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TECHNOLOGY AND ECONOMIC PERFORMANCE

HEARING

BEFORE THE

JOINT ECONOMIC COMMITTEE CONGRESS OF THE UNITED STATES

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

SEPTEMBER 12, 1991

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THURSDAY, SEPTEMBER 12, 1991

TECHNOLOGY AND ECONOMIC PERFORMANCE

THURSDAY, SEPTEMBER 12, 1991

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The Committee met, pursuant to notice, at 9:25 a.m., in room 2318, Rayburn House Office Building, Honorable Lee H. Hamilton (vice chairman of the Committee) presiding.

Present: Representatives Hamilton and Armey, and Senator Bingaman.

Also present: Dorothy Robyn and Mark Forman, professional staff members.

OPENING STATEMENT OF REPRESENTATIVE LEE H. HAMILTON, VICE CHAIRMAN

REPRESENTATIVE HAMILTON. The Joint Economic Committee hearing will begin.

The purpose of today's hearing is to discuss the report by the Carnegie Commission on Science, Technology and Government entitled "Technology and Economic Performance: Organizing the Executive Branch for a Stronger National Technology Base."

The link between technology and economic performance is strong. Major productivity increases since World War II can be traced to scientific breakthroughs and new technology, such as semiconductors, advanced materials, and genetic engineering.

Economists tell us that technological change has been responsible for as much as two-thirds of productivity growth since the Depression. Moreover, the new growth industries are knowledge-based and depend on the continuous generation of new scientific and technological insights.

The Federal Government has played and will continue to play an important role in promoting science and technology, but a vigorous debate is occurring around the question of just what that role should entail and whether existing Federal institutions and missions remain adequate.

We are fortunate to have with us today three experts on the subject.

Admiral Bobby Inman chaired the Carnegie Commission Task Force on Science, Technology and Economic Performance that prepared the report we'll be discussing today. His government experience includes 10 years as Director of the National Security Agency and Deputy Director of Central Intelligence. Admiral Inman helped to launch this country's first

electronics consortium, MCC, in Austin, Texas, and has chaired the Federal Reserve Bank of Dallas.

Lewis Branscomb has also served on the Carnegie Commission Task Force. He was Chief Scientist and Vice President of IBM from 1972 until 1986, and before that Director of the National Bureau of Standards, now the National Institute of Standards and Technology. Currently, Dr. Branscomb is on the faculty of the John F. Kennedy School of Government at Harvard University.

Murray Weidenbaum is a member of the economics faculty of Washington University in St. Louis and directs the University's Center for the Study of American Business. He was President Reagan's first chairman of the Council of Economic Advisers. He previously served as Assistant Secretary of Treasury for Economic Policy and corporate economist for Boeing Company.

Gentlemen, we are very pleased to have all of you with us. I'll ask my colleague, Congressman Armey, if he has any statement.

OPENING STATEMENT OF REPRESENTATIVE ARMEY

REPRESENTATIVE ARMEY. Thank you, Mr. Chairman.

Let me, first of all, Mr. Hamilton, express my appreciation for your holding these hearings. I intend to stay, I hope, until they are through, and I do have a formal opening statement that I would like to put in the record.

But in lieu of that and in my interest with getting right on with the witnesses, just let me say that I approach this subject, as I do so many, by first going back and checking Adam Smith's, "The Wealth of Nations," where he wrote about the question of entrusting the allocation of scarce capital resources to a government entity, and he said, if I might paraphrase, "nowhere would it be more dangerous than in the hands of those that have had folly and presumption enough to think themselves fit to exercise it."

So, this is where I'm coming from. I always go back to the economic book of genesis, which may be one of the four or five books in the field that ever needed to have been written.

Thank you.

[Written opening statement of Representative Armey follows:]

WRITTEN OPENING STATEMENT OF REPRESENTATIVE ARMEY

Mr. Chairman, I am glad that we have such distinguished witnesses here today to discuss National Technology Policy. This is an area that has seen charged debate for much of the past decade. Current Congressional proposals incorporate more than $1 billion in spending to establish this variant of industrial policy.

I believe that the American economy possesses the qualities necessary to be the world's economic leader. Recent data show that our nation's economy still outperforms Japan, Germany, and all other competitors. We continue to outpace all other countries in both volume and rates of growth of exports. At the same time, the growth in our imports from other industrialized countries has been steadily declining for six of the last seven years.

Yet, it is also clear that there is still more room for economic growth. It seems to me that this must come from the commercial marketplace if there is to be a sustainable improvement in America's standard of living.

We have tremendous evidence that the free-market works. After experiencing feeble economic performance in the late 1970s and early 1980s, American manufacturers shifted from focusing on cutting cost to improving quality. American manufacturing now has improved its productivity to a level that is three times higher than service sectors. Manufactured exports have been growing at a 15% annual rate for five years. The key to the comeback of American manufacturing, according to the National Association of Manufacturers, was the return to fundamentals -- "innovation, investment, productivity, aggressive selling, customer service, and unrelenting attention to cost and quality."

Manufacturers talk of government's ill-conceived initiatives that miss the mark of what's needed to keep the economy performing well. They would rather see investment tax incentives and relief from burdensome regulations.

The evidence of industry's ability to help itself is irrefutable, but there is little evidence of the government's ability to help industry. In the free market, the role of innovation, quality, and price are indisputable; companies must respond to market needs or find a new line of work. I am hard pressed to come-up with examples of where a political body could help industries better than these mechanisms of the marketplace. In particular, I fear giving billions of taxpayers' hard-earned dollars to a group of government officials who would not have free market mechanisms to ensure that the money would be spent wisely. Instead, those industries with the most PAC money and strongest lobbies might get most of the money. Billions may go to the oldest American companies, without helping the economy. Or worse, it may be used to enable older companies to compete against new companies, thereby stifling the inherent growth forces of our competitive economy. I can't help but wonder if the Apple computer corporation might not have been squashed by the Carnegie Foundation's proposal, had it been in effect in the early 1980's?

There have been several technology policy initiatives over the past 6 years, none of which has been as effective as private efforts. While the Carnegie Commission's report attempts to resolve problems affecting the effectiveness of current efforts, many questions remain. First, what are the likely benefits of its recommendations? Industries' problem is how to transition emerging technologies into useful products, while cutting costs and improving quality. The report's

recommendations do not address industries' difficulties in these areas. Second, what are the likely costs of implementing the report's recommendations -- how many staff years would be needed and what would the administrative costs be? For each taxpayer dollar spent on research, how much would go to the administrative overhead recommended by this proposal? The authors have not considered what portion of federal R&D dollars would be consumed by their approach, nor have they compared costs of alternative approaches against likely benefits. Third, what criteria could be used for determining how to implement a national technology policy that would enable decision makers to determine commercially-useful projects? Fourth, how would this approach keep government funded commercial R&D from competing directly against corporate-funded R&D? How would it make sure that the government doeS not give an unfair advantage to one company by turning over the government research to a company who will use it to compete against other American companies that have been funding their R&D? Would this not lead to a rapid drop in private R&D? Who owns the property right to that technology?

I look forward to hearing answers to such questions during today's hearing.

REPRESENTATIVE HAMILTON. That's a pretty harsh condemnation of all the other economists, Congressman Armey.

[Laughter.]

We'll begin with your observations. Let's just proceed across the table. Admiral Inman, we'll begin with you and take you in order, and then we'll turn to questions.

PREPARED STATEMENT OF ADMIRAL B.R. INMAN, CHAIRMAN, CARNEGIE COMMISSION TASK FORCE ON SCIENCE, TECHNOLOGY AND ECONOMIC PERFORMANCE, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

ADMIRAL INMAN. Thank you, Mr. Chairman. It's an honor to be with you this morning for the presentation.

In keeping with the past custom before these Committees, with your permission, I will submit a formal statement for the record, and in the interest of time, I will try to accelerate through my remarks.

You will see in the published report a distinguished and hard-working panel that had very differing views on who worked hard. It was not easy to get the consensus that we have in this report.

I would point out that the formal document lists the membership of the Council and also the Advisory Council. The Advisory Council did not take part in the process and did not formally review and approve the document. Particularly for the congressional members who are part of that Council, I am not committing them to having already signed on to approve the entire document.

Let me tell you what this report does not cover. It is not a prescription for what industry needs to do to be competitive in the international marketplace, and we all recognized from the beginning that ultimately industry has to provide the performance that let's us be successful. But government does create the environment in which that competition takes place, and government has played a role in this element for most of the history of the republic.

Our report deals only with issues of science and technology. In our discussions, we recognize that to be competitive you have to deal with the cost of capital, a skilled and motivated work force, a strong base of science and technology, and factors where industry alone must lead, such as in quality, innovation, productivity and safety, and safety of the individuals and environment.

We zeroed in on how government deals with the issues of science and technology, both from a point of view of investing and in creating the climate in which industry performs.

After much debate, this panel reached a consensus, in the climate in which we now find the country, proposing to create new institutions and organizations was simply not feasible because of a lack of support. So, our focus was on how we took the existing structures and tried to make them

more effective at accomplishing what are already long-established government roles.

I don't need to remind this body that a government role in science and technology was established by a Republican Administration in the 1860s and recognized not only the importance of science, but also began a process of focusing on technology specifically in those days to support agriculture.

I would highlight four specific areas in the report. There are a great many recommendations, but four I believe stand out in importance.

The first is the need to create a single, national technology base. We really had that coming out of World War II, and we drew on that great base that had been developed for the conduct of war to help expand an economy.

But over the last 30 years, we have steadily put in place, by law, regulation and practice procedures for defense procurement that have steadily led us to a unique defense technology base, a process that makes it extraordinarily difficult to draw on for the best commercial practice.

So, one of the major thrusts comes from recognizing that 30 years ago defense led in the creation of many of the advanced technologies in this country. Today, in most of those that are important to us, commercial practice leads defense.

So, a major underlying thrust is to move toward a process that thinks in terms of the need for a single technology base, and the importance of defense being able to draw much more easily and hopefully much less expensively on a broad commercial base.

The second and third work in parallel. The first of those is to look carefully at the already established role for the National Institute of Standards and Technology, growing out of the long National Bureau of Standards' experience of working with commercial industry, but to specifically enhance their efforts in focusing on generic technologies that can be of direct use in the commercial sector.

The third will likely be controversial, but it is to accept the reality that the Defense Advance Research Projects Agency is a premiere institution in dealing with dual-use technologies. It also is an institution that is already geared to work broadly with other agencies and with industry. The proposal is that it become the National Advance Research Projects Agency.

Let me underline the specific requirement that NARPA must have a government customer, prospective customer for its research. They would not undertake research activity if only commercial use were foreseen. But we would broaden its charter to permit the transfer of money and responsibility to undertake technology projects to serve other branches of the government beyond defense, while recognizing that defense remains its primary customer.

The fourth area deals with daily decisionmaking in address issues of science and technology. We note and support the legislation that makes the Science Adviser and the Office of Science Technology Policy the central focus in the Executive Branch for the development of policies

related to science and technologies. We acknowledge the role of the Council of Economic Advisers in appraising the issues that are coming for decision, and particularly the role of the Office of Management and Budget in ensuring the funding of those areas before policy decisions that have been made.

A focus of this report is on reconceptualizing the role of the National Security Council to think more broadly, going forward of this country's national security, beyond matters of simply diplomacy, arms control, the size and deployment of our defense forces, and to get a process in dealing with these issues of science and technology where the policies that are being proposed by the other organizations are brought on a daily basis for consideration by the President.

There are many other elements of the report that I hope we'll have a chance to explore with you in the question phase.

Thank you.

REPRESENTATIVE HAMILTON. Thank you, Admiral Inman.

[The prepared statement of Admiral Inman, together with an attachment and the Carnegie Commission report, follows:]

PREPARED STATEMENT OF ADMIRAL INMAN

Introduction

My colleague, Dr. Lewis Branscomb, and I are pleased to present to you the report of the Carnegie Commission on Science, Technology, and Government entitled *Technology and Economic Performance: Organizing the Executive Branch for a Stronger National Technology Base.* The report was prepared by a task force that I chaired, and was approved by the Commission in June of this year.

The Commission was established by Carnegie Corporation of New York in 1988 as a bi-partisan group of scientists with government background and non-scientists with an interest in science and technology. Its mandate is to recommend ways to improve the organization and decision-making processes of government so that it can respond to the changes brought about by science and technology. The Commission has addressed a number of technology-impacted areas such as defense, economic development, the environment, education and even the courts. We do not deal explicitly with what government policy should be in these areas, although organization and policy are often intertwined. Our dual concern throughout is to help the nation exploit the dramatic potential of science and technology while avoiding their unintended consequences.

The names of the members of the Commission, its distinguished advisory council, and of the Task Force are found in your copies of the report. The Commission has a special committee dealing with science, technology and Congress, chaired by Dr. John Brademas, which has its own bi-partisan congressional advisory committee. That 44-member committee includes Senators Bingaman, Gore and Kennedy and Representatives Hamilton, Scheuer and Fish from this Committee.

In my remarks, I will review the report briefly, giving special emphasis to the implications for our national security -- because of what I believe to be the extremely close connections between national and economic security. Dr. Branscomb, who was Director of the National Bureau of Standards and later Vice-President and Chief Scientist of IBM, will elaborate on the recommendations regarding the support of commercial technology by the Department of Commerce and the need to develop mechanisms for diffusion of new technologies in the interest of improved economic performance.

I. Relationship between technology and economic performance.

The report begins by noting that economic growth requires sustained growth in productivity, and that a major contributor to productivity is the development and diffusion of technology. America needs to be a technological leader in many fields, and a competitor in all. (Of course, there are other important contributors to economic growth, including particularly capital investment and a skilled and motivated work force.)

Primary responsibility for developing and diffusing commercial technology lies with industry. However, there is an important role for government. The report focusses on that role, and more particularly on organization and

decision-making in the Executive branch related to enhancing American technological leadership.

II. Changes in U.S. technological leadership as it deals with the economy and national security.

The Commission sees three major changes in America's technological position since the 1960's:

First, American commercial technological leadership has eroded in many areas. The recent report of the private Council on Competitiveness, *Gaining New Ground:Technology Priorities for America's Future*, gives the best concise description of this erosion, industry by industry. The U.S. faces particular problems, for example, in process technology and its application--the technology of manufacturing and production. In the past, the U.S. comforted itself with the belief that while it was losing market share and trade balance in low tech goods, its position at the high tech end of the spectrum remained reasonably secure. It failed to recognize that continuing technological change was important to the low tech sector of commodity-like manufactured products--such as memory chips, and that revenues from the high end of the technology spectrum might not be sufficient to support the rate of innovation necessary to stay ahead.

Second, there has been a change in the technological leadership position of the Defense Department. In technology areas that were relevant to the military in the 1950's and the 1960's, defense technology led commercial technology. Today, in technologies that are important in both commercial and defense areas, such as computers and communication, the Department of Defence is a follower and not a leader.

Third, the commercial technology base has become more and more inaccessible to the military technology base, in part because of complex military accounting and procurement policies, and in part because of the rapid growth of commercial technology. In effect, the United States now has two technology bases, one tied to defense industry and the other tied to commercial industry.

These changes add up to a significant relative decline in our technical position. This occurs at the same time that the end of the Cold War is bringing reduced defense budgets.

The Commission notes that both economic and military security will depend on commercially driven-technology in the future, and stresses the importance of moving toward a single national technology base. The need for new technology policies and programs will place important demands on the government's ability to devise, evaluate, and oversee technology programs.

III. The Federal role in advancing technology to improve economic performance

There are three justifications for federal support of advances in technology. First, there are a number of explicit government missions--health, defense, basic science, agriculture, and space--that include, indeed require, investments in technology research and development. Second, government has played a major and critical role in the past in supporting "infant" technologies, such as nuclear power, aircraft, and communication and weather satellites, until they reached a size to be competitive. Finally, in those areas of commercial technology where the company performing the development cannot capture the full benefit from investing in technology

research, the private sector is likely to "under invest" from a societal standpoint. Thus, the Commission agrees with the Administration that the government should provide development support for "pre-competitive and generic" technology.

IV. An improved Federal executive organization for developing and implementing technology policy.

The world is changing rapidly and our national priorities will also change in ways that we cannot now predict. To deal with these changes may require major organizational changes in the long run, and the Commission report recommends a number of important initial steps:

With respect to policy development on technology, the Commission focused on the Executive Office of the President, within which many offices and councils now look at different pieces of the problem. The report recommends:

--that the Office of Science and Technology Policy be designated as the focal point for identifying and formulating technology policy issues, and for providing analytic support for program development and evaluation. We also feel that the proposed Critical Technologies Institute, if its mandate is more broadly defined, could perform some of the long-range analytic backup.

--The report further recommends that the National Security Council take the lead within the Executive Office in coordinating and integrating the various policy perspectives on those matters that link national security, economic performance, and technological strength.

With respect to policy implementation, the Commission wants to link government and industry more closely, and sees a particular need in so-called "dual-use" technologies to connect defense and commercial technologies.

Our major recommendations here include:

--transforming the Defence Advanced Research Projects Agency into a National Advanced Research Projects Agency, still in the Department of Defense. The new NARPA would focus more heavily on dual-use technology, and reach out to commercial organizations that have traditionally not worked with Defense. Of course NARPA will, like DARPA, continue to support purely military technologies and high-risk, long range technologies which could have substantial military promise. We also suggest that NARPA support advanced technologies that are primarily aimed at the missions of other federal departments and agencies, but only when other agencies request and pay for that support.

--giving central responsibility to the National Institute for Standards and Technology (NIST) in the Department of Commerce for the support of pre-competitive and generic technology not within the missions of other departments and agencies. NIST has a long history of interaction with industry, and is particularly well placed to work on developing mechanisms for diffusing technology. Dr. Branscomb will elaborate on the NIST role.

--developing mechanisms for departments and agencies that support technology, such as NASA, the Department of Energy, the National Science Foundation and the National Institutes of Health, to fund and

diffuse pre-competitive and generic technologies that fall under their purview.

There are many other recommendations which you can see in the report.

The Task Force did not address some important institutions and problems. For example, Congress has played a major role in defining the government role in linking technology and economic performance, in the Trade Bills and in the Defense Appropriations acts, for example. Suggestions for improving the way that Congress deals with issues of science and technology have been left to the committee chaired by Dr. Brademas that I mentioned earlier. The States have also begun to forge important links with industry, and the Commission is examining the role of the states through a separate task force headed by former Governor Richard Celeste. Improved science and math education may be the most important long range step America can take to improve its economy. Dr. Branscomb chairs the Commission Task Force on Science Education, and its report will be coming out on September 16.

V. Conclusion

The end of the Cold War and the relative decline in our technical position call for new technology policies and programs that will meet the need of the next century. In the future, both economic and military security will depend on commercially driven technology. The United States now has two technology bases, a defense technology base and a commercial technology base. The nation must move toward a single national technology base. This will place important demands on the government's ability to devise, evaluate, and oversee technology programs.

If these first-step recommendations and others in the report are implemented, the Carnegie Commission believes that the federal government will have a much stronger capability to devise and implement technology programs that will serve American defence and commercial industry, as well as the analytic capacity to review and improve those programs in a volatile, exciting and very promising post-Cold War era. America will be on its way to regaining technological leadership.

Thank you for the chance to appear before the Committee. Dr. Branscomb and I would be glad to answer any questions you may have.

BIOGRAPHICAL INFORMATION

Admiral Bobby R. Inman, USN, (Retired)

Admiral Inman was born at Rhonesboro, Texas on April 4, 1931, and graduated from the University of Texas at Austin (B.A., 1950). He entered the Naval Reserve the following year and was commissioned as an Ensign in March 1952. Over the next nineteen years he served on an aircraft carrier, two cruisers and a destroyer as well as in numerous assignments ashore in Naval Intelligence.

He graduated from the National War College in 1972, was selected for promotion to Rear Admiral in January 1974 and was promoted to Vice Admiral in July 1976. In February 1981, he was promoted to the rank of Admiral, the first Naval Intelligence Specialist to attain four star rank. He retired with the permanent rank of Admiral on July 1, 1982. Between 1974 and 1982 Admiral Inman served in tours as Director of Naval Intelligence; Vice Director of the Defense Intelligence Agency; Director of the National Security Agency and Deputy Director of Central Intelligence. From January 21, 1983 until December 31, 1986, he served as Chairman and Chief Executive Officer of the Microelectronics and Computer Technology Corporation (MCC) in Austin, Texas. From December 31, 1986 to December 31, 1989, he served as Chairman, President and Chief Executive Officer of Westmark Systems, Inc., a privately owned electronics industry holding company. Admiral Inman served as Chairman of the Federal Reserve Bank of Dallas from January 1987 to December 1990.

Admiral Inman is a member of the Board of Directors of Dell Computers, Fluor, Science Applications International, Southwestern Bell, Temple Inland and Xerox. He serves in a volunteer status as a Director of the Council on Foreign Relations and the Center for Excellence in Education. Admiral Inman is a member and a trustee of the National Academy of Public Administration. He serves as a trustee of the California Institute of Technology and Southwestern University. He serves as the Vice Chairman of the President's Foreign Intelligence Advisory Board. Admiral Inman serves on the Executive Committee and as an active participant on the Business-Higher Education Forum, the Carnegie Commission on Science, Technology and Government and the Council on Competitiveness.

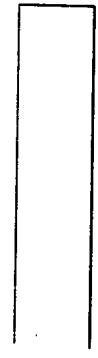
TECHNOLOGY AND ECONOMIC PERFORMANCE:

ORGANIZING THE EXECUTIVE BRANCH FOR A STRONGER NATIONAL TECHNOLOGY BASE

SEPTEMBER 1991

A REPORT OF THE

CARNEGIE COMMISSION
ON SCIENCE, TECHNOLOGY, AND GOVERNMENT



The Carnegie Commission on Science, Technology, and Government was created in April 1988 by Carnegie Corporation of New York. It is committed to helping government institutions respond to the unprecedented advances in science and technology that are transforming the world. The Commission analyzes and assesses the factors that shape the relationship between science, technology, and government and is seeking ways to make this relationship more effective.

The Commission sponsors studies, conducts seminars, and establishes task forces to focus on specific issues. Through its reports, the Commission works to see that ideas for better use of science and technology in government are presented in a timely and intelligible manner.

Additional copies of this report may be obtained from the Commission's headquarters.

TECHNOLOGY AND ECONOMIC PERFORMANCE:

ORGANIZING THE EXECUTIVE BRANCH FOR A STRONGER NATIONAL TECHNOLOGY BASE

SEPTEMBER 1991

A REPORT OF THE
CARNEGIE COMMISSION
ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

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ACKNOWLEDGEMENTS

This report of the Carnegie Commission on Science, Technology, and Government was prepared by its Task Force on Science, Technology, and Economic Performance. The members of the Task Force were:

Admiral B. R. Inman, Chair
Norman R. Augustine
Lewis M. Branscomb
Daniel Burton
Ashton B. Carter
Theodore Cooper
Edward E. David
Robert M. Frosch
William G. Howard
Philip A. Odeen
William J. Perry
Robert M. Solow
Elmer B. Staats

The report was adopted by the Carnegie Commission at its meeting on June 26, 1991. The Commission is grateful to Admiral Inman for his leadership and to the Task Force members for their substantial contributions. The Commission also thanks staff members David Z. Robinson, David Z. Beckler, and David M. Kirsch who provided support, and William D. Stotesbery for his editorial assistance.

Joshua Lederberg, Co-Chair
William T. Golden, Co-Chair

EXECUTIVE SUMMARY

Improved national economic performance requires sustained growth in productivity. The development and diffusion of new technology and its underlying science have been a major source of such growth.

Historically, the federal government has contributed to technological growth in many ways, indirectly through economic policies, and directly as part of traditional governmental interests in defense, space, health, science, and agriculture. Military research and development in particular created a defense industry technology base which in certain fields both led and assisted commercial technology development. In the two decades that immediately followed World War II, American commercial technology was the strongest in the world.

Three major changes have occurred in recent years. First, American commercial manufacturing leadership has eroded in many sectors—particularly the automotive, electronic, and semiconductor industries—at the same time that growth in the world technology base and the globalization of industrial activities have increased international economic interdependence. Second, in fast-moving dual-use fields (those with both commercial and defense applications), the Department of Defense has gone from being a technological leader to a follower, as commercial demands for increasingly complex components determine research and development priorities. Third, the commercial technology base has become more and more inaccessible to the military technology base in part because of complex military accounting and procurement policies and in part because commercial research and development have grown much more rapidly.

Primary responsibility for the advance and use of commercial technology rests with private industry. There is, however, an important federal role in supporting "generic" technology, i.e., technology that can contribute to a broad spectrum of uses. The Department of Defense and other federal agencies should have programs that enable their technology developments to serve commercial industry as well. In particular, the Department of Defense should replace military with dual military-industrial standards which will be guided primarily by industrial needs wherever commercial applications dominate the market.

Although in the long term there might be major organizational changes required to support generic technology, the Task Force believes that any approach that does emerge will be evolutionary and require careful evaluation and monitoring. The Task Force recommends, as a start:

- *that the National Institute of Standards and Technology (NIST) in the Department of Commerce have a central responsibility for supporting generic and pre-competitive research and development (R&D) not within the missions or R&D programs of other departments and agencies.* The recently started Advanced Technology Program could, in time, become an important vehicle for such support, although it is now funded at a very low level ($35 million). NIST should also have a key role in promoting diffusion of technology to the commercial sector.

- *that the Defense Advanced Research Projects Agency (DARPA) be transformed into a National Advanced Research Projects Agency (NARPA), to provide stronger linkages between modern military needs and high-technology commercial industry.* NARPA must retain its responsibility to the military services while helping to create a national, rather than solely a defense, technology base. In addition to its role in support of military technologies that affect more than one service, it should support (a) dual-use technologies, (b) long-range, high-risk, and generic technologies with potentially high payoff, and (c) advanced technologies leading to products designed to meet the mission objectives of non-defense government agencies when requested and supported by those agencies.

- *that other departments and agencies that support technology, such as the National Aeronautics and Space Administration (NASA), the Department of Energy, the National Science Foundation, and the National Institutes of Health, develop mechanisms for funding and diffusing pre-competitive, generic technologies that fall under their purview.*

There is need for a structure in the White House and Executive Office of the President that can develop and review federal programs and initiatives for advancing and diffusing technology, and can assure consistent and timely policy and program decisions. Many agencies and policy councils are now involved in these decisions. The Task Force recommends:

- *that the Office of Science and Technology Policy (OSTP) exercise lead responsibility in the Executive Office of the President for identifying, formulating and evaluating policy issues related to the national technology base for consideration by other appropriate Executive Office councils and offices.* OSTP should strengthen its internal analytical capabilities, and fully use the legislative

authority granted to the recently mandated Critical Technologies Institute to enable it to perform technology policy research and analysis. In analyzing and formulating technology policy issues bearing on economic performance, OSTP should work jointly with the Council of Economic Advisers.

- *that the National Security Council include in its purview broad issues of science and technology policy related to strengthening the national technology base, reflecting the substantial overlap between military and commercial technology and the rising interdependence of economic strength and national security.*

The Task Force makes additional recommendations to OSTP, to the Department of Defense, the Department of Commerce, and the other departments and agencies aimed at strengthening and broadening their interactions with the private sector, and suggests that a Presidential directive be issued to implement the recommendations.

INTRODUCTION

The assumptions upon which our economic decisions have been made in the past are changing.

The only permanent source of improved economic performance is the sustained growth of productivity, and advances in the development and use of technology and its underlying science have been a major source of such growth.[1] That is the fundamental connection between science, technology, and economic performance.[2]

The new economic context has been discussed in a variety of reports analyzing U.S. competitiveness—a world economy transformed by developments in science and technology, the rapid rise in technology-based productivity of U.S. trading partners, globalization of high-tech industry, and a relative decline in the performance of American companies.[3] Most of these trends have been evident since the early 1960s, when the U.S. share of world exports began its decline.

If the care and feeding of this vital connection could be consigned safely to normal commercial processes, our task would be easy. But both theory and experience tell us that the private sector is likely to underinvest in science and technology from the standpoint of returns to society.

The changing defense context is more recent and more radical. The relaxation of East-West tensions and the corresponding long-term reduction in defense expenditures (with its impact on the defense technology base) are forcing a restructuring of our military establishment.[4] The U.S.

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1. See, for example, *The Economic Report of the President, 1990*, or Dale W. Jorgenson et al., *Productivity and Economic Growth* (Cambridge: Harvard University Press, 1987).

2. Technology will be even more important in the future as competition for natural resources increases, and environmental protection and sustainable development become a higher priority.

3. See, for example, the reports of the Council on Competitiveness, e.g., *Picking Up the Pace: The Commercial Challenge to American Innovation* and *Gaining New Ground: Technology Priorities for America's Future* (Washington, D.C.: The Council on Competitiveness, 1988 and 1991). Another report is MIT Commission on Industrial Productivity, *Made in America: Regaining the Productive Edge* (Cambridge: MIT Press, 1989). Several related reports have discussed the defense technology base and the defense industrial base, including *Deterrence in Decay* (Washington, D.C.: Center for Strategic and International Studies, May 1989); *Holding the Edge* (Washington, D.C.: Congress of the United States, Office of Technology Assessment, OTA-ISC-420, April 1989); and National Academy of Engineering, *Technical Dimensions of International Competitiveness* (Washington, D.C.: National Academy Press, 1988).

4. *New Thinking and American Defense Technology* (New York: Carnegie Commission on Science, Technology, and Government, August 1990), pp. 11-12.

is shifting from a bipolar strategy to a new approach based on the need to respond to regional conflicts. These changes are long-term in nature, and their implications for government policies and decision-making structures are profound. This is particularly true as government and the private sector grapple with the challenges confronting our nation's continued economic pre-eminence.

In the past, U.S. defense research expenditures were large scale and defense technology was more advanced than most commercial technology. Government investments in the defense technology base helped build the commercial technology base almost inadvertently. But U.S. defense technology expenditures are now a much smaller fraction of total global expenditures, and defense-supported technology lags rather than leads the marketplace in many areas.

In the future, both economic and military security will depend on commercially-driven technology,[5] and the government must work deliberately to advance civilian as well as military capacity in order to create a true national technology base. Separate enclaves serve neither the commercial economy nor national security.

Technology innovation, development, commercialization, and distribution are fundamental to our economic performance, and industry has the primary responsibility for their effective management. Government policies and programs, however, play a crucial role in promoting that process and require a coherent decision-making structure at the highest levels of government. The organization of the Executive Branch to invent, propose, and carry out sound federal technology policy is the major focus of the Task Force and this report.

What we propose is not an industrial policy. Our proposals are designed to favor a vital national *capability*—the creation and application of new technology. The whole technical complex is involved in this process, including basic research, technology development, and the embodiment of technology in the design and production of commercially usable products.[6]

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5. The critical technology lists in appendix A substantially overlap. They are from (a) *Emerging Technologies: A Survey of Technical and Economic Opportunities* (Washington, D.C.: U.S. Department of Commerce, Technology Administration, Spring 1990), and (b) *The Department of Defense Critical Technologies Plan* (Washington, D.C.: Department of Defense, May 1989).

6. Incipient technologies, such as nuclear energy and space communication, could never have gotten started at all in a purely private market unless they had been helped to reach a certain scale or get a certain distance down the "learning curve" before they could hope to compare with existing technologies.

