THE DECISION MAKING PROCESS IN U.S. SCIENCE AND TECHNOLOGY POLICY

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David W. Cheney
Patrick Windham
Tomoe Kiyosada
Christopher T. Hill
George R. Heaton, Jr

Technology Policy International
www.technopoli.net
An International Consultancy with Representatives in Boston, Washington, Silicon Valley and Tokyo

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Preface

This report was commissioned by the Japan Science and Technology Agency in 2003 in preparation for a study tour to examine science and technology policy making in the United States. Undertaken by the authors as independent consultants in the firm of Technology Policy International*, the work and its findings derive in significant part from their experience in government, the private sector and academic life. The opinions herein do not necessarily reflect the views of the Japan Science and Technology Agency or the institutions with which the authors are affiliated.

David W. Cheney*
Silver Spring, MD
Dcheney@compuserve.com

Tomoe Kiyosada
McClean, VA
tkiyopee@hotmail.com

Christopher T. Hill
Washington, D.C.
Chrishll@erols.com

Patrick Windham
Atherton, CA
PatWindham@aol.com

George R. Heaton, Jr.**
Newton Centre, MA
GRHeaton@aol.com

* Project Manager
**Managing Principal, Technology Policy International

* A description of Technology Policy International and brief biographies of the authors appear at www.technopoli.net.

About the Authors

George R. Heaton, Jr. is a member of the faculty at the Worcester Polytechnic Institute in Massachusetts and an independent consultant in science and technology policy, environmental policy and law. Trained as a lawyer, Mr. Heaton has been on the faculty of the Massachusetts Institute of Technology, and has worked widely for public and private technical and policy institutions in the U.S and abroad. Maintaining extensive professional and personal relations in Japan, Mr. Heaton was a Visiting Professor at Saitama University in 1986-87 and the First Foreign Scholar of the Ministry of Health and Welfare in 1989-90.

David W. Cheney is associate director of the science and technology policy program with SRI International in Rosslyn, VA. He was vice president of the Internet Policy Institute and a senior executive in the U.S. Department of Energy, serving as director of the Secretary of Energy Advisory Board, and advisor to the Deputy Secretary on industrial partnerships and national laboratories. He held posts with the Council on Competitiveness, the Optoelectronics Industry Development Association, the Competitiveness Policy Council and the Congressional Research Service. He has degrees from MIT and Brown University and was a visiting researcher at Saitama University.

Christopher T. Hill is Vice Provost for Research and Professor of Public Policy and Technology at George Mason University in Fairfax, Virginia. After earning three degrees in chemical engineering and practicing in that field at Uniroyal Corporation and Washington University in St. Louis, he has devoted the past twenty-five years to practice, research and teaching in science and technology policy, including service at MIT, the Office of Technology Assessment, the Congressional Research Service, the National Academy of Engineering and the RAND Critical Technologies Institute.

Tomoe Kiyosada is a Senior Science and Technology Policy Analyst at SRI International and holds visiting fellow positions at the National Institute of Science and Technology Policy (NISTEP), the National Institute of Advanced Industrial Science and Technology, and the National Institute for Materials Science in Japan. Previously, as an analyst of NISTEP, Ms. Kiyosada conducted analyses for the Council for Science and Technology Policy to help set priorities in governmental R&D funding. Ms. Kiyosada received a Masters of Engineering from University of Tokyo in 1997 and Bachelors in Engineering from Osaka University in 1995.

Patrick Windham is a consultant on science and technology policy issues and a Lecturer in the Public Policy Program at Stanford University. From 1984 until 1997, he served as a Senior Professional Staff Member for the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation, United States Senate. He helped Senators oversee and draft legislation for several major civilian science and technology agencies and focused particularly on issues of science, technology, and U.S. industrial competitiveness. Mr. Windham received an A.B. from Stanford University and a Masters of Public Policy from the University of California at Berkeley.

Introduction

This report addresses how new science and technology initiatives are formed in the United States. This is not a simple process to describe, because there are many paths by which new initiatives can form. The ideas for new initiatives can come from many sources, and different organizations have been influential in forming different initiatives. There are, however, some common features and patterns to the formation of initiatives. This report is intended to help the reader understand the formation of new science and technology policy initiatives in the United States by explaining the institutions and processes involved, and by providing some examples that illustrate both the differences and common features in new initiatives.

For the purpose of this study, a science and technology "initiative" can be a significant new science and technology program or a collection of existing programs that have been targeted for greater increases in funding (and usually higher level management attention). Some initiatives by this definition are within one agency, whereas others involve the coordination of programs across several agencies.

The report is organized in three sections. The first provides a brief description of the institutions and organizations involved in science and technology initiatives, with an emphasis on the unusual features of U.S. institutions. The second section describes the budget process that science and technology (and other) programs go through, because an understanding of this process is essential to understanding how science and technology initiatives are formed. The third section provides some examples of science and technology initiatives and discusses their common features and differences.

Overview of Science and Technology Policy Institutions

This section provides an overview of key institutions and actors in science and technology policy in the United States. In the United States, power and influence over science and technology policy are divided and shared by many players. Many institutions and organizations compete to have their ideas and interests prevail. The process of forming new initiatives can be viewed as a competition of ideas and influence. In this competition, the players are constantly reforming their teams to get the best advantage, and the winning players and teams vary from time to time and issue to issue.

The four key groups involved in science and technology initiatives are:

- the Congress, which debates, shapes, and provide funding for all Federal programs;
- the executive branch agencies, which propose many initiatives and execute the initiative that succeed;
- the Executive Office of the Presidency, which has control over the President's budget and provides direction over the agencies;
- the many external groups, such as industry, universities, think tanks, and states, which are the source of ideas for many initiatives, and whose support is critical to the success of initiatives.

For any initiative to be successful, it needs ultimately to have the support, or at least the consent, of each of these four groups.

Congress

The U.S. Congress passes laws that establish and direct Federal agencies that are involved in technology policy. Congress also determines the budget for the government and provides the annual funding for each agency.

The legislative branch of government in the United States is unusual in several ways. Compared to the legislatures of most countries, the U.S. Congress is more powerful, more independent of the executive branch, is less disciplined (in the sense that members frequently act independently, and Congress frequently changes its own rules), and has access to much greater information resources.

Both houses of Congress have approximately equal power. The House of Representatives (“the House”), has members who face election every two years and who represent individual Congressional districts. House members tend to be more focused on the immediate needs of their constituents. Because it has more members than the Senate, its members can specialize more on technical issues. The Senate has two Senators from each state, serving staggered six year terms. The Senate is more deliberative, is less formal in its operation, and is somewhat more likely to take a national or international view on issues.

Most of the work of Congress is done through its committees, and each house of the Congress has about 20 regular committees. Most of the committees are “authorizing committees” and specialize in particular substantive areas, such as defense, energy, health, and transportation. They pass legislation that provides the legal framework for the agencies and they “authorize” – give permission – for agencies to spend funds and set funding guidelines, but they do not actually provide the funds. Two other committees, the House and Senate

Appropriations committees, pass the legislation that provides the annual funding for each of the agencies, and thus are especially powerful committees.

Science and technology policy within the Congress is divided among many different committees, including authorizing committees and appropriating committees. No committee or other body in Congress in either House has responsibility for all R&D programs, and none has an overall coordinating role. Instead, science and technology are treated under the committees and subcommittees that have jurisdiction over the departments and agencies in which R&D and other science and technology activities are located. The effect of this fragmentation is that there is no consistent view coming from the Congress on science and technology on either budget issues or policy issues.

