's request of the President's Council of Advisors on Science and Technology (PCAST), Brookings' Smith notes that "Bush has attended most of its meetings or some part of

all of them" since Bromley's assumption of OSTP leadership.

The inaugural PCAST meeting was held at Camp David on Feb. 3, 1990. Members include Bromley, who acts as chairman; Dr. Norman Borlaug of Texas A&M; Solomon Buchabaum of AT&T Bell Laboratories; Professor Charles Drake of Dartmouth; Mary Good of Allied Signal; Ralph Gomory of the Sloan Foundation; LeHigh University president Peter Liking; the Smithsonian's Thomas Lovejoy; John Montague of Ford Motor Company; Duqueane University's Thomas Murrin; Professor Daniel Nathans of Johns Hopkins University; David Packard of Hewlett-Packard; and Princeton University president Harold Shapiro.

According to the senior Senate aide, "There was a weakness at the outset (of Bromley's tenure at OSTP) in the lack of private sector input. He has fixed that, he has really focused the industry input, and the industry is now organizing itself to provide more coherent input."

The Policy Report

The roots of Bromley's success in forging a coherent federal science and technology policy process, particularly with regard to the industrial policy controversy, are seen most immediately in the fact that he secured Senate confirmation of all four of OSTP's

Bromley succeeded in securing creation of the Critical Technologies Institute (CTI) despite intense opposition within the Bush administration.

presidentially appointed associate directors, the first time all four have been confirmed since OSTP was returned to the White House in 1976 (see sidebar).

The fruit, though, is embodied in a presidential report to Congress issued by OSTP in 1990 on the Bush administration's overall technology policy, as well as in Bromley's success in securing creation of the Critical Technologies Institute (CTI) despite intense opposition within the Bush administration.

Issued against a backdrop of the specter of plummeting defense budgets and the loss of millions of defense industry jobs brought about by the then-declining influence and power of the Soviet Union, the OSTP technology policy report hewed to what appeared to be a tight line between industrial policy advocates demanding more aggressive federal actions and those within the Bush administration and elsewhere who contend the free market, not the government, should pick winners and losers in science and technology.

Generally, OSTP under Bromley has sided with the laissez-faire advocates of a limited role for the federal government, but with a crucial twist made necessary by a dilemma facing Bromley and which is hinted at in the report's introduction:

"The goal of U.S. technology policy is to be achieved by maintaining a strong science and technology base, a healthy economic environment conducive to innovation and diffusion of new technologies, and by developing mutually beneficial international science and technology relationships.

"Implementation of the policy must recognize that all parts of the economy, the federal government, state and local governments, industry and academia, have roles to play.

"The education system provides the essential flow of well-trained, innovative manpower. Researchers in academia, the federal laboratories and industry all contribute to the science and technology base. Industry makes the investments necessary to turn this knowledge base into commercial products and processes.

"Federal, state and local governments support research both directly when they fund specific R&D projects, and indirectly through tax and other incentives for private R&D investment.

"The federal government also sets the overall macroeconomic and legal environment in which industry's decisions about product and process development and commercialization takes place."

But putting concrete details on the federal government's macro role pinpoints the dilemma confronting Bromley and OSTP in the industrial policy debate, as described by Pike:

"How do you have an industrial policy when you don't have an industrial policy? The entire notion that the government should intervene in the economy is extremely controversial and the guiding premise of the Bush administration is that the least governed are the best governed."

That attitude, Pike contends, precludes development of a systematic approach by the federal government to helping the defense industry and other key segments of the U.S. economy in the transition from Cold War military spending levels to smaller defense budgets and increased technological competition in the commercial sectors.

The crucial twist becomes evident in the report's acknowledgement that the government should "participate with the private sector in pre-competitive

research on generic, enabling technologies that have the potential to contribute to a broad range of government and commercial applications."

The Government's Role

That phrase, "pre-competitive research on generic, enabling technologies" cracked open the Bush administration's doors to limited government actions.

Thus, according to the 1990 report, the government's primary duty is to:

- create an environment conducive to technological competitiveness by ensuring that technology policy concerns are factored into the formulation of related policies (e.g. fiscal, monetary, trade, environment, etc.) with the overall objective of enhancing U.S. economic growth.

- encourage private technology-related investment through federal monetary and fiscal policies. For example, reducing the capital gains tax and making permanent, as well as enhancing, the tax credit for research and experimentation will provide

The government should "participate with the private sector in pre-competitive research on generic, enabling technologies that have the potential to contribute to a broad range of government and commercial applications."

incentives for added investment. Incentives can also be provided through appropriate tax policies.