Successful technology policies by themselves will not ensure economic success. Many variables, including trade policies, cost of capital, investment in production capabilities, industrial structure and management, education and work-force skills will continue to affect economic performance. But the government should have the organizational capability to create and maintain a climate conducive to investment and risk-taking. The President's official statement on U.S. Technology Policy makes that point:[7]

> . . .A nation's technology policy is based on the broad principles that govern the allocation of its technological resources. Competitive market forces determine, for the most part, an optimal allocation of U.S. technological resources. Government can nonetheless play an important role by supplementing and complementing those forces. . . .The principal role of the Federal Government will be to provide an environment conducive to long-term economic vitality, and not to allow special interests to divert attention or resources from this goal.

7. Executive Office of the President, *U.S. Technology Policy* (Washington, D.C.: Office of Science and Technology Policy, September 26, 1990): See appendix B.

PART I
TECHNOLOGY POLICY AND THE CHANGING PARADIGMS

The government's ability to formulate and execute effective policies which support the development of the national technology base will be of central importance in dealing with the challenges ahead. Distinctions between the defense technology base and the civilian technology base have blurred, and their effective integration will provide an additional source of technological strength for government and industry.[8]

ECONOMIC/TECHNOLOGICAL PERFORMANCE

The erosion of U.S. technological dominance has received widespread attention. A recent report by the Department of Commerce, for example, states that the U.S. is losing ground to Japan in all but two of twelve key technologies.[9] The Computer Systems Policy Project, sponsored by the nation's largest computer manufacturers, has concluded that, if current trends continue, we will face serious problems in sixteen critical information processing technologies.[10]

Other indicators of lagging performance in leading technologies relative to those of other nations have been widely reported—for example, a decreasing percentage of U.S. patents issued to U.S. citizens, declining market shares and trade balances, and less frequent citations of U.S. research in professional literature.[11] The U.S. also faces particular problems in process technology and its application—the technology of manufactur-

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8. By technology base, we refer to both "public" technological knowledge capable of being shared and used by a large technical community and proprietary technological knowledge embedded in specific organizations.

9. *Emerging Technologies, A Survey of Technical and Economic Opportunities* (Washington, D.C.: U.S. Department of Commerce, Technology Administration, Spring 1990).

10. *Perspectives: Success Factors in Critical Technologies* (Computer Systems Policy Project, 1735 New York Avenue, NW, Suite 500, Washington, D.C. 20006; July 1990).

11. Detailed statistics are available from several sources and, for the purposes of brevity, are not repeated in this report. See, for example, the publications of the Council on Competitiveness, particularly *Gaining New Ground*, March 1991. The *Science and Engineering Indicators* reports of the National Science Board also provide great detail in these areas.

ing and production. U.S. firms have been notably slow in adapting production lines to new technologies, and where they have adapted they have done so conservatively.

The ultimate result of this erosion can be seen in the poor competitive position of particular U.S. industries dependent on those key technologies in which the decline has been most significant and of longest duration. Consider two examples: Fifteen years ago U.S. companies made 95 percent of the telephones and 80 percent of the television sets for U.S. homes. Today, U.S. companies make 25 percent of the telephones and 10 percent of the television sets sold here.[12] The Department of Commerce recently documented the shift in the U.S. telecommunications industry from a $1.1 billion trade surplus in 1978 to a $2.6 billion deficit in 1988, and concluded that the U.S. has lost the low end of the global telecommunications market.[13]

Perhaps the most widely cited example of U.S. technological erosion is the U.S. semiconductor industry. Semiconductors are vitally important since they represent the basic technology for most modern electronic processes and products. In 1970, the Japanese had none of the world market share in dynamic random access memories (D-RAMs), a particular type of semiconductor device; by 1988, the Japanese share of the vendor marketplace had reached 80 percent.[14] The 1989 report of the National Advisory Committee on Semiconductors extensively documents this and other disturbing trends in U.S. technological capability in semiconductor-related areas.

In addition to consumer electronics and computer memory chips, Japanese firms have made great inroads in autos and machine tools. German firms have built market share in many lines of industrial machinery. The loss of U.S. industrial leadership is not, however, uniform across all industries. In some important sectors such as chemicals, pharmaceuticals, aircraft and aircraft engines, U.S. firms continue to compete very effectively,[15] although even here U.S. market share is eroding.

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12. Abelson, Philip H., "Federal Policies in Transition," *Science*, 242:4886 (December 13, 1988), p.1621. The Task Force concern is not primarily about ownership of specific corporations, but rather how much of the value added is produced in the United States. Many American firms have overseas plants, and many foreign firms have American plants.

13. *U.S. Telecommunications in a Global Market* (Washington, D.C.: U.S. Department of Commerce, Technology Administration, August 1990).

14. *A Strategic Industry at Risk* (The National Advisory Committee on Semiconductors, 1555 Wilson Blvd., Suite 500, Arlington, VA 22209; November 1989), p.9.

15. The recent Council on Competitiveness report, *Gaining New Ground: Technology Priorities for America's Future* (footnote 2) describes in depth the situation in various industries.

Dominating the low end of the market provides Japanese firms with the high cash flow necessary to enable them to attack the high end successfully, and this is the "trickle-up" strategy they have followed in automobiles, machine tools, consumer electronics, personal computers, microwave ovens, and countless other areas. They have also used their mass production markets to build up a demand-driven world market share in manufacturing capital goods. Much of this involves ingenious design, but not much in the way of radical technological innovation.

Military/Strategic Posture

Scientists and engineers were mobilized in World War II, and the United States emerged from that war as the dominant international power—politically, economically, and technically. The Department of Defense strongly supported the advance of military technology after the war, and some of that technology spun off into the civilian economy. The size and scope of defense technology investments still have a powerful impact on commercial technology, but the defense technology base is increasingly dependent on developments in the commercial sector.

The importance of economic considerations in national security policy is reflected in the 1990 White House statement on "National Security Strategy of the United States":[16]

> America's national power continues to rest on the strength and resilience of our economy. To retain a position of international leadership, we need not only skilled diplomacy and strong military forces, but also a dynamic economic base with competitive agricultural and manufacturing sectors, an innovative research establishment, solid infrastructure, secure supplies of energy, and vibrant financial and service industries.

Traditionally, the national security of the United States has been viewed in terms of its military capability. Since the end of World War II, the United States has maintained an effective deterrent to war, focused primarily on the threat from the Soviet Union and the possibility of confrontation in Europe.

With the advent of profound changes in the Soviet Union, the U.S. military is undergoing a comprehensive reassessment of its strategy. In the face of Congressional criticism that the U.S. defense establishment lacks a

16. *National Security Strategy of the United States* (The White House, March 1990), p.21.

long-range strategic vision, the Pentagon is engaged in a major effort to define an effective strategy for a dramatically changing world. Despite the rather substantial scale of the Gulf war, all indicators are that the future will require a substantial reduction and re-deployment of forces, increased reliance on rapid reaction forces, and increased emphasis on reserves for support functions.

The Carnegie Commission report, *New Thinking and American Defense Technology*, emphasizes the importance of technology to this emerging defense strategy:[17]

> . . .Technology is an important insurance policy against an uncertain strategic future. It will help to preserve future options to meet a possible renewal of the Warsaw Pact threat, as well as the varied and changing but pressing demands of regional conflicts, proliferation of military technology to unstable nations, terrorism, and drugs. Preserving, and indeed broadening, the defense technology base in the face of a reduction in overall defense spending is thus an example of the "new thinking" required by the dramatic turn in world events.

Throughout the 1950s and 1960s, a major source of U.S. technological advance was the support of research and development by the Department of Defense (DoD). In 1960, DoD funded half of all U.S. R&D, and the U.S. accounted for two-thirds of all the R&D in North America and Western Europe combined.[18] Thirty years later, DoD supports just one-third of U.S. R&D, and the U.S. share of the total has dropped off to one-half. In fast-moving dual-use fields (those with both commercial and defense applications) like microelectronics, DoD has gone from being a technological leader to a follower, as commercial demands for increasingly complex components determine research and development priorities.[19]

At present, military technology, even in firms that do substantial commercial business, is essentially segregated from commercial technology. In effect the United States has two technology bases, a defense technology base and a commercial technology base. This separation could be afforded when the United States led the world in both commercial and military

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17. *New Thinking and American Defense Technology*, pp. 10-11.

18. John Alic, Lewis M. Branscomb, Harvey Brooks, Ashton B. Carter and Gerald Epstein, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, to be published by the Harvard Business School Press, Winter 1991-92. The title is provisional.

19. See *New Thinking and American Defense Technology*, particularly pp. 11-13.

technology. However, overall defense budgets will decline in the future, and the defense technology base will have to draw more easily from the commercial sector for national security needs. This will require the nation in the long run to have a single technology base that will serve both military and commercial needs—a *national technology base.*[20]

Moving toward a national technology base will be necessary as well for advancing the technological component of economic performance. Defense support of technology will continue to be very substantial, and—particularly in so-called "dual-use" fields—can contribute substantially to the growth of the economy.

Thus, two challenges face our national technology policy: to ensure a sufficient level and quality of effort in technology generation, and to apply technology more effectively in support of our national security and economic health.

20. Ibid., pp. 24-27.

PART II
THE ROLE OF GOVERNMENT IN TECHNOLOGY POLICY AND PROGRAMS

Government can do many things to create and maintain an environment within which industry based in the United States can achieve success in the marketplace for goods and services. For example, it can:

- promote fiscal and monetary policies that encourage innovation and make capital readily available for technological development and its embodiment in productivity improvement.

- maintain a legal system that protects intellectual property and adapts to changes in the nature of intellectual assets, with an equitable allocation of rights as an incentive for meaningful investment.

- support a trade policy that ensures an open multilateral trading system.

- maintain a regulatory climate that stimulates innovation while promoting common benefits such as a clean environment, a stable financial system, and sound business practices.

Working with state and local governments, the federal government can help to insure:

- that the current and future work force attain a level of skill and motivation equal to or better than that of any other nation.

- that the country has in place a physical and technological infrastructure—roads, communications (including new technologies such as fiber optics), available energy and water, a capacity for investment, police and fire protection—that preserves its status as a cost-effective, efficient, and secure place to do business.

A History of Government-Industry Teamwork

In addition to these actions, of course, the federal government has had a historic role in supporting research and technological development underpinning economic performance. For example, over the last century, the government has invested in research and development in many areas that advance government missions in cooperation with the private sector:

- Agriculture — where the investment in agricultural research and extension work has multiplied crop yields and productivity.
- Health — where the National Institutes of Health and other federal agencies have greatly increased our understanding and capacity for control of disease.
- Space — where our concern over Sputnik made possible a revolution in communications and opened up new vistas for deeper understanding of the planetary environment and the universe.
- Defense — where government and industry teamwork has established U.S. international leadership, particularly in aircraft and computing.
- Energy — where research on peaceful use of nuclear energy led to the development of civilian reactors.
- Basic science — where it is generally agreed the U.S. still leads the world, albeit with a declining margin.
- Graduate training — where government support has helped most of today's scientists and engineers to obtain doctoral degrees.

While this record is remarkable, it would be serendipitous if the aggregate of individual agency missions covered the full range of base technologies required for a modern competitive industrial society. Indeed, this is not the case. Some policy broader than simply the support of federal missions must drive our national technology investments. Furthermore, with the singular exception of agriculture, government is paying inadequate attention to the diffusion of government-generated technology to the people and firms that can make best use of it in the economy.

Organizing for a Strong National Technology Base

The country is strongly committed to economic advance through a market economy, one that is not directed top-down from government but rather relies on decentralized initiatives and competition within the private sector. However, there is much to be done by both the government and private industry, separately and in cooperation, to build and draw on the national technology base.[21]

The government needs an effective mechanism or process by which it can decide when it is appropriate to support or aid technological development and when that support should come exclusively from the private sector. For example, the Bush Administration believes that it is appropriate for the federal government to support "pre-competitive, generic technology."[22] What does this statement mean in operational terms? What are the criteria for deciding which technologies to emphasize? Which departments and agencies should undertake technology support? Where is the proper boundary line between government action and private initiative? Should government support be contingent upon the rapid dissemination of results to accelerate adoption? If so, how can incentives for private development investments be maintained? There must be a government decision-making structure to address these questions and then to get beyond rhetoric to build effective programs. The government must also have an assessment and evaluation capability regarding the national technology base and the ability of firms to contribute to and draw on that base.

This report centers on government's role in ensuring a strong national technology base—specifically on changes in government organization and decision making that are needed to improve its contributions to economic performance. These changes should take place within an overall strategy that takes full account of the global nature of modern industrial

21. See *New Thinking and American Defense Technology* and appendix B.

22. The Federal Register suggests the following definitions for these terms: *Generic Technology*—A concept, component, or process, or the further investigation of scientific phenomena, that has the potential to be applied to a broad range of products or processes across many industries; *Pre-competitive Technology*—Research and development activities up to the stage where technical uncertainties are sufficiently identified to permit assessment of commercial potential and prior to development of application-specific commercial prototypes (Federal Register, Vol. 55 No. 65, April 4, 1990), p. 12505.

technology.[23] The following mechanisms are needed in the Executive Branch to develop and implement effective government technology policies:

- a structure for formulating, developing, reviewing, and evaluating federal programs and initiatives for technology, and for oversight and review of key programs.
- analytical support for that structure that is competent in both economics and technology and can assess likely long-term developments as well as respond to issues of the moment.
- a top-level decision-making process that will use the analyses effectively in reaching sound and timely policy and program decisions.
- mechanisms for assuring funding allocations to implement key science and technology programs approved by the Congress.
- effective execution, management and coordination of key programs by the appropriate departments or agencies.

23. Another task force of the Commission is dealing with improving science education, which many members believe is one of the most critical problems affecting economic performance. For this reason, this report does not deal with that issue.

PART III
FEDERAL EXECUTIVE ORGANIZATION FOR TECHNOLOGY

Decisions about federal policies involving technology and the economy are currently made in various offices and policy councils within the Executive Office of the President, depending on the issue. This division of responsibility may be appropriate for dealing with many specific questions related to technology or economic performance, but an improved mechanism for consistent policy formulation, implementation, review, and oversight is essential. There is need for a place in the Executive Office that has a comprehensive understanding of what is happening in the economy, especially in relation to technology development and diffusion, and some means to insure that policy initiatives and instruments of implementation do not act in conflict with each other.

OSTP AND THE SCIENCE ADVISER

The key official of the Executive Branch with regard to overall technology policy is the Assistant to the President for Science and Technology (the President's Science Adviser). The Science Adviser also serves as the director of the Office of Science and Technology Policy (OSTP), which was established within the Executive Office of the President by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to:

- advise the President of scientific and technological considerations involved in areas of national concern;
- evaluate the scale, quality, and effectiveness of the federal science and technology effort;
- advise the President on technological aspects of federal budgets and assist the Office of Management and Budget (OMB) with an annual review and analysis of proposed funding for research and development (R&D); and
- assist in providing leadership and coordination of federal R&D programs.

OSTP staff work with the director to discharge these responsibilities. They review agency programs, attend budget review sessions at OMB, and help the director on issues on which he advises the President. The Associate Director for Industrial Technology takes primary responsibility within the office for issues dealing with technology policy, represents OSTP on the Committee on Industry and Technology of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), and oversees the preparation of the critical technologies report mandated by Congress. He also oversaw preparation of the report, *U.S. Technology Policy*[24]

Other Executive Office Organizations

Several offices and policy councils in the Executive Office of the President, in addition to OSTP, address issues related to technology policy.

The **Council of Economic Advisors** (CEA) advises the President on all matters of economic policy. The importance of technology and the government's role has been discussed in its annual reports. The chairman of CEA is a member of the Economic Policy Council, the Council on Competitiveness, and the Council on Foreign Investment in the United States.

The **Office of Management and Budget** has the primary budget decision-making role where agency programs are concerned or where organizational changes or legislation are called for. Its director is a member of the Economic and Domestic Policy Councils. OMB is also responsible for promoting interagency operational coordination as well as overall government procurement policy.

The **U.S. Trade Representative** is a central figure in the decision-making process on international trade matters.

The **White House Office**, and particularly the Chief of Staff, plays a key role in technology policy when Presidential decisions are called for. The Chief of Staff and the Assistant to the President for Economic and Domestic Policy are also involved on many issues before they reach the President.

The principal mechanism for analyzing policy issues for Presidential decisions that involve multiple agencies is the Cabinet-level council in the Executive Office. Five councils now deal with issues involving technology and economic performance:

24. Executive Office of the President, *U. S. Technology Policy* (Washington, D.C.: Office of Science and Technology Policy, September 26, 1990). See appendix B.

National Security Council (NSC): The NSC staff is directed by the Assistant to the President for National Security Affairs, and its meetings are chaired by the President. The Vice President and Secretaries of State and Defense are among its members. The Chairman of the Joint Chiefs of Staff and the Director of Central Intelligence are statutory advisers. Within the policy council structure, NSC is the first among equals. The Assistant briefs the President daily. Its staff of about 100 brings together materials and policy positions from the key departments and agencies involved, and it has a formal process for implementing its decisions through the same agencies. NSC has been involved in issues involving technology required to meet national security needs and international technology transfer. It has tended to operate at the policy rather than the program level.

Economic Policy Council (EPC) and **Domestic Policy Council** (DPC): These interagency councils are chaired by the President but have chairmen *pro tem*, the Secretary of the Treasury in the case of EPC,[25] and the Attorney General for DPC.[26] EPC is the primary focus for economic policy and trade issues. It has been the major council dealing with interagency issues involving technology and the economy. DPC is concerned with interagency questions in which economic and international concerns are not considered primary. These councils have very small staffs, and their work is accomplished by using interagency working groups to develop options for review by council members. A joint EPC/DPC interagency group on science and technology has been established under the Science Adviser, but it has not been active so far.

Council on Competitiveness: The President's Council on Competitiveness is chaired by the Vice President.[27] It establishes interagency working groups, and its reports are presented to the President. The Council has focused on five issues: biotechnology, protection of property rights, product liability, regulatory relief, and the federal drug approval process.

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25. The members of EPC are: President (Chair); Secretary of the Treasury (Chair, *pro tem*); Vice President; Secretary of State; Secretary of Agriculture; Secretary of Commerce; Secretary of Labor; Secretary of Transportation; Director, Office of Management and Budget; U.S. Trade Representative; Chairman, Council of Economic Advisers; Chief of Staff to the President; Director, Office of Science and Technology Policy.

26. The members of DPC are: President (Chair); Attorney General (Chair, *pro tem*); Vice President; Secretary of Education; Secretary of Interior; Secretary of Health and Human Services; Director, Office of Management and Budget; Chief of Staff to the President; Director of the Office of Science and Technology Policy; Secretary of Housing and Urban Development; Secretary of Energy; Administrator, Environmental Protection Agency.

27. The members of the Council on Competitiveness are: Vice President (Chair); Attorney General; Secretary of the Treasury, Secretary of Commerce; Director, Office of Management and Budget; Chairman, Council of Economic Advisers; Chief of Staff to the President.

Federal Coordinating Council for Science, Engineering and Technology (FCCSET): Chaired by the director of OSTP, FCCSET membership includes department and agency heads or chief technical officials from departments and agencies involved with technical issues.[28] FCCSET's primary function is to recommend policies to promote more effective planning and administration of federal scientific, engineering, and technological programs affecting more than one federal agency. FCCSET, which often meets at Cabinet level, works through interagency working groups, often with the participation of a representative from OMB. Its reports are dealt with through the normal budget process, although OMB gives special consideration to interagency programs developed through FCCSET. It has established a Committee on Industry and Technology chaired by an Undersecretary of Commerce.

Other Executive Office councils consider special aspects of technology policy, such as the National Space Council and the Council on Environmental Quality. The President's Council of Advisers on Science and Technology (PCAST) provides an important means by which the President can obtain advice on science and technology (S&T) issues from sources outside of government.

The large number of organizations involved in the Executive Office make it difficult to have consistent mechanisms for identifying, formulating and reviewing technology policies and programs. If, in the future, the nation is to have a single national technology base, such mechanisms need to be developed.

28. The members of FCCSET are: Assistant to the President for Science and Technology and Director, Office of Science and Technology Policy (Chair); Secretary of the Interior; Secretary of Agriculture; Secretary of Health and Human Services; Secretary of Energy; Secretary of Education; Administrator, Environmental Protection Agency; Administrator, National Aeronautics and Space Administration; Assistant to the President for National Security Affairs; Director, National Science Foundation; Under Secretary for Economic Affairs, Department of State; Deputy Secretary of Defense; Secretary, Department of Commerce; Under Secretary, Department of Housing and Urban Development; Deputy Secretary, Department of Transportation; Deputy Secretary, Department of Veterans Affairs; Director, Office of Management and Budget.

PART IV
DEVELOPING AND IMPLEMENTING TECHNOLOGY POLICY

The focus of this report is the organization of the Executive Branch to address technology policy. The report addresses several key questions:

- How should policy issues be identified and formulated?
- Where should analytical support for policy options and responses reside?
- How well does the decision-making process deal with these issues and options?
- How are decisions executed and funded?
- How is the implementation of policies monitored and evaluated?

IDENTIFYING, FORMULATING, AND EVALUATING POLICY ISSUES

Some office within the Executive Office of the President should have responsibility for dealing with the technological dimension of economic performance: developing and responding to new ideas; interacting with the nongovernmental community; and making sound and cost-effective technological judgments. The office should formulate as well as collate ideas and facilitate their consideration. Most importantly, it should be a central focal point for identifying policy issues involving more than one department or agency for consideration by the appropriate body in the Executive Office.

THE TASK FORCE RECOMMENDS that the Office of Science and Technology Policy retain and exercise lead responsibility within the Executive Office for identifying, formulating, and evaluating policy issues related to the technological aspects of economic performance.

THE TASK FORCE RECOMMENDS FURTHER that the two organizations chaired by the Science Adviser continue to play central roles in technology policy and program oversight and evaluation:

- the Federal Coordinating Council for Science, Engineering and Technology, by reviewing new program proposals and monitoring interagency policies and programs.
- the President's Council of Advisers on Science and Technology, by tapping the ideas, experience and independent views of an outstanding group of scientists, engineers, social scientists, and technologists drawn from universities and the private sector.

FCCSET and PCAST provide a broad view of pressing science and technology issues and a means to develop and monitor government-wide approaches to technology policy. PCAST, whose membership should continue to include social as well as natural scientists, has met on a number of occasions with the President and senior White House staff. Senior policy makers are increasingly active in the meetings of FCCSET. Its committees now include staff from the Office of Management and Budget (OMB), and its reports are accepted broadly within and outside the government.

The Task Force believes that OSTP and FCCSET must play central roles within the government in technology policy and program oversight and evaluation. While operational oversight should be the responsibility of each specific mission agency, policy oversight should be the responsibility of OSTP and FCCSET. Special emphasis should be given to agency activities and national technical capabilities that contribute to economic performance, including technology transfer and diffusion to and within the commercial sector. Information gained in the oversight process should feed into the policy research and analysis mechanisms proposed below, with OSTP and FCCSET playing the central role. OSTP also has an important role in monitoring agency performance. As new programs are developed, their evaluation will be a critical responsibility.

The Task Force is convinced of the vital importance of establishing productive relationships with the widest possible range of industrial and scientific/engineering organizations. The National Academies complex and particularly the recently established Manufacturing Forum can provide a

rich sounding board. Scientific, trade, and professional associations are useful resources in particular areas. OSTP is a critical link, and should be clearly charged to work with PCAST in initiating and coordinating a broad-based outreach program aimed at creating a wide network of resources.

Analytical Support for Technology Policy Development

The Task Force concludes that existing analytical support for technology decision making is inadequate. Decision making embracing economic, trade, regulatory, and technology policies would benefit from enhanced analytic capabilities. Some of the analytical work should be long-term.

The following questions illustrate the kinds of issues requiring analysis by OSTP or other Executive Office agencies:

- How do particular economic, fiscal and regulatory policies influence technological innovation and related investment and risk taking?

- What criteria should guide federal investment in pre-competitive, generic technologies and federal involvement in promoting cooperation with and among private organizations?

- How well do the various methods of coupling government-sponsored R&D with potential commercial technology work? Where are the shortcomings and successes (e.g., technology transfer from national laboratories, the Defense Advanced Research Projects Agency's technology insertion program, SEMATECH)? What are successful models of technology transfer and diffusion?

- How effective are the many state initiatives in technological development for economic growth, and what mechanisms should be used to promote their interaction with the federal government?

- What do the European and Japanese technology support programs actually involve, and in what ways are they successful or unsuccessful? Would corresponding approaches fit in our different cultural context?

THE TASK FORCE RECOMMENDS that OSTP increase its capability for technology policy analysis through a dedicated in-house analytical staff backed by adequate resources. Impartial evaluation of new and proposed government programs will be a major part of the analysis.

The National Science and Technology Policy, Organization, and Priorities Act of 1976 calls on OSTP to "initiate studies and analyses, including systems analyses and technology assessments, of alternatives available for the resolution of critical and emerging national and international problems, and insofar as possible, determine and compare probable costs, benefits, and impacts of such alternatives."

The difficulties encountered by OSTP in the past in executing its congressional mandate were documented in a 1989 report of the House Committee on Science, Space, and Technology:[29]

> The view that OSTP has been unable to execute the broad S&T policy and coordination responsibilities outlined in Public Law 94-282 has been more prevalent in recent years. In particular, the perception exists that OSTP has failed to provide the needed long-range planning required to develop a coherent national R&D effort and that coordination between federal agencies, in most cases, is suboptimal. . . . These deficiencies may be attributed to the decrease in permanent staff that has occurred in OSTP in recent years.

Since that comment was written, the OSTP budget was increased from $1.6 million in FY 1989 to $2.8 million in FY 1990 and $3.6 million for FY 1991. The FY 1989 staffing level of twelve was increased to an authorized level of thirty-nine in FY 1990 and to forty-three in FY 1991, about half of whom are professionals. Given the broad range of analyses needed, the staff will probably have to increase further, and given the recent large increase in federal pay scales, the budget will probably have to increase as well.

Outside dedicated analytical institutions such as the Rand Corporation, the Institute for Defense Analyses, and the Urban Institute have been used successfully in other areas of government, particularly defense and

29. *Setting Priorities in Science and Technology*, Report of the Committee on Science, Space, and Technology of the U.S. House of Representatives, 101st Congress, 1st Session, HR 101-310 (Washington, D.C.: U.S. Government Printing Office, 1989), p. 9.

intelligence, where deep technical knowledge and independent technical judgment are required. If proper relationships are established, such an organization can also assure continuity and institutional memory through changing political administrations.

A possible step in this direction was taken in 1990 with the creation of the Critical Technologies Institute (CTI). CTI was created in the Defense authorization bill as a Federally Funded Research and Development Center (FFRDC) to provide research and analytic support to OSTP. Oversight is provided by a twenty-one-member board of trustees, chaired by the director of OSTP and including the Secretaries of Defense, Energy, Health and Human Services, and Commerce, the administrator of NASA, and the director of the National Science Foundation (or their designees). The board also includes four other members of FCCSET and ten members from industry and universities.

CTI's first year's budget of $5 million (which can be spent over two years) is to be used for an assessment of critical technologies and related national objectives. If this latter part of its mandate is broadly defined, the institute's reports could be very valuable not only to OSTP, but to the Executive Office as a whole. However, its initial funds come from the Department of Defense and there is no assurance that funds will be appropriated in future years. After this initial period, the bulk of the funding should come from the OSTP budget.

The Administration requested recision of the appropriation for CTI on July 23, 1991, and has opposed additional funding in the OSTP budget, on the grounds that such an office was unnecessary. The Task Force believes that the broader part of the CTI mandate concerning assessment of "related national objectives" can be an important task consistent with Administration goals.

While this potential new resource for OSTP and the Executive Office could greatly increase the government's analytic capability, contracted-for analytic capability is by its nature coupled less closely to the other parts of the Executive Office of the President than in-house capability. Both are needed.

THE TASK FORCE RECOMMENDS that OSTP establish the recently mandated Critical Technologies Institute so that it can perform technology policy research and analysis responsive to Executive Office requirements. This external capability must complement and not supplant enhanced in-house resources for OSTP.

Executive Decision Making for Technology Policy

There is a pressing need to increase the level of Presidential attention to science and technology issues bearing on economic performance. The Executive Office of the President is the locus for top-level policy decisions involving technology and the economy. Decisions about these policies are made in a large number of individual White House and Executive Office agencies and policy councils (See Part III, above). An effective mechanism is needed for assuring consistent policy oversight and decision making. An area of particular importance is the need for integration of the defense and commercial technology bases.

There is no organizational mechanism at the Presidential level currently addressing the critical policy linkage between the defense technology base and the commercial technology base. The National Security Council (NSC) is the only council with a sufficiently high stature and a sufficiently broad mandate to bridge the other councils and to consider issues of technology and economic performance within a common framework for Presidential decision making. Specifically:

- NSC has the broadest scope and capabilities of any policy council and is regularly chaired by the President;
- the Assistant to the President for National Security Affairs has daily access to the President; and
- NSC has the most highly developed staff and decision-making process among the White House councils.

THE TASK FORCE RECOMMENDS that the role of the National Security Council include concern with broad issues of science and technology policy related to the strengthening of the national technology base. This approach is based on the view that economic performance is critically important to national security and that technological vitality is of central importance to the economy.

This recommended expansion of the role of NSC is consistent with the original charter included in the National Security Act of 1947, which stated that the National Security Council should:

> . . .advise the President with respect to the integration of domestic, foreign, and military policies relating to the national security so as to enable the military services and the other departments and agencies of the government to cooperate more effectively in matters involving the national security, and
>
> . . .consider policies on matters of common interest to the departments and agencies of government concerned with the national security, and. . .make recommendations to the President in connection therewith.

In offering this approach, the Task Force recognizes that NSC has not traditionally concerned itself with economic or technology policy issues, and that certain economic and policy issues fall within the purview of other policy councils. Furthermore, the march of events around the world inevitably results in NSC giving priority attention to relatively short-term questions.

Several members of the Task Force also question whether NSC has the staff capability and outlook to permit this kind of reconceptualization of its mission. Clearly, the current structure of NSC would need to be revised, and financial and staff allocations would be required to strengthen substantially the council's economic and technological orientation and capability. NSC membership would have to continue to be augmented on occasion by the Secretary of Commerce, the Secretary of the Treasury, the United States Trade Representative, the chairman of the Council of Economic Advisers (CEA), or/and the Science Adviser.

The mechanisms already developed by the National Security Council and its staff, including ways to get decisions made and to follow up on them, lead to a consistency in approach and implementation in national security matters that is needed in the area of national economic performance. While there may be other mechanisms for the Executive Office to develop this consistency, the broadening of NSC seems the most straightforward.

Even without a reconceptualization, or as a step in that direction, NSC's mandate should be understood to include technology policy issues of immediate national security relevance. These issues include:

- maintaining an adequate technology base for military needs in the face of major defense budget cutbacks;

- controlling the international export of vital technology, while forging productive research partnerships with other governments and empowering U.S. firms to compete effectively in world markets;

- establishing national security requirements for the domestic technology base; and

- encouraging the integration of the defense technology base and the civilian technology base.