The Committee on Science in the House of Representatives (known formerly as the Committee on Science, Space and Technology) is the committee with the broadest jurisdiction over the entire scientific and technical enterprise. It has authorizing responsibilities in the House for NASA, the National Science Foundation, the Office of Science and Technology Policy, R&D in the Department of Commerce, Department of Transportation, and Environmental Protection Agency, and non-weapons R&D in the Department of Energy. In addition to these authorizing responsibilities, the Science Committee has oversight over all non-defense R&D activities, which means that it can hold hearings and conduct investigations over such other activities as NIH and USDA R&D, but it cannot initiate legislation affecting their basic authorities. The committee serves as the focal point for scientific and technical matters in Congress, in part because of the expertise of its professional staff. At the same time, in budgetary terms, the Science Committee has no influence over the largest departmental R&D budget—that of the Department of Defense. It also has not sought much influence over health-related R&D in NIH, in part owing to the power of the

House Committee on Commerce (formerly Energy and Commerce) which has primary jurisdiction over NIH.

The Appropriations Committee has much power over R&D because it controls the funding for all Federal agencies. Many of the thirteen subcommittees of the Appropriations Committee have jurisdiction over some aspect of federal R&D spending. For none of them, however, is R&D their central concern. Some of the appropriations subcommittees have jurisdiction that corresponds to essentially a single government department or agency, while others fund several agencies. One of the most important subcommittees for R&D is the Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies (known as "VA-HUD), which funds the National Science Foundation, NASA, and the Environmental Protection Agency. But it also funds other areas, including public housing subsidies, and benefits for veterans of the U.S. military. So members of this subcommittee must make trade-offs between funding research and space missions versus shelter for the poor, and health care for veterans.

It is relatively easy to submit new legislation or to hold a hearing to raise an issue to national attention, but it is much more difficult to get legislation passed and signed into law. Congressional hearings are an important as forum to debate and form a national consensus around issues. All legislation, including legislation that determines science and technology budgets, has to go through many steps to become law, including approval by committees and approval by the full House and Senate. Because there are many steps in this process, and because it is relatively easy to stop or delay the legislation at any one of many steps, few pieces of legislation make it through the whole process to become law. There are always many more bills than there is time for the House or Senate to consider. There is always competition for time, both at the level of the committee, where the committee chairman has a great deal of influence over what is discussed in that committee, and at the level of the full House and Senate, where the leadership determine which bills are allowed to be debated and voted on.

Unlike in parliamentary governments, where the prime minister is a member of the legislature and a leader of a major political party, the U.S. Congress is quite independent of the President. Of the last five Presidents, only one (George Bush senior) had been a member of Congress, and he had been out of Congress for over 15 years when elected President. Members of Congress, although members of a party, frequently vote as individuals. They vote independently and their constituents in their districts track their voting records. If members of Congress vote in a way that follows their party leadership but is at odds with the views of the constituents in their districts, they are less likely to be reelected. The President can not be assured of support within his own party for his legislation.

The effect of such an independent Congress is that support for the President's initiatives is never assured. Proposals will almost always receive critical scrutiny. Both sides of an issue try to find analyses and experts that support their view. How well these analyses and experts can convince the lay public is key in determining which point of view wins. Because analysis and expert opinion are used as weapons in the political process, with the exception of a few institutions that have well-established reputations for non-partisanship, neither analyses nor experts are assumed to be objective.

Because the loyalty of Members of Congress to the President or party leadership is relatively weak, individual members will act very vigorously to promote the interests of their state or district. Members of Congress with important R&D institutions in their districts, such as major federal laboratories or major research universities, will often choose a committee where they can support that institution. These members' actions in their committee, therefore, are sometimes quite parochial, and their stance on particular issues may be better predicted by constituent pressures than by party or ideology. For example, Senators and Representatives from the state of New Mexico, which has two large national laboratories, can be expected to be strong supporters of R&D at those laboratories since the economic health of the region is very dependent on federal R&D funds for its well being.[2] Similarly, one can expect representatives from Silicon Valley, or the Boston area, or the Austin, Texas region to be strong supporters of policies and funding for technology.

The Congress has access to extensive sources of expertise and information that include its own large staff and the staff's of the Congressional own research and support agencies. In addition, Congress gets information from other sources, including hearings, the executive agencies, the National Academy of Science, and independent experts.

Unlike legislatures in many countries, the U.S. Congress has a very large, and, in many cases, highly trained staff. The typical Congressman has a staff of about 15, divided between their Washington and district offices. Each Senator has staff of 30 or more. Each committee also has its own professional staff, often numbering more than 50, many of whom have advanced degrees and many years of experience in subject of the committee. In all, there are well over 10,000 professional staff members serving the Congress.

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[2] More than 10 percent of the gross state product of New Mexico is attributable directly to federal R&D funding, which is more than twice the proportion of such major federal R&D performing states as California, Massachusetts, and Maryland.

The key staff members are the staff directors of committees and subcommittees, the legislative directors and administrative assistants of members with influence in science and technology affairs, and the staff of the members who serve in formal leadership positions. In addition, some other committee and member office staff have substantial influence, due to their expertise and experience or because they are closely linked to a powerful member of Congress.

In addition to its staff, Congress is also served by three major analytical and information support organizations that are part of the legislative branch of government. These are:

- The Congressional Research Service (CRS) of the Library of Congress;
- The Congressional Budget Office (CBO); and
- The General Accounting Office (GAO).

Congress also receives information through hearings. Congressional hearings serve as an important public forum in which policy issues are raised and debated. There is a potential legislative angle to almost any issue of national importance, and a committee of Congress will take an interest in exploring these issues. Hearings are held by Committee in areas related to their jurisdiction. If it is a highly visible topic, several committees will find a reason to hold a hearing on the topic. Hearings are generally open to the public, except where information is secret for national security reasons. Important or newsworthy hearings are often nationally televised on cable TV (C-Span). Other hearings will be covered by more specialized media, including trade publications and newsletters.

The House Science Committee, as the committee with the most interest in science and technology, holds the most hearings related to science and technology issues. They are likely to hold hearing on major new initiatives at various stages. Often they will hold hearings on a subject well in advance of it becoming a major initiative, again after an initiative has been proposed in the President's budget, and then will hold hearings to check on the progress of an initiative once it is in place.

In addition to its own staff and the staff of its support agencies, Congress is also able to get information from other sources. Congressional staff members receive briefings from many groups, conduct their own studies, and take trips to get information that they want. Because of the power and influence of Congress, groups from around the country are usually happy to provide information. In fact, as will be discussed below, there are many organizations in Washington that have been established to provide Congress with information that supports the views of a particular constituency.

The Congress is also able to direct the executive agencies to provide information or to commission independent studies by other groups, such as the National Academy of Sciences. There is extensive communication with the executive branch agencies, both through formal means such as hearing, reports, and official correspondence, and through extensive informal networks among the executive branch and Congressional staff. Relationships are typically are strongest between parts of the Congress and the executive branch that share interests. Communication is generally better between the executive branch and members of Congress from the same political party as the President, or between an executive agency and a member of Congress who is a strong supporter of the agency.

Another key source of information for Members of Congress is their constituents. Members of Congress pay special attention to information and views from individuals and organizations in their state or electoral district. In the realm of technology policy, this may be the President of a university, the director of a national laboratory, or the chief executive officer of a company in their district. Witnesses at hearings are frequently chosen to include constituents of some of the key members of the committee.

Executive Office of the President

The Executive Office of the Presidency includes the White House and the offices that directly support the President. It has responsibility for coordination and policy direction of the executive branch agencies. The EOP includes the White House and its staff, the Office of the Vice-President, and several offices that play important roles in science and technology policy, including the Office of Science and Technology Policy (OSTP), the Office of Management and Budget (OMB).

The most visible of these in technology policy is the Office of Science and Technology Policy. The Director of OSTP serves as the science advisor to the President. The role of OSTP depends very much on how the President wants to use it. Under the first President Bush, for example, OSTP was clearly subservient to several more powerful staff members in the White House and OMB. Under President Clinton, OSTP had more authority to oversee and coordinate the R&D programs of the departments and agencies than under Bush, including a clear role working with OMB in the budget process. Under the second President Bush, OSTP has been active, but appears to have less direct connection to the White House.