- provide an appropriate legal environment at the federal level that removes unnecessary obstacles to innovation. Reducing the uncertainties about antitrust enforcement related to

inter-firm cooperation in research and technology development encourages the pooling of limited resources and a rapid diffusion of results while still protecting against anti-competitive practices.

- revise federal procurement regulations and practices to permit greater integration of government and commercial production at the factory level, as well as encourage greater innovation and efficiency in development and production. Also encourage the use of commercial products, to the extent feasible, for defense, space and other government applications.

- improve opportunities for companies to commercialize technologies and computer software developed during the performance of government contracts by allowing the contractors to retain rights in technical data and by protecting their trade secrets.

- provide a stable regulatory environment in order to decrease risk for private investment.

- seek greater harmonization of regulations and standards for products and processes with our major trading partners.

- encourage increased U.S. participation in multi-lateral international standardization efforts through the standards activities of the National Institute of Standards and Technology.

- seek better international protection of intellectual property to allow more benefits to be recovered from R&D investments.

Calling the report "an important breakthrough for the Bush administration," the senior Senate aide noted that in the document "For the first time, Bush said it is okay to do pre-competitive generic technology assistance by the government. That was Bromley's fingers."

Critical Technologies

Bromley and OSTP have also played an important role in the "Critical Technologies" aspect of the industrial policy debate, including helping to forge a compromise with Congress on creation of the Critical Technologies Institute (CTI) proposed in 1990 by Sen. Jeff Bingaman (D-NM).

Originally, Bingaman wanted OSTP to be responsible for direct oversight management of CTI, but opposition

from the White House, including Bromley, forced reconsideration of the CTI plan originally funded in the 1990 Department of Defense budget bill.

"A lot of jockeying went on but the bottom line was that OSTP was in a bind for several reasons," said the Bush official. "OSTP's credibility is dependant on its being an honest and neutral broker in matters of science and technology policy. Giving OSTP the institute would have instantly made OSTP a picker of winners and losers."

The compromise provides for NSF to select a contractor to manage CTI, with oversight by a special committee chaired by Bromley and including Scrowcroft and Boskin of the White House, Deputy Defense Secretary

That phrase, "pre-competitive research on generic, enabling technologies" cracked open the Bush administration's doors to limited government actions.

Donald Atwood, HHS Secretary Louis Sullivan, NASA administrator Daniel Golden, Secretary of Energy James Watkins, Commerce Undersecretary Robert White, NSF director Walter Massey and OMB's Richard Darman.

The institute will look at emerging technologies and operate as a policy and advisory shop that will produce a series of reports for consideration of government officials.

Computer Network Debate

Bromley and OSTP are not without critics, as seen in the debate over a nationwide computer network proposed by Sen. Albert Gore (D-TN), the Democratic vice presidential nominee. A related network proposal was suggested by Bromley.

Such a computer network would

function somewhat like the Nexis, Lexis and Mexis data services owned by Meade Data Central, Inc., and would link computers in government agencies, universities and private businesses, allowing information to be obtained and exchanged at high speed.

"Such a government-sponsored network would be a costly mistake. If a system is needed, the private sector can develop it more efficiently without taxpayer assistance," observed Heritage Foundation analyst Bryan Johnson in a highly critical study. "Worse, government involvement could hinder the private development of such a system."

"The OSTP plan assumes that government knows better than private businesses what customers want and which companies and technologies can best develop goods and services. But there is no evidence that government bureaucrats know best, and good reason to believe they do not."

And on the increased funding of federal research activities cited by Bromley and other OSTP officials, Pike notes that "There is a lot of credit to go around, but let's remember that this is something that Congress has been pretty enthusiastic about," he said. "One would look in vain for some major scientific or technical initiative that the Bush administration proposed and that they succeeded in implementing over the strong objection of the Hill."

Waiting for November

Bromley's future tenure at OSTP depends upon the outcome of the November election, and he has given no indication of his plans thereafter, regardless of the outcome.

"Now, there is a certain problem of disorganization as we move into the election, but one has to give high marks to Bromley for playing a very constructive role in bringing a measure of coherence into science policy and agency coordination and defining priorities," said Brookings' Smith.

Whatever Bromley's future may hold, he has, according to the Senate majority aide, "done a lot of missionary work and helped, through his phrases like 'pre-competitive generic technology,' in working with the pragmatic majority in Congress." □