In suggesting a broader role for NSC, the Task Force stresses that it is not intended to displace related functions of the other Executive Office policy councils, such as the Economic Policy Council, the Domestic Policy Council, and the Council of Economic Advisers.

When NSC deals with issues of technology and the economy, the director of OSTP and the chairman of CEA should be involved as a matter of course. To the extent that the implemented recommendations of this report are successful, a number of the day-to-day activities of NSC will be focused on the use of science and technology to enhance economic performance and military strength.[30]

Since the role of CEA is to be the President's economic analysis staff, it cannot stand apart from the work of NSC. However, the purview of CEA goes well beyond that task. It covers advising the President on matters of fiscal and monetary policy, exchange rates, and regulation, among many others.

The staff of CEA should be available along with OSTP to provide backup for NSC, even if that means some enlargement of CEA. (It should be kept in mind, however, that the relatively small size of CEA may be an important element in its ability to maintain high intellectual standards.)

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30. The increasingly intimate interrelationship between the economic and social performance of American society and its national security and global influence is the subject of a recent article by Robert Hormats in *Foreign Affairs*. Dr. Hormats writes, "To succeed the United States will require not only vision but also more investment, more savings, more emphasis on education and more ambitious goals for research, development, and health care. It will require stronger, more purposeful economic leadership at all levels." See Robert D. Hormats, "The Roots of American Power," *Foreign Affairs* 70, no. 3 (Summer 1991), pp. 132-149.

THE TASK FORCE RECOMMENDS:

- that the National Security Council serve as a mechanism for coordinating and integrating the various policy perspectives of councils and offices in the Executive Office of the President on those matters that link national security, economic performance, and technological strength; and

- that OSTP be given responsibility for analyzing and formulating technology policy issues jointly with the Council of Economic Advisers for consideration by other appropriate Executive Office councils and offices.

Funding Technology Investment Decisions

Decisions regarding the use of technology to improve national economic performance take a variety of forms. While decisions regarding regulatory, trade, and tax policy might not require specific appropriations, decisions involving government support of technological advances or infrastructure do require funding. Timely and adequate funding is critical. The Task Force concurs with the procedure proposed in the "Federal Science and Technology Budget Priorities":[31]

> We believe that the President's Science and Technology Adviser, working closely with the director and professional staff of OMB, is best suited to coordinate both phases of the proposed S&T budget priority process. . . .
>
> Early in the budget cycle, the President should provide the agencies and departments with specific guidance on his S&T priorities in cross-cutting areas and on major S&T initiatives.
>
> Agency budget submissions should be developed, analyzed, and adjusted in terms of this initial guidance and the questions posed in the preceding discussion of the framework.

31. National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Federal Science and Technology Budget Priorities: New Perspectives and Procedures* (Washington, D.C.: National Academy Press, 1988), p.12.

Within this framework, the Science Adviser and OMB act in a capacity of "certifying" that budget submissions reflect the Administration's technology priorities.

THE TASK FORCE RECOMMENDS:

- that OMB and OSTP interact closely throughout the fiscal year to ensure that department programs are technically strong and meet the criteria for support set by the President. The FCCSET mechanism should review for gaps or overlaps in support.

- that departments and agencies with technical missions (such as NASA, the Department of Energy, and the National Institutes of Health) develop mechanisms for funding generic and pre-competitive commercial technology under their purview. They should also act as catalysts to convene industry groups and to supply seed money for ad hoc initiatives.

- that the Department of Defense (DoD), especially through the Defense Advanced Research Projects Agency (DARPA), continue to support critical defense technologies. However, because of the importance of the commercial sector to DoD, this support should include specific mechanisms for incorporating commercial technology in military systems and shared development of dual-use technologies for use in both commercial and military markets.

- that the Department of Commerce, through the National Institute of Standards and Technology (NIST), be funded to support generic technologies that apply to a number of industries and firms through the Advanced Technology Program.[32]

- that funding for the National Science Foundation programs of research and education in both science and engineering be considered a vital part of the overall federal program to assure a strong national engineering base.

32. See pp. 36-41 for a discussion of the role and charter of DARPA and NIST.

Implementing Technology Policies

Sound technology policy decisions, based upon thoughtful and careful analytic input, are only a first step. The responsibility for implementation must rest in the Executive departments and agencies.

Particular departments and agencies (for example, NASA, National Institutes of Health (NIH), and the Departments of Defense, Commerce, Agriculture, and Transportation) have responsibilities for supporting research and development within assigned mission areas.[33] Within DoD, the Defense Advanced Research Projects Agency (DARPA) supports high-risk military technology complementary to or beyond the individual service missions. The Department of Commerce, through the Advanced Technology Program (ATP), supports pre-competitive technology that will enter the industrial base. The National Science Foundation has principal responsibility for research in the basic sciences and engineering, primarily in universities. In each case, the existing organizations contribute to the national technology base, but their missions need to be augmented or clarified to make a more effective contribution.

THE TASK FORCE RECOMMENDS:

- that the role of departments and agencies with R&D missions (DoD, USDA, DoE, NIH, NSF, NASA, etc.) be clarified with regard to the generation and diffusion of commercially relevant technologies.

- that a Presidential directive be issued defining the responsibilities of the federal government and the roles of Executive agencies for developing generic and pre-competitive R&D benefiting U.S. economic performance. The directive should be based on Presidential statements on technology policy and the 1990 annual report of the Council of Economic Advisers which endorse federal support of pre-competitive, generic technology.

33. The Steelman Report of 1947 led to the policy that agencies should support basic research that was relevant to their missions. It did not recommend that the agencies should support relevant technology development. See John R. Steelman, *Science and Public Policy: A Report to the President* (Washington, D.C.: The President's Scientific Research Board, 1947). President Eisenhower issued an executive order establishing the principle that every agency making substantial use of S&T resources should proportionally reinvest in the source of that knowledge—basic science.

No national consensus has yet emerged on whether there should be a central agency with the mission of supporting technology advancement benefiting economic performance, much less how such an agency might be organized. Some have proposed a major organizational change such as restructuring the Department of Commerce into a Department of International Trade and Industry, or creating a new R&D agency with a commercial focus—a "Civilian Advanced Research Projects Agency."

The Task Force believes that any approach which does emerge is likely to be evolutionary, which will require careful evaluation and monitoring. As a start, the Task Force has focused on (a) reinforcing a key role for the National Institute of Standards and Technology (NIST) in the Department of Commerce, and (b) enlarging the role of the Defense Advanced Research Projects Agency.

The Department of Commerce and NIST

The Technology Administration in the Department of Commerce coordinates the department's technology activities with the goal of enhancing U.S. competitiveness. It is headed by the Undersecretary for Technology. Its Office of Technology Policy has responsibility for developing policy initiatives on particular domestic and international issues, such as Japan/U.S. cooperation on intelligent manufacturing systems, identifying means of eliminating barriers to technology commercialization, and promoting technology transfer. The administration also supervises the National Technical Information Service, and NIST. Major responsibilities in the area of technology support were given to the department in the Trade Act of 1988. Among them were the Advanced Technology Program (ATP), the Manufacturing Technology Centers, and industrial extension activities. These programs are managed by NIST.

ATP enables NIST to begin to play a strong role in the development of generic technologies with commercial promise—filling in the technology gaps in agency missions and executing special commercial technology projects. It can also perform a key role in helping to catalyze scientific and technological cooperation among companies.

As envisioned by the Task Force, ATP would emphasize precompetitive, generic commercial technologies applicable over a range of industries. NIST would be expected to maintain a close relationship to commercial industry and to understand the commercialization process. It would seek to catalyze and stimulate R&D cooperation and joint ventures between and among firms. NIST's predecessor, the National Bureau of Standards, already had close connections with some industries through industrial experts serving on advisory panels as well as collaborative projects and "guest workers" from corporate laboratories.

NIST's in-house program includes materials characterization, test method development, the invention of new tools and scientific instruments, and a broad range of scientific and technical information services of industrial importance. The ATP program offers an opportunity to expand the scale of this work, and to develop mechanisms for coupling to user interests.

Manufacturing technology deserves special emphasis. Commercial industry's primary competitive problems include the cost and quality of its product and the speed with which a firm can react to market information. This is a task of incremental advance, centered on the production process. Building on the broad range of NIST experience, ATP should invest in research that supports process characterization and realization, and in the automation required to reduce cost and increase quality. The development of tools, techniques, and generic design information has been a characteristic of successful federal programs in aviation (through NASA and its predecessor, the National Advisory Committee on Aeronautics). This is also the focus of SEMATECH, the joint industry-government program to develop the semiconductor industry, and the same route taken by the Ministry of International Trade and Industry (MITI) in Japan.

An important feature of the NIST program will be to maximize the diffusion of the benefits to end users, especially those small- to mid-size firms that often are unable to perform up to the existing state of the art.[34] It would not be inappropriate for NIST to spend as much as half its development funds to insure the successful diffusion of results from the other half.

Unlike DARPA, NIST has not had much experience in contracting for external R&D projects. It will have to develop criteria for the choice of programs and direction, and these will change over time. Furthermore, mechanisms will have to be developed for coordination of the ATP program with programs in the other agencies. The FCCSET Committee on Technology and Industry could be an important forum for such exchange of information and advice.

The biennial list of critical technologies, prepared for the President by a panel of individuals from government and industry selected by OSTP, could be a useful guide to the program as it develops its priorities and criteria for choice.

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34. Erosion of the technology base may be even worse in small and intermediate supplier firms that provide components and subsystems to the large manufacturers, and their position relative to their foreign counterparts may be much weaker than that of the large multinational firms that receive the most policy attention both on the commercial and military sides. These firms, often defined by their technical specializations, are the least well connected to the U.S. science and technology system, with the exception of a few regional high-tech clusters mainly in biotechnology and microelectronics.

Over the longer term, if ATP and other external programs grow, the Technology Administration will have to develop mechanisms to enable NIST to both manage important technology programs and continue to be a major national laboratory serving the nation's industries. This may have to include new organizational arrangements within DoC.

NIST should also play an important role in increasing the ability of DoD to use commercial technology. One of the major barriers to such use stems from a rigid insistence on military specifications ("milspecs"). In some semiconductor purchases, for example, because of the need for suppliers to meet milspecs, defense buyers pay up to ten times as much as commercial buyers for equivalent parts. As quality continues to improve in U.S. manufacturing, the need for military specifications designed to insure reliability should decline. NIST should take the lead in cooperating with DoD in establishing standards that would be functionally applicable both to industrial and defense applications.[35]

THE TASK FORCE RECOMMENDS:

- that NIST have a key role in government policies for promoting technology diffusion to the commercial sector.
- that NIST be recognized as having a central responsibility for supporting generic and pre-competitive R&D that has potential commercial application over a range of industries and does not fall within the missions or R&D programs of other departments and agencies (including the proposed National Advanced Research Projects Agency). The Advanced Technology Program, although very small at present, has the potential to grow into this role.
- that NIST and DoD jointly develop standards that are functionally applicable both to defense and commercial industry.

35. See *New Thinking and American Defense Technology*, pp. 26-27.

A National Advanced Research Projects Agency

The mission of DoD's Defense Advanced Research Projects Agency is to "develop revolutionary technologies that can make a significant impact on the future of the United States defense posture, and ensure that those technologies effectively enter the appropriate forces and supporting industrial base."[36] DARPA operates with a budget of approximately $1.46 billion and approximately 160 full-time staff.

THE TASK FORCE RECOMMENDS:

- that DARPA be transformed into the National Advanced Research Projects Agency (NARPA). The precise form and timing of subsequent changes within NARPA should reflect experience with the new organizational arrangement and the need to maintain the momentum of its R&D program and close ties with the military services.
- that the charter of NARPA, building on present DARPA responsibilities, should include direct support of:
  - dual-use technologies;
  - long-range, high-risk, and generic technologies with potentially high payoff; and
  - advanced technology leading to products that would be used to meet the mission objectives of non-defense agencies, when requested by them.

The proposed restructuring of DARPA to provide stronger linkage to the technology developed by high-tech commercial industry is not intended to dilute the historic scope of DARPA and its predecessor the Advanced Research Projects Agency. The renamed agency, NARPA, would continue to be in the Department of Defense, and would continue to invest in technologies of great potential military importance viewed from a longer-term perspective than the services will or should take. Many of

36. Testimony of DARPA director Craig I. Fields before the Committee on Science, Space, and Technology of the U.S. House of Representatives, March 1, 1990.

NARPA's projects will doubtless continue to draw on firms specializing in defense work. Some, like the Stealth fighter developments in the 1980s, may be highly classified or even "black" programs. No relationship with the commercial sector can be expected with these latter programs.

An increasing fraction of the work supported by NARPA, but not all, will be dual-use technology, that is, those technologies that are useful in both the defense and commercial markets. The number of technologies vital to defense that are also the focus of heavy private investment will grow. For example, command, control, communications, and intelligence activities will be of increasing importance; these are areas in which the private sector often leads defense firms in the technical sophistication of products in the field. NARPA should help move the nation toward the creation of a national technology base. As we approach this goal, defense will benefit by getting timely and low-cost access to commercial technology, and commercial companies will benefit by the increase in research and development funds available to them for defense purposes.

Collaboration with commercial firms will change how NARPA works. With the likely contraction of defense R&D budgets, along with a substantially smaller defense establishment, NARPA will find it necessary to seek collaboration with commercial industry. This implies changes in NARPA's mode of operation and its criteria for project selection: In order to attract the collaboration of industry, there will have to be some give-and-take. NARPA will not be able to control all decisions about management or about technical goals. The cooperative agreement may prove a more appropriate tool than the contract for much of this work.

NARPA will continue to invest in qualitatively new capabilities. However, the type of work funded will probably not change that much from what DARPA is currently funding. Most DARPA technologies are aimed at exploring the feasibility of new concepts that bring qualitatively new function to defense capability. Thus, the projects often involve relatively new science and are addressed at the level of prototypes to test technical feasibility. Relatively few DARPA projects are concerned with incremental improvements for existing weapons systems—to make them cheaper, extend their accuracy, or to provide interfaces to other subsystems. This is the role for the service design and acquisition organizations.

NARPA's charter must include an emphasis on both product and process technologies.[37] Furthermore, a deep knowledge of, and close work

37. The Task Force had extensive discussions on the definitions of process technology. Though no final definition was reached, process technology, as used here, is intended to mean to improve productivity, efficiency or output, increase yield, and/or lower cost. Process technology might include such areas as manufacturing, engineering design, software design, and office productivity. There is a close relationship between product and process technology, and the Task Force does not believe the distinction is clear enough to serve as a means of defining a research mission.

ing relationship with, industry will be vital to NARPA's success. NARPA should stimulate cooperative ventures with, and within, industry, and develop techniques for the commercial diffusion of the technologies it generates. However, NARPA should not have a role in developing products for the commercial marketplace and should develop criteria for closing off funding when the technology is ready and able to be commercialized.

NARPA should approach advanced technology projects that may be requested by non-defense agencies just as DARPA currently approaches projects for the military services. The new mechanism by which OSTP develops a list of critical technologies (using input from DoD and DoC) could be a useful way to establish priorities. The Task Force recommends that the President's Science Adviser review dual-use and non-military projects of NARPA. This is in line with the recommendation contained in the Carnegie Commission's *New Thinking* report that the Assistant to the President for S&T "review and recommend new modalities for the transfer of defense technology to commercial applications and for the timely use of commercially developed technology in defense systems."[38]

The Task Force further believes that the funding for NARPA projects of interest to non-defense departments and agencies should come from those departments. Clearly, DoD would retain the major stake in NARPA and be the major source of funds. However, where non-military departments and agencies have technology needs which they believe DARPA could address effectively, they should assist it by defraying the cost of research.

The Task Force emphasizes that the proposed NARPA would not supplant the R&D activities of defense or non-defense departments and agencies. Just as the individual services currently maintain their own R&D efforts, often working in cooperation with DARPA, the non-defense agencies would continue to maintain R&D programs required to perform their missions. If NARPA shows that it can manage technology programs efficiently, these agencies can choose to fund certain NARPA projects as part of their program.

The Department of Defense

The Task Force has two additional recommendations affecting DoD, in addition to the recommendations regarding the further development of DARPA's role. First, the Department of Defense is still a major consumer of science and technology, funding more than one-seventh of the R&D performed in the industrialized world. One-third of all American scientists

38. *New Thinking and American Defense Technology*, p.25.

and engineers outside of biomedical fields work on defense projects. DoD "withdraws" from the high technology pool, and will continue to withdraw substantially in the future. It should therefore continue to make "deposits" into that pool through support of basic and applied research. It will be necessary to increase the percentage of the research, development, test and evaluation (RDT&E) budget allocated to basic and applied research if deposits are to be brought closer into balance with withdrawals.

Second, the Department of Defense reimburses contractors' overhead expenses for independent research and development (IR&D). The IR&D program should be used to encourage companies to align their defense and commercial technology efforts to the mutual benefit of both. Present DoD regulations and practices for cost recovery tend to discourage diffusion of dual-use technologies into commercial industry.

In these recommendations, the Task Force reflects its endorsement of proposals contained in the Carnegie Commission's *New Thinking* report.[39]

THE TASK FORCE RECOMMENDS:

- that, in view of the substantially increased reliance by DoD on the commercial sector for procurement of R&D-intensive products and as a major consumer of science and technology, DoD resupply the national technology base from which it draws, by increasing the proportion of the RDT&E budget that goes to basic and applied research.

- that DoD reimbursement policies for independent research and development should be interpreted to cover commercial as well as defense research expenditures, particularly where dual-use technologies or technologies identified in a national critical technology plan are involved.

Foreign Technology Assessment

Increased awareness of the contribution of R&D and technological innovation to economic growth has led U.S. trading partners to devise

39. See *New Thinking and American Defense Technology*, pp. 19 and 25.

policies and programs aimed at the support of domestic technology-intensive companies and industries. Direct government intervention in Japan and in European countries has led to pressures for similar support policies and practices in the U.S.—both individually and through the European Community.

It is difficult to gauge the effectiveness of such programs, and they may not work in the American culture. To the extent government interventions are effective, we can gain from that experience. To the extent the interventions are trade distorting, we need to resist them bilaterally and in intergovernmental forums.

> **THE TASK FORCE RECOMMENDS** that the Department of Commerce monitor and assess the policies and practices of foreign countries and the European Community in promoting R&D and technological innovation for commercial purposes, and provide those assessments to OSTP and FCCSET for subsequent referral to a White House/Executive Office policy council, where policy response is indicated.

Other Issues

There are several other issues that the Task Force considered in its discussions. While these issues are beyond the scope of the report, they deserve mention and more detailed consideration in related or subsequent studies by the Carnegie Commission.

The Role of Congress

It is impossible to discuss the organization and decision-making aspects of national technology strategies without addressing the role of Congress. For example, Congress has taken the lead in establishing the ATP program in the Department of Commerce, in requiring OSTP to establish a list of critical technologies, and in establishing the Critical Technologies Institute. Congress's Office of Technology Assessment has written useful analyses of technological issues. Although the Task Force discussed aspects of congressional organization, it defers to the Commission's Committee on Science, Technology, and Congress to assess the mechanisms by which Congress decides on technology policies and programs.

The National Laboratories

The Task Force discussed the role of the national laboratories in the Departments of Defense and Energy in technology transfer and diffusion. The challenges and impediments in this area have been the subject of many reports, and the Task Force believes that brief mention in this document cannot do the subject justice. The Task Force does note, however, that the national laboratories, including contractor-operated laboratories, should be utilized more systematically as a source of R&D and S&T personnel for the benefit of the commercial sector. Industry personnel need to be involved early enough in the development process to influence the evolution of the technology and acquire a sense of "ownership." There may also be areas of pre-competitive, generic technology, such as improving manufacturing productivity or reliability, where the laboratories could contribute. This would be consistent with recent congressional actions amending the Stevenson-Wydler Act to emphasize the importance of technology transfer to industry.

State and Local Initiatives

State and local governments have made large investments in support of industrial development, primarily in R&D-intensive companies. Their programs and support mechanisms offer a test bed for the development of federal programs and policies promoting civilian technologies. In its discussions, the Task Force noted its concern about the adequacy of efforts by the Department of Commerce to fulfill its congressionally mandated responsibility to collect and assess information on state and local initiatives in the promotion of productivity, technology, and innovation. These assessments are important to OSTP and the FCCSET Committee on Technology and Industry as they consider the design and support of federal civilian technology programs.[40]

40. The Commission has established a Task Force on Science, Technology and the States to review these issues in depth.

CONCLUSION

The effectiveness with which the nation as a whole acts in developing and promoting technology-based economic growth is an important factor in the future well-being of the country. As the lead actor in the national interest, the federal government has an inescapable role to play.

In the 1989 edition of its annual assessment of Soviet military power (the first in the wake of changing East-West relations), the Department of Defense states:[41]

> If the United States proves unable to compete effectively in areas of advanced technologies, it would incur the most severe economic and security consequences: markets would be lost, the U.S. industrial base would erode, and the United States would become increasingly dependent upon offshore technologies for its defense at the same time as its economic health weakens.

Of course, even high market share in areas of the most advanced technology with limited markets may not be enough. During the 1960s and most of the 1970s the U.S. comforted itself with the belief that while it was losing market share and trade balance in low-tech goods, its position at the highest-tech end of the spectrum remained secure. It failed to recognize that continuing technological change was important to the low-tech sector of commodity-like manufactured products, and that revenues from the "high end" of the technological spectrum might not be sufficient to support the rate of innovation necessary to stay ahead. The much greater mobility of technical know-how and capital that exists today leaves a much narrower window for recovery of innovation costs before a new product is superseded in the world market. Unless the U.S. can continue to enjoy the revenue for the larger low-tech end of the market it may lack the resources to sustain the required pace of innovation at the high-tech end.

Ultimately, the willingness of the Administration to move from the organizational status quo in the area of technology policy depends upon (a) its assessment of the seriousness of the domestic situation and the international threat, and (b) its view of the extent to which government technology policies will really make a difference in U.S. economic performance.

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41. United States Department of Defense, *Soviet Military Power* (Washington, D.C.: Department of Defense, 1981), p.139.

At present, there is no high-level mechanism for assessing the nature and seriousness of the problems and developing policy options to address them in cooperation with the private sector. The federal government must recognize that an international competition for technological-industrial leadership is now under way, and effective technological transfusions take a very long time.

APPENDIX A
Comparison Between Military and Civilian Critical Technologies Lists

Department of Defense Critical Technologies Report[42]	Department of Commerce Emerging Technologies[43]
composite materials	advanced materials
machine intelligence and robotics	artificial intelligence
software productivity	high-performance computing
data fusion	digital imaging technology
simulation and modeling	—
computational fluid dynamics	—
parallel computer architecture	—
signal processing	—
photonics	optoelectronics
semiconductor materials and microelectronic circuits	advanced semiconductor devices
biotechnology materials and processes	biotechnology
—	medical devices and diagnostics
—	flexible computer-integrated manufacturing
superconductivity	superconductors
passive sensors	sensor technology
sensitive radars	—
signature control	—
air-breathing propulsion	—
pulsed power	—
weapon system environment	—
hypervelocity projectiles	—
high energy density materials	—

42. *Department of Defense Critical Technologies Plan* (Washington, D.C.: Department of Defense, May 1989).

43. *Emerging Technologies: A Survey of Technical and Economic Opportunities* (Washington, D.C.: U.S. Dept. of Commerce, Spring 1990).

APPENDIX B
EXCERPT FROM *U.S. TECHNOLOGY POLICY*[44]

A nation's technology policy is based on the broad principles that govern the allocation of its technological resources. Competitive market forces determine, for the most part, an optimal allocation of U.S. technological resources. Government can nonetheless play an important role by supplementing and complementing those forces. Technology policy is not something that, once set in place, remains immutable. Broad principles exist, but effective technology policy requires sufficient flexibility to permit response to changing national and international situations. We are in an era marked by increased international economic interdependency and increasingly stronger technological capabilities in other industrial nations. These factors pose competitive challenges for U.S. firms as well as opportunities. In formulating a national technology policy, consideration must be given to a nation's traditions, its strengths and weaknesses, and the international environment in which it exists.

In almost all respects, the U.S. science and technology base remains the world's strongest. The Nation's research universities and the ability of its people to innovate remain the envy of the world. Nonetheless, industrial competitiveness depends on many factors besides technology. Our strengths in technology and innovation have not prevented an erosion in market shares of U.S. companies in many industries. As new products mature, the advantage quickly shifts from the innovator to the efficient producer. We have also seen the importance of high rates of capital investment for the industrial competitiveness of Japan, Europe, and the Pacific Rim countries.

The competitive challenges American firms face are multifaceted and complex. There will be no facile, short-term solutions. We, in this Administration, believe it is essential that we recognize and use the strengths of our economic system more effectively to help U.S. firms remain competitive. In order to do so, all elements of our society must recognize that while we possess many strengths and assets, problems do exist, and that we can mobilize our resources and solve them. At the same time, we need to refrain from actions that might distort our basic system of free enterprise — the Nation's ultimate strength.

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44. Executive Office of the President, *U.S. Technology Policy* (Washington, D.C.: Office of Science and Technology Policy, September 26, 1990), pp. 1-6 (out of 13 pages).

In order to build on its strengths, U.S. society needs to focus on ensuring:

- a quality workforce that is educated, trained, and flexible in adapting to technological and competitive change;
- a financial environment that is conducive to longer-term investment in technology;
- the translation of technology into timely, cost competitive, high quality manufactured products;
- an efficient technological infrastructure, especially in the transfer of information; and
- a legal and regulatory environment that provides stability for innovation and does not contain unnecessary barriers to private investments in R&D and domestic production.

In addition, the Federal Government, industry, and academia need to take advantage of opportunities for:

- technology transfer and research cooperation, particularly involving small and mid-sized companies;
- building upon state and regional technology initiatives; and
- mutually beneficial international cooperation in science and technology.

With its proven human resources and successful tradition of manufacturing, U.S. industry can assert the leadership required to meet the competitive challenges and to capitalize on its opportunities. The principal role of the Federal Government will be to provide an environment conducive to long-term economic vitality, and not allow special interests to divert attention or resources from this goal.

The following sections provide more detail on the Administration's goals and strategy to implement its technology policy, and then highlight some of the steps that it has already taken to improve the economic and technological competitiveness of U.S. industry.

Goal of Technology Policy

The goal of U.S. technology policy is to make the best use of technology in achieving the national goals of improved quality of life for all Americans, continued economic growth, and national security.

Strategy to Implement U.S. Technology Policy

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 sector 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 take place.

In that context, the Administration's strategy to implement U.S. technology policy includes the following major elements:

Role of the Private Sector

While the government plays a critical role in establishing an economic environment to encourage innovation, the private sector has the principal role in identifying and utilizing technologies for commercial products and processes. In particular, the private sector has the responsibility to:

- conduct research and development to advance industry-related knowledge and technology;
- identify and aggressively pursue potential commercial applications for technologies developed by its own laboratories as well as by universities, Federal laboratories, and foreign sources;

- increase quality, output, and productivity by undertaking necessary investments in physical capital;
- improve the skills and abilities of its workforce to meet its specific needs; and
- participate cooperatively in improving the quality of U.S. education.

Government policies can help establish a favorable environment for private industry to conduct these activities, but cannot substitute for aggressive private sector action.

Government Incentives for the Private Sector

- 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, environmental, 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 differential and making permanent as well as enhancing the tax credit for research and experimentation will provide 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 interfirm cooperation in research and technology development encourages the pooling of limited resources and a rapid diffusion of results while still protecting against anticompetitive practices. Reducing the antitrust uncertainties about joint production ventures will also enable firms to cooperate in the development and introduction of new products.
- 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.

Education and Training

- Revitalize education at all levels including not only the training of scientists, engineers, and the technical workforce, but also educating our population to be sufficiently literate in science and technology to deal with the social issues arising from rapid scientific and technical change. Achieving such a goal will require a broad-based approach involving business, academia, and educational organizations, as well as Federal, state, and local governments.

- Develop a framework for Federal interagency coordination and collaboration in mathematics, science, engineering, and technology education. The goal is to define an effective and appropriate role for the Federal government in support of the states, localities, and universities as they improve science and technology education to build human capital in the U.S.

- Encourage continuing education and training, recognizing that, particularly in scientific and technological fields, education must be a lifelong activity.

Federal R&D Responsibilities

- Increase Federal investment in support of basic research. Private industry does not invest heavily in basic research because the payoffs are so unpredictable and diffuse that individual firms cannot be confident of fully recovering their investments. However, the long-term potential benefits of this research are so large that society cannot afford not to make the investment, especially in university research, which, in addition to new knowledge, also produces trained scientists and engineers of the future.

- 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. In many cases these technologies have evolved from government-funded basic research, but technical uncertainties are not sufficiently reduced to permit assessment of full commercial potential. In pre-competitive research, which occurs prior to the development of application-specific commercial prototypes, research results can be shared among potential competitors without reducing the financial incentives for individual firms to develop and market commercial products and processes based upon the results.

- Continue the Federal Government's development of products and processes for which it is the sole or major consumer, such as national defense, provided that no commercially available products can be substituted. The government, in such cases, must rely principally on the private sector to undertake the development process. Revise current Federal procurement regulations to strengthen the abilities of companies involved in developing and demonstrating these products to use the same research results and technologies for commercial purposes.

- Maintain a strong Defense technology base to provide options for future weapons systems development and to help avoid technological surprises by potential adversaries. Special emphasis needs to be placed on shortening the time required for transferring R&D results to production and on using commercial products.

- Streamline Federal decision-making structures and mechanisms to eliminate unnecessary and cumbersome regulations and practices that inhibit industrial competitiveness.

- Encourage international cooperation in science and technology, where mutually beneficial, and inform U.S. researchers of opportunities to participate in R&D initiatives outside the U.S.

Transfer of Federally Funded Technology

- Improve the transfer of Federal laboratories' R&D results to the private sector. Where appropriate, these laboratories should give greater consideration to potential commercial applications in the planning and conduct of R&D, and these efforts should be guided by input from potential users. To achieve this goal, there must be a closer working relationship among these laboratories, industry, and universities. Defense-related laboratories can make major contributions while still providing adequate safeguards for classified information.

- Promote increased industry-Federal laboratory-university collaboration, including personnel exchanges, to help convert Federally-supported R&D into new technologies that the private sector can then turn into commercial products and processes.

- Promote and encourage access by U.S. industry to Federal laboratories within the guidelines established by the Federal Technology Transfer Act of 1986 (P.L. 99-502), other existing legislation, and Executive Order 12591.

- Expedite the diffusion of the results of Federally-conducted R&D to industry, including licensing of inventions and removal of barriers to commercialization of Federally developed computer software.

- Encourage direct laboratory-industry interaction within broad, flexible Federal guidelines, since effective technology transfer occurs at the operational level.

Federal-State Activities

Recognize the importance of decentralization, and encourage states to develop programs that take into account the individual characteristics of each state. Federal programs in such areas as education, training, the national infrastructure, and regional generic technology centers, should build upon state initiatives.