To coordinate the R&D activities of all the departments and agencies, President Clinton created by executive order in late 1993 a National Science and

Technology Council, whose members are cabinet members, agency heads, and chiefs of certain EOP offices. The NSTC is chaired by President and vice-chaired by the Vice President.[3] The NSTC in turn has formed committees in substantive areas, such as Environment and Natural Resources, Technology, Homeland and National Security, and Science. These committees are co-chaired by a senior OSTP staff member—typically an assistant director—and by one or more senior political appointees from relevant departments or agencies. There are also a series of subcommittees and working groups on specific topics. Each committee defines a strategy and set priorities for R&D funding within its jurisdiction as input to the annual budget making process. The NSTC process, as well as earlier cross agency coordinating organizations (such as the Federal Coordinating Committee in Science, Engineering and Technology – FCCSET) under the first President Bush, serve as a natural place for the formation and coordination of cross agency initiatives.

Also operated under the auspices of OSTP is the President's Council of Advisors in Science and Technology (PCAST). This is the President's advisory committee for science and technology. As with OSTP, its influence depends on how the White House uses it. Some President's have used it extensively; others not at all. The current PCAST has conducted a number of studies for OSTP, including some that provide guidance to various initiatives. For example, PCAST currently has a working group that is focusing on the nanotechnology initiative.

The Office of Management and Budget (OMB) has important authority over the R&D activities of the federal government. It influences the programs of all agencies through its role in preparing the President's annual budget submission to the Congress. Its budget making role goes well beyond mere

[3] The full NSTC rarely meets. Most of the activity is done by its committees.

accounting for agency requests -- it is the mechanism by which the President sets forth his annual goals to the agencies that frame their allowable budget requests, it accepts or rejects the agency budget requests on behalf of the President, and it controls most of the negotiations that go between the agencies and the President when agencies are displeased with their budget ceilings.

OMB is headed by political appointees, but most of its staff are career civil servants, despite the Office's close ties to the President's political agenda. The assistant director of OMB for energy and science has the responsibility to compile each year a summary of all federal R&D funding requests, after the budget is complete. This compilation is the closest that the U.S. government comes to forming an "R&D Budget" for the year. OMB also involved in putting together the budget for the science and technology initiatives in the President's budget.

Departments and Agencies

The major cabinet departments that support R&D, and are involved in science and technology initiatives, are the departments of Defense, Energy, Agriculture, Health and Human Services, and Commerce. Important independent agencies in science and technology are National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF).

Departments

Departments differ from independent agencies in that Departments tend to be larger and more political. A Department may have 50 or more political appointees who change with each change in Presidency and whose job is to implement the President's policies. An independent agency typically has only a few people who are appointed by the President, and the top people in the agency are normally expected to be less politically motivated in their actions.

These executive Departments and agencies work to a large degree independently of each other. They tend to be overseen and funded by different committees of Congress, as described earlier in this chapter, and typically have different constituencies and supporting associations, as will be described later in this chapter. Bureaucratic rivalry is in general less intense than in the Japanese system, due in part to the greater depth of political appointees in each agency (as described below) and in part due to greater mobility of people in and out of agencies compared to the Japanese system. Coordination, and to some extent management, is provided by the executive office of the Presidency, through OSTP, OMB, and the NSTC, as described above.

Department of Defense

The Department of Defense is focused on developing new technologies for the military. A large part of the Department of Defense's R&D budget is for development, testing, and evaluation of weapons systems, but it also supports R&D into technologies that have broader uses. Although at one time much of this work was done in relative isolation from the commercial sector, in recent years it has been recognized that many critical defense technologies, such as computing and information technologies, rely on related work in the private sector. Some of the key parts of the Department of Defense in technology policy are:

- the Defense Advanced Research Projects Agency, which funds advanced technology development across a broad of basic technologies, from materials to computing;
- the Army Research Office, the Air Force Research Office, and the Office of Naval Research, each of which funds R&D specific to the needs of their branch of the military.

Department of Energy

The Department of Energy has responsibility for developing new energy technology, for nuclear weapons, and for conducting fundamental science research and operating scientific user facilities. The Department conducts much of its research through the National Laboratories. The main elements of the Department are:

- the National Nuclear Security Administration, which has responsibility for the nuclear weapons program;
- the Office of Science, which supports fundamental research in physics, materials, life and environmental sciences, and computing;
- the Office of Energy Efficiency and Renewable Energy, which supports R&D on energy efficiency and renewable energy technologies;
- the Office of Fossil Energy, which develops fossil energy technologies; and
- the Office of Nuclear Science and Technology, which is responsible for nuclear energy technology.

Department of Health and Human Services

The Department of Health and Human Service's main science and technology element is the National Institutes of Health (NIH), which funds the vast majority of basic medical research in the country. Over the past 20 years, NIH has grown dramatically so that its annual budget is approximately $28 billion, which is about half of all non-defense R&D.

Department of Commerce

The Department of Commerce has general responsibility for promoting U.S. business, and is the only part of the government with a mandate to promote general industrial technologies. The key elements of the Department with respect to science and technology policy are the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology, which conducts research on measurement technologies and also manages the Advanced Technology Program and the Manufacturing Extension Program.

Independent Agencies

The key independent agencies with responsibility in science and technology policy are the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA).

NSF funds research, primarily in universities, across the whole range of science and engineering. Much of its technology work is funded through its engineering division, which funds a number of Engineering Research Centers which also receive industrial funds.

NASA's work is primarily in developing space systems (planetary probes, space shuttle, space station) and conducting space and earth science, but it also funds a aeronautics program that is of direct interest to the aerospace industry. Much of its work is conducted through its laboratories and centers.

Non-Governmental Organizations

The U.S. science and technology policy system relies heavily on a large network of individuals and groups that provides advice, influence, and expertise to shape the development of policy. This network connects the many sources of information with the many elements of the Congressional and executive branches of government that formally develop policy. There are two main reasons for extensive use of external advice. First, the decisions to be taken are often complex and technical, thus requiring expertise beyond what is immediately available in government. Second, the American system has a penchant for pluralism and diversity, which the mechanisms of advice are designed to satisfy.

This section describes the various types of organizations that provide information and expertise and/or advocate interests. They include advisory committees, the National Academy of Sciences, various think tanks, universities and laboratories, industry groups, issue advocacy organizations, professional associations, and others.

Advisory committees

Many agencies of the Federal government have advisory committees that provide policy advice on issues related to technology. Advisory committees are required to have balanced membership (representing an appropriate diversity of views and backgrounds for the issues being addressed). Meetings, with certain exceptions, need to be open to the public and announced in advance, and background materials and reports should be made public. Many advisory committees are established to bring technical expertise into an agency. They are also established to allow an agency to be sensitive to the needs of a broad community and to help get the support of that community.

Advisory committees perform many different roles, including recommending and reviewing new initiatives. Several standing advisory committees deserve particular mention. The PCAST (President's Committee of Advisors on Science and Technology), discussed previously, is the country's highest-level technical advisory board and draws on the most eminent members of the academic and industrial communities. The Defense Science Board (DSB) has served a similar purpose for the DOD and has been uniquely powerful in history not only because of the predominance of defense in science and technology policy but also because of its ability to conceptualize new policy initiatives. The National Science Board is unique in its longevity and breadth of vision, concerned both with the health of science and technology in the US and its statutory functions with respect to the National Science Foundation. The Secretary of Energy Advisory Board provides advice to the Secretary of Energy on issues concerning the policy and management of the Department. In recent years it has produced major studies on priorities for energy R&D and on the management of the national laboratories.

National Academies

National Academy of Sciences (NAS), a non-governmental organization, was chartered by the Congress during the Civil War (1863) to advise the Federal government on pressing scientific issues. From this beginning, the Academy has grown into a large complex consisting of the academies of science and engineering, the Institute of Medicine, and the National Research Council (NRC). Whereas the academies themselves are membership organizations, elected from the country's eminent scientists and engineers, the NRC is an operating research institution, turning out many technical and policy reports of the highest quality, often oriented toward portraying the state of the art, on a frequent basis.

Policy Research Institutes

There are many of policy research institutions whose reputations are high and who are involved in many of the issues of the day. A partial, illustrative list of these that have been involved in technology policy issues includes:

- The Rand Corporation
- The Center for Strategic and International Studies
- The World Resources Institute

- The Carnegie Institute

These organizations receive support from a variety of sources, including philanthropic foundations, corporations, and government. A number of the large foundations—Sloan, Ford, Rockefeller, Pew and MacArthur, for example—have been steadfast and generous over the years in their support for independent analysis relating to important issues of public policy involving science and technology. The policy research institutes, while usually not the source of ideas for initiatives, often do analyses that strengthen or weaken the case for initiatives.

Universities

The American university community plays a key role in defining and implementing US science and technology policy. Because science and technology policy depends so heavily on knowledge and expertise, the influence of academe has been strong and continuous. The academic influence has long been felt at the very top of the science and technology policy hierarchy. For example, the President's Science Advisor has usually been drawn from academe, and the post was looked on, in part, as a voice for academic science. Most Federal advisory committees draw their membership in significant part from the academic community.

Because individual academic scientists perform such a large share of Federally sponsored research, they are active in defining policy in many ways—from serving on peer review committees to lobbying for particular programs. Academic scientists and engineers often participate in the discussions that prepare the groundwork for new initiatives, and the often testify before the Congress on the need for initiatives.

Within recent years, the format for academic community influence on science and technology policy may have become more formalized. Many of the large universities, including MIT and the University of California, maintain Washington offices to monitor trends and represent their interests in various public forums. Universities also participate regularly in issue-oriented advocacy, through groups such as the Council on Competitiveness (described below).

Federal dollars going to universities are economically significant in many communities, both for the direct impact of Federal dollars and because Federally funded R&D can serve as a catalyst for private sector economic development in the area. Members of Congress have become advocates for funding for their university, and for funding in the fields in which their university excels. Universities have collaborated with powerful members of Congress to direct funds to their universities outside of the normal resource allocation processes.

Federal Laboratories

The Federal Laboratories also play a significant role in the policy process. Because funding for the laboratories is concentrated in specific Congressional districts (in contrast to National Science Foundation or National Institutes of Health funding, which is spread more thinly among universities), the funding of individual laboratories is very important to specific members of Congress. The large Department of Energy National Laboratories can be significant contributors to the local economy, especially when the laboratories are in less populous states such as New Mexico, Idaho, and Tennessee.

The DOE laboratories, because they are operated by contractors, have more independence in policy matters than do the government-owned, government-operated laboratories more common in other agencies. Many of the DOE laboratories or their contractors have Washington offices, and many of the laboratories send some of their personnel on temporary assignments in Washington to support members of Congress or the Executive Branch. In this way they help build links between Washington and their laboratory, as well as provide technical expertise to the policy process.

The DOE National Laboratories have been deeply involved in the development and execution of most science and technology initiatives, in part because they have facilities (scientific instruments and computing) needed in many initiatives, in part because they can manage large scale projects, and in part because they are well connected to Washington.

Industry

Industrial participation in developing science and technology initiatives occurs both through the efforts of individual firms representing their own interests and through industrial associations advocating the common interests of a particular sector. In Congressional hearings on new policy initiatives, the voices of individual firms are solicited, and welcomed when volunteered. While the firms so engaged will vary with the particular issue, certain large, technology-oriented companies are strong participants in science and technology policy. IBM, AT&T, Hewlett-Packard, Motorola, Intel, TRW and 3M are good examples of companies whose Washington representatives and chief executives are frequently involved in technology policy.

Issue Advocacy Organizations

Issue advocacy organizations have long been an important feature of the public policy debate in various policy areas. Advocacy institutions have arisen in the context of specific science and technology policy issues. Two examples of this trend include:

- the Council on Competitiveness, a membership organization with significant staff and publication capabilities, whose analyses of US competitiveness have been very influential in framing this issue;
- the National Coalition for Advanced Manufacturing, a coalition of manufacturing companies, other industry groups, and technology extension centers that formed to advocate programs to promote advanced manufacturing.

Professional Associations

Associations of technical professionals have long been among the strongest supporters of Federal science and technology policies, particularly as they affect the situations of individual scientists and engineers. The IEEE (Institute of Electrical and Electronic Engineers) is the largest such organization. The APS (American Physics Society), and the AIChE (Chemical Engineers) are smaller but also important players, with a strong tradition of involving members in public service roles, such as Congressional fellowships. The AAAS (American Association for the Advancement of Science), though not strictly speaking an association of well-defined professionals, has for many years contributed meaningfully to the development of national science and technology policy.

Analysis of U.S. Science and Technology Policy Institutions

The U.S. institutions that participate in the development of science and technology initiatives collectively have a number of characteristics that set them apart from other countries. One characteristic is the number, size, and diversity of institutions involved in science and technology policy. This is in part a function of the size of the country, but it also a function of the national tendency to avoid the concentration of power in single institutions. A second characteristic is the important role of political institutions in the technology policy process. The Congress plays a stronger role vis a vis executive agencies than in many countries, and the executive agencies have more political appointees in senior policy positions than do the bureaucracies in many other countries. A third characteristic is the number of non-governmental entities -- think tanks, associations, issue advocates, and others -- that are involved in the policy process.

Although there are clearly strengths and weaknesses in the American institutions for technology policy, one can argue that they have, in general, served the country well. In particular, the system promotes a large amount of discussion and incorporates a broad diversity of views, which may be essential for a country at the forefront of science and technology to move forward when the desirability of alternative paths is unclear.

The R&D Budget Process

Before explaining how new initiatives are formed, it is important to discuss the ordinary budget process, as new initiatives can be simply considered to be variations on the process of R&D budget formation. There are two distinct parts of the U.S. government's budget process: the development of the budget within the executive branch, and the consideration of the budget by the Congress.

Agency Budget Development Process

The budget process in the executive branch typically begins over 2 years before the start of a new fiscal year. For example, agencies are working in 2003 to develop their fiscal year 2005 budget, which will be submitted to Congress in February 2004, worked on by the Congress from February to September 2004, and will take effect in October 2005. For a year or two preceding the presentation of the President's budget, people in the R&D agencies, as well as universities and laboratories and industry groups, are putting together ideas and proposals for the budget. They want to develop the strongest arguments for funding both existing programs and new initiatives. Input from universities, laboratories, and industry is helpful not only to generate ideas but also to develop political support for new initiatives.

Each element within an agency puts forward its budget, and tries to sell it in the way it believes is most effective, either relating it to Administration priorities, national needs, or political interests. Agencies and groups that receive government funding almost always want much more funding that the amount available, so there is almost always strong competition for funds.

The President, working with the Office of Management and Budget and the Office of Science and Technology, will set overall target budgets for each agency and will also lay out some priorities for the coming year. In the Clinton Administration, there was a joint memo from the OMB Director and the OSTP director specifying, in a general way, budget priorities in science and technology.

The Agencies formally submit their budgets to the OMB in August or September, a little more than a year before the start of a new fiscal year. OMB will reviews the budget to see how well it fits with the President's priorities and the overall budget. In October or November, OMB will "pass back" the budget to the agency with OMB's changes, which typically cuts the budget below that the agency has requested in some areas, but may also increase the budget in some areas that are high priorities for President. After this, there is frequently negotiation between the agency and OMB director. Then the budget is combined with the budgets of the other agencies to make up the President's budget, and which is presented to Congress in February of each year.