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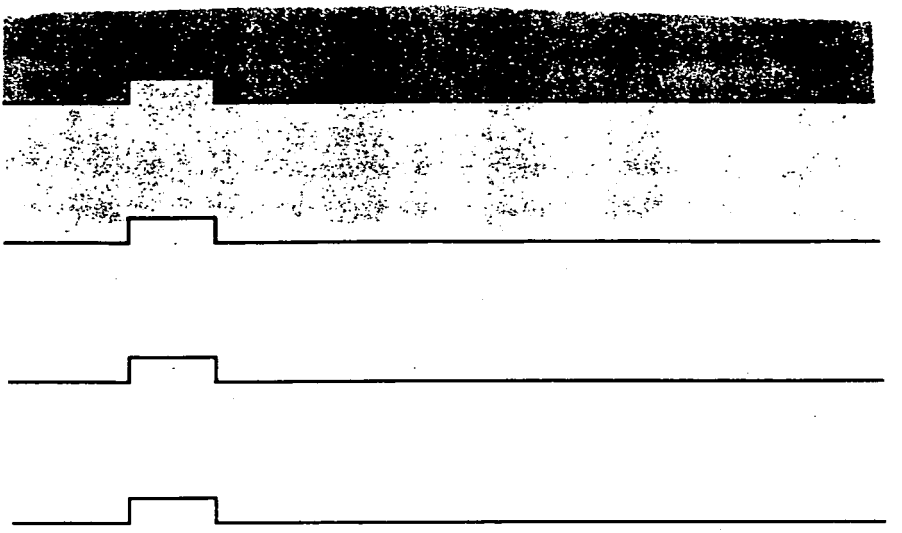

CARNEGIE COMMISSION
ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

10 Waverly Place, New York, NY 10003
Phone: 212-998-2150 Fax: 212-995-3181

REPRESENTATIVE HAMILTON. Mr. Branscomb, please proceed.

PREPARED STATEMENT OF LEWIS BRANSCOMB, MEMBER, CARNEGIE COMMISSION TASK FORCE, KENNEDY SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY

MR. BRANSCOMB. Thank you, Mr. Chairman.

Economists are the first to say that if we want a healthy economy the government has to help create a sound economic environment within which the private sector competes. The same principle applies to technology policy.

The goal of technology policy ought to be to make the United States the place where people want to invest, where workers are skilled and have interesting and productive jobs. In short, we need a policy that I would call "capability enhancing."

There is an emerging consensus for such a policy. I don't believe the divisive debates about industrial policy any longer need to be a big constraint, and I would point to two examples.

One is the document that the White House sent forward to the Congress on September 26, 1990, just about a year ago, which told us what the U.S. technology policy should be from the Administration point of view. I believe the first page and a third of that document is an eloquent conservative but also realistic statement about the kind of policy we need, not one in which the government decides what technology to generate, but one which the academics would call a "diffusion-oriented" policy aimed at effective access and utilization to technology.

Second, I would refer to a document that was handed out to the press a couple of weeks ago, a letter to Senator Bingaman from Jerry Jasinowski, the President of the NAM, who quotes in that letter the long-standing policy of the NAM. I put that in my formal testimony because I don't believe that any thoughtful individual who has looked at modern technology policy would differ from it. I think it's an excellent statement and entirely consistent with the document I just referred to.

Now, there are three elements of a technology policy for the country today and tomorrow.

The first is to understand what our defense technology policy should be. The second is to understand what the policies of the government should be with respect to the role of civil agencies in their concern for industrial technology performance. The third are policies for managing these policies, namely, how should the Executive Office of the President deal with these issues.

With respect to defense, it's important to emphasize that our report does not mission the Defense Department to fix the civil economy. Anybody who has studied the problems of competitiveness in American industry will understand that the defense industry is not a prototype for how commercial industry should compete. The defense industry meets an entirely different kind of market environment than the commercial industry meets. But the

defense community must be able to engage more effectively with dual-use technology, and there are two reasons.

The first, as Admiral Inman has already pointed out, is that in many areas industrial technology leads that which the Defense Department finds within its defense contractor community. Even in IBM the defense contracting division looks to IBM's commercial divisions for their microelectronic technology to a large degree.

Second, the Defense Department is going to have to learn how to work with commercial industry in order to get access to that commercial technology. We all know that if you want to collaborate with someone and you want to share skills, you need a partnership arrangement. So, Defense is going to have to be a partner with the private, commercial sector and not call the tune on a top-down basis, as it can with its own contractors.

The areas of technology most critical to commercial competitiveness tend to be what we call downstream technologies; namely, those concerned with production, quality, cost and rapidity of response to market signals. These areas are also important to defense because they determine the cost and speed of response of the industry to defense needs. So, defense is at stake in this area, and it needs both to learn and also to ensure that its contractors have these kind of capabilities.

That's what leads me to believe that the NARPA concept is sound. It is a concept in which defense appropriations are spent only for defense purposes, but the program is run in a way that is realistic about the nature of the world economy.

If there are other agencies of the government that have a congressionally chartered mission to develop new areas of technology of commercial interest, then we envision that funds might be transferred from a civil agency to NARPA to carry out such a project, taking advantage of DARPA's skill at managing such projects.

Second, is the question of the civil agencies. NIST, the old NBS, which I ran for several years, has 90 years of experience with the kind of technical knowledge that is most useful on a day-to-day basis for enhancing industrial productivity. The Congress and the President have given NIST three new missions in this area, including the Advanced Technology Program, as perhaps is appropriate for a learning phase. It's going to be a while before those new activities have real impact.

My colleagues and I at Harvard have a book that will appear early in the spring or late in the winter called, "Beyond Spinoff – Military and Commercial Technology in a Changing World." In that book we identify four areas of underinvestment in commercially relevant technology by the government. In three of these, we believe that there is an unambiguously clear economic justification for public investment.

First, is the "path-breaking" technology for which DARPA has probably the best track record, where clearly the risks are high, commercial opportunity long delayed, and where the issues are primarily technical. This is the path through which new science becomes new industry. Industry clearly underinvests because appropriability is low.

Second, is what we call "infrastructural" technology. In Washington, I believe, it is more often called "generic" technology, which is often boring and practical, having to do with the base of technical knowledge that a sophisticated modern industrial firm requires to be efficient. This is what NIST is good at. The problem is that in the past NIST has confined such work to in-house activity in its own laboratories.

Examples of infrastructural technology are the characterization of materials, the development of accurate test methods, specification for technology processes, and measurement technology. These are the grist of industrial productivity. Until the Congress set up the Advanced Technology Program, there was not a means for engaging universities and industry directly in this kind of work to supplement what NIST does in-house.

The third category, we call "strategic." This is the area where one gets closest to going beyond conventional economic reasoning. This area is where the Nation decides that there is an industry whose health is critical to the Nation's well-being as a whole. The industry has come to the government to ask for a relationship; industry is willing to put its money where its mouth is and is looking for a partnership with government. In this case, the technical risk is probably relatively modest. The business risk is obviously substantial because the health of an industry is at stake.

My personal view is that Sematech is such an example. I think it is a justified example, but you want to be sure all the other policies are in place that are necessary to make sure that the success of the enterprise is highly likely.

The fourth category is perhaps the most important of all. It has to do with how the government works with the private sector to ensure the effective diffusion and application of existing knowledge. Here, I would cite, as one example that the Congress and the Administration both seem to favor, the National Research and Education Network (NREN), which Senator Gore and others have been very involved in.

NREN can pay off by aggregating a market for commercial information services for allowing people to collaborate more efficiently than they could otherwise do.

Now, let me emphasize that I believe that the economists have correctly identified the criteria that should be applied to justify public investments in technology, and they are basically two.

First, the externalities from the technology—the social returns from the widespread diffusion of this technical knowledge—should be well in excess of the cost. That tells you that it's a good investment, but how do you tell that it's a good public investment? The answer is, if the appropriability to those who invest in the technology is low, then they will underinvest. I believe that is the case for many of the things we're talking about.

These are the attributes of what is called a public good. We all understand that basic science is a public good; there is really no debate about that among liberals and conservatives.

What we need to do is to ask ourselves, in light of modern science and engineering, how do we decide what technical knowledge is a public good today? I would insist from my experience in industry that there are large areas in the world of technology where in fact the technology is a public good. I would cite the two examples that I just gave, infrastructural or generic technologies that are widely shared and efficiency generating; and the path-breaking technologies that are close to science, have high risk, have huge potential paybacks to the country, but are long delayed. Third, the investment in the national infrastructure, clearly a community investment and not something individuals can do.

Now, finally, let me say that there is a great deal of discussion in Washington about lists of critical technologies. I think these lists are important because they tell us where as a nation we may want to go. What they don't do is tell you what to do when you get there. For example, biotechnology is a critical technology in the Nation's future, given all the projections of economic growth in this field. What aspects of biotechnology should the government invest in, and what part should the private sector do?

That's what brings me back to these criteria behind which I believe there is a growing consensus. We should not damn all government efforts simply because we haven't thought precisely enough about the nature of technical knowledge and the government's role in it. We should define technology policies on the basis of experience in industry and government that is stable and going to be effective.

My view is that this report provides a road map for some early steps that the country can take to move us down this road. It does not describe where in fact the institutional structure might be 10 or 20 years from now.

Thank you.

REPRESENTATIVE HAMILTON. Thank you very much, Mr. Branscomb.

[The prepared statement of Mr. Branscomb follows:]

PREPARED STATEMENT OF MR. BRANSCOMB

It is a privilege to join Admiral Inman for this discussion of the technological roots of American economic competitiveness and what Americans should do to insure a bright future for our country in an increasingly competitive global economy. Admiral Inman has summarized the key points in the Carnegie Commission's report.[1] I would like to expand on some parts of the Commission report and on the subject of technology policy for the U.S.

Our report focuses on how the Executive Branch of government might address the technological dimensions of competitiveness through improved organization and decision making, taking the existing structures and capabilities of the agencies into account as a guide to next steps. Some critics might think this effort is premature; some think we must first resolve a national debate over the dangers and virtues of industrial policy.

The emerging consensus behind a capability-enhancing technology policy.

There are still large differences of opinion about the government's role in macro-economic policy, which, like technology policy, is also a critical element of competitiveness strategy. I believe, however, that few advocates of centrally planned industrial policy remain, and a very broad consensus already exists to define what government should and should not do in science and technology.[2]

Let me cite as evidence of that consensus the technology policy sent by the White House to Congress on Sept. 26, 1990.[3] This document represents an important shift in emphasis a focus on federal missions and basic science to insuring that U.S. workers and managers have effective access to the best and most appropriate technology, and can use it quickly and economically. The new emphasis is on technological infrastructure, education, skills enhancement, and technology diffusion. The policy recognizes that under certain

circumstances technological knowledge as well as basic research can be a "public good," to use the economist's language. When such knowledge has wide ranging applicability, low appropriability to the investor but high generic value, it is likely to be rapidly shared in the economy. Such knowledge is thus characterized as "generic and pre-competitive*". President Bush and Secretary Mosbacher have repeatedly recognized the appropriateness of federal investments in pre-competitive, generic R&D.

Spokesmen for private industry are on the same track. Perhaps it is no surprise that the Council on Competitiveness, a private, non-profit body composed primary of top executives from high-tech industry have made this case very strongly.[4] Even more impressive is the policy of the National Association of Manufacturers. That association is not known as a shrinking violet when it comes to protecting the private sector's freedom from government control. Its president, Jerry J. Jasinowski, described the association's policy in a letter to Senator Bingaman supporting the Advanced Manufacturing Technology and National Critical Technologies Acts of 1991 as follows:

> Federally funded R&D more relevant and useful to meeting the competitive needs of the nation should be considered on its merits, not on the basis of ideology....Generic manufacturing R&D efforts, focused on base-building technologies and processes rather than specific products should be promoted. ...The federal government should also assist - not control - state and local governments in their efforts to promote local technology development. ...Government and industry should expand their support for manufacturing-related research activities as well. In short, the best and latest R&D must be applied to manufacturing to make and keep U.S. industry the most productive, cost-effective, and market-responsive in the world.[5]

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* One might better say "non-competitive," or better still "non-proprietary" since its value may apply to downstream engineering activities such as quality control or field service as well as upstream before proprietary products are developed. The key feature of non-competitive or non-proprietary technologies is that firms are generally willing to share or publish them.

As I have described in a recent paper[a], these ideas form the basis for what I call a "capability-enhancing" technology policy for America. Increasingly they are supported at least in principle by the administration and in the Congress -- Such a policy is designed for a global economy, for its focus is not so much on foreign vs. U.S. ownership of firms but rather on how to make the U.S. the best place in the world for good working conditions and competitive, environmentally sensitive industry.

What we need to be debating now is how, not whether, federal and state governments and the private sector will respond to the extraordinary changes that have swept the world in the last decade, even in the last few weeks. Democratic free enterprise has never been held in higher regard in the world than today. The Soviet Union[b] has made the case against centrally planned economies better than any American opponent of "industrial policy" could. Most Americans do not see government as the first or most important tool in turning around our economy. But few would deny that government exerts great influence over the nation's technological capability. The nature of that influence is poorly understood by most people. "New thinking"[6] in technology policy must address restructuring government policy and institutions so that they more effectively support both private and public needs.

There are three places to start: defense, the civil technology agencies, and the Executive Office of the President.

Defense technology policy

On the defense side, the U.S. has begun a transition of enormous importance for the nation. Although still very important, defense technology will continue its decline as a primary

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[a] Lewis M. Branscomb "Toward a U.S. Technology Policy," *Issues in Science and Technology*, Volume VII, No. 4, Summer 1991. This paper is submitted to the Committee for possible inclusion in the record of the hearing.

[b] The world's newest oxymoron.

source of stimulation of the nation's technology base. Technological infrastructure will rise in importance as a source of industrial vitality. While defense and commercial products may continue to diverge from one another, the supporting technologies will more and more become "dual use."[8]

Increasingly dependent on technology developed commercially, the Defense Department will need to change its acquisition policies in order to gain access to the commercial technology base. It will also have to put more emphasis on "downstream" technologies concerned with low cost, high reliability production in the interest of keeping its own costs down and because these technologies are key to commercial competitiveness. These facts tell us three things:

* We should not expect defense agencies to take primary responsibility for the job of helping commercial industry become more competitive; defense will have to focus on staying modern, flexible, and economical.

* Defense agencies will have to pay more attention to dual use technologies, both because defense technology now lags commercial technologies in many militarily critical areas and because it is through partnerships in dual use technology that defense has the best chance to gain access to leading commercial technologies.

* More emphasis must be given, both by defense agencies and in support of commercial industry productivity, to process technology and manufacturing systems to bring these areas of technology in balance with "upstream" emphasis on product-oriented R&D. This

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[8] The changing relationship of military and commercial technology and its implications for technology policy in the U.S. are explored in considerable depth in a book now in press: J. Alic, L.M. Branscomb, H. Brooks, A. Carter, and G. Epstein, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, Boston: Harvard Business School Press, in press, 1992. See Lewis M. Branscomb, "The Case for a Dual-Use National Technology Policy," Aspen Quarterly, Vol. 2, No. 3, Summer 1990, pp 33-52.

emphasis is well expressed in pending legislation sponsored by many members of this committee.[7]

This led the Commission's task force to conclude that DARPA's demonstrated capability to develop pathbreaking dual use technologies will be even more needed in the future. But the correct rationale must support that mission, a rationale that puts defense needs first in DARPA's budget, but sees those needs in terms of a national technology base, not a defense industry "ghetto." An important indirect effect of that policy will be that even as DARPA becomes a smaller fraction of the nation's technical effort, and focuses on long-term defense needs, its positive contribution to the national technology base can grow.

Civilian technology policy

Thus with defense influence in the nation's economy decreasing,[a] the government must learn how its civilian agencies can play more constructive roles. The so-called mission-oriented agencies, such as NASA and the Department of Energy (DoE), contribute in specified areas of technology. But in the past they have tended to follow the pattern of defense agencies, focusing their investments in massive federal projects for which they have operational responsibility. Except in their supporting research role, which has always been very important to the economy, they have not attempted to go much beyond technology transfer programs in helping industry improve its process technologies, increase productivity, and accelerate commercialization.

The National Institute for Standards and Technology (NIST)[b] has a unique track record in

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[a] It is striking that already the U.S. spends twice as much on health care as it does on defense -- both technologically intensive sectors of the economy. Biotechnology growth is expected to outpace defense industry growth for a good many years.

[b] Located in the Department of commerce, NIST was formerly the National Bureau of Standards. I was an NBS technical staff member from 1951 to 1969 and Director from 1969 to 1972.

of 90 years of service to commercial industry, emphasizing non-proprietary ("pre-competitive") generic technologies of particular importance to manufacturing productivity and economic efficiency. NIST has developed test methods and helped the private sector use them in consensus industrial standards, which are basic for quality control. NIST researchers are experts on characterization of processes and materials, so essential to automated production. NIST support for the national system of measurement and its international compatibility speed up technical progress and reduce costly errors and poor quality.

These activities have enjoyed participation by guest workers from private industry for many decades. However, because NIST (NBS) budgets have always been severely constrained, almost all[8] of NIST's work was conducted in-house until recently. With growing recognition in the Administration and the Congress that the nation's competitiveness problems are severe and must be addressed in partnership with the private sector, important steps have been taken to make it possible to expand the scale industrially-vital generic research and accelerate its diffusion to industry. The first step was the passage of the 1989 Omnibus Trade and Competitiveness Act, which authorized NIST to cost-share research work with industry.[8] The Advanced Technology Program is still in its early learning phase, still defining what it means by "generic, pre-competitive technology."[9]

Criteria for federal investments in industrially-relevant technology.

My colleagues and I at Harvard have given considerable thought to the criteria that should govern federal investments in technology to support the national industrial base.[10] Current federal policy focuses on mission-relevant R&D plus basic research and relies on indirect incentives to encourage commercialization. This policy results under-investment in four categories of technology.

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[8] An except was the Precision Measurements grants program initiated when I was Director of NBS ten years ago.

The first is pathbreaking technology, usually arising from new science, in which the technical risks are very high, and the prospect of commercial returns are remote in time but potentially large in magnitude. Industrial lasers, computers, genetic engineering have all led to new industries after a decade or two of government-funded research and development. This kind of federal investment was the hallmark of defense research in the 1960's, when the commercial impact was high because high-tech industry was still immature and the U.S. faced little foreign competition in high technology. DARPA has been particularly effective in making pathbreaking technology investments, many of which have had dual usage, stimulating both new military capabilities and new commercial industries as well. The Carnegie Commission report recognizes this fact and notes that DARPA's experience in this area could be made available to civil agencies, which would be expected to underwrite the costs so they would not detract from military capability. This is the rationale for evolving DARPA to NARPA, the National Advanced Projects Agency, as an early step that would take advantage of management efficiency and dual use synergy.

The second is infrastructural or generic technologies -- where technical risk and business risks are usually moderate and underinvestment arises more from low appropriability than from high risk. NIST's in-house research program, described above, is the best example of such research. But it is also important to remember that much dual use technology created by defense expenditures is also of this kind. The primary defense-commercial synergy in sub-sonic aircraft, for example, arises from common tools and materials, such as design automation technology, from flight simulation and high-strength, low-weight composites. Much, perhaps most, such infrastructural technology was financed from defense procurement and commercial sales, rather than from defense R&D. The ATP program in Commerce purports to support generic technology, but many of the initial projects look more like pathbreaking, DARPA-style projects than generic technology. Nevertheless, among government agencies, NIST's technical capability and knowledge of commercial industry provides the best model for managing a program of investment in infrastructural technologies.

The third category of underinvestment is the most politically sensitive: strategic technology investments. In this case a determination is made that technological support to a specific, vital sector of industry is in the national interest. The best current example is SEMATECH, a consortium of microelectronics firms which, with DARPA-industry cost-sharing, is attempting to insure that the U. S. microelectronics manufacturing tool industry is able to remain competitive with Japanese firms as technical requirements become increasingly severe. In such cases technical risk should be contained; business risk is clearly high. Strategic technology programs come closest to industrial policy of the four categories, for two reasons: a specific sector of industry is identified as intended beneficiary and other provisions of law, trade, or economic policy may be necessary to ensure that the entire effort succeeds. As a result such projects will be the exception, not the rule.

The fourth area of under-investment is perhaps most serious of all: investment in the diffusion and application of both new and existing knowledge. Here education, school-to-work transition, worker training are especially important.* So too is industrial extension, particularly to help smaller and middle-sized firms use technology to improve manufacturing quality and costs. Expanded science and technology information services, including the evaluation and dissemination of technical knowledge to enhance access and usability should also be encouraged. Both the Administration and the Congress are pursuing investments in knowledge infrastructure[11] such as the NREN computer network, which, like the INTERNET on which NREN is based, will enhance the accessibility of technical information services, thereby aggregating a national market, and encourage cross-sectoral collaboration as well.

Executive Office of the President

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* The federal role in reform of pre-college math and science education is dealt with in another Carnegie Commission report to be released on Monday, Sept. 16, 1991. See *In the National Interest: The Federal Government in the Reform of K-12 Math and Science Education*, New York: Carnegie Commission on Science, Technology, and Government, Sept. 1991.

The policy evolution envisioned in this testimony, and in the Carnegie Commission report, will, like all "new thinking" in political affairs, take time. During the period of evolution use must be made of existing institutions and established patterns of policy. One of the most enduring such patterns is the notion that technology investments made for defense purposes are well understood and accepted, while new civilian agency programs like ATP are feeling their way. New institutions, like the Commerce Technology Administration and the new name and mission for NIST, start from very modest budgets, and must earn the confidence of the Congress, the business community, and the public. Much of the content of the U.S. high tech agenda deals with dual use technology.

For all these reasons it makes good sense to consider equipping the NSC with the capability to take explicit account of the health of the technology base of commercial industry at the same time it concerns itself with defense technology. Increasingly, trade and technology relations will become coupled to defense security relations, as the participation of Japan in the Gulf War partnership illustrates. Economic and military dimensions of national security are sure to become less and less easily distinguishable.

The Office of Science and Technology Policy clearly has the most specific responsibility for technology policy. But that responsibility cannot be isolated in one White House staff, as already noted. From a national security perspective, the President is likely to look primarily to the NSC. From a trade and growth perspective, technology policy is a part of economic policy, where the CEA has special oversight and the Economic Policy Council provides a policy forum. The President's Assistant for Science and Technology can be especially helpful in pulling all these threads together, which only the President can do. Every multinational, high-tech corporation has a Chief Technical Officer who helps the CEO pull address the technological dependencies of all his business goals. The President of the United States needs the same capability, and his authority and interest must provide his aids with their authority. For this reason in particular, we urge that the Assistant for Science and Technology be the focal point for technology policy, but he or she needs to be able to work through and with the other key organs of the Executive office.

In conclusion, let me say that I am quite optimistic about the future directions for U.S. technology policy. There is a growing consensus on its importance and its general outlines. There are many issues of policy and of implementation to be addressed, not the least of which involves resource allocation in a time of very tight budgets. But this committee can play a very important role in bringing about the needed changes.

End notes.

1. *Technology and Economic Performance: Organizing the Executive Branch for a Stronger National Technology Base*, New York: Carnegie Commission on Science, Technology, and Government, September 1991.

2. Lewis M. Branscomb "Toward a U.S. Technology Policy," *Issues in Science and Technology*, Volume VII, No. 4, Summer 1991.

3. *The U.S. Technology Policy*, Washington DC: Executive Office of the President, Sept. 26, 1990. This important document was prepared by OSTP with participation from OMB and was cleared through the White House staffs.

4. *Gaining New Ground: Technology Priorities for America's Future*, Washington DC: Council on Competitiveness, March 1991.

5. Jerry J. Jasinowski, President, National Association of Manufacturers, letter to Senator Bingaman dated June 18, 1991, released June 19, 1991 by Senator Bingaman.

6. President Gorbachev introduced the idea of "New Thinking," a phrase that has been picked up in America as well to dramatize how much the world has changed, and how obsolete some habits have become. See, for example, *New Thinking and American Defense Technology*, New York, Carnegie Commission on Science, Technology, and Government, August 1990.

7. *Advanced Manufacturing Technology Development, Deployment, and Education Act of 1991*, and the *National Critical Technologies Act of 1991*, as embodied in the National Defense Authorization Act for Fiscal Years 1992 and 1993, Calendar No. 169, 102nd Congress, first session, U.S. Government Printing Office, Report 102-113, July 19, 1991.

8. The 1989 Act (P.L. 100-418) created the Commerce Department's Technology Administration and established three important new activities at NIST: the Advanced Technology Program (ATP), the establishment in cooperation with states of Manufacturing Technology Centers and an industrial extension program.

9. A useful study of this question was made for the Department of Commerce office of the Undersecretary for Technology by Vincent J. Ruddy of the John F. Kennedy School of Harvard University, entitled "Criteria and Processes to Support Generic, Pre-competitive, and Enabling Technology Development," April 9, 1991.

10. *Beyond Spinoff*, chapter 12.

11. Lewis Branscomb, "A Public Policy Perspective," in Brian Kahin, ed., *Information Infrastructure for the Nineties*, New York: McGraw Hill, to appear fall 1991.

CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS

Professor Lewis M. Branscomb
Director, Science Technology and Public Policy Program
Albert Pratt Public Service Professor
(617) 495-1853

John F. Kennedy School of Government
79 J.F.K. Street
Cambridge, Massachusetts 02138
Fax: (617) 495-5776

LEWIS M. BRANSCOMB

Dr. Lewis M. Branscomb, is Albert Pratt Public Service Professor at the John F. Kennedy School of Government of Harvard University and directs the school's Science Technology and Public Policy Program in the Center for Science and International Affairs. He is a member of the Carnegie Commission on Science, Technology and Government, was a member of the task force that prepared the Commission's report on Technology and Economic Performance discussed in today's hearing.

Before retiring in August 1986, Dr. Branscomb was vice president and chief scientist of International Business Machines Corporation and a member of the Corporate Management Board.

A research physicist, Dr. Branscomb was appointed director of the National Bureau of Standards (now NIST) by President Nixon in 1969. He joined the Bureau in 1951. In 1979 Dr. Branscomb was appointed by President Carter to the National Science Board, the policy board for the National Science Foundation, and in 1980 he was elected chairman, serving until May 1984.

Dr. Branscomb was graduated from Duke University *summa cum laude* in 1945. He was awarded M.S. and Ph.D. degrees in physics by Harvard University in 1947 and 1949. During his career, he has taught at Harvard, where he was a junior fellow in the Society of Fellows, the University of Maryland, University College in London, and the University of Colorado. Until his appointment to the Harvard faculty he was an elected Overseer of Harvard University.

Dr. Branscomb has received the Rockefeller Public Service Award, the Samuel Wesley Stratton Award, the Gold Medal for Exceptional Service from the United States Department of Commerce, the Procter Prize from the Scientific Research Society, and the National Civil Service League Award. He is the 1987 recipient of the National Academy of Engineering's Arthur M. Bueche Award. He holds honorary doctor of science degrees from fourteen

colleges and universities.

Among his other presidential appointments, Branscomb was appointed to President Johnson's Science Advisory Committee, President's Commission for the Medal of Science and President Reagan's National Productivity Advisory Committee. He is a member of the National Academy of Engineering, the National Academy of Sciences and the National Academy of Public Administration.

He serves on the Technology Assessment Advisory Committee to the Technology Assessment Board of the United States Congress.

In 1987 he was appointed a Director of the Massachusetts Centers of Excellence Corporation by Governor Dukakis of Massachusetts, and in 1991 to the Governor's Council on Economic Growth and Technology by Governor Weld.

REPRESENTATIVE HAMILTON. Mr. Weidenbaum, please proceed.

PREPARED STATEMENT OF MURRAY WEIDENBAUM, CENTER FOR THE STUDY OF AMERICAN BUSINESS, WASHINGTON UNIVERSITY

MR. WEIDENBAUM. Thank you, Mr. Chairman.

It's a great pleasure to be back before the Joint Economic Committee.

Technological progress is a prime driving force in the global economy, and that makes this hearing so appropriate. But the report of Carnegie Commission is very disappointing.

A distinguished group, the Commission contains many old friends and former colleagues. Its report makes some good points. However, it is fundamentally wrong in urging a larger role for government where the public sector has little capability, and ignoring the responsibilities uniquely the role of government.

I have prepared a report with a very different orientation and submit it for your consideration. I'll summarize very briefly.

The United States does not have a competitiveness problem. Allegations to the contrary don't justify a new federal role in technology. We face a continuing competitiveness challenge. I don't mean to quibble.

American-produced goods and services are more than holding their own in world markets. Our merchandise exports rose 74 percent between 1980 and 1990. The U.S. does have a large, declining trade deficit. Merchandise imports rose more rapidly than exports in the past decade. In large measure, this reflects the fact that we're a high consuming, low-saving society. That's an important concern to economic policymakers, but it transcends the issue of competitiveness in technology.

Surely, our steady trade surplus in high-tech products belies the need for special government help for commercial technology. Like many other areas, such as education and retirement benefits, federal priorities in science and technology are arrived at indirectly by adding up the parts of departmental budgets that go for R&D. A change in overall budget priorities can result in an inadvertent reduction in federal support of science and technology. A shift from defense with a high R&D content to entitlements with no R&D means a reduction in federal spending for R&D.

Nevertheless, there is no need for a master plan of federal R&D. NASA shouldn't expand just because someone in the White House is anxious to support technology. But we shouldn't ignore the adverse effects of large defense cuts on R&D, especially on basic research where private firms underinvest for good reason. The Commission, however, is misguided in urging DOD to spend more on basic research. Off-setting increases should go to civilian agencies, such as NSF.

By the way, I've never met an advocate of socialism in the Federal Government. It's just that there are a lot of people that want to add a teeny-weeny bit of government to help the business system work better. Over the years, as a result, numerous wasteful sudsidies have been

enacted—shipping subsidies, credit subsidies, syn-fuel subsidies. The Commission's proposals for government support of commercially relevant technology fall in this category. Government has no capacity for choosing new technology.

One question is easy to answer. How would the government decide which industries and projects to support? The government favors politically powerful older companies that have invested substantially in a Washington presence and whose employees fear for their jobs. New firms may be economically strong, but they're politically weak. They lack an extended record of political contributions or a large group of agitated employee/voters. The result is an uneven contest favoring old-line business and old technology over the new.

Bill Proxmire, an active member of this Committee for years, was fond of saying, "Money will go where the political power is. Anyone who thinks government funds will be allocated to firms according to merit has not lived in Washington very long."

The U.S.-Japanese semiconductor agreement illustrates the danger. The agreement helped some firms but hurt our computer industry. The results were typical of special interest legislation benefitting some sector at the expense of the national interest.

Recall, in the early 1980s, the U.S. industry outsold the Japanese. The Japanese responded by investing more than the Americans. By the mid-1980s, they began to outsell U.S. firms. Today, American companies are asking for a handout. That's an unjustified reward for poor business judgment, a terrible precedent for other companies to follow. Our answer should be, "Sorry, fellows, welfare is for poor people."

There is a modest role for government in supporting technology, issuing patents and setting technical standards. But under our private enterprise system, private firms decide where to invest and what risks to take. Government should facilitate the flow of technology by creating a favorable economic climate, and that role needs to be improved.

The obstacles the government has erected should be reduced. After all, what good would it do for the Federal Government to support high-tech enterprises if at the same time government erects statutory and administrative road blocks to the use of new technology?

The hysterical reaction to the use of the protein BST in increasing milk production is not unique to biotechnology. Witness the spectacle of consumer advocates vehemently opposing the innovation because it would reduce the price of milk, and State Legislatures caving into this nonsense.

Also the U.S. boasts a world class pharmaceutical industry. The government response: FDA and congressional committees are cracking down on the industry. How will giving FDA unprecedented police powers accelerate the use of technology? Because regulatory agencies grandfather existing products, the main burden of expanding regulation falls on new undertakings and new technology. The most useful federal action to promoting technology is to eliminate these government barriers.

In my paper I also describe needed revisions in antitrust laws and administration, in patents, and in tax incentives in lieu of expenditure subsidies.

Another question the Committee asked is, what should be the role of the Defense Department in promoting commercial competitiveness? The answer is zero. The Pentagon should reduce the obstacles to its procurement of state-of-the-art products available in commercial markets.

The Commission urges DOD to subsidize civilian R&D because it's an important user. There is no limit to that line of reasoning. The military, market basket ranges from missiles to mittens, from ground support equipment to golf balls. The specialization of labor still holds. That's why DARPA works well, most of the time. But DARPA shouldn't become NARPA with a diffuse mission extending to all the technology sponsored by civilian agencies.

Lou Branscomb has warned that defense R&D tends to be too slow, too centralized, and too micromanaged to be transferred successfully to the private sector. As an alumnus of the defense industry, I agree. Another federal effort to force-feed the process would be wasteful.

Moreover, using the military budget to support civilian technology will politicize the process. Go no further than the Corps of Engineers for an illustration. The Corps' military functions are first rate. Its civilian dam building is embroiled in local politics. Some urge the Commerce Department to invest more heavily in a technology base. But having a federal civilian bureaucracy determining which areas of technology to support is only marginally better than having the Pentagon do it.

The Carnegie Commission proposals don't deal with the fundamental conditions that encourage investment in civilian technology—lower costs of capital and expanding economic opportunity. In fact, the increase in budget deficits resulting from their proposals would make it more difficult to achieve those conditions.

According to a high-level former Commerce Department official, "business executives only want the government involved in high-risk, long-term, expensive high-tech research projects." But inevitably the political process will decide which lucky few are "high risk," "long term" and "high tech." Politically weak, new companies by default would not be "high tech," or "high risk," or "long term."

My favorite recommendation to congressional Committees considering proposed new federal spending is still, "Don't just stand there, undo something."

Thank you very much.

[The prepared statement of Mr. Weidenbaum, together with an attachment, follows:]

PREPARED STATEMENT OF MR. WEIDENBAUM

Technological progress is a prime driving force in the global economy, which makes this hearing so appropriate.

But, the report of the Carnegie Commission on Science, Technology, and Government, which is a major focus of this hearing, is very disappointing. A distinguished group, the Commission contains many old friends and former colleagues. Its report raises important questions and makes some good points. However, it is fundamentally wrong in urging a larger role for government where the public sector has little capability and in ignoring the responsibilities that belong to government.

I have prepared a report with a different orientation and submit it for your consideration. I'll summarize briefly.

Competitiveness

The United States does not have a competitiveness problem. Allegations to the contrary do not justify a new federal role in technology. We do face a continuing competitiveness challenge. I don't mean to quibble. American-produced goods and services are more than holding their own in world markets. Our merchandise exports rose 74 percent over the ten years 1980 to 1990.

Note: Murray Weidenbaum is Director of the Center for the Study of American Business at Washington University in St. Louis. The views expressed are personal. This statement draws on his forthcoming book, *Small Wars, Big Defense* (Oxford University Press).

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Surely our steady trade surplus in high-tech products belies the need for special government help for commercial technology.

Existing Policy Toward Science and Technology

Like many other areas such as education and retirement benefits, federal priorities on science and technology are arrived at indirectly — by adding up the parts of department budgets that go for research and development (R&D). A change in overall budget priorities can result in an inadvertent reduction in federal support of science and technology. A shift from defense (with a high R&D content) to entitlements (with no R&D) means a reduction in federal spending for R&D.

Nevertheless, there is no need for a "master plan" of federal R&D; NASA should not expand just because someone in the White House is anxious to support technology. But we should not ignore the adverse effects of large defense cuts on R&D, especially on basic research, where private firms underinvest for good reason. The Commission is misguided in urging DOD to spend more on basic research. Offsetting increases should go to civilian agencies such as NSF.

Proposed Support for Commercial Science and Technology

I have never met an advocate of socialism in the federal government. However, quite a few people want to add a "teeny weeny" bit of government intervention to help the business system work better. Over the years, numerous wasteful subsidies have been enacted — shipping subsidies, credit subsidies, synthetic-fuel subsidies. The

Commission's proposals for government support of commercially relevant technology fall in this category. Government has no capacity for choosing new technology.

One question is easy to answer: how would the government decide which industries and projects to support? Government favors politically powerful, older companies which have invested substantially in a Washington presence — and whose employees fear for their jobs.

New firms may be economically strong, but they are politically weak. They lack an extended record of political contributions or a large group of agitated employees/voters. The result is an uneven contest that favors old-line business and old technology over the new.

Former Senator William Proxmire, an active member of this committee for many years, was fond of saying, "Money will go where the political power is. Anyone who thinks Government funds will be allocated to firms according to merit has not lived in Washington very long."

The U.S.-Japanese semiconductor agreement illustrates the danger. The agreement helped some firms, but hurt our computer industry. The results were typical of special-interest legislation, benefitting some sector at the expense of the national interest.

Recall that in the early 1980s, the U.S. semiconductor industry outsold the Japanese. The Japanese responded by investing more than the Americans. By the middle 1980s, they began to outsell U.S. firms. Today, American companies are asking for a handout. That is an unjustified reward for poor business judgment, a terrible precedent for other companies to follow. Our answer should be clear: "Sorry fellows, welfare is for poor people."

The Boundary Between Government and Private Initiative

There is a modest role for government in supporting technology — issuing patents and setting technical standards. Under our private enterprise system, private firms decide where to invest and what risks to take.

Government should facilitate the flow of technology by creating a favorable economic climate. That role needs to be improved. The obstacles that government has erected should be reduced. What good would it do for the federal government to support high-tech enterprises, if at the same time government erects statutory and administrative roadblocks to the use of new technology? The hysterical reaction to the use of the protein BST in increasing milk production is not unique. Witness the spectacle of "consumer advocates" vehemently opposing the innovation because it would reduce the price of milk — and state legislatures caving in to this nonsense.

The United States boasts a world-class pharmaceutical industry. The government's response? FDA and congressional committees are "cracking down" on the industry. How will giving FDA unprecedented police powers accelerate the use of technology?

Because regulatory agencies often "grandfather" existing products, the main burden of expanding regulation falls on new undertakings and new technology. The most useful federal action to promote technology is to eliminate some of these governmental barriers.

The Role of Defense and Other Agencies

What should be the role of the Defense Department in promoting commercial competitiveness? The answer is zero. The Pentagon should reduce the obstacles to its procurement of state-of-the-art products available in commercial markets.

Some urge DOD to subsidize civilian technology because it is an important user. There is no limit to that line of reasoning. The military marketbasket ranges

from missiles to mittens, from ground support equipment to golf balls. Specialization of labor still holds, which is why the Defense Advanced Research Projects Agency (DARPA) works well — most of the time. DARPA should not become NARPA (the National Advanced Research Projects Agency), with a diffuse mission extending to all technology.

Lewis Branscomb of Harvard warns that defense R&D tends to be too slow, too centralized, and too micro-managed to be transferred successfully to the private sector. As an alumnus of the defense industry, I agree. Another federal effort to force-feed the process is wasteful.

Moreover, using the military budget to support civilian technology will politicize the process. Go no further than the Corps of Engineers for an illustration. The Corps' military functions are first rate. Its civilian dam building, in contrast, is embroiled in local politics.

Some urge the Commerce Department to invest more heavily in a technology base. A federal civilian bureaucracy determining which areas of technology to support is only marginally better than having the Pentagon do it.

The Carnegie Commission proposals do not deal with the fundamental conditions that encourage investment in civilian technology — lower cost of capital and expanding economic opportunity. The increase in budget deficits resulting from the Commission's proposals would make it more difficult to achieve those conditions.

According to a former Commerce Department official, business executives only "want the government involved in high-risk, long-term, expensive, high-technology research projects." But inevitably the political process will decide which lucky few are "high-risk, long-term," and "high-tech." Politically weak companies by default would not be "high-tech" or "high-risk" or "long-term."

My favorite recommendation to congressional committees considering proposed new federal spending is still, "Don't just stand there, undo something."

MURRAY WEIDENBAUM
Biographical Sketch

Murray Weidenbaum has been an economist in three worlds -- business, government and academia. He holds the Mallinckrodt Distinguished University Professorship at Washington University in St. Louis, where he also serves as Director of the University's Center for the Study of American Business.

From January 1981 to August 1982, Dr. Weidenbaum served as President Reagan's first Chairman of the Council of Economic Advisers. In that capacity, he helped to formulate the economic policy of the Reagan Administration and was a spokesman for the Administration on economic and financial issues.

Dr. Weidenbaum was the first Assistant Secretary of the Treasury for Economic Policy. Earlier he served as Fiscal Economist in the U.S. Bureau of the Budget and as the Corporate Economist at the Boeing Company. He is a member of the boards of directors of the May Department Stores Company, Contel Corporation, Harbour Group, and the American Council for Capital Formation.

He received his B.B.A. from City College of New York (1948), his M.A. from Columbia University (1949), his Ph.D. from Princeton University (1958), an LL.D. from Baruch College (1981) and an LL.D. from the University of Evansville (1983). He has been a faculty member at Washington University since 1964 and was the Chairman of the Economics Department from 1966 to 1969.

Dr. Weidenbaum is known for his research on economic policy issues, taxes, government spending and regulation. He is the author of five books; his latest, a paperback edition of Rendezvous With Reality: The American Economy After Reagan, was released by Basic Books in the fall of 1990. His forthcoming book, Small Wars, Big Defense, is due out the end of 1991. He has written several hundred articles in publications ranging from the American Economic Review to The Wall Street Journal. He also prepares regular columns for The Christian Science Monitor and The Los Angeles Times.

Dr. Weidenbaum's international activities include serving as Chairman of the Economic Policy Committee of the Organization for Economic Cooperation and Development in 1981-82 and lecturing at universities and research institutes throughout Western Europe and Asia. In 1984, he received the National Order of Merit from France in recognition of his contributions to foreign policy. Recently he was a member of a Presidential Mission to Poland.

Technology and Economic Performance: A Different View of the Federal Role

by Murray Weidenbaum

The pace of technological progress is a prime driving force in our increasingly global economy; government policy on technology needs to be reconsidered in that light. The United States is heavily reliant on the fruits of science and technology to provide its basic strength, both military and economic. Over the years, this nation has maintained its strong military posture, not by having the largest armed force, but by relying on the most technically sophisticated, up-to-date arsenal of weapons and equipment, and the technically trained people to operate them.

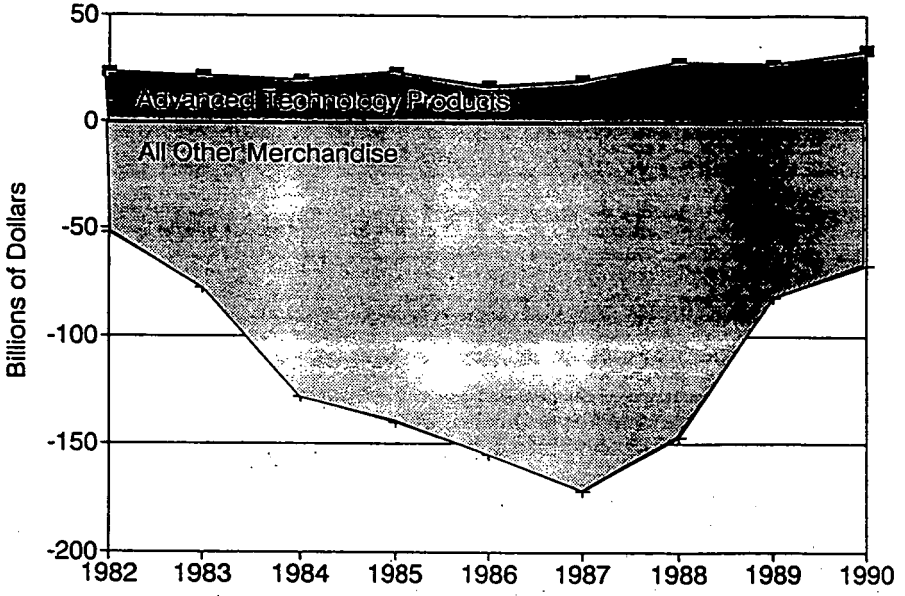
Similarly, high-tech companies maintain a favorable balance of trade, while the low-tech companies have suffered most severely from foreign competition (see Figure 1). R&D-intensive industries also experience greater increases in productivity than the other sectors of the economy. Clearly, advances in technology are a key to the continuation of both the military and the economic power of the United States.

What is not so apparent is the proper course for governmental policy toward technology, especially its use in the private sector. This report addresses the key issues that have to be faced in deciding that important federal role in fostering the development and use of technology. The sections that follow cover national competitiveness, existing science and technology policy, proposed support for commercially relevant technology, the proper boundary between government and private initiative, and the future role of the Department of Defense and other federal agencies.[1]

Murray Weidenbaum is Mallinckrodt Distinguished University Professor and Director of the Center for the Study of American Business at Washington University in St. Louis. This report draws heavily on his forthcoming book, **Small Wars, Big Defense** (Oxford University Press). The author is indebted to Kenneth Chilton, Arthur Denzau, and Bruce Petersen for helpful comments on earlier drafts of this paper and to Harvey James for research assistance.

Figure 1

Trade Balances in Advanced Technology and All Other Products



Source: Computed from data of the U.S. Bureau of the Census.

National Competitiveness

R&D Trends

An important aspect of aggregate economic policy is to maintain an environment conducive for financing and performing commercially oriented technology. To judge by the numerical results, that necessary environment has been created in recent years, although not necessarily at the optimum level. In the two decades prior to 1980, the federal government was the number one funding source for R&D in the nation. In the 1980s, however, the private sector outspent the public sector on R&D (see Table 1).

The implication of this shift from public to private sponsorship of R&D deserves more attention than it has received. First of all, it is noteworthy that the private sector has risen to dominance even though a rapid expansion in Defense Department funding of R&D occurred during much of the same period. Secondly, the change in relative importance of private versus public funding means that commercial needs, rather than government programs, now dictate the greater part of the work of American scientists and engineers. Although we cannot pinpoint the precise results, an enhanced flow of new products and improved production processes should occur in the private sector of the American economy during this decade as a result.

Trade Trends

In any event, the proponents of direct federal support for commercially relevant technology point to the large U.S. trade deficit as an indicator of a lack of national competitiveness. It is easy to show that the United States has lost its "supremacy" in the global economy in the four decades since the end of World War II. In 1950, the United States generated approximately 40 percent of the world's gross product and 17 percent of world trade. In the past few years, in striking contrast, the U.S. share of gross product has dropped to about one-fourth of the global total and its trade to about 14 percent.[2]

Table 1

Federal Versus Industry Financing of R&D
(in billions of dollars)

Decade	(1) Federal Government	(2) Private Industry	(3) (1)-(2) Difference
1961-70	129.0	72.7	+56.3
1971-80	203.8	183.3	+20.5
1981-90	518.8	569.7	-50.9

Source: U.S. National Science Foundation.

Historical analysis explains that shift quite readily. In 1950, the economies of Western Europe and Japan were still recovering from the devastation of World War II. Under those circumstances, the American economic giant had little difficulty dominating many world markets, particularly its own. Such a powerful position was bound to be transitory, however, as the economic competitors regained their traditional strength, with very substantial help from both the U.S. government and its citizens. In fact, by 1960, the U.S. share of world trade already had declined to 13 percent, approximately the current ratio.

It is intriguing to note that the Soviet Union did not take as benign an attitude as the United States in the postwar period. It shackled the economies of defeated nations within the sphere of its control. The subsequent poor economic performance of all of the Eastern bloc economies is hardly a tribute to that approach.

As James Schlesinger has noted, perhaps the United States should have done better in the period since World War II, "but we have not done all that badly."[3] The United States remains the leading economic, political, and military power in the world. A recent survey of Japanese views reported that "the United States is still a vital nation with unchallenged military

power, the world's largest economy, an affluent lifestyle, and natural abundance that leaves resource-poor Japan in awe."[4]

The notion that the United States is in decline is simply inaccurate, in any absolute sense. The United States is not becoming poorer, and its economy is not weak or feeble. In 1990, U.S. farms, mines, factories, and offices produced $5.5 trillion of goods and services — a record high and double that of second-place Japan. At best (or worst) the proponents of the decline hypothesis are forced to rely on relative comparisons.

This upbeat conclusion is not just the result of Americans patting themselves on their backs. Similar, and more strongly worded, sentiments were voiced by the managing director of Credit Européen:

> Since the early eighties, after a decade of relative decline, the United States has clearly regained its rank as the leading economic and political superpower in the free world. Neither the erratic movements in the dollar exchange rate, nor the huge U.S. balance of payments deficit and foreign debt can reverse that judgment which is shared by a great majority of Europeans.[5]

The Competitiveness Challenge

The United States does not have a competitiveness problem, but faces a continuing competitiveness challenge. This distinction is not a quibble. American-produced goods and services are more than holding their own in world markets. Our merchandise exports rose from $224 billion in 1980 to $390 billion in 1990, a 74 percent increase over the decade.

Inevitably, not every company is doing that well — while other enterprises are reporting results much above average. The political noise level is uneven among the two groups. The poor performers have every incentive to come to Washington in search of government help. The stronger companies, in contrast, are too busy designing, producing, and marketing their products to lobby for federal aid.

The United States does have a large, albeit declining, trade deficit. Merchandise imports rose over the past decade at a more rapid rate than exports, approximately doubling from $250 billion in 1980 to $498 billion in 1990. In large measure, this reflects the fact that

the United States is a high-consuming, low-saving society. This is an important concern to economic policymakers, but it transcends the issue of competitiveness and technology.

The triple-digit federal deficits have exerted a powerful, and negative, effect on the trade balance of the United States. For any nation, if domestic saving is inadequate to finance both capital formation and government borrowing, an inflow of foreign funds will result. The foreign funds are earned, in turn, by exporting more than trading partners are importing. Those U.S. budget deficits cannot be blamed on foreigners; they definitely have a made-in-America label.[6]

To some degree, the high exchange rate value of the dollar in international trade in the early 1980s made imports especially cheap (and our exports relatively expensive). However, since the peak reached in early 1985, the value of the dollar has declined substantially, albeit irregularly. This change helps dampen our imports as well as encourage our exports, thus reducing the trade deficit.

Some of the change in the U.S. trade position is cyclical. Our imports tend to decline with recession here, while our exports depend heavily on economic conditions overseas. Thus, a portion of the recent reduction in the overall trade deficit may be temporary. A renewal of economic growth in this country should exert an upward pressure on imports while economic weakness overseas may dampen exports.

In any event, American industry continues to be challenged, in domestic as well as in foreign markets, by a growing variety of European and Asian companies. Some of these foreign competitors are benefitting from the diffusion of technology across the global economy. This is especially true in Asian-rim nations, such as Thailand and Malaysia, which are joining the ranks of rapidly developing nations. In other cases, the economic consolidation of the European Community is beginning to develop economies of scale and other efficiencies resulting from the elimination of numerous national barriers to commerce.

In this global economy, American firms cannot rest on their oars. U.S. companies must continue to develop a competitive advantage through constant improvement of products

and manufacturing processes — which means in large part applying the results of science and technology. Nevertheless, the steady U.S. trade surplus in high-tech products belies the need for special government help because of a supposed lack of technological competitiveness (see Figure 2).[7]

Existing Science and Technology Policy

Given the great variety of missions assigned to federal agencies, it is difficult to identify precisely the nature of federal policy toward science and technology. In effect, that policy must be inferred by the expenditures and other actions of many different parts of the federal government.

For example, several major departments of the federal government are large financial supporters of research and development, notably the Departments of Defense, Energy, and Health and Human Services. Altogether, federal departments and agencies financed $69 billion of R&D in 1990, almost one-half of all of the R&D performed in the United States.

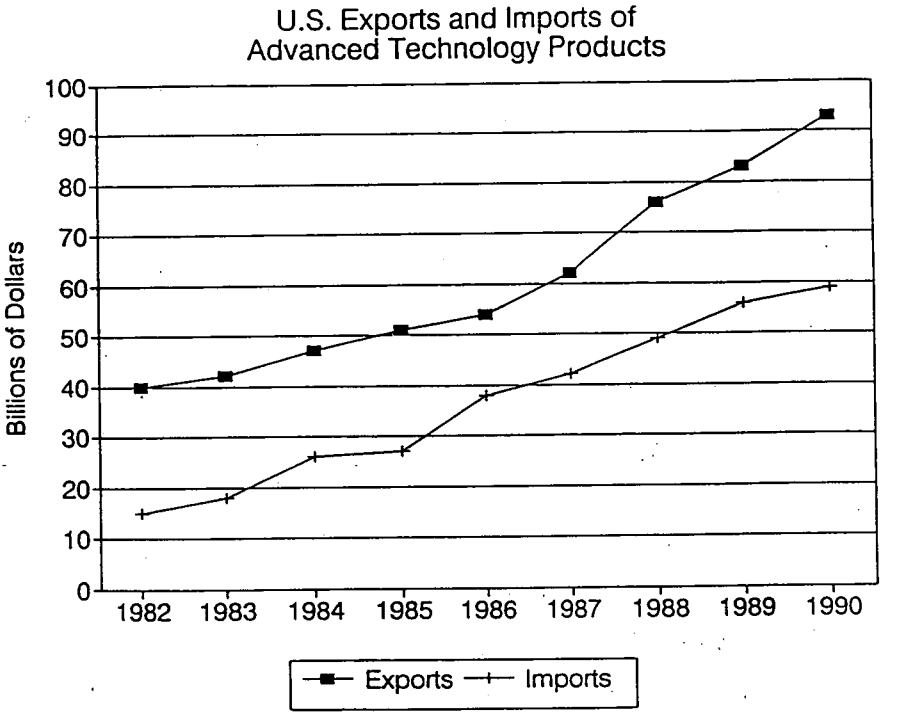
However, the President does not present an overall budget for R&D nor does Congress enact one. As in many other areas, such as education and retirement benefits, analysts must discover science and technology priorities indirectly — by adding up the many parts of departmental budgets that are devoted to research and development.

In effect, therefore, a change in overall budget priorities can result in an inadvertent expansion — or reduction — in federal support for science and technology.[8] A shift from defense (with a very high R&D content) to entitlements (with no R&D component) will invariably mean a decrease in federal financing of R&D. As can be seen in Table 2, there is great variation in the R&D-intensity of federal agencies.

However, it is difficult to identify any significant benefit from changing the way that the Executive Branch and the Congress traditionally budget mission-oriented R&D. The Department of Defense and the requisite defense committees of the Congress are in the best

Figure 2

U.S. Exports and Imports of Advanced Technology Products



Source: Computed from data of the U.S. Bureau of the Census.

Table 2

Federal Agency R & D and Total Outlays in 1988

Department or Agency	R&D Outlays (in billions)	Total Outlays (in billions)	R&D Percentage of Total
Above-average R&D Ratios			
National Science Foundation	$1.5	$1.9	78.9%
NASA	4.8	9.1	52.7
Energy Department	5.1	10.5	48.6
Commerce Department	.4	2.5	16.0
Defense Department (military)	36.5	299.6	12.2
Interior Department	.4	5.4	8.2
Environmental Protection Agency	.4	4.9	7.4
Below-average R&D Ratios			
Agriculture Department	1.0	50.7	2.0
Health and Human Services Department	7.1	375.1	1.9
Transportation Department	.3	26.3	1.1
Veterans Affairs Department	.2	27.6	.7
Agency for International Development	.1	5.2	.2
All other	.7	237.1	.3
Total: Federal Government	$58.5	$1055.9	5.5%

Source: Compiled from data prepared by the U.S. National Science Foundation and the Office of Management and Budget.

position to determine how much and what kind of R&D is needed to carry out the national defense mission. Ditto for the Departments of Agriculture, Transportation, etc. There is no need for a "master plan" of total federal R&D. NASA should not expand its activities just because some official in the White House is anxious to support technology.

But, as a practical matter, neither Congress nor the Executive Branch should blithely ignore the adverse effects the major defense cutbacks that are underway will have on the size and composition of R&D performed in the United States. Basic research merits special attention because of a limiting characteristic: the organization doing the work cannot prevent

others from benefitting from the results; indeed, public policy encourages the widest use of this type of "public good." Thus, business firms tend to underinvest in this category of R&D. The desirable response is not to grant the Defense Department a special budget for basic research, but to provide offsetting increases to such civilian-oriented agencies as the National Science Foundation.

Proposed Support for Commercially Relevant Technology

There are few, if any, advocates of socialism in the federal government. However, people often want to add a "teeny weeny" bit of government guidance to help the business system work better. Over the years, numerous government subsidies have been enacted.[9] Most of these interventions in the private sector — farm subsidies, shipping subsidies, credit subsidies, synthetic-fuel subsidies — have been shown to be wasteful or outright counterproductive. Despite their surface attractiveness, proposals for direct government support of commercially relevant technology fall into this category. Government has demonstrated no capacity for choosing among promising new technologies. Witness the space shuttle still seeking to define its mission or the financially hemorrhaging superconducting super collider.

Past experience with government trying to force technological innovation is not comforting. The billions of dollars that the federal government wasted in the abortive attempt to develop a commercial synthetic-fuels industry was part of a vain effort to reduce our dependence on imported energy.[10] Unfortunately, it is only the latest example of the basic failure of "industrial policy" efforts that extend back to the days of the Reconstruction Finance Corporation scandals in the 1950s.[11]

Thus, it is easy to answer the question: "How would the government decide which industries, technologies, and projects to support?" On the basis of experience, government will favor politically powerful firms, which usually means older, labor-intensive companies. Over the years, these firms have invested substantial amounts of resources in improving their

presence in Washington. Moreover, these firms are the "squeaky wheels," suffering the most from competitive forces.

New and growing firms may be economically strong, but they usually are politically weak. They possess neither a record of extended financial contributions to political candidates nor a detailed knowledge of lobbying techniques nor a large group of agitated employees/voters. The result is a very uneven contest that favors old-line businesses over new enterprises, and old technology over new. Former Senator William Proxmire was fond of saying, "Money will go where the political power is. Anyone who thinks government funds will be allocated to firms according to merit has not lived or served in Washington very long."

To be fair, it should be noted that every business going to Washington for financial help detests and resents the term "subsidy." Their executives always describe what they seek as an investment in future economic growth or some such worthy pursuit. Each supplicant industry fervently believes in competition, especially on the part of its suppliers. But when other companies attempt to sell similar products at lower prices or better products at the same price, that is "unfair competition" or "predatory pricing" or, worse yet, "foreigners capturing our markets." Thus, supposedly government needs to respond.

The U.S.-Japanese semiconductor agreement illustrates the danger that such rhetoric creates. The agreement surely helped some firms, but at the expense of the U.S. computer manufacturing industry. The results are typical of special-interest legislation, benefitting some industry or company or region, but at the expense of the national interest.

As recently as the early 1980s, the U.S. semiconductor industry outsold Japanese firms. Japanese companies responded by investing more heavily than their American counterparts — at a time when U.S. firms could have afforded to stay ahead of the foreign competition. Not surprisingly, by the middle 1980s, Japanese semiconductor producers began to outsell U.S. firms.[12] Today, the American companies are asking for a generous handout from the taxpayer. That would be an unjustified reward for poor business judgment. It also

would be a terrible precedent that other companies would be encouraged to follow. The answer should be clear: "Sorry fellows, welfare is for poor people."

A more fundamental response to the advocates of direct federal support for commercially oriented science and technology is that such outlays would be unfair to the many other companies that pay the taxes to finance these subsidies and who would see the money go to their competitors. Nevertheless, it is necessary to respond to the concern that society as a whole may underinvest in applied research and development because of various imperfections in the market economy. For example, potential entrepreneurs and financiers of new high-tech ventures may lack adequate information about the opportunities in and returns from such investments. Indeed, studies show that the overall returns on applied research and development are quite high in relation to traditional economic activity.[13]

Under the circumstances, government action to lower the private sector's decision-making threshold on R&D would be useful, provided it would be done in a manner that preserves the entrepreneurial nature of the individual firm's decision making (this would not be the case with large-scale direct subsidies).

An alternative to expenditure subsidies is available and it would be more equitable and more effective: the federal government should provide generalized tax incentives for private-sector investment, including such activities as R&D. There are several attractions of this approach. It would be available to all private companies that pay U.S. income taxes. Those private companies receiving the incentive would choose the projects they wish to undertake. Finally and most relevant, the private firms doing the R&D would continue to bear most of the financial risk; the government's share would be much smaller.

A reduction in the corporate income tax would be a fundamental change. Such action would lower the cost of capital to American business and thereby lengthen the time horizon for economically attractive investments in R&D and capital equipment.

Alternatively, the existing R&D tax credit could be improved. Researchers in this field continue to debate the benefits and costs of the existing R&D tax credit.[14] There is one

aspect, however, that is not controversial: the reluctance of Congress to enact this provision on a permanent basis sharply reduces its effectiveness. Grudgingly extending the credit a year or two at a time makes it much less likely that companies will take account of this incentive in their decision making on long-range commitments to R&D, such as building expensive new laboratories.

The Proper Boundary between Government and Private Initiative

Much of the pressure for more federal subsidies of private business, including its use of science and technology, comes from citing the example of Japan. Japan's Ministry of International Trade and Industry (MITI) is often heralded as a fine example of successful business-government cooperation, but the details are not as convincing. MITI tried to keep Mazda and Honda out of the auto business because it badly underestimated the growth of Japan's export market. Then there was MITI's textile fiasco. MITI bought and scrapped 180,000 looms to finance the textile cartel that it set up. At the same time, however, 160,000 illegal looms came into production. In fact, more textile companies were operating in Japan after MITI's efforts than before.[15]

On a more positive note, the Japanese response since 1987 to the rising yen in world currency markets is very revealing. On their own, Japanese companies took quick and tough actions to restore their global competitiveness. Within weeks, or at most months, of the change in the external financial environment, many of them adopted vigorous campaigns to improve productivity. Efforts to upgrade quality were made. Some manufacturing operations were quickly moved to lower-cost locations and, in some cases, senior executives reduced their own salaries. MITI was not particularly involved at all.

In any event, U.S. policy should be based on U.S. institutions and experience. Thus, there is a modest role for government in connection with commercially oriented technology, such as operating a patent office and setting technical standards. Basically, under our private

enterprise form of economy, the private sector makes the decisions as to where to invest, what risks to take, and what technologies to spur and which to discard.

Government can — and should — facilitate the flow of technology from the laboratory to the commercial marketplace by creating a favorable economic climate. That role can stand considerable improvement.

To start with, government should reduce the numerous government-erected obstacles which discourage private firms from investing in risky long-term ventures. As is well known, a basic way of reducing the cost of long-term investments is to lower the cost of capital (which over the years has been higher in the United States than in Japan). The most direct way for the federal government to do that is to reduce the extent to which the Treasury competes for the limited supply of private saving via deficit financing.