Congressional Budget Process

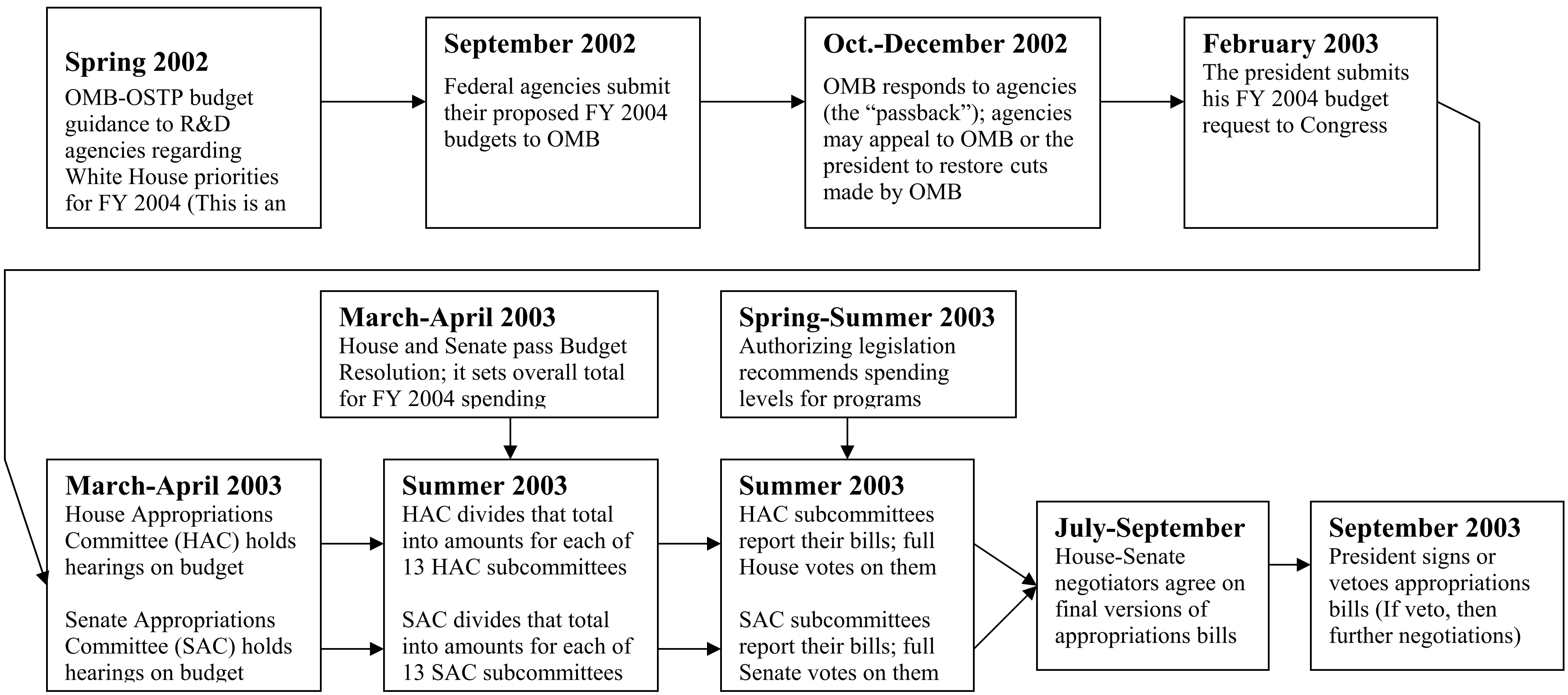
Much of the work of the Congress is to determine the funding levels for the Federal government. Many technology policy issues, including the desirability and size of key technology programs, are addressed through this process.

There are three separate but closely connected processes involved in determing the budgets for programs. There is the budget process, led by the House and Senate budget committees, which makes recommendations to the full House and Senate on the general makeup of the Federal budgets. There is the authorization process, run by the various authorizing committees, that examines in detail the budget for each Federal agency and program, and recommends the funding each should get. Authorizing committee also make changes in law that affect the agencies' missions. And finally there are the House and Senate Appropriations committees, which actually provide the funding for Federal agencies. These three processes, budget, authorization, and appropriations, fit together in an annual cycle that begins when the President submits his budget to the Congress in February and needs to be completed by the beginning of the new fiscal year on October 1st.

A simplified version of the overall budget process, both for the executive branch and the Congress is shown in Figure 1. It is illustrated for the 2004 fiscal year. The figure does not show either the work that went on, often involving both the agencies and their non-governmental stakeholders, before the Spring of 2002 to develop the proposals for the agency budgets. It also does not show the input from both government agencies and external groups, that goes into the Congressional decision-making processes on the budget. It should also be noted that the deadlines in the diagram can be somewhat flexible. Often the Congress fails to pass all of the appropriation bills by the beginning of the new fiscal year. In that case, Congress generally passes “continuing resolutions” that allow the continued operation of the agencies until their appropriations bills are passed.

SUMMARY OF THE BUDGET PROCESS OF THE UNITED STATES GOVERNMENT

For each fiscal year (FY), the U.S. federal budget process takes approximately 18 months. This chart summarizes the process that led to appropriations (funding amounts) for the current fiscal year, FY 2004, which began on October 1, 2003. "OMB" is the White House Office of Management and Budget, and "OSTP" is the White House Office of Science and Technology Policy. Note: If Congress and the president do not reach agreement by the start of the new fiscal year (October 1), then "continuing resolutions" fund the agencies at the previous year's spending levels until final agreements for the new year are reached.



The Formation of New Initiatives

Overview

As discussed in the previous section, the policy-making process in the U.S. federal government has several key features:

- The American system is decentralized. Political power is especially decentralized in science and technology, since the U.S. has many R&D agencies rather than a single "ministry of science and technology." Many groups – Congress, the president, directors of executive agencies, the courts, and regulatory commissions – have political power and may advocate new policy ideas.

- Presidents and members of Congress are often looking for new ideas that they hope will be popular with constituents, will meet particular political needs, or will advance their political philosophies. So there is a "demand" for new policy ideas.

- Many "policy entrepreneurs" want to propose policy ideas to these officials. So there is also a "supply" of new proposals.

- Because Americans believe that science and technology are tools to be used to help achieve larger policy goals – such as defense, health, energy, and economic growth – new national needs often create an opportunity for policy entrepreneurs to propose new or expanded science and technology programs in those areas. For example, the U.S. has recently increased spending on research for homeland security and biodefense.

- While the process for proposing new policies and programs is generally decentralized, any new ideas proposed within the executive agencies of the government must be reviewed by (1) the White House and its powerful budget office, the Office of Management and Budget

(OMB), and (2) the powerful Appropriations Committees of the U.S. House of Representatives and the U.S. Senate.

- Finally, and related to the last point, while many different political actors can propose new ideas and programs, the decentralization of power means that the advocates of a new policy must build a political coalition and persuade other actors to accept the idea. In particular, it is important to win broad support in Congress.

These various features create a situation in which many political actors can propose new science and technology policy initiatives. This leads to a flexible but sometimes chaotic system – one in which many political officials and policy entrepreneurs can propose imaginative policy ideas and in which there is active debate about what policies and programs are best. However, any proposal that requires government funding must undergo a review by the formal OMB and Congressional budget process, and every new proposal requires support from a broad coalition before it will be adopted and implemented. So policy-making in the United States is a process of building coalitions and, in particular, building coalitions in Congress to enact legal authority and actual funding for new programs.

The American science and technology policy system is also highly flexible in a second way: the agencies that fund R&D and the institutions that perform R&D are themselves both competent and very flexible. Government funding agencies, for example, can take new appropriations from Congress and fairly quickly issue solicitations, review proposals, and make research awards.

R&D performers – government laboratories, universities, companies, and other organizations – also can respond relatively quickly to new funding opportunities. American universities can rapidly respond to new opportunities for federal R&D funding; professors can quickly organize new laboratories, recruit new student assistants (drawing on foreign as well as American students), and begin research projects. U.S. National laboratories have similar flexibility. The directors of these laboratories have some discretionary funds (laboratory-directed R&D) that can quickly be allocated to respond to new opportunities, and the laboratories excel in developing proposals for new funding. Of course, these capabilities only exist because the federal government and industry have invested for many years in building up the competence of the nation's R&D organizations. But once these organizations exist, they can respond rapidly to new federal programs. This flexibility helps the United States carry out new R&D initiatives.

Types of R&D Initiatives

As discussed previously, the R&D initiatives can either be new or expanded R&D activities, and can be either a single agency or multi-agency activity. R&D initiatives can be created in several different ways:

- Some initiatives emerge "from the bottom up to the top," that is, from the scientific and engineering communities, particularly from mid-level federal scientists and engineers and their colleagues in academia and industry. These researchers may see a particular need or opportunity, and through long discussions they formulate a proposal (which may involve one federal agency or several). Either a few of these officials or allies in the policy community may then become policy entrepreneurs, actively looking for senior government officials who might adopt the proposal and carry it forward through the political process. Examples of initiatives formed in this way include the Human Genome Project and the Nanotechnology Initiative.

- In some cases, senior executive branch officials may face a political problem or see a political opportunity and are looking for an R&D initiative to help with this situation. Examples include federal support in the mid-1980s for the National Center for Manufacturing Sciences, which occurred because the Reagan Administration wanted to do something to help the U.S. machine tool industry; Al Gore's interest in the early 1990s in working with the automobile industry, which led to the government-industry Partnership for a New Generation of Vehicles (PNGV); and the interest of the Bush Administration and the automobile industry to show that they were working together on the development (over a very long period of time) of cleaner, more efficient automobiles, an interest which led to FreedomCar and FreedomFuel.

- Occasionally, an industry group will push for a major new federal R&D initiative and will try to persuade a president and Congress to back it. One notable example in the 1980s was Sematech, the semiconductor manufacturing technology initiative. However, in general the leaders of large American companies show little interest in federal R&D, so industry-led R&D initiatives are relatively rare.

Congress is rarely the entity that first proposes a new initiative in a particular area of science and technology. Congress usually lacks the technical expertise and confidence to create a new proposal in, say, nanotechnology. But key members of Congress often like and support new large interagency initiatives that come from the executive branch, and in fact often develop laws that endorse and formally establish such initiatives. For example, Congress has passed laws formally establishing the HPCC and global change program, and this year Congress is considering proposals (bills S. 189 and H.R. 766) to create a similar law for the National Nanotechnology Initiative. Congress also sometimes proposes new R&D programs (in the sense of new government offices for specific purposes), such as the creation of the Commerce Department's Advanced Technology Program (ATP).

Several other features of U.S. R&D initiatives also are important:

- Not all ideas for new initiatives lead to actual activities. New initiatives can be expensive – they almost always involve new federal funding – and may require a great deal of time and effort to "sell" to Congress. As a result, a proposal must prove particularly popular within the executive branch before an agency or OMB will propose including it in the administration's annual budget request.

- Initiatives almost always build on some existing government R&D activities. In nanotechnology, for example, the National Science Foundation (NSF), DOE, and the National Institute of Standards and Technology (NIST) had already sponsored research in this area for several years before President Clinton's advisors proposed a major new initiative to him.

- Interagency initiatives have particular benefits in the U.S. Government. At a minimum, they serve as a way for several agencies to get additional funding for exciting or important areas of research – and to get that money in ways that use, and do not threaten, existing agency jurisdictions. In a few cases, interagency initiatives are more than just a way to get more money; agencies also can support each other's missions in important ways. For example, in the Global Change Research Program the National Aeronautical and Space Administration (NASA) provides satellite images that help researchers sponsored by the National Oceanic and Atmospheric Administration (NOAA) and NSF to analyze climate changes.

- Sometimes U.S. presidents decide to label particular initiatives as "Presidential initiatives." For example, President Clinton chose to announce the nanotechnology technique in one of his own speeches, and took a particular interest in it. However, calling something a "Presidential initiative" does not change it in any significant way, except to tell Congress and others that the president cares about this activity.

We can illustrate all of these points made in the discussion above by looking at several case studies of important U.S. R&D initiatives.

Examples of U.S. R&D Initiatives

ARPANET and the Internet

In 1966 a mid-level official in the Defense Department's Advanced Research Projects Agency (later the Defense Advanced Research Projects Agency, DARPA) proposed to develop new a system that would enable computers made by different companies to communicate with each other. The proposed project did not have immediate military value (although it was hoped that it would allow ARPA-funded scientists to share some then-expensive computing resources. DARPA's mission then, as now, was to push for interesting new technologies that may one day produce major benefits for the Defense Department and society in general. The mid-level official, Bob Taylor, proposed a computer-networking project to his boss, the agency director, and it was approved. This kind of project did not require special approval from either the White House or Congress; it was small and within existing budgets.

In 1969 the agency's contractors switched on the new system of communications equipment and software, and the ARPANET was born. Originally, it was only a technology demonstration project, a testbed and not an operational network. But gradually people in the defense research community found practical uses for it, including remote access to supercomputers and a new activity called e-mail.

DARPA continued to support R&D and technology developments in this area. In particular, it sponsored work by two gifted computer scientists, Bob Kahn and Vint Cerf, to develop a software protocol that would allow different computer networks to talk to each other. So, for example, people using

ARPANET could communicate with separate networks run by DOE or others. This effort to allow interoperability and communication led to the TCP/IP protocol.

The original ARPANET was available only to DOD-funded researchers, but by the early and middle 1980s other researchers, particularly university scientists, wanted access to similar computer-networking services. After much discussion, the Reagan Administration decided to give NSF the authority and funding to contract for a larger set of high-speed computer networks for all government-funded university researchers. This initiative became known as NSFNET, and it soon became very popular. Soon commercial corporations and others who were not government-sponsored researchers clamored for access to this government-funded system. By the end of the 1980s, commercial telecommunications companies began to see an economic opportunity here, and the government decided to transfer the technology and business to them. The commercial Internet was born, using the government-funded technology.

The original ARPANET was a small initiative, in the sense that it was created within an existing agency budget without the need for new Congressional appropriations or approval. But when NSF proposed to create a related NSFNET, both the White House and Congress had to decide whether to provide additional funds. This became an important initiative, although within a single agency. The White House and Congress did approve the new NSF network and related activities. And soon after, growing interest in computer networking contributed to the creation of the first formal U.S. interagency R&D effort – the High-Performance Computing and Communications Initiative.

High-Performance Computing and Communications

In 1986 then-Senator Al Gore wrote a piece of legislation that asked President Reagan's White House Office of Science and Technology Policy (OSTP) for a report on computer networking issues and opportunities. Senator Gore was the first member of the Senate to see the scientific value of supercomputers and computer networking, and he worried that the basic computer networks of the time might not have the capacity that the scientific community wanted. His request was friendly but also an effort to push the Reagan Administration to think about this issue. It turned out that many senior science and technology officials in the executive branch were already thinking long and hard about computing issues.

On November 20, 1987, OSTP Director William Graham submitted a report that included recommendations for computer networking, plus much more. The report[4] presented recommendations for a coordinated interagency effort to advance all of high-performance computing: supercomputers, software technology and algorithms, networking, and basic research and human resources. OSTP developed its proposal in close consultation with interested agencies, particularly DARPA, NSF, DOE, and NASA.

The Reagan Administration, and later the first Bush Administration, followed up by requesting budget increases to carry out the plan. Senator Gore and other Congressional science and technology leaders strongly supported the program and worked to get the necessary appropriations. Senator Gore then went a step further and introduced legislation, modeled on the OSTP report, to create a formal HPCC program and recommend long-term funding for it. His legislative proposal became law, the High-Performance Computing Act of 1991 (U.S. Public Law 102-194).

The HPCC initiative has continued over the years, with updated R&D goals and occasionally new names. In the mid-1990s, the Clinton-Gore Administration updated the initiative and gave it a new name, Information Technology for the 21st Century. The current Bush Administration has continued the interagency effort, although again with another name, Networking and Information Technology R&D.[5]

Today it is one of three formal interagency R&D efforts in the U.S. Government; the other two are the Global Change Research Program (sometimes also called the Global Change Science Program) and the National Nanotechnology Initiative. Table 1 summarizes recent Congressional appropriations and presidential funding requests for these three programs.

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[4] Office of Science and Technology Policy, Executive Office of the President, "A Research Strategy for High Performance Computing," November 20, 1987.