The task here is more than a simple-minded reduction in budget deficits. Some approaches — such as tax increases which reduce the funds available for private investment — would do more harm than good. In contrast, bringing down the deficit by curtailing the government's consumption-oriented outlays would be a real plus.

Moreover, numerous regulatory restrictions inhibit the growth of corporate R&D. After all, what good would it do for the federal government to pour vast sums into high-tech enterprises if at the same time federal, state, and local governments erect statutory and administrative roadblocks to the application of new technology?

The fact is that the deregulating trend of the late 1970s and early 1980s has been replaced by a major expansion of government regulation of business.[16] Consider America's world-class pharmaceutical industry, which generates a substantial excess of exports over imports. Congressional committees are responding to that positive situation by "cracking down" on the industry via proposed new legislation that would grant the U.S. Food and Drug Administration police powers unprecedented for a regulatory agency.[17] Any effect on the flow of new technology resulting from this "crackdown" is bound to be negative, especially since the committees seem oblivious to such impacts of their actions.

It is intriguing to note that, in a large number of cases — chemicals, pharmaceuticals, and biotechnology — the potential supply of venture capital appears to be quite adequate. The major constraints on commercializing the advances in technology arise from government actions.[18] The hysterical reaction to the use of the protein BST in increasing the production of milk is, unfortunately, not a unique experience. Witness the spectacle of "consumer advocates" vehemently opposing the move because it would reduce the price of milk — and state legislatures following their lead by preventing the use of this advance in biotechnology.

Because many regulatory agencies exempt existing facilities, products, and processes from their directives, the main burden of rapidly expanding regulation falls on new enterprises, new undertakings, and new technology. The concern over the proper federal role in promoting new technology should extend to at least reducing if not eliminating many of those new burdens.

There is a modest direct role for government in supporting commercially oriented technology and, here too, some reforms would be desirable.[19] For example, a simpler and more effective patent system would encourage the creation and diffusion of technology. Such a change would ensure that smaller inventors are not overwhelmed by the cost of obtaining patents and defending them against legal challenges. Also, larger firms would be encouraged to seek patents rather than protecting their new products and processes by maintaining secrecy.

In addition, revisions in the antitrust laws are needed to avoid impeding the formation of joint ventures to develop new technology. Often, the capital requirements to develop what is termed "generic" or "pre-competitive" technology are beyond the financial capability of a single firm. Waiving or amending the antitrust statutes would be a far more sensible approach than urging the federal government to provide the necessary financial support.

The Future Role of Defense and Other Federal Agencies

The question has been raised as to the role of the Department of Defense in promoting commercial competitiveness. The direct role, properly, should be zero. A potential indirect

role might be quite constructive, both for the military and civilian sectors: it is for the Pentagon and the Congress to reduce the obstacles to military procurement of state-of-the-art products available in commercial markets.[20]

Some historical perspective on developments in military R&D and its relation to the civilian sector is necessary. For much of the period since the end of World War II, the scientific and technological efforts of the U.S. military establishment have set the pace for the American economy. The Department of Defense has been a major financier of R&D as well as the largest purchaser and developer of new scientific applications. In the absence of an explicit federal technology policy in the 1950s and the 1960s, the practices of the Pentagon became, to a very large extent, the de facto U.S. technology policy.

Past spinoffs from military technology constitute an impressive group — computers, jet airliners, composite materials, communications equipment, and scientific instruments. For decades, many companies primarily oriented to civilian markets benefitted from commercial use of "spin offs" from high-powered defense research and development.

Indeed, for much of the period since the end of World War II, a major attraction of defense work was the ability of commercial firms to keep abreast of the latest developments in military science and technology. The Raytheon Corporation adapted radar technology to develop the microwave oven (first called the "Radarange"). Boeing drew on its military aircraft design work on the B-47 and KC-135 in developing the 707 commercial airliner, although the 707 and the KC-135 were both descended from a common company-sponsored prototype (the "dash 80").

Over the past decade, the relationship between military and civilian R&D has changed very substantially. The roles of the public and private sectors often have been reversed in the military sphere itself. If a technology has both civilian and military use, the more advanced models are more likely now to be seen in Radio Shack than in military systems.

Dr. William Perry, former Undersecretary of Defense, cites the example of semiconductors, where the differences between defense and commercial technologies are not

very great. Extremely detailed military specifications have isolated defense production, dividing the U.S. industrial base between defense and commercial uses. Perry believes that, due to the rigidity of military specifications and requirements, chips made for the Defense Department are 10 times more expensive and nearly two generations behind their commercial counterparts.[21]

Many currently deployed defense systems use technologies dating to the 1970s or earlier. The existing acquisition process, which often requires as much as 20 years to move a major weapon system from R&D to deployment, increases costs and limits technological innovation. This drawn out development process also reduces the return on contractor-financed investments in defense R&D and thus reduces the incentives for such undertakings.[22]

The B-2 Stealth bomber and the Seawolf submarine both have computer chips in key components that are merely run-of-the-mill, rather than the latest state-of-the-art. The design of electronic parts in these weapons had to be frozen years ago in order to meet the requirements of the lengthy military production cycle. But, since then, the civilian computer industry has continued to innovate at a rapid pace.

Increasingly, the ability of the armed services to develop advanced weaponry depends on how well they and their contractors can "spin on" civilian advances to military products. Military research in electronics, for example, is now so exotic and slow that it offers little commercial use. The tables have turned. DOD has become a net user of civilian research.[23]

Many barriers impede the transfer of advanced technology from the civilian economy to the military establishment. The military acquisition process has become increasingly cumbersome, costly, and onerous. To prevent their civilian-oriented divisions from becoming "contaminated" by the military's bureaucratic approach, many companies selling to the armed services go out of their way to insulate their military work.

Thus, fiber optics companies doing business with the Department of Defense have set up special divisions to do so. In that way, the military's special accounting, auditing, and personnel requirements do not apply to the rest of the company. In the case of computer

software, the Department of Defense has set up a standard for weapons, committing itself to use of software written in its Ada computer language whenever possible. As a consequence, the software industry increasingly is being divided into separate civilian and military sectors and innovations in one sector are not quickly transferred to the other.

Some regulatory changes can help. Because American technology is increasingly oriented to civilian needs, federal acquisition regulations should be modified to encourage, or at least permit, the defense establishment to economize on its spending by drawing more on commercial product developments. That, of course, is much easier said than done.

The people in the Pentagon who make a career out of writing military specifications can be expected to object to any attempt to buy more off-the-shelf commercial products, whether they provide the DOD with superior technology or not. Such a shift in government purchasing on a large scale would put many regulation writers and acquisition reviewers out of work.

Also, "Buy American" provisions of the federal procurement laws inhibit purchasing from the open market. Officials responsible for acquisition must carefully check whether any one of the numerous components of a product contains a single forbidden foreign element. Other obstacles to buying more off-the-shelf commercial products include the rules on steering a certain percentage of procurement to small, handicapped, and minority firms and the onerous "do-it-by-the-numbers" provisions of the Competition in Contracting Act.

Some suggestions for utilizing the results of civilian R&D in military activities would go much further than merely liberalizing procurement procedures. When they view the absolute size of the military budget (even after the currently contemplated reductions), many people who are concerned with the lagging international competitiveness of American industry see a new source of financing for their proposals. That is, they would have the Department of Defense directly finance civilian technology.

Some who urge the Department of Defense to subsidize civilian science and technology use as a justification the fact that the armed services are important users of society's pool of

scientific and technical knowledge.[24] But there is no limit to that line of reasoning, given the large military purchases of items ranging from missiles to mittens, from ground support equipment to golf balls.

Lewis Branscomb, Director of the Science Technology and Public Policy Program at Harvard, warns, moreover, that defense R&D tends to be too slow, too centralized, and too micro-managed to be transferred successfully to the private sector. Defense researchers tend to be too far removed from the product development process of private industry and from commercial markets to have much impact.[25]

These concerns have led to proposals to expanding the role of the Defense Advanced Research Projects Agency (DARPA) as a convenient way of bypassing traditional military procurement procedures. Little known and small in size by Washington, D.C., standards, DARPA awards contracts totalling over $1 billion each year to over 300 corporations and universities to conduct high-risk research. Over the past 30 years, DARPA-funded projects have led to the development and commercialization of computer time-sharing, advanced aeronautics, new types of software and new telecommunications procedures.

DARPA already is financing private sector R&D in a variety of areas — superconductivity, advanced semiconductors, high-definition television (HDTV), and very sophisticated types of integrated circuits. While DARPA justifies its sponsorship of these projects because of their expected relevance to military missions, many of the technologies being developed are expected to help American industries compete in commercial markets. About one-half of DARPA's budget is currently allocated to such dual-use technologies that have both civilian and military applications.[26]

However, DARPA has experienced its share of flops. After spending $200 million, it closed the books on an experimental helicopter-airplane. Another project that fell short was a scheme to use artificial intelligence to guide a combat vehicle over rough terrain.[27]

Some compare DARPA with the Japanese Ministry of International Trade and Industry (MITI). Unlike DARPA, MITI is a cabinet-level agency charged with the broader mission of

enhancing the nation's international competitiveness. Expanding the role of DARPA to include all of the civilian technology that other federal departments and agencies are willing to sponsor, as is now being urged, would dilute DARPA's mission and weaken its focus. To a significant degree, DARPA has succeeded by virtue of its ability to bypass much of the Pentagon bureaucracy. If it gets much larger, it likely would lose that special characteristic.

A more fundamental objection to using the military budget to support private sector technology is that it will politicize the process. Giving the Department of Defense — rather than the marketplace — the authority to choose which technologies and which firms to receive its funds provides opportunity and incentive for exerting political pressures. History tells us that such opportunities will not go unused for long.

We need to go no further than the Army Corps of Engineers for an illustration of this concern. The Corps' military functions are first rate. Its civilian dam building, in contrast, is embroiled in politics and generates numerous projects with little economic justification. The Corps' sorry record of generating "pork" for powerful legislators is hardly a precedent to justify expanding the promotional role of the Department of Defense in the civilian economy.

Rather than having the Defense Department serve as an agency of industrial policy, some analysts have urged that the role be given to a strengthened Department of Commerce to invest more heavily in the development of the nation's technology base. Indeed, in late 1988, Congress converted the staid old National Bureau of Standards into the National Institute of Standards and Technology (NIST). The expanded agency is gearing up to hand out $10 million in seed money to the private sector to develop high-tech proposals in areas ranging from fire prevention to HDTV. Current proposals being considered in Congress would raise NIST's subsidy kitty to $250 million a year by 1992. That approach — where a federal civilian agency determines which new areas of commercial technology will be subsidized by government — is only marginally better than giving the role to the Pentagon.

However, none of these proposals for greater federal financing of civilian technology deals with the fundamental conditions that encourage investments in civilian technology —

such as lower cost of capital and expanding economic opportunities. To the contrary, the increase in budget deficits — and in Treasury borrowing in financial markets — resulting from these ambitious spending plans would make it more difficult to achieve those favorable conditions.

The justification for receiving government handouts are, on occasion, quite ingenious. According to a former Commerce Department official, business executives do not advocate an industrial policy; "they want the government involved in high-risk, long-term, expensive, high-technology research projects."[28] Or, in the words of one academic supporter, "The government should not give handouts, but it should help strategically placed industries at strategic times."[29] But inevitably the political process would decide which "high-risk, long-term," "strategic" industries and projects are to be selected. The lucky few chosen would, by definition, meet those subjective requirements. Politically weak companies by default would not be "strategic" or "high-risk" or "long-term." The results would be indistinguishable from a federal spending program formally labeled "industrial policy."

Conclusion

There are many important tasks that only government can perform, ranging from ensuring the national security to providing a system of justice. But one thing that democratic political systems cannot do well at all is to make critical choices between particular firms and competing technologies.

A far more satisfying answer to the desire to generate a higher level of technological effort in the private sector than government subsidy is to reduce the existing obstacles facing high-tech firms in the American economy. Many of the barriers to commercializing technology, it turns out, have been erected by governmental policies in the tax, regulatory, and antitrust areas. It is foolish to attempt to offset those negative effects through another round of federal spending.

Governmental policymakers must learn to refrain from jumping every time a constituency asks for help. The current pressure to "do more" for the promotion of technology is not an exceptional case. The most cursory examination of past and current large-scale efforts of the federal government to promote the use of civilian science and technology does not inspire confidence in the ability of federal agencies to choose among alternative technologies and their uses.

Identifying new shortcomings in the private sector does not automatically justify another round of governmental intervention in the economy. The well-publicized "market failure" may be overshadowed by even larger "government failure." Perhaps the best response to government officials who want to solve problems in the market economy is to reply, "Physician, heal thyself."

Notes

1. For a contrary view, see *Technology and Economic Performance: Organizing the Executive Branch for a Stronger National Technology Base* (New York: Carnegie Commission on Science, Technology, and Government, September 1991).

2. *Economic Report of the President* (Washington, D.C.: U.S. Government Printing Office, 1990); Handbook of *Economic Statistics* (Washington, D.C.: Central Intelligence Agency, 1988); "World Output in the 1980s," *Economic Insights*, July/August 1990, p. 19.

3. James R. Schlesinger, "We Sometimes Forget . . . How Powerful This Nation Is," *New York Times Magazine*, June 18, 1988, p. 27.

4. Susan Chira, "With Mixed Emotions, Japan Sees U.S. in Decline," *International Herald Tribune*, July 1, 1988, p. 4.

5. Fernand Roll, "An Economist's Perspective on the Future of Europe," address given at Miami University, Oxford, Ohio, September 30, 1988, p. 2.

6. Murray Weidenbaum, *Rendezvous With Reality: The American Economy After Reagan* (New York: Basic Books, 1990), pp. 110-111, 120.

7. A product category must meet three requirements in order for the Census Bureau to classify it as "advanced technology": (1) the product must contain technology from "a recognized high technology field," (2) it must represent "leading edge" technology in its field, and (3) the technology must constitute a "significant" part of the product. *Trade in Advanced Technology Products*, SB-2-89 (Washington, D.C.: U.S. Bureau of the Census, August 1989), p. 2.

8. Murray Weidenbaum, "A Note on R&D and Changing National Priorities," *Technology in Society*, Vol. II, 1989, pp. 331-334.

9. See Congressional Budget Office, *Federal Support of U.S. Business* (Washington, D.C.: U.S. Government Printing Office, 1984).

10. *Synthetic Fuels: An Overview of DOE's Ownership and Divestiture of the Great Plains Project* (Washington, D.C.: U.S. General Accounting Office, 1989).

11. Arthur T. Denzau and Clifford M. Hardin, *A National Development Bank: Ghost of the RFC Past* (St. Louis, Mo.: Washington University, Center for the Study of American Business, 1984).

12. *A Strategic Industry at Risk* (Washington, D.C.: U.S. National Advisory Committee on Semiconductors, 1989), p. 9.

13. See Zri Griliches, "Introduction," in Zri Griliches, editor, *R&D, Patents and Productivity* (Chicago: University of Chicago Press, 1984), p. 4.

14. See Kenneth M. Brown, *The R&D Tax Credit: An Evaluation of Evidence on Its Effectiveness*, Joint Economic Committee Staff Study (Washington, D.C.: U.S. Government Printing Office, 1985).

15. Arthur T. Denzau, *Will An "Industrial Policy" Work for the United States?* (St. Louis, Mo.: Washington University, Center for the Study of American Business, 1983), pp. 3-5.

16. Murray Weidenbaum, *The New Wave of Business Regulation* (St. Louis, Mo.: Washington University, Center for the Study of American Business, December 1990).

17. See, for example, H.R. 2597, The Food, Drug, Cosmetic, and Device Enforcement Amendments of 1991.

18. See Joyce Tait et al, *The Status of Biotechnology-Based Innovations* (London: Centre for Technology Strategy, 1990).

19. See Richard C. Levin, Alvin K. Klevorick, Richard R. Nelson, and Sidney G. Winter, "Appropriating the Returns from Industrial Research and Development," *Brookings Papers on Economic Activity*, 1987, No. 3, pp. 783-820.

20. See *New Thinking and American Defense Technology* (New York: Carnegie Commission on Science, Technology, and Government, August 1990).

21. *May 22, 1990 Task Force Minutes*, Task Force on Defense Spending, the Economy and the Nation's Security, Washington, D.C., p. 2.

22. Joseph F. Pilat and Paul C. White, "Technology and Strategy in a Changing World," *Washington Quarterly*, Spring 1990, p. 87.

23. Jacques S. Gansler, *Affording Defense* (Cambridge: MIT Press, 1989), p. 91.

24. See *Technology and Economic Performance*.

25. Quoted in *Technology and Competitiveness* (New York: Japan Society, 1990), p. 17.

26. B. R. Inman and Daniel F. Burton, "Technology and Competitiveness: The New Policy Frontier," *Foreign Affairs*, Spring 1990, p. 131.

27. Evelyn Richards, "Should Uncle Sam Be Technology's Godfather?", *Washington Post Weekly*, May 7, 1990, p. 71.

28. Quoted in Fred Barnes, "Bushwhacking," *Business Month*, January 1990, p. 71.

29. Gary H. Anthes, "Economist Supports Fed High-Tech Involvement," *Federal Computer Week*, February 19, 1990, p. 28.

REPRESENTATIVE HAMILTON. Well, thank you, Mr. Weidenbaum.

We've got a good start here this morning with these excellent statements, setting out fairly clearly some of the issues we want to discuss with you, and we'll begin with questions by Senator Bingaman.

SENATOR BINGAMAN. Thank you, Mr. Chairman.

Mr. Weidenbaum, I think you very eloquently stated the usual response that I've heard from some of this Administration to most of what is proposed in this area. No. 1, there is no problem; No. 2, if there is a problem, the government shouldn't have any part in fixing it; and, No. 3, even if the government should have a part, the Defense Department shouldn't participate. Those seem to be the three main arguments, as I understand it. Is that an accurate statement of your position?

MR. WEIDENBAUM. Not quite, Senator, because there is another part of it. The government is part of the problem. An important role for government is to reduce those obstacles that government itself has put in the way of development and use of new technology.

SENATOR BINGAMAN. You think that whatever problems we face in being competitive in new technologies is because the government has been in the way. Is that what you're saying?

MR. WEIDENBAUM. Yes, and I cite biotechnology as a prime example.

SENATOR BINGAMAN. Am I wrong in thinking that biotechnology is an area where we continue to lead the world, because we spend about $8 billion a year in NIH research and development?

MR. WEIDENBAUM. That has certainly helped. I haven't knocked it. But why haven't we commercialized more of the biotechnology? There you have to look at the legislative process in state governments and the regulatory process of the Federal Government.

SENATOR BINGAMAN. So, you're saying that even though we lead the world in biotechnology, as a result of federal expenditure, the failure of U.S. pharmaceutical companies and others to commercialize that technology is because of government obstacles. Is that what you're saying?

MR. WEIDENBAUM. It certainly is true in the case of BST, which I cite in my paper. The Feds giveth and the Feds taketh away.

SENATOR BINGAMAN. Well, I don't know enough about the details of BST; but it would strike me that biotechnology is one area where we lead precisely because of the Federal Government expenditure and support for basic research and development, historically. We have done much better in biotechnology than in most of the areas that are being discussed in these various reports.

The same in aerospace. Your point here is that the Department of Defense's role in supporting commercial technology should be zero. You say, "The role of the Defense Department in promoting commercial competitiveness should be zero." How do you explain the historical involvement of the Department of Defense in support for the aerospace industry?

MR. WEIDENBAUM. As an old Boeing man, I'll be delighted to do that. It was the Air Force of course that financed the key work on the B-47, on the B-52, on the KC-135, but not on the 707 and it's follow-on derivatives—commercial derivatives. It's Boeing that put up the money for the 707, 727, 737, 747, and 757.

SENATOR BINGAMAN. So, you don't think that the success of the U.S. commercial aerospace industry is largely, or at least in some significant part, a result of the fact that our Defense Department has put tens and hundreds of billions of dollars into both support for R&D and procurement. The Department of Defense has been the customer that has allowed a great deal of this R&D to occur over many decades, it would seem to me. Is that wrong?

MR. WEIDENBAUM. It's not wrong, but there is an important distinction, frankly, that is missing. The DOD did all that, not to support commercial technology, but solely to meet the needs of the national security. I think that's appropriate. That's absolutely right. And commercial companies saw the commercial fallout from the defense R&D, and the commercial companies put in their own capital to get the commercial fallout. That's the private enterprise system at work.

SENATOR BINGAMAN. But it strikes me that it's not quite the private enterprise system. I mean we're saying that because of Federal Government investment in aerospace-related R&D we have been able to succeed, or at least that's a significant reason why we have been able to succeed, in the sale of—Boeing accounts for a great deal of what we sell—high-tech products. You cite the fact that we have a good trade relationship on high-tech products. A lot of that is aerospace.

MR. WEIDENBAUM. Yes, sir.

SENATOR BINGAMAN. And a lot of that is a result of the Department of Defense expenditures. Is it a coincidence that when you go through the U.S. industrial makeup in agriculture, we do very well. The Federal Government invests very heavily. In aerospace we do very well. The Federal Government invests very heavily. In biotechnology we do very well. The Federal Government invests very heavily. There are other areas where we are not doing so well, and the Federal Government invests very little, and my concern is that it seems to me there may be some logical correlation between the extent of the Federal Government's involvement in some of these things and how well we do in the commercial sector.

MR. WEIDENBAUM. I would add a related point. If the Senator is convinced that the Federal Government should do more to encourage civilian technology, then the question comes, "how should the government go about doing that?" Federal expenditure subsidies just are one alternative.

An examination of what are the barriers to more private spending on technology will surface the regulatory problems, the antitrust and patent problems that are neglected.

SENATOR BINGAMAN. I think the point that I understood Admiral Inman to make was that they explicitly set out not to address all issues in the competitiveness spectrum but to focus on technology.

How do you respond to the conclusions of the Council on Competitiveness Report that Admiral Inman was involved in very heavily called, "Gaining New Ground." Have you reviewed that? They go through and identify a series of high-tech areas in which they feel that the U.S. is lagging our foreign competitors, and when you read that report you do not reach the same conclusion that you have here, which is that there is no competitiveness problem. Have you reviewed that report, and how do you respond to it?

MR. WEIDENBAUM. Not being a member of the Administration, I haven't received the report. I would be delighted to comment on it.

SENATOR BINGAMAN. No, it's a private group. The Council on Competitiveness is a private-sector group.

ADMIRAL INMAN. Industry developed. No government involvement at all.

SENATOR BINGAMAN. Right. I think George Fisher of Motorola is now the President of the Council. You haven't seen that report?

MR. WEIDENBAUM. I don't recall seeing it, no, sir.

SENATOR BINGAMAN. Let me ask on this more specific question about broadening DARPA's function. We've had a proposal here in the Congress— probably several proposals for several years now—to do just that; to either set up a civilian DARPA or to change the rule or mission of DARPA; to try to have them take on a bigger chunk of the responsibility for federal support for generic technology.

I think politically that has proven very difficult to sell. The Administration and the Department of Defense strongly oppose it. Some allege that this is where Craig Fields ran into difficulties, although that's subject to dispute, I guess, depending on who you talk to. Does it make more sense to take one of the existing agencies, in this case, DARPA, and say, OK, we're going to give them that job rather than trying to do that through OSTP, or trying to establish some other entity? I guess that's a basic question you folks grappled with and reached a conclusion on.

Admiral Inman, maybe you could elaborate on it.

ADMIRAL INMAN. Senator Bingaman, if one could start with a blank sheet of paper and create any entity you wanted without regard to the size of government, there probably would have been a majority that would have said create some civilian-advanced research projects agency.

As we went through the discussion of the realities, our sense was of a broad public perception that the role of government should be shrinking and not growing. In that climate, trying to create an entirely new organization and give it some charge, and particularly when it didn't have a clear sense of who its customers were, was simply not likely to be a successful effort. Therefore, we should look at the institutions that already exist that have demonstrated capability, and say can you make changes

that get additional benefit for the private sector and for government without a significant addition of people or new organizations. And that's how we came to NARPA. The bulk of the opposition at Defense, as I sense it, represents a fear that this is simply a cloak for diverting defense research funds in other areas.

If one looks at the past record, the country still does lead in some technological areas, and in others we're losing or have lost. One of those where we lead strongly is in the information-management area.

DARPA's investments at Sanford, at Carnegie Mellon, and at MIT were fundamental to creating this country's ability to lead in the commercial marketplace. So, this program focused precisely on understanding that process and expanding it.

I would like 30 minutes to respond to my good friend, Dr. Weidenbaum. I think he read a different report than we wrote. There is no master R&D plan. There is just a fundamental issue about expansion of defense-funded basic research. That doesn't go to industry. The bulk of the basic research funding goes to universities and always has. It broadens that base, and that's why we're interested in it.

So, the image that this is the large industries once again trying to come to the federal trough, I think, is just a great distortion of this effort. It is saying government exists, government has a role, government already funds, and government is very inefficient and ineffective in much of that, and can you make some changes that offer the prospect of substantially greater effectiveness from the dollars you're now spending and from the organizations that exist. The image that this is an effort to break the budget just is a total misreading of the effort.

SENATOR BINGAMAN. Yes, Mr. Branscomb.

MR. BRANSCOMB. I think it's important to appreciate that one of the changes sweeping the world is that governments have a lot less control over the technological capabilities in their nations than they had before, as a result of interdependence and with the enormous growth of the private, high-tech industry around the world.

Our report doesn't advocate a larger role for government. It advocates a smarter role in a declining context. The government's role is declining as a percentage of national R&D. Since 1960 government R&D has grown in real terms substantially. But it has grown two and a half times less rapidly than private-sector R&D.

Private-sector R&D is growing around the world, including in Japan and Germany, where there is very little defense R&D. Yet, the government still is the source of half the R&D in this country. It's over $60 billion a year.

So, the question, in my opinion, is how does the government do this in a smart way to get more bang for its buck?

The second point is that our suggestions for an altered role for DARPA have much more to do with military effectiveness than they have to do with indirect consequences to the economy.

The Defense Department, in its own interest, is going to have to find a way to get better access to commercial technology. It will have to do that in a partnership role rather than in a command economy role, which they are accustomed to with their defense contractors. There will be a substantial benefit, but the benefit comes not from picking commercial products to develop. The benefit comes from this country not having to pay for two economies, which it's doing today, and instead paying for one, namely, a single technological capability in a highly diversified industry that serves primarily commercial markets and, by the way, also meets the needs of our government.

Now, I'll grant you that it's very hard to make the case for a NARPA without slipping over into the notion that this is a surrogate civil agency, which has a charter to develop any technology it likes.

I'm opposed to the government picking technologies and investing in any part of the technology. The notion of a technology includes both the idea of technical knowledge and also the facilities, the institutions and the capability to deliver the technology that will create goods. If a technology can't create goods, it isn't a technology. So, there are large parts of every technology that should be the exclusive domain of private industry.

But having said that, it doesn't follow that there is nothing in technology that is a public good. That to me simply says that we have to be much more precise in our understanding of the nature of the technical world of today.

I notice that my friend, Mr. Weidenbaum, has a very selective confidence in government capacity. He advocates the government should create a good economic policy to provide an environment for the private sector. He is very strongly not in favor of the government doing the same thing for the technical environment in which the private sector operates.

I claim the government doesn't do either very well. I have a lot of complaints to make about our macroeconomic policy, but this is not the time and place to do it.

But I believe that we have to be less simplistic as we try to define the government's technical role. And just to give a plug to legislation now under consideration, Senator Bingaman has proposed some important ideas for how the Defense Department's interest in manufacturing capability will serve the interests of our Defense Department and indirectly have a benefit to the country.

SENATOR BINGAMAN. Mr. Chairman, I don't want to go on here and keep you from asking questions.

REPRESENTATIVE HAMILTON. Well, we'll rotate.

SENATOR BINGAMAN. Fine.

REPRESENTATIVE HAMILTON. We'll go to Congressman Armey, and then to me, and then back to you.

Congressman Armey, please proceed.

REPRESENTATIVE ARMEY. Thank you, Mr. Chairman.

Mr. Weidenbaum, let me begin with you and just say I thank you for your testimony, and if I may be presumptuous, Adam Smith thanks you as well.

MR. WEIDENBAUM. Thank you, sir.

REPRESENTATIVE ARMEY. This is a very interesting proposal. As I understand, what you propose is a NARPA, an extension of the concept of DARPA to the nondefense sector of the economy for the purpose of conducting fundamental basic science and technological research, which would thereby be available as a public good to either public or private uses.

Mr. Inman, is that a correct understanding?

ADMIRAL INMAN. There would have to be a government customer. We would not encourage NARPA to undertake any research where they only foresaw commercial use of the product. That belongs to the private sector.

REPRESENTATIVE ARMEY. Of course, you understand that the Federal Government in particular is a very undiscriminating purchasing agent for the American people, and they will damn near buy anything.

ADMIRAL INMAN. Congressman Armey, if you look back again at history, what you find is that in the time of great success, both in funding our defense needs much less expensively and boosting the economy, the largest investor in research was the Department of Defense. That research, conducted largely through the Office of Naval Research and its counterparts, was done with great confidence in the clear understanding that when you invest in technology at the outset you frequently don't know what product may emerge from it.

REPRESENTATIVE ARMEY. Well, I appreciate that, but I hope you appreciate that for all of the vagaries of its diversions of thought and energy the Defense Department still is probably the most well-focused purchasing organization within this framework of the Federal Government. That is to say, they do have a clearly well-defined and quite often quite technologically well-defined set of objectives that they're trying to accomplish.

I'm taking myself, as it were, back to choice theory relating to Armey's axiom No. 1, that the market is rational and the government is dumb, and the fundamental reason that the government is dumb is that the government so often doesn't know what it's trying to achieve, whereas private people in the private sector do.

The Defense Department, to a greater extent than most government agencies, has a clear and often, as I said, technologically well-defined idea of what it is trying to achieve.

ADMIRAL INMAN. It has a good concept technologically of what it's trying to achieve, but it now has a procurement process that, in my view, is a disaster. It was infinitely better in the 1950s than it is now.

REPRESENTATIVE ARMEY. I couldn't agree with you more. This also takes me then to the discipline of psychology where the psychologist defines crazy as doing more of the same thing and expecting different results.

[Laughter.]

REPRESENTATIVE ARMEY. And I think what you're suggesting is that after World War II and for some time after it our Defense Department had an enormously successful record of leading in the cutting edge of technology and providing the spinoff effects for the rest of the economy.

As the politicians, more and more for political reasons, fixed the defense procurement process to their satisfaction, we've fouled it up to the point where we have made the defense industry a lagging sector in this area, and I think this largely comes down to the whole concept of project selection.

The French, for example, have been pioneers in the whole area of project analysis, using the fundamental concepts of discounted present value. That gets to be very difficult to do in an area where the benefits defined are so ambiguous, and so one wonders.

Let me give you an example. Armey's axiom is that sooner or later every elected officials will be made a jackass by politics. I always fear that the superconducting supercollider may be my turn, since I'm from Texas and I worry about that daily.

Now, here we're talking about a relatively massive investment of federal funds in the area of science and technology, the benefits of which are a dream for our children and grandchildren's future. Of course, being an old academic, naturally I believe that I might find some truth or some allegiance to truth in the academic community if only I go to my friends in the natural sciences.