[5] For details on the current program, its budget, and its organization, see http://www.hpcc.gov/

Table 1. FY 2002 and FY 2003 Appropriations and FY 2004 Bush Administration Requests for Three Interagency R&D Initiatives

Table 5. Interagency Science and Technology Initiatives
(budget authority in millions)

	FY 2002 Actual	FY 2003 Estimate 1/	**FY 2004 Budget**	Change FY 03-04 Amount	Change FY 03-04 Percent
National Nanotechnology Initiative					
National Science Foundation	204	221	**247**	26	11.8%
Defense	224	243	**222**	-21	-8.6%
Energy	89	133	**197**	64	48.1%
NASA	35	33	**31**	-2	-6.1%
Commerce	77	69	**62**	-7	-10.1%
National Institutes of Health	59	65	**70**	5	7.7%
Other (EPA, DOT, Justice, DHS, USDA)	9	10	**18**	8	80.0%
Total Nanotechnology	697	774	**847**	73	9.4%
Networking and Information Technology R&D					
Commerce	36	38	**39**	1	2.6%
Defense	439	442	**461**	19	4.3%
Energy	306	310	**317**	7	2.3%
Environ. Protection Agency	2	2	**2**	0	0.0%
Health and Human Services	347	374	**441**	67	17.9%
NASA	181	213	**195**	-18	-8.5%
National Science Foundation	662	678	**724**	46	6.8%
Total IT R&D	1,973	2,057	**2,179**	122	5.9%
U.S. Global Change Research Program (Climate Change Science Program)					
National Science Foundation	189	203	**213**	10	4.9%
Energy	117	129	**133**	4	3.1%
Commerce (NOAA)	100	118	**136**	18	15.3%
Agriculture	55	66	**73**	7	10.6%
Interior	26	26	**26**	0	0.0%
Environ. Protection Agency	21	22	**22**	0	0.0%
National Institutes of Health	56	59	**61**	2	3.4%
NASA	1,090	1,112	**1,068**	-44	-4.0%
All Other	12	12	**17**	5	41.7%
Total USGCRP	1,666	1,747	**1,749**	2	0.1%

Source: OMB supporting data for FY 2004 Budget.
1/ FY 2003 figures (except for DOD) are based on the President's FY 2003 request, and will be revised when FY 2003 appropriations are complete.
AAAS - Preliminary February 6, 2003 - will be revised.

Source: American Association for the Advancement of Science, "FY '04 Budget Proposes Defense and Homeland Security Increases, Modest Growth for Other R&D Programs," February 6, 2003, available at http://www.aaas.org/spp/rd/prel04p.pdf

Global Change Research Program

The other major interagency research initiative of the Reagan-Bush I years was the Global Change Research Program (GCRP). As mentioned earlier, this important initiative continues to this day.

This initiative arose in the late 1980s. It originally came from the scientific community, both academics and working-level government scientists. By the mid-1980s, the combination of advanced satellite imaging, powerful supercomputers, and new computer modeling techniques created a major new opportunity to improve global climate models. Meteorologists, oceanographers, and other earth scientists began to formulate detailed research plans and began to lobby both agency directors and Congressional staff.

Agency directors began to support the proposal, and for at least three reasons. First, this would be genuinely exciting and valuable research. Second, the proposed program would not threaten existing agency missions, responsibilities, and budgets and in fact, if successful, would lead to additional appropriations ("new money") for the participating agencies. And, third, the various agencies would support each other in important ways. For example, as mentioned earlier, NASA satellite images would be very valuable to researchers and climate modelers supported both by NSF and the National Oceanic and Atmospheric Administration (which contains the U.S. National Weather Service).

The administration of the first President Bush endorsed the initiative and requested Congressional appropriations for it. Congress agreed to most of the requested funding. And senior Congressional leaders, such as Senate Commerce

Committee Chairman Fritz Hollings, sponsored legislation endorsing and formally establishing the program.[6]

The global change program is seen by many to be a scientific and organizational success, which is remarkable given the continuing intense debate in the United States over whether global warming is real or not. However, the history of this initiative also offers at least one important caution. In this type of highly interdependent initiative, in which each participating agency depends on the others, it is important that all of the agencies get the appropriations requested by presidents. If one or more agencies fails to get the necessary funds, the whole program suffers. In the case of global change research, NOAA consistently has received less than its requested funding, causing some problems in the overall program.

National Nanotechnology Initiative

On January 21, 2000, President Bill Clinton announced a major new interagency research initiative in nanotechnology. He made the announcement at the California Institute of Technology, where in 1959 physicist Richard Feynman gave a famous talk on the possibility of building materials from the bottom up, atom by atom.

President Clinton's National Nanotechnology Initiative arose for several reasons – a combination of "evangelists" in the scientific community who

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[6] For details on the Global Change Research Program and the Global Change Research Act of 1990 (Public Law 101-606), see its official Web site: http://www.usgcrp.gov/usgcrp/about/default.htm

discussed the promise of this new technology and argued for federal funding; agency scientists who, in a bottom-up fashion, began to think about a possible federal initiative; a president who, his staff knew, liked science and technology; and, very importantly, a small group of policy entrepreneurs within the White House staff who researched the issue, worked with agency officials to develop a credible plan, and then took that plan to the president. In addition, these same policy entrepreneurs worked with leaders in industry and academia to build a broad political coalition in favor of that initiative and used that coalition to build bipartisan support within Congress.

Several other factors helped them build support for the nanotechnology initiative. First, Americans retain a deep faith in long-term research programs, especially when they hold the promise of major breakthroughs. Second, the late 1990s were a time of budget surpluses, meaning that obtaining federal money for new ideas was easier than in a time of severe budget deficits. Third, many scientists in the United States liked the initiative not only because of nanotechnology's promise but also because of a broader desire for new federal programs that would fund and train physical scientists, a group that had received less priority after the end of the Cold War. Fourth, the U.S. semiconductor industry, a politically influential group, gave strong support to the initiative. And, finally, program advocates cast it largely as an initiative to support research in universities and government laboratories rather than to fund research in industry. This stance pleased conservative Republicans who had opposed earlier Clinton proposals for direct government support of industrial technology development efforts.

The political success of this initiative can be seen not only in the funding it received in 2000 from a Republican-led Congress but also from the fact that the second President Bush has continued the program. It remains a popular activity.

DOE's Hydrogen Programs: FreedomCAR and Fuel

As mentioned earlier, not all major R&D initiatives in the U.S. Government are interagency efforts. Some exist within single departments or agencies. A notable example is the Bush Administration's R&D work in hydrogen-powered transportation. The administration has sought Congressional appropriations for two related activities within the Department of Energy: FreedomCAR, which supports research on fuel cells and other vehicle technologies, and FreedomFuel, which supports R&D to advance hydrogen production, storage, and infrastructure (infrastructure such as possible "gas stations" to supply hydrogen for fuel-cell vehicles).

The Bush initiative is based in part on an earlier initiative developed during the Clinton Administration by then-Vice President Al Gore and the U.S. automobile industry. That earlier effort was called the Partnership for a New Generation of Vehicles (PNGV). While technically an interagency initiative – Commerce Under Secretary Mary Good ran the program for much the Clinton Administration – it in fact was mainly an R&D partnership between DOE and the car companies. The stated goal was to develop vehicles that could achieve fuel efficiencies of 80 miles per gallon, without sacrificing car safety. The initiative also covered advanced automobile manufacturing technologies. Clearly, the automobile companies had large R&D laboratories of their own, but one premise behind the program was that DOE laboratories had advanced technologies that might be useful to the industry.

PNGV developed largely because of an unusual political agreement. Vice President Gore wanted to improve automobile fuel efficiency and reduce fossil fuel emissions that add to global warming. He was interested in how advanced technologies might help with that effort. For their part, the leaders of the U.S. car companies wanted to avoid immediate legislative mandates to increase fuel efficiency, and they were interested in projects that would show they were moving in the right direction and therefore would reduce political pressure in Congress for immediate improvements in automobile fuel efficiency. Joining PNGV seemed to them a good way to help reduce that political pressure without costing much.

By 2001 PNGV made some technical progress, but the U.S. automakers showed little interest in making current vehicles more fuel efficient – especially since American consumers wanted to buy so many inefficient sport-utility vehicles and pickup trucks. The industry still worried, however, about efforts in Congress to force short-term improvements in automobile fuel efficiency. So there was interest in continuing some program that would suggest that the industry would eventually improve efficiency. Meanwhile, however, the new Bush Administration did not want to support any program associated with Mr. Gore. The final result was to maintain an R&D effort that helped the industry politically but to eliminate the Gore version. The Bush Administration seized on the idea of hydrogen, and so PNGV changed into FreedomCAR and later, as well, FreedomFuel. [7]

While no study has yet been written on the origins of the FreedomCAR idea, available evidence suggests that one policy entrepreneur played a key role: Bob Walker, former Congressman from Pennsylvania, former Chairman of the House Science Committee, a highly partisan Republican with close ties to the Bush Administration, and a long-time advocate of R&D on hydrogen vehicles. He (and perhaps others, as well) offered something the Bush Administration and U.S. car industry wanted: an R&D proposal that would help the industry in its arguments against immediate changes in fuel-efficiency standards, was sufficiently long-term that the industry would not be forced to build hydrogen cars any time soon, seemed technologically exciting, and met the Bush Administration's need to have something other than Al Gore's R&D project.

In his FY 2004 budget request, announced in February 2003, President Bush proposed $1.7 billion in funding for the combined FreedomCAR and FreedomFuel initiative over the next five years, including $720 million above and beyond what the then-current level of effort would spend. For FY 2004 itself, the president requested $273 million in DOE funds.[8] Congress is still deciding about this request.

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[7] A DOE explanation for how PNGV was converted to FreedomCAR, see http://www.ott.doe.gov/freedom_car_fact_sheet.shtml. While the Bush Administration has terminated government support for PNGV, it survives (in a smaller way) as a private venture. For details, see http://www.pngv.org/.

[8] For details on the two initiatives, see www.eere.energy.gov/hydrogenfuel.

This two-part hydrogen initiative is likely to continue for some years to come, despite skepticism from some observers about the energy and environmental value of hydrogen vehicles.[9]

Its should be noted that the FreedomCAR and FreedomFuel are part of a larger initiative, the Climate Change Technology Program, which consists of a very large range of energy efficiency and energy production technologies. But this "initiative" is a collection of existing programs that has not receive large funding increases.

Biodefense Research at the National Institutes of Health

Another recent initiative within a single federal department illustrates how major new national crises can sometimes lead to rapid increases in funding. The anthrax attacks of fall 2001, combined with concern the Al-Qaeda might try to use biological weapons, led to a major increase in federal biodefense research. Almost all of this funding has gone to the National Institutes of Health (NIH), and particularly its highly respected National Institute of Allergy and Infectious Diseases (NIAID).

In FY 2002 (a budget prepared before the Septemer 11, 2001 attacks), NIH had $275 million for bioterrorism-related research and infrastructure (the

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[9] Skeptics in the United States raise two questions about possible hydrogen vehicles. First, how will the hydrogen itself be generated? If coal or nuclear plants are used to create the electricity to separate hydrogen from water, then the pollution and cost involved could be high. Second, and related, how efficient is it to use large amounts of energy to separate out hydrogen from water and then distribute and use that hydrogen, as opposed to investing in improved fossil-fuel or hybrid vehicles? Advocates of hydrogen argue, though, that less polluting and more efficient ways of generating hydrogen may be found, such as possible biological processes that use bacteria to produce the hydrogen.

infrastructure being mainly research laboratories). In FY 2003, that total grew to $1.7 billion – one of the largest research funding increases in modern American history. In FY 2004, it appears that the total at NIH will fall slightly, to $1.6 billion, but according to the American Association for the Advancement of Science funds for biodefense research grants (excluding facilities) would more than double because less of the total will be devoted this year to the construction of biodefense research facilities; many facilities are already being built with FY 2003 funds.[10]

This illustrates that some initiatives are strongly driven by external events. External events create opportunities for increased funding, and agencies usually respond quickly to the opportunity with proposals. Agencies such as NIH can respond quickly to such opportunities in part because most of their funds go to external organizations -- they do not need to hire large numbers of new people to conduct the new research, but rather provide grants to people in universities and medical schools to do the research.

A Proposed Initiative That is Not Yet Funded

Another case study illustrates how difficult it can be to persuade the administration and Congress to fund a new initiative. This is the proposed initiative on light-emitting diode (LED) lighting. This example helps show why only a few large-scale initiatives ($50 million a year or more in funds) receive funding.

[10] These numbers come from American Association for the Advancement of Science, "Senate Proposes $1 Billion Increase for NIH, House Matches Requested Boost of $726 Million," July 10, 2003, http://www.aaas.org/spp/rd/nih04s.pdf.

Following the invention in Japan of the blue LED In 1993, it became clear that there is the potential for substantial energy saving from replacing conventional light bulbs with LED lights. The technology for LEDs lighting is new and still faces significant technical and economic hurdles, so more R&D is needed. In 1998, a committee of the National Research Council recommended a major U.S. initiative to develop LED lighting. An industry group, the Optoelectronics Industry Development Association, OIDA, began working with the Department of Energy to develop an initiative.

In 2001, OIDA and several supporters in Congress, particularly Senator Jeff Bingaman, proposed a new initiative in R&D for LED lighting. Bills that would have provided a ten year authorization for $50 million per year in LED lighting R&D passed the House and the Senate in 2001 and 2002, and was included in an overall energy bill. This bill, however, failed to be approved by Congress in 2002. On January 15, 2003, Senator Bingaman and Senator Dewine introduced S. 167, a proposed law that would direct the Secretary of Energy to establish a Next Generation Lighting Initiative. In July 2003, the Senate passed its version of H.R. 6, the large proposed Energy Omnibus Act, and that Senate version included that lighting initiative. (Senator Bingaman is the top Democrat on the Senate Energy Committee, so he is in a special position to push this proposed initiative.)

In early November 2003, House and Senate negotiators agreed on a compromise version of H.R. 6, and its section 905 does indeed direct the Secretary of Energy to establish that Next Generation Lighting Initiative. However, as of the time that we are writing this report for JST, two large uncertainties remain: will the Senate in fact agree to the proposed compromise bill or instead block it, and even if the bill establishing the initiative passes, will the Congressional Appropriations Committee actually provide funding for the initiative? The answers are not yet clear, so the LED proposal still has a long way to go before it is funded and operating.

In this case, many of the ingredients for a successful initiative appear to be in place: support from the National Academy of Science, industry, the relevant Federal agency, and some degree of support from Congress. Even so, however, it is difficult to gain approval for a new initiative. In this case, some of the resistance may be due to the general reluctance of the Republican Congress to support industrially relevant technology, as well as the overall budget deficit and competing budget priorities.

Identifying Future U.S. R&D Initiatives

The preceding analysis suggests that there have been several major "drivers" of new R&D initiatives:

- A dramatic event or urgent problem, such as the anthrax attacks, the September 11, 2001 attacks, or SARS. These create the need and the political climate for major new programs.

- Major new scientific or technological opportunity that combines exciting research possibilities, the interests of key federal departments and agencies, and a good fit with the political ambitions of the White House and Congress. Examples include nanotechnology, the human genome initiative, or high temperature superconductivity research in the 1980s.

- When supporting research is a politically attractive approach to a national problem (often substituting for other actions that are more costly or controversial, as in the case of global warming.)

- In some special circumstances, when the leaders of an important U.S. industry argue for long-term R&D projects that will help keep America at the forefront of that field. The semiconductor industry's lobbying for Sematech in the 1980s is an example.

To identify future initiatives in advance, one could monitor areas that pertain to some of the "drivers" identified above. While external events are by their nature unexpected and difficult to predict, it would be possible to m, it is possible to identify emerging scientific and technological opportunities by monitoring interagency technical workshops, technical subjects discussed in Congressional hearings, and topics discussed in major advisory committees. Many proposals for initiatives are discussed in these venues. Nevertheless, it is difficult to predict which proposals will get enough support to grow into major initiatives.