Well, immediately I'm told by the biologists and the chemists that this is a waste of the taxpayers' money. You ought to be spending that on biological or chemical research. I say ah-ha, vested interests, conflict of interests and these scientists are chasing ambulances. So, I then go to the physics department, and I find that even in the physics department I get conflicting testimony. I go to the engineering schools, and I get conflicting testimony.

And, quite frankly, what I find is a direct correlation between the endorsement of the science and the need for the science, and the viability of the science and the future payoff of the science, and the exact research specialization of the physicist or the engineer. Them that's going to get part of the cash in the process in the future are all for it, and them that ain't are all ag'in it.

Now, the only thing that I have learned that I feel is a substantial lesson in this process of trying to determine if a superconducting supercolider is a good investment, is that scientists are just as capable of chasing ambulances as lawyers. That's the only firm lesson I've gotten out of the process.

Now, I'm told well, remember, it's going to be under the guidance of the Department of Energy. It is my belief that the Department of Energy has purchased more white elephants per dollar of budget in its existence than the military has, and the most notable and almost comical example, of course, is the coal gasification plant in Butte, North Dakota, which still amazes me.

The plant was built in an environment that was so hostile that when they found that it was economically and technologically unfeasible they couldn't even afford to mothball it because of the harsh winters. Only a government agency could be so foolish.

Now, we know why the coal gasification plant is in Butte, North Dakota, and Quinton Burdick can tell you in even more specific terms. In a latter day—in the last year or two—it would have been in West Virginia, but it didn't make it. I'm sure there may be an effort made to move it to West Virginia, which takes us then to an observation Mr. Weidenbaum made. When money is spent for whatever purpose by politicians, the money goes where the power goes. We all know that, "A Nation In Ruins," by virtue of the good work of Pat Choate, who said—what I pointed out to him in 1964 while we were graduate students—that if the Nation neglected its infrastructure it fails.

Now, you know, even us Stiglerites would acknowledge that there is at least some basis to justify government investment in public infrastructure and highways and roads, and yet we fouled that up. Here, we have a highway bill that we can't fund—$11 billion of which is clearly defined by anybody who has got any definitive basis for doing so as pork—that is, demonstration projects that have never gone through the authorizing committee and were put in by the Appropriations Committee. Forty percent of the $11 billion is in four congressional districts, and it doesn't take a great deal of imagination to guess which four congressional districts these are. These are the districts in which you have a congressman with a power position relative to the allocation of that money.

Now, what I fear in this process, and the reason I go on this diatribe, and understand if you will, is I fundamentally distrust government. I don't look for individual aberrance. I think we are by and large true and honorable men doing our duty as we see it. But Armey's axiom is even sane people will act insane within an insane institution, and government is inherently an insane institution. So, I see systemic aberrance and not individual aberrance, and I want to be very clear on that.

But if we should establish such an organization, would we not in fact have the allocation of very scarce research and development funds in compliance with political success criteria rather than technology, scientific, or even commercial success?

ADMIRAL INMAN. Congressman Armey, we have not had that for DARPA in the past. It's one of the smaller ones that has been accepted. So, I don't understand the logic that says the change to NARPA, where you're still limiting it to government funding, is going to open this to the political leadership.

REPRESENTATIVE ARMEY. Well, the reason that you've had a fairly good track record in DARPA, as opposed to the rest of the government—for example, the Department of Agriculture, which is just a horrible damn experience—is because DARPA, one, relates to a legitimate, necessary mission of the Federal Government, where there can be a well-focused, well-defined set of objectives, a challenge to meet and so forth; and, two,

it still lies, by and large, to a greater extent than most of the agencies of the Federal Government, under the jurisdiction of the Executive Branch where accountability is coupled with authority.

I mean, for example, the Agriculture Department by example is just fundamentally run by the House and Senate Agriculture Committees and there is no accountability, except that which falls by default to the President. Congress, of course, is very little concerned about the extent to which the President lives with the vagaries of accountability for their actions.

But the President and the Pentagon and the American people have managed to maintain some executive control over the Defense Department. They are certainly intruded against by Congress with their parochial interests, and my favorite example being a Member of Congress who voted for the submarine built in his district, but voted against the weapons on the submarine that weren't built in his district, and intended apparently to ram the enemy with that submarine.

So, I think what I worry about, as Thomas Sole says, it is not faith but evidence that tells us that in this business of allocating scarce resources among competing ends there will be a rational, productive job done of it by the market. But in the business of allocating scarce resources among competing ends, the government will fundamentally err, because there will be a confusion with respect to the very fundamental question of what are we trying to achieve here and on whose behalf are we trying to achieve it.

And I would fear that as you took DARPA and made it NARPA and let the politicians, even more explicitly and with a sense of greater presumptuousness, believe they have got their hands now on the levers of allocation of scarce resources—the science and engineering research—that we would end up with very parochially attractive things, which, frankly, from all the fears of my lifetime, I fear may be all in the world. The superconducting supercolider was.

I always kid that when I used to think it was a middle linebacker for the Cowboys I was ready to vote for it in a minute. But I don't think you can give me, or find anybody that can give me, a consensus of opinion and so forth that can be convincing and uncontestable about, is the superconducting supercolider a legitimate, necessary and highly predictably productive expenditure of the taxpayers' money.

ADMIRAL INMAN. Congressman Armey, I live in Texas and I vote there, and I'm happy I'm not here to defend the SCSC issue. You're addressing a set of fears that I can't discount at all and wouldn't even try.

We're driven by an entirely different set of fears, that if we don't make changes, Defense ultimately is going to pay vastly more to try to access the state-of-the-art technologies we need.

If you watched on your television daily, the Gulf War command, control, and precision weapons were the key difference. But the state-of-the-art effort in much of that now isn't in the defense research, but it's out in the commercial research. And unless we create a climate where we are

encouraging the linkage that assures that access and not repeating the investment for it, we fear our defense is going to be twice as expensive and much less effective over the long run. So, it's an issue of creating a better balance.

I have to tell you that I have been alarmed at actions I have seen in the last several years of earmarking large science projects for specific geographic locations. It, in my mind, walks away from 40 years or longer of looking carefully at peer review and even accepting biases among those peers of what they think is important.

The move away from that to earmark large investments for specific geographic locations is a worry to me about where it may go. I don't believe this Carnegie task force opened a door for an expansion of that. In fact, we have tried to reasonably, subtly put some brakes on that approach by what we tried to put in place in the way the policies are developed. They may not be successful, but it's a try in that direction.

MR. WEIDENBAUM. I find it hard to see how you put brakes on the process by giving, what is now a Defense Department R&D agency, DARPA, a new charter that would enable it to do any technology research that is financed by any federal civilian agency.

REPRESENTATIVE ARMEY. Mr. Chairman, let me just end with two observations and a quick response from you. I think there may be two better alternatives.

Would it perhaps be better if the government made less of a taxation intrusion against the earnings of a business, and I don't want to say tax concession because that concedes that the government has a right to screw up business with their tax laws. So, less of a tax intrusion against the revenues of the business that would allow them to use more of their earnings for research and development. It's called a tax concession.

I was intrigued by your idea, and I think Mr. Branscomb suggested it, that perhaps we could have a consortium of business enterprises that got together in an agreement to do joint research. My guess is that if you have a good many firms to get together and pool their resources and put together a partnership arrangement that you would probably end up having the government bring antitrust legislation against them.

ADMIRAL INMAN. Congressman Armey, I had the pleasure of creating the first of those in this country and running it for 4 years, and, in fact, locating it in Austin, Texas.

REPRESENTATIVE ARMEY. I understand that, but is it devoid of government——

ADMIRAL INMAN. And in fact, once we had it created, we were able to persuade the Congress to give us antitrust relief with the National Cooperative Research Act of 1984. So, I strongly endorse that as an approach, and I do think much could be done with the tax code to help. That's a different issue that is not being dealt with.

The experience I had in a totally private-sector funded R&D environment was that we still couldn't get a great many of the companies

that provides funds to focus on accelerating their use of the technology that was being created. Even if you did everything we've recommended in this report, there still is no guarantee that the U.S. industry is going to change and compete at the international marketplace in all these areas effectively. That's a great frustration I have after 9 years now in the private sector of how we find our way to compete.

MR. WEIDENBAUM. But that has been the experience time and time again. Private companies are very reluctant to take on the R&D results generated by consortia, by government agencies, and they are much more prone to utilize, to commercialize the R&D in their own laboratories, which gets you back to promoting private R&D by reducing regulatory obstacles and providing some incentives.

MR. BRANSCOMB. Mr. Weidenbaum, you simply have to be more precise in your understanding of what constitutes R&D. R is research and D is development, and it covers a huge spectrum of things.

I was responsible for the technology strategy of a company that spends $4 billion of private money on R&D. There was no federal money involved in that, and I can tell you that the company I worked for did not want to lose any of its proprietary assets on its internally developed products with which it competes around the world.

I can also tell you that we spent $200 million a year in a research laboratory whose primary purpose was to find out what's going on outside the company, get access to it and learn from it.

The Chief Executive Officer of the company I used to work for will tell you, because he has been in Washington doing that, that the fate of our computer industry really does depend on the technical knowledge environment. That company does not want the government to tell it what products to develop, and in no way does it want the government to subsidize its commercial-product development. But you have to be a little more sophisticated about the nature of technology.

We've changed a letter in DARPA's acronym, maybe mostly to get attention to our suggestion. But the fact of the matter is that unless DARPA has a charter to explore dual-use technology, it's going to go down the tubes with the rest of the Defense Department into a defense ghetto. We'll go back to having arsenals, and we will have a poorly defended country. Or, alternatively, DARPA and the rest of the Defense Department is going to have to realize that the United States now lives in a world of technology, most of which is private, a large part of which is not even located in the United States. Defense is going to have to use it.

So, the question is how do you equip this agency to access commercial technology in the interests of the U.S. Defense Department. I know people will seize on this suggestion and say, oh, this is a way of lifting up the edge of the tent so that every camel in America can run underneath.

Yes, that is a big hazard. If we accomplish anything this morning, it should be to recognize that this issue has got to be debated wide open. If it is debated wide open, then I believe that people will begin to understand

that there are right and wrong answers and that there is a way to sort the problem out.

I tried to deal with those in a fairly short paper that I wrote this summer called, "Toward A U.S. Technology Policy," which I would hope you would include in the record.

REPRESENTATIVE ARMEY. Without objection, we'll be glad to include it.

MR. BRANSCOMB. Thank you, and it deals with these questions.

Let me finally say, on the issue of pork barreling government programs and depriving government managers of the opportunity to manage things the way they ought to be, the Congress could make one huge contribution to avoiding that by appropriate legislation that restrains itself.

Thank you.

[A paper written by Mr. Branscomb follows:]

LEWIS M. BRANSCOMB

Toward a U.S. Technology Policy

A more activist approach is needed to secure the benefits of science. Remarkably, the White House is stirring.

After forty years of federal mobilization of the nation's technology to compete with its enemies in the Eastern bloc, the U.S. government is concerned about the ability of American industry to compete technologically with its friends in the West. The shift from military to commercial demands on the nation's scientific and technological base has generated a national policy debate, which has so far focused on two questions: whether federal agencies should invest directly in commercially relevant science and technology; and, if so, what kind of projects should be funded by which agencies.

On one side are laissez-faire conservatives and neoclassical economists, who would limit federal R&D activities to academic basic research and the pursuit of federal agency missions (such as defense, space, and atomic energy), while relying on market forces to stimulate commercial investments in science and technology. This point of view is usually attributed to the president's chief of staff, John H. Sununu; his economic advisor, Michael J. Boskin; and his budget director, Richard G. Darman. Their desire to restrict the role of government in favor of reliance on market forces has led to several noteworthy policy outcomes: the demise of a Department of Commerce initiative in high-definition television, intended to revive the U.S. consumer electronics industry; limited federal investment in the commercial technology base through the Defense Advanced Research Projects Agency (DARPA); and curtailment of the highly visible role of former DARPA director Craig Fields in advocating such investments before Congress.

On the other side are some semiconductor-industry executives, labor advocates, and liberal economic interventionists, particularly in the Congress, who have criticized the administration's caution. Although very few of these people would admit that they are calling for an "industrial policy," they have urged the government to match the managed trade and strategic technology interventions of other nations.

Lewis M. Branscomb is director of the Science, Technology, and Public Policy program in the Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University. He is coauthor of *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, to be published by Harvard Business School Press, winter 1991–1992.

Senator John Glenn favors a "civilian DARPA" to invest in R&D areas identified as key to the revitalization of strategic industries. The National Semiconductor Commission has called for vigorous federal action to reverse the U.S. microelectronics industry's loss of market share. Its first report even asked that the federal government provide capital under favorable terms to finance the industry's revival, although this idea has been set aside.

The search for a political and economic middle ground between a laissez-faire economic policy and a full-blown industrial policy made little progress until quite recently. A new approach, which appears to have the makings of a consensus, urges the development of a U.S. "technology policy," in which the federal government helps develop and provide access to the technical knowledge on which the competitiveness of commercial enterprises depends. Among the advocates of an explicit technology policy are science and technology policy scholars, civilian high-tech industry executives (including members of the private Council on Competitiveness), some microeconomists, and several influential technology advocates within the Bush administration, including Assistant to the President for Science and Technology D. Allan Bromley, Department of Commerce Undersecretary for Technology Robert White, and former National Science Foundation director Erich Bloch.

Breaking new ground

Bromley, speaking for the administration, made himself the leader of this middle-ground approach by sending to the Congress last September a formal document entitled "The U.S. Technology Policy." Washington wags said that the most important thing about this little-publicized report was its title page. But a team headed by James Ling, staffed from Bromley's Office of Science and Technology Policy (OSTP) and Darman's Office of Management and Budget (OMB), spent 14 months crafting the policy and gaining its acceptance. Building a consensus in the White House for any document with the words "technology policy" in the title was no small achievement.

The body of Bromley's technology policy report sketches the current menu of federal technology activities and their budgetary allotments for fiscal year 1991. In this description of reality one sees a continuation of policies the U.S. has followed since World War II, whereby the federal government funds high levels of basic scientific research along with ambitious national engineering projects intended to maintain the nation's superpower status in matters technological. Examples include the space station, the Strategic Defense Initiative, the superconducting supercollider, and the Human Genome Project. This "mission-oriented" strategy, similar to that pursued by Britain and France, takes a supply-side approach to the development of new technology; it assumes that the innovations generated by new projects will eventually trickle down to other sectors.

The conceptual part of the White House technology policy, however, breaks important new ground. It prepares the way for a shift to a demand-side strategy that would help U.S. enterprises find, adapt, and put to use the best technology available. The report reaffirms the administration's intention to "participate with the private sector in precompetitive research on generic, enabling technologies that have the potential to contribute to . . . commercial applications."

In particular, the document calls for a threefold increase in funding in FY 91 for the fledgling Advanced Technology Program (sponsored by the National Institute of Standards and Technology within the Department of Commerce), established in 1988 to invest directly in commercial technology that will enhance industrial competitiveness. The policy also commits the administration to investments in an "efficient technological infrastructure, especially in the transfer of information." For instance, it contains a request for $92 million to upgrade and rationalize the Internet, a collection of over 2000 computer networks, into a National Research and Education Network serving schools, universities, government, and industry.

The strong emphasis on technology absorption also represents a departure from past dependence on "trickle down" of technology from federal missions to commercial firms—often called "spinoff." The new policy suggests the establishment of cooperative research projects to enable small and mid-sized companies to build on state and regional technology initiatives. And it calls for improved public education in math and science as well as worker retraining, so that the work force can keep pace with technological change.

The document provides no details on how these new objectives should be carried out, how the agencies

involved will acquire the competence to manage them, or how funds are to be allocated. Moreover, the budgets involved represent only a small share of science- and technology-related funding, most of which is still devoted to large, mission-driven projects. Nonetheless, OSTP has accomplished a significant first step in gaining clearance through a skeptical White House for a policy that gives the Congress and the nation a more direct approach to enhancing and applying U.S. science and technology capabilities.

A good diffusion strategy gives as much emphasis to imported knowledge as it does to home-grown.

The technology policy put forth by OSTP would move the U.S. policy in the direction of strategies followed by Germany, Switzerland, and Sweden, which emphasize bringing the benefits of new technology more quickly and broadly to their manufacturing firms. Policy tools include school-to-work transition programs, apprenticeship programs, and collaboration between firms and government research institutes.

Japan also stresses technological infrastructure to support its industry's competitiveness. Professor Fumio Kodama, research director of the National Institute of Science and Technology Policy of Japan, claims that the Japanese government has followed a technology policy rather than an industrial policy. Its strategy, he says, "promoted developments first in assembly technology, then in component technology, and finally in materials—a sort of 'needs-pull' approach that started with downstream products and then worked back upstream to develop whatever was necessary for their production."

Although scholars describe these kinds of policies as "diffusion-oriented," the term "capability-enhancing" is perhaps more descriptive. They are not so much distributive in their objectives as they are aimed at enhanced power to absorb and employ technologies productively. Capability-enhancing policies are designed to prepare workers for an increasingly sophisticated work environment and develop their problem-solving abilities, to accelerate the commercialization of innovative ideas, to increase the productivity and lower the cost of industrial production, and to increase the capacity of all firms, large and small, to use technology to improve their competitiveness. The net effect of a capability-enhancing policy is to diffuse economic benefits and increase competition not by "picking winners" but by increasing innovative capacity.

Attention downstream

Bromley has thus taken two steps forward in framing the debate about the nation's scientific and technical future. He has helped establish the legitimacy of technology policy as the correct focus of debate, stopping short of industrial policy. This first step makes possible the second: a discussion of the balance to be struck between creating and using technology.

Bromley recognizes that the science policy, supported by conservatives and liberals alike, is important but insufficient to ensure the economy's competitiveness. His success in substituting a policy based on investment in technology for one that emphasizes investment only in R&D is a more significant change than many people realize. Although laypeople may be under the impression that technology is simply the natural consequence of scientific activities, there is much more to creating technology than R&D. In fact, only 30 to 35 percent of the scientists and engineers in industry are engaged in R&D. The rest are engaged in "downstream" activities: refining process technologies, creating production systems, and improving existing technology through field experience.

With rare exceptions these "downstream" activities in technology are not the province of Ph.D.s and professors. (A most interesting exception is chemical engineering, the only academic field of engineering or science in which students understand that they are being trained to develop processes and design production facilities. Significantly, the U.S. chemical industry is highly competitive with those of both Japan and Germany.) Production processes and other downstream technologies must be mastered by hundreds of thousands of engineers and by millions of skilled workers.

Most of these people work in small to mid-sized firms for which design and production technology is a critical competitive factor. But such firms cannot af-

ford to do research as it is known in universities, national laboratories, and the biggest companies. They develop their technology through evolutionary engineering on the factory floor, and through relationships with their customers and suppliers. How well these firms find, adapt, and use technology determines how long they will be in business, at least under American ownership.

Very little federally sponsored R&D touches these firms directly. They are at the ends of the paths through which research-generated technology diffuses to the private sector. The torrent unleashed by federal military and space activities is a tiny trickle by the time it reaches the majority of U.S. firms. Government policy must give more emphasis to helping them use technology to better effect, and less emphasis to the trickle-down policies of federal "mission-driven" R&D.

The next steps

Although demand-side technology policy has a long and honored history in agriculture—new tools and techniques brought to farmers by agricultural extension agents made U.S. agriculture the most productive in the world—its record in commercial manufacturing has been very spotty. Contemporary political accommodation to the idea of "technology policy" began with President Reagan's acceptance of the 1988 Trade and Competitiveness Act, whose technology policies were designed by Senator Ernest Hollings of South Carolina and widely supported by both Republicans and Democrats in the Congress.

The act established a new Technology Administration in the Department of Commerce and gave a new name—the National Institute for Standards and Technology—and a new mission to the venerable National Bureau of Standards. NIST's new mission includes three programs, all viewed with some suspicion by economic conservatives: the Advanced Technology Program to finance "precompetitive generic" research in commercial firms; an experimental technology-extension program to help smaller manufacturers improve their productivity; and the establishment of manufacturing technology centers in cooperation with the states. White House skepticism, however, has restricted these three NIST programs to less than three percent of DARPA's R&D budget, despite a generous congressional authorization. Thus the three Commerce programs must be regarded as very tentative experiments in capability-enhancing technology policy.

In 1989, Senator Jeff Bingaman and the Senate Armed Services Committee began asking first the Department of Defense, and more recently OSTP to identify for the Congress a list of "critical technologies" deserving of federal investment. Meanwhile, Department of Commerce officials developed such a list of their own. Actually, the construction of "critical technology" lists has become a small industry, for they have also been published by the U.S. Council on Competitiveness, by the Japanese, and by the European Community. All of the lists are virtually identical—suggesting the merits of investing in technologies other than those on everyone else's list. In any case, a list of technologies alone provides no guidance on what governments should specifically do about them.

So what might the next steps be in implementing a capability-enhancing strategy for the United States? The Department of Commerce, the defense establishment, the specialized technology agencies (the Department of Energy and NASA), the education and training agencies (the Departments of Education and Labor, the National Science Foundation, and the National Institutes of Health), the White House, and state governments must all rethink the roles they play in supporting the development of U.S. scientific and technological capabilities.

The starting point is a *changed attitude toward the technical achievements of others*. In comparison with Japanese companies, Americans suffer extensively from the "not invented here" syndrome. This shortcoming—the byproduct of a technology strategy focused on maintaining national prestige—is costly in both time and dollars. A good diffusion strategy, by contrast, gives as much emphasis to importing knowledge and adapting it for use as it does to accessing home-grown knowledge. Funding to collect and evaluate information from abroad and the acquisition of new technologies through joint projects with the Japanese and the European Community can help achieve this goal.

To provide *better access to science and technology information* (STI), the federal government should capture the benefits from its $70 billion annual R&D investment by reversing the downward trend in support for quality control, user adaptation, and dissemination of R&D results. The OSTP needs to coordinate

efforts across all the agencies—as it did twenty years ago through its Committee on Scientific and Technical Information—by mandating that agencies serve information users through centers for data evaluation, compilation, and dissemination as well as through commissioned review papers and the consolidation of technological knowledge in engineering handbooks.

OSTP should also work closely with OMB to reexamine and strengthen the guidelines for agency science and technology information policies, which are embodied in OMB Circular A-130, soon to be reissued. This document describes the obligations of agencies to distribute information to the public. With scientific and engineering professional societies beginning to experiment with electronic journals, it is essential that policies that encourage dissemination of reliable information be adopted.

Infrastructural research may not be as glamorous as pathbreaking discoveries, but it helps industries respond to market signals.

The government's investment in the National Research and Education Network (NREN)—a central part of the strategy to develop the nation's information infrastructure—will make expanded STI services accessible to thousands of laboratories in universities, industry, and government. By aggregating a national market for such services, it can attract investment by private information vendors as well as justify increased government efforts in STI.

NREN will also contribute to *building a stronger industrial base of dual-use technologies*—products and techniques that meet both civilian and military needs. Today we support two weakly connected economies: Defense draws its technology from government funding, while commercial companies remain largely dependent on their own investments. As the defense budget declines, the government will become more dependent on access to an increasingly sophisticated commercial high-tech industry. This suggests that commercial and defense programs will need to share a common technological base. Toward this end, OSTP and the National Security Council should work together, as recommended by the Carnegie Commission, to coordinate the technology strategies of military and civil agencies.

The increased focus on critical dual-use technologies means that R&D projects will have to be broadly applicable, producing generic or enabling technologies that have the potential for broad use in many sectors of industry. A new class of "public good" technologies—new tools, test methods, processes, and materials—will thus emerge. Such infrastructural research may not be as glamorous as pathbreaking discoveries leading to new industries, but it contributes directly to the capability of today's laboratories and plants to achieve the lowest-cost, highest-quality, and quickest response to market signals. NIST's new Advanced Technology Program is in the early stages of just such a program of infrastructural investment.

In addition, federally-funded R&D should begin to *focus on the "downstream" phases of the innovation cycle*. Most government agencies, primarily interested in research to create new capabilities, contribute little to process or manufacturing technology. But quality of products can only be ensured if production processes are themselves innovative and continuously improved. It will be particularly unfortunate if the Department of Commerce's ATP program emulates DARPA and other mission agencies and fails to focus attention on "downstream" technical challenges.

NIST is, however, experimenting with other ways to enhance "downstream" performance, notably through provision of industrial extension services to help smaller companies identify and take advantage of technological opportunities to improve their manufacturing performance. These services are offered through a growing array of state-initiated programs that promote innovation and productivity growth. Taken together, the states are spending over a billion dollars on such programs. But many of them enjoy a few years of exceptional success, only to die when a political change in state government accompanies a recession year, as happened recently in Massachusetts. The federal government should help stabilize what is otherwise a very innovative set of state initiatives

by matching the funds spent on these programs.

The final area where action is needed is certainly the most important in the long run: *investment in human resources*, which ultimately determine the capacity both to create and to use technology. Three issues stand out. First, the state of pre-college math and science education is a national scandal, requiring major commitments from the Department of Education and the National Science Foundation to help turn things around. In particular, these two agencies need to develop a mechanism for creating educational innovations and diffusing the best of them throughout the country. Many have been shown to be successful in experimental situations, but—as with new technologies in our factories—the rate of adoption of new ideas in our schools is very slow. The Carnegie Commission for Science, Technology, and Government is preparing recommendations for ways these two agencies might collaborate more effectively to this end.

The second issue is the future of U.S. universities, which perform a critical role in the creation and diffusion of knowledge. If universities are to promote innovation, they must be able to attract American students to technical careers. The federal government should significantly expand student aid, reversing the trend of recent years, in order to keep tuition within a tolerable range and ease financial pressures on the universities. For their part, the universities need to reform their engineering curricula so that they conform with the realities of high-tech design and production. The traditional bias toward product research must be balanced with proper attention to the sophisticated problems of manufacturing systems.

Finally, the Departments of Education and Labor, together with the states and private industry, need to articulate a strategy for preparing young people to make the transition from school to work. In Germany, for instance, three-quarters of the non-college-bound among high school students receive three years of rigorous apprenticeship, combining one or two days a week of academic training with work experience under a "master" trainer. A stiff theoretical and practical exam then qualifies them for respectable industrial jobs. U.S. schools need to take more responsibility for preparing and placing students; at the same time, U.S. industry needs to take a long-term approach to improving workers' skills and opportunities.

A capability-enhancing technology policy is not an alternative to our existing science policy. Farsighted public investments in new research and pathbreaking technology will continue to be important, especially with the expected reduction in defense-related R&D. A more activist technology policy is, however, necessary to secure the benefits of scientific discovery, which in turn will sustain public support for continued research investments.

Japan and Germany have insatiable appetites for technology; both run deficits in their balance of payments for intellectual property. The United States and Britain, on the other hand, enjoy large (although declining) positive balances in patent licenses and royalties. The cure for the American and British problems is not the diversion of science investments to diffusion, but investments in both. This will energize the economy not only to demand more science but to use it more effectively.

Nor can U.S. policy be conducted in isolation from the rapid globalization of the world economy and the mobility of technology and capital. We have seen only a beginning of the trend to acquisitions, joint ventures, and strategic alliances between firms in different nations. The content of manufactured goods will increasingly contain components of multinational origin. It will be harder and harder to know what an "American firm" or a "foreign product" really means. Under these circumstances, the duty of our government is to focus its attention on making the United States a most attractive place for the generation and use of high-quality innovative technology. In short, the government's role is to increase the comparative advantage of Americans and their institutions.

Recommended reading

Henry Ergas, "Does Technology Policy Matter?", in Bruce Guile and Harvey Brooks, *Technology and Global Industry: Companies and Nations in the World Economy*. Washington, D.C.: National Academy Press, 1987.

Megan Jones, "Helping States Help Themselves," *Issues in Science and Technology* 6, no. 1 (Fall 1989): 56–60.

Robert Reich, "Does Corporate Nationality Matter?", *Issues in Science and Technology* 7, no. 2 (Winter 1990–91): 40–45.

REPRESENTATIVE ARMEY. Mr. Chairman, I must go to another session, and let me thank you for your generosity.

Let me just say, gentlemen, I hope you will understand that my fear is that we could create legislation that would allow our government to do for science and technology what it has done for agriculture and education, and that is a fear that I can't run away from.

Thank you.

REPRESENTATIVE HAMILTON. Thank you, Congressman Armey.

The Chairman will get a word in here eventually.

[Laughter.]

Senator Bingaman has to go, and I wanted to turn to him for a few questions.

SENATOR BINGAMAN. I'll just ask one question, Mr. Chairman. I gather that an underlying premise of this set of recommendations is that we do have, just as a matter of fact, a convergence of military and civilian technology development to an extent that has never existed before and that that change in the way science and technology is performed requires us to rethink the way we support——

MR. WEIDENBAUM. We all agree on that.

SENATOR BINGAMAN. Well, I guess if we all agree on that—that this convergence is taking place—I wonder if we really have as much disagreement in practice as seems to be here.

DARPA, today, is the major source of funding at the federal level for research into advanced materials, research into software development, research into high-performance computing and electronics of various kinds. Now, that is all dual-use. There is no question that that's dual-use, and what you're suggesting, as I understand your report, is that we be a little more explicit about the fact that that is a legitimate function for DARPA.

You're not suggesting that DARPA should go off and support technologies that don't have a very real defense application, but you are suggesting that the fact that they also have a nondefense application should not be an impediment to DARPA's taking the lead in seeing that this country stays competitive in those. Is that an accurate statement?

ADMIRAL INMAN. You've got it exactly right.

SENATOR BINGAMAN. But it seems to me that, in practice, we're moving in that direction, or I hope we're moving in that direction. I'll tell you, there is the constant sort of ideological argument that takes place around here that this is not an appropriate government function.

Much of the progress that has allowed us to do things like winning the Persian Gulf War was a result of DARPA investments in R&D at an early stage, and I think that if we're going to remain competitive in national security and if we're going to remain competitive economically, DARPA has to continue to play a very lead role.

I don't know if, just because of all of the mind fields that exist around here, whether this is the politically most salable way to go at this. But I

think it's very good food for thought, and I commend you for the report. I think it's excellent, and I appreciate your testimony.

ADMIRAL INMAN. Thank you.

MR. BRANSCOMB. Thank you.

MR. WEIDENBAUM. Senator, may I urge you, if you go that direction, to think in terms of limits, because as long as you open the tent to every civilian agency that can fund any technology of joint use at a time when the military market basket covers 90 percent of what is produced in the civilian economy, you've enabled an agency, if it so desired, to cover virtually every technological development in the country.

I don't think that's intended by the folks here. But as someone who has been observing the expansion of government since he served in Harry Truman's Budget Bureau in the late 1940s, every big government spending program starts very small.

SENATOR BINGAMAN. Well, I would suggest to you that the level of Federal Government support, or the percentage of the federal budget going to support the technology base has declined significantly over the last few decades, and we've not doing near as well now as we were in the 1960s, and I think part of what this report is intending to address is that problem.

We're spending so much money on supercolliders that we don't have any left over for the kinds of things that will really make a difference in our ability to compete in the world. You know, when you add the supercollider and the space station and all the rest of these enormous construction projects, and they have a scientific bent, but to say that these are science projects is stretching the truth. They're construction projects which are being carried out under the guise of science.

So, I think we need to do something along the lines that are proposed here. As I say, I haven't had a chance to really review all the specifics of it, but I think it's a very useful contribution.

Thank you, Mr. Chairman.

REPRESENTATIVE HAMILTON. Thank you, Senator Bingaman.

Let me go back to the beginning point here on industrial competitiveness. I was struck strongly by your comment, Dr. Weidenbaum, that the United States does not have a competitiveness problem. Now that just flies in the face of everything I've been hearing and thinking, and there seems to be a big gap between you and our other witnesses here on that point.

Rather than turning to you, let me turn to Admiral Inman and Mr. Branscomb here. How does that statement strike you?

ADMIRAL INMAN. Mr. Chairman, as you know, when I retired in 1982 from my government service, after looking at a lot of options, I elected to get involved in creating a joint research venture, owned by competing companies in an industry because of their perception— not a government perception—that they were beginning to lose their competitive edge with regard to the Japanese.

As research venture was put in place, it led me to begin to delve deeply into the issue of the country's success at what is increasingly an

international marketplace. For me, the ultimate goal here is jobs. I listened to the macroeconomists say how wonderfully the country has benefited from these cheap products of great quality and that overall the consumers benefited.

I accept that as valid and set it aside as essentially irrelevant when I think about my country and the standard of living that I hope my children and their friends will have.

I look at the period of 1982 to 1988 when we created 8.8 million new jobs in this country. Well, when you look more carefully, we actually created 10.4 million new jobs in what we loosely call the service sector, from investment bankers to fast-food emporiums. We lost 1.2 million jobs in manufacturing and 400,000 in the extractive industries. Of the 1.6 million jobs lost, the average weekly wage was $444. Of the 10.4 million created, the average weekly wage was $272.

So, for a great many of our citizens who were working in the 1980s, their standard of living has declined, and that has been largely obscured because the economists look at household income, and increasingly indeed there are two adults working to keep that family income growing.

Well, I am absolutely persuaded that we are not only losing our competitive edge in many industries—not just a few—but that it directly translates to jobs for American citizens, and unless we address these problems, that trend is indeed going to continue.

REPRESENTATIVE HAMILTON. So, we've got a huge competitiveness problem, and it's defined for you in terms of jobs.

ADMIRAL INMAN. And at least 10 million people already feel it in their pockets.

MR. WEIDENBAUM. May I respond.

REPRESENTATIVE HAMILTON. Yes, I'll give you time to respond, Dr. Weidenbaum, but let's go to Dr. Branscomb first, and then we'll go to you.

MR. BRANSCOMB. Let me say that I don't really care whether we call it a competitiveness problem or a competitiveness challenge. A challenge is often both a problem and an opportunity, and I think we have a competitiveness problem and a competitiveness opportunity.

I teach a course on science and technology strategies for competitiveness at the Kennedy School, and we tried in that course to go through the macroeconomic tests for what the character of this competitive situation is. It's a very tricky business, and I will defer to Mr. Weidenbaum on what trade balances—manufacturing marketing shares and so on—tell you and what they don't tell you. I really don't think that makes any difference.

The reality is that the United States has a much more sophisticated set of competitors overseas than it used to have, and a lot of firms haven't really awakened to that.

A lot of American companies don't think they're in international competition. Why? Because they don't export their products. But they are in international competition because their customers see competitive products from abroad on the market shelf.

Now, how do we tell if we have a competitiveness problem? Well, from a technological point of view, I would suggest that if you read the MIT book, *Made In America*, and look at the documentation of the problems that certain selected sectors of the American economy have in product design for manufacturability, in manufacturing cost and quality and in speed of response to market, that case is documented so well that there is no way you can not agree that those areas of the industry have a big problem competing.

And I can tell you it's not only true in industries like automobiles, which people constantly deride as perhaps not being as well managed as some others, but it's true in the IBM corporation and it's true in our greatest high-tech companies. They came late to the realization that manufacturing was as technically a sophisticated problem as new-product development is, and they're now learning you have to put your smartest engineers into process work and manufacturing and not closet them in an R&D ivory tower, and then patiently wait the 10 years it takes for that stuff to show up in the marketplace.

Now, that doesn't tell you whether the government has something to do or not, but it sure tells you we have a problem. Now, we don't have a problem everywhere. I'm a Director of Mobil Corporation, and our oil industry does just fine and the Japanese can't touch it.

ADMIRAL INMAN. And chemicals do very well.

MR. BRANSCOMB. But there really is a job to do if we want to look down at the details.

REPRESENTATIVE HAMILTON. Well, if I understand Dr. Weidenbaum's point, and take the semiconductor industry, he says, I think, in his statement that it's a matter of investment. That's why we slipped because we didn't invest. The Japanese invested and we didn't.

What's your response to that?

MR. BRANSCOMB. It's quite clear that in the most precipitous part of the decline of the dynamic RAM market the Japanese invested countercyclically. It's a very cyclical industry, and the companies tend to introduce new technology that drives up the costs but increases the production volume of bytes. They absorb that technology as they go down the learning curve, and then they introduce another track of technology.

The Japanese invested at a time when it didn't seem to make near-term good business sense to do it. As a result of taking a big financial hit early, they were there with the right technology before the U.S. companies had the cash to do it.

Now, you can ask, is that because the cost of capital is too high here? Is it because too large a part of our equity market is dominated by pension funds that are not interested in the long term and don't even know much about the companies they invest in? Or is it because the firms themselves didn't invest in the process technology, didn't have the right technical strategy, couldn't hire engineers with the right point of view about manufacturing versus development, needed a stronger knowledge base and

needed more cooperation within the industry? I think the answer is all of the above.

ADMIRAL INMAN. And the cash—when you've got a lot of cash—it does permit investment if you wisely do it. Once you get on the downside where you don't have the cash and you don't have the investment, and particularly when the equipment manufacturing part of it is already undercapitalized, that's where something like Sematech then comes into play to try to get the industry back in the game by getting the fundamental investment in the equipment technology.

REPRESENTATIVE HAMILTON. Does this mean that American business just made bad judgments?

MR. BRANSCOMB. They were late.

REPRESENTATIVE HAMILTON. They made bad judgments, and now we're coming along and we're going to reward them for bad judgments; is that right?

ADMIRAL INMAN. No. What we're saying is that it's so important to the overall economy that you do an investment for a period of time to try to get them back into the competitiveness process.

I have a strong desire to see sunset laws in a lot of these, whether it's quotas for imports or the rest of it.

REPRESENTATIVE HAMILTON. You have confidence that government can sunset?

ADMIRAL INMAN. It has not been demonstrated that often.

MR. BRANSCOMB. I don't think it's a we/they issue, Mr. Chairman. I spent 20 years in the government and 15 years as an executive in a private company. My view is that we all have a problem. I can remember serving in the Commerce Department under Secretary Maurice Stans, back in 1972. He told the Congress that he was a conservative and believed in a limited role for government, but already in 1972 the decline of U.S. high-tech market share was of grievous concern to him. He felt the Congress ought to do something in the technology area, and he was pressing for that.

We have had a long time to try to learn what it is about our competitors that enables them to do so well. Many Americans still believe that the reason the Japanese do so well is because they have some special ideology, or social homogeneity, or something that explains it. It doesn't explain it all.

The Japanese found a better technological paradigm for running competitive companies, and we're learning it. The government has a part to play.

REPRESENTATIVE HAMILTON. Mr. Weidenbaum, I want to give you some time to respond, but if you'll hold just a moment.

[Chairman confers with staff member.]

REPRESENTATIVE HAMILTON. Excuse me, go ahead.

MR. WEIDENBAUM. By the way, I take it that Admiral Inman's answer to your question, is the semiconductor industry asking for a bailout, it

seems to be a reluctant yes. But let me get back to his fundamental measurement of the competitiveness situation.

To put it straightforward, you don't measure competitiveness by inputs, such as employment, but by output, that is production. If you look at the manufacturing sector of the United States economy as a share of the GNP, you have a straight line for the last 30 years. Why? How do you reconcile that manufacturing is growing as fast as the economy but employment in manufacturing isn't? Simply because you're getting a much more rapid rate of productivity increase in manufacturing than in services. In other words, you can produce more with fewer people. That's precisely how you enhance your competitiveness, by enhancing your productivity.

If you look at the manufacturing sector properly, the U.S. manufacturing is holding its own. You know, year after year after year, U.S. production—physical production—hits a new all time high.

REPRESENTATIVE HAMILTON. Dr. Weidenbaum, let me ask you, do you support DARPA?

MR. WEIDENBAUM. Yes.

REPRESENTATIVE HAMILTON. You support what they do now as you understand their function?

MR. WEIDENBAUM. Acknowledging, as I do in my prepared statement, that they make some goofs, too.

REPRESENTATIVE HAMILTON. I understand that, but I mean the concept of it is OK with you?

MR. WEIDENBAUM. Sure.

REPRESENTATIVE HAMILTON. DARPA, as I understand it, puts money into all kinds of things—food processing, apparel, optics and many, many other things—that I'm sure have some defense relationship, but, my goodness, they have enormous civilian application as well.

MR. WEIDENBAUM. But I feel much more comfortable with optics than food.

REPRESENTATIVE HAMILTON. And apparel.

MR. WEIDENBAUM. Yes, although I can see very specialized apparel and food needs.

ADMIRAL INMAN. The troops who had to eat MREs would probably applaud the DARPA.

[Laughter.]

REPRESENTATIVE HAMILTON. What about this recommendation in the report that is one of the key sentences: The National Institute of Standards and Technology in the Department of Commerce have a central responsibility for supporting generic and pre-competitive research and development, not within the missions of the R&D programs of other departments and agencies.

Would you agree with that?

MR. WEIDENBAUM. That's too sweeping a statement.

REPRESENTATIVE HAMILTON. What does pre-competitive generic R&D mean? Maybe I ought to ask them. They're the ones that wrote it.

MR. WEIDENBAUM. As Mr. Branscomb properly pointed out, R&D is not a lump. It's a spectrum, basic research, applied research and development. I have no problem with the government heavily supporting basic research.

REPRESENTATIVE HAMILTON. Well, what's the difference between basic and generic and pre-competitive?

MR. WEIDENBAUM. Those are terms of art.

REPRESENTATIVE HAMILTON. Well, they are becoming very important terms, I mean because they really draw the lines here.

MR. WEIDENBAUM. As I read this, pre-competitive technology is the kind of technological research that companies on their own don't seem to have sufficient incentive to perform. But I could conjure up circumstances with a different government policy environment where the companies would have the incentive to do more of the pre-competitive technology research, such as a research consortium allowed by waving antitrust provisions, such as developmental research encouraged by reducing some of those regulatory barriers.

REPRESENTATIVE HAMILTON. Dr. Branscomb, what do you mean by that phrase, generic and pre-competitive? What's the difference between that and basic research?

MR. BRANSCOMB. The essential difference is that basic research is generally thought of as the kind of scientific work that scientists do, driven largely by their curiosity about the natural world with no serious intent that it should have some identified practical application, even though everybody has faith.

REPRESENTATIVE HAMILTON. IBM doesn't sponsor any basic research?

MR. BRANSCOMB. It does a little bit.

REPRESENTATIVE HAMILTON. It does a little bit, but not much.

MR. BRANSCOMB. It does a little bit in its corporate laboratory simply to attract the brightest minds from our universities.

REPRESENTATIVE HAMILTON. But basically not.

MR. BRANSCOMB. In fact, it's very interesting. In Washington there are great debates about basic research, applied research and development. I have never met anybody in industry that ever used the words basic and applied research. We never did in IBM. IBM invests in research of value to the company, and it doesn't care whether the motive of the investigator or the motive of his boss is predominant in choosing the target. The artful manager will provide people with incentives to think they're doing it for themselves anyway.

So, the introduction of the notion of pre-competitive, which I think really means noncompetitive, that is something companies in a consortium like MCC would think was in their individual as well as collective interests to do. That's really what pre-competitive means.

Generic means a piece of research of such broad application that it's unlikely that the investor will capture enough benefit to justify doing it, and that the aggregate benefits to the economy far exceed the cost.

That attribute is also true of basic research, but generic research includes a great many things that do not touch the frontiers of science but are nevertheless very important practical things to do. The best example would be the characterization of materials.

REPRESENTATIVE HAMILTON. In the sentence I just read, do you see anything in that sentence that differs from present Administration policy?

MR. BRANSCOMB. Nothing. The President has made six speeches in which he has advocated that his Administration will support pre-competitive, generic research. The Congress has written it into law, and the Commerce Department is doing it.

REPRESENTATIVE HAMILTON. So, in that respect your report simply states present policy.

MR. BRANSCOMB. That's correct.

REPRESENTATIVE HAMILTON. Now of course there are some differences, I presume, and let's explore that a minute. What are the differences in your report from Administration policy today?

MR. BRANSCOMB. Let me defer that one to the author.

ADMIRAL INMAN. We have recommended a number of things for the Office of Science and Technology Policy. The only area there that's not in keeping with our current policy is our belief that they need an in-house research capability to really study the proposed policies.

REPRESENTATIVE HAMILTON. Who needs it?

ADMIRAL INMAN. OSTP.

REPRESENTATIVE HAMILTON. OK.

ADMIRAL INMAN. So that's one area where we've gone beyond the Administration recommendations.

REPRESENTATIVE HAMILTON. That's an organizational issue.

ADMIRAL INMAN. An organizational issue. The second organizational issue is in how you get decisions made on a daily basis, the role for the National Security Council. The third area is in fact the organizational redefinition of DARPA's role.

REPRESENTATIVE HAMILTON. But that's more than just an organizational change.

ADMIRAL INMAN. It's an organizational change, and it offers the opportunity for some investment change. It does not specifically call for investment change, but the worry in the definition here that the Administration has is that it's going to take money away from defense. It isn't a worry that there is a proposal that's going to cause additional expenditures.

REPRESENTATIVE HAMILTON. And you don't think that's a legitimate worry.

ADMIRAL INMAN. I don't think it will occur. But their worry is that this is a process to raid the defense budget for research for other entities.

REPRESENTATIVE HAMILTON. Well, why do you leave this NARPA in Defense? I mean, look, you're talking about long range, high risk, and generic technologies with potentially high payoff.

ADMIRAL INMAN. Because 80 to 90 percent of its activity will still be for defense.

REPRESENTATIVE HAMILTON. Well, why should the 10 or 15 percent be controlled by the Defense Department if it's basically commercial?

ADMIRAL INMAN. Our sense is that Defense doesn't control in this case. If you look at DARPA's unique role of investing in areas like artificial intelligence and creating the capacity at Stanford, at Carnegie Mellon, and at MIT, which have now given this country a commercial lead in those areas, you could characterize that as a Defense control. But it was really DARPA seeing far broader potential technology uses that would have defense application even though they didn't know at the time.

REPRESENTATIVE HAMILTON. Obviously, you think this is an important part of your recommendation, NARPA. You are expanding beyond DARPA. You are pushing it into the commercial area. Why should the Secretary of Defense be controlling that?

ADMIRAL INMAN. What finally brought us to this proposal was not a concern of how DARPA expanded its empire. It was a totally different direction. How did we ensure over this rapidly changing world that DARPA would have access and working relationships with the companies where state-of-the-art technology is being done, those are not defense contractors.

REPRESENTATIVE HAMILTON. You know a lot more about this than I do, but they were very active in developing our computer capabilities, right?

ADMIRAL INMAN. Absolutely.

REPRESENTATIVE HAMILTON. What is the difference in your conception here of NARPA from the old DARPA, which got into computers?

ADMIRAL INMAN. It simply gives them a legitimate role for what they have already done.

MR. BRANSCOMB. There is a a feature that you invented out of your experience at NSA, which is worth mentioning, and that is that one of the characteristics of NARPA is a management structure that explicitly involves the Secretary of Commerce and the Director of OSTP, as well as the Secretary of Defense. That's a device that is designed to try to make sure that from a management environment point of view NARPA looks at its mission with full recognition of what the technology situation of the country is, and it can coordinate its activities with things that are done in NIST and elsewhere.

REPRESENTATIVE HAMILTON. Well, one of the functions of NARPA would include direct support of advanced technology leading to products that would be used to meet the mission objectives of nondefense agencies when requested, right?

ADMIRAL INMAN. When requested and when they brought money.

REPRESENTATIVE HAMILTON. So, that means the Secretary of Defense is going to make a judgment about a request from the Secretary of Commerce with regard to competitive technologies of some kind.

ADMIRAL INMAN. Actually, he clearly will consult, and in the structure we have here, OSTP and OMB are going to be watching it. But the example we used here, and it may not be a good one, Mr. Hamilton, is my experience as the Director of the National Security Agency, where I met the needs of the State Department and others. Anybody who had classified information they needed to protect, I would provide service for. Overwhelmingly, my customer was the Department of Defense. The Secretary of Defense is the individual I would turn to daily more or less, and if I ran into a conflict, I would go there for appeal. But it was the clear charter to reach beyond just the needs of defense, and to deal with the needs of other departments and agencies that was more cost effective.

REPRESENTATIVE HAMILTON. Now, how do you deal with the question Dr. Weidenbaum raises about limits? I mean how do you set the technology priorities in NARPA? Do you go into that in your report?

ADMIRAL INMAN. We do go into it to some degree, and we try to get the government to look across all of its areas in setting priorities, which it has not done in the past. That's under what we have to say about the Science Adviser and the Office of Science and Technology Policy.

Again, there will not be universal excitement about this proposal from within Defense, because they will see that it gives the opportunity for others to intrude on the decisionmaking process where it is now totally within the Department of Defense. So, our view is that that's a price worth paying to get more efficient use of what you already have existing, as opposed to going and creating separate organizations.

REPRESENTATIVE HAMILTON. You would see NARPA, Dr. Branscomb, as going into the—I forget what you call them—path-breaking technologies.

MR. BRANSCOMB. Yes. If I were writing the sentence in the report that refers to NARPA's mission, I wouldn't couple the word path-breaking or high-risk with the word generic, because my picture of what generic technology is, is much more like what NIST does in-house, which I don't regard as high-risk. I regard it as high generic value and high social return, or high economic return in industry. People use the word generic in Washington right now to mean whatever it is the Administration is willing to do that goes beyond what they were willing to do 5 years ago. I'll grant you it doesn't mean a lot more than that in the way it's often used.

REPRESENTATIVE HAMILTON. Your view is that there is a consensus emerging about this technology policy, Dr. Branscomb?

MR. BRANSCOMB. Yes, sir.

REPRESENTATIVE HAMILTON. Now, the technology policy is an interesting new phrase. Where did that come from anyway? I don't follow this as closely as you folks do. Where did we come up with that one? That's a way to get away from "industrial policy," I guess.

MR. BRANSCOMB. Yes, sir, absolutely.

REPRESENTATIVE HAMILTON. Industrial policy is a bad word, isn't it now?

MR. BRANSCOMB. Yes.

REPRESENTATIVE HAMILTON. Nobody is for an industrial policy.

ADMIRAL INMAN. It has become theological.

MR. BRANSCOMB. But clearly an industrial policy has several components, and we shouldn't be ashamed of talking about an industrial policy of the United States. We have an industrial policy, and it's largely laissez-faire, as it should be.

REPRESENTATIVE HAMILTON. Well, you didn't mention it in your report.

MR. BRANSCOMB. No, sir. It wasn't a report on industrial policy.

REPRESENTATIVE HAMILTON. You switched away from it.

MR. BRANSCOMB. This is a report on technology.

ADMIRAL INMAN. I'm guilty, Congressman Hamilton.

REPRESENTATIVE HAMILTON. You keep changing the terms on me all the time. I mean, I'm still on industrial policy and you fellows are talking about technology policy, and I don't understand the difference.

ADMIRAL INMAN. I've gone back to your youth, Mr. Chairman. I've gone back to the roots of looking at a discussion of the legitimate role of the government in technology policies that I trace all the way back to the Lincoln Administration, and that I pick up with the development of NASA and other activities, and found there was strong, repeated bipartisan support for the value for the country, and suddenly I find the theological debates about industrial policy. So, I just decreed we wouldn't use the term "industrial policy."

REPRESENTATIVE HAMILTON. The White House has a paper, don't they, on technology policy?

MR. BRANSCOMB. Yes. It's quoted in the back of this report.

REPRESENTATIVE HAMILTON. What does technology policy mean?

MR. BRANSCOMB. Technology policies are the policies at the government level that concern the government's mission, resource allocation, and operations of technology activities—all technology activities. So, technology policy in that sense deals with all of technology. It goes beyond the component of economic policy that is technology. If you're thinking about the part of the economy that has to do with industry, and there is more to the economy than industry, it has at least three components. It has a component of macroeconomic policy; it has a component of technology and trade policy; and there are other policies as well.

The effort to get the discussion around technology policy, which has been going on now at least as far back as Jordan Baruch's report for the Carter Administration, is to distinguish those decisions the government should make about the stewardship of the Nation's technological well-being from the decisions the government needs to make in its stewardship of the country's macroeconomic condition, because there are different federal roles in different parts of each of these.

I think most of the debate and the reason hearings like this are so important is because they allow us to try to be a little more precise and a little more meticulous in sorting out what we mean by these words we use. So, it's a very important question.

ADMIRAL INMAN. Mr. Chairman, if you will give me one more crack at it from 9 years in the private sector now.

REPRESENTATIVE HAMILTON. Sure.

ADMIRAL INMAN. If you would ask me what is industrial policy, I would say it would include cost of capital, a skilled and motivated work force, a strong base for science and technology and supporting infrastructure, quality innovation, and safety and productivity.

In this report, we've zeroed in on a small part of it—science and technology—and looked at the policies there as opposed to dealing with the broad range of problems, all of which I believe need to be addressed.

REPRESENTATIVE HAMILTON. I'll give you a moment, Dr. Weidenbaum, but I just want to pursue this consensus thing a little bit. We've got the White House paper—I guess that's the work of Mr. Bromley—on U.S. technology policy, but the White House backed away from that, didn't they?

MR. BRANSCOMB. No, they didn't back away from it.

REPRESENTATIVE HAMILTON. Didn't I understand at one point they said the report does not represent the views of the White House?

MR. BRANSCOMB. It was the "Critical Technologies Report."

REPRESENTATIVE HAMILTON. That was a different report.

ADMIRAL INMAN. It got characterized in a national newspaper in a way that caused them to change what they had——

MR. BRANSCOMB. But that report was not a report of the White House or of the OSTP. That report was a report of the Critical Technologies Panel. If you read it, you will find on the title page the word OSTP.

REPRESENTATIVE HAMILTON. OK. And it is that report the White House backed away from?

MR. BRANSCOMB. Yes, sir.

REPRESENTATIVE HAMILTON. And the U.S. technology policy paper, which Mr. Bromley put out, the White House did not back away from?

MR. BRANSCOMB. No, sir, certainly not.

REPRESENTATIVE HAMILTON. What about this Critical Technologies Institute? That is something that the White House has opposed, right?

ADMIRAL INMAN. Yes, sir. It was introduced in legislation. We were in the process of recommending an in-house research capability for OSTP when that legislation came out. So, we tried to co-opt it since it was something already authorized, and then we found that the Administration objected to putting it in place. So, we did yet the fourth rewording of that part just before the report came out.

REPRESENTATIVE HAMILTON. Why does the White House object to the Critical Technologies Institute?

ADMIRAL INMAN. I think that they object to Congress mandating adding an organization or people. It wasn't their idea.

REPRESENTATIVE HAMILTON. That's the core of their objection?

ADMIRAL INMAN. That's the core of the objection.

REPRESENTATIVE HAMILTON. It's not an objection that runs to function?

ADMIRAL INMAN. I'm not sure. I can't really speak for them.

REPRESENTATIVE HAMILTON. All right. Well, I understand that. But in any event, your report endorses the idea of the Critical Technologies Institute; is that correct?

ADMIRAL INMAN. We endorse the need for an in-house research capability to support the Office of Science and Technology Policy to get much more critical examination of proposals.

REPRESENTATIVE HAMILTON. And in-house means what there?

ADMIRAL INMAN. That it belongs to the government and not to go out and contract for it, and that in this case we were prepared to accept the proposed Critical Technologies Institute as a quick way to get there.

MR. BRANSCOMB. Which doesn't imply that we think OSTP should spend a great deal of time making a list of technologies.

REPRESENTATIVE HAMILTON. Do you think your report has very broad support in the American business community?

ADMIRAL INMAN. The parallel report, "Gaining New Ground," has very broad support.

REPRESENTATIVE HAMILTON. Now that's the private-sector report.

ADMIRAL INMAN. It was the private-sector report that looked at the technologies, evaluated where we stood and made a number of recommendations. This report, which purely talks about how government functions, has had very little private-sector input.

I have to tell you, Mr. Chairman, that in my experience in these 9 years I find leadership in the private sector surprisingly ill-informed about government functions. That's why they go and pay lobbyists to tell them how to deal with issues before Congress, as opposed to dealing with them directly, and are inclined to just throw up their hands about whether it can be improved.

There is a tendency I find, having lived on both sides, to look at the relationship between industry and government as adversarial rather than as cooperative, and I find that in government agencies as well as in leadership in the private sector.

REPRESENTATIVE HAMILTON. I didn't review your membership on this Committee, but you had a lot of private-sector people, didn't you?

ADMIRAL INMAN. There are a lot of us who have worked in the private sector, and most of us, I think, have a shared government and private-sector or academic experience.

REPRESENTATIVE HAMILTON. Dr. Weidenbaum.

MR. WEIDENBAUM. Just a few quick comments. I don't feel obliged to endorse every action of the Bush Administration, including technology

policy, but I do want to make a distinction between the very substantial legislative mandate for economic policy in the form of the Employment Act of 1946, which is also the charter for this distinguished Committee, and note that there is no real counterpart in technology policy. So, I do see here an expansion, to use a neutral term, of the role of the government in the society in the form of this new notion of technology policy.

What I find scary is a fundamental justification reading from the Carnegie Commission report, and think of the logic. DOD withdraws from the high technology pool and will continue to withdraw substantially in the future. It should therefore continue to make deposits into that pool through support of basic and applied research, etc.

Let me take another stab at that. The DOD withdraws from the pool of trained and educated manpower and therefore, in the spirit of this report, the DOD should make deposits into the pool of trained and educated manpower. The same logic, and now we get the Federal Government via the DOD into supporting schools and colleges that produce trained manpower.

What scares me is that once you open this door, there is no limit to the expansion of the government's role in this major area of the economy.

REPRESENTATIVE HAMILTON. Dr. Branscomb, did you have a comment there?

MR. BRANSCOMB. No, sir.

ADMIRAL INMAN. I do, Mr. Chairman, if I may. We aren't creating anything new there. We're simply trying to recapture the great leadership that Dr. Vannevar Bush provided to this country in the 1940s in creating a process, and we're trying to keep it going. I don't know, I may want to consider some of the other proposals that Dr. Weidenbaum offers here as things we ought to examine of other ways to make deposits on the education issue as well.

REPRESENTATIVE HAMILTON. Let me ask you, the comment we hear so frequently is that we have marvelous capabilities in research and technology and breakthroughs and all the rest of it, but that we are not able to commercialize it quickly. I presume that's what your report is getting at in a major way. Why is it we haven't been able to commercialize it? Why do we have all these brains pouring out all this stuff, and then we haven't been able to convert that quickly?

ADMIRAL INMAN. For so many years it was a domestic economy, and time was not a particularly urgent factor as long as other U.S. companies weren't in a rush either. Thirty plus years ago we opened the doors to help grow an international trading system, and, overall, we have benefitted from it, but we haven't changed our internal practices. A few companies have.

I had 21 shareholders at MCC. Four of those 21 were fleet-of-foot in looking at what was happening. They did it in different ways. In one case, engineers constantly wandered through, looking for things to improve their products, but only 4 out of 21 really were oriented—from my observa-

tion—toward the need in this new world to be much faster at taking research to product.

REPRESENTATIVE HAMILTON. Are we making progress?

ADMIRAL INMAN. Yes, we're making progress but awfully slowly. But we are making progress.

MR. BRANSCOMB. My answer would be that our firms do better at that today than they did in the 1960s. But what they didn't realize is that Japan and Germany were inventing a whole new way to do it, using the engineering that we created but institutionalizing it differently in the companies. Instead of starting with research and having a science-push notion of how you would commercialize products, the Japanese have started with manufacturing as the central activity in the company, and then have pulled the technology into manufacturing from development and research. So, they focused much more on design for manufacturability, much more on automated production, and much more on process technology.

Our companies are learning to do that, and I think it's moving quickly. I think some of the U.S. export data in manufacturing look very favorable. Largely, thanks to the fact that the Japanese and the Germans gave as much money for our fight in the war, the U.S. had a positive balance of accounts last quarter. But even without that, we would have had only a $5 billion trade deficit. So, we are making progress.

REPRESENTATIVE HAMILTON. Are we, in your judgment, as a nation underinvesting in R&D?

MR. BRANSCOMB. We are certainly underinvesting in the right kind of R&D. I think probably in fact we're underinvesting in R&D, as a whole, if you agree with my analysis that a lot of defense R&D, particularly the D part, has marginal consequences to the economy.

REPRESENTATIVE HAMILTON. All right.

MR. BRANSCOMB. We, of course, include the private sector when I say that, and I think little sized companies, in particular, are underinvesting.

REPRESENTATIVE HAMILTON. Dr. Weidenbaum, do you support the idea of Sematech?

MR. WEIDENBAUM. If the Congress were considering it today, I would be very luke warm or negative, but given the fact that the investment has been made and it's in operation, I would shoot at another target.

REPRESENTATIVE HAMILTON. All right. I have a lot of questions, but I also have another hearing this morning. So, I probably had better move to that as quickly as I can. I want to give you an opportunity to conclude with any concluding remarks that you might want to make.

Now, I would like you to address one thing. Dr. Weidenbaum reads this report and sees it as an expansion of the role of government in science and technology. That's really your underlying fundamental fear in this report, correct?

MR. WEIDENBAUM. Yes, sir.

REPRESENTATIVE HAMILTON. Dr. Branscomb, if I recall your testimony a moment ago, you said it was not an expansion of the role of government, but indeed government's share was getting less overall, and you didn't see it as an expansion.

MR. BRANSCOMB. I see it as a change in the character of the government's relationship to commercial technology, which is inevitable because of the change of events, and I will concede to Mr. Weidenbaum that it makes the problems politically tougher.

REPRESENTATIVE HAMILTON. And you're a little uneasy about some of those political decisions being made in this area, as I gather from your testimony.

MR. BRANSCOMB. Absolutely, because this government is our government, and we have to make it work.

REPRESENTATIVE HAMILTON. OK. Let's have time for any concluding comments, if you have any. I think we've had a really good discussion and I appreciate it.

Dr. Weidenbaum, please proceed.

MR. WEIDENBAUM. One point I would underscore is the neglected opportunity for cranking in the concerns that this panel properly has raised of promoting private-sector technology into the regulatory decisionmaking process. And when I say process, I mean especially at the congressional end in writing the regulatory laws, and also at the other end of Pennsylvania Avenue in administering the regulatory law, because we're seeing a rapid expansion of government regulation of business that not only doesn't take into account the impact on technology, but in good measure is setting up a whole new series of obstacles to the commercialization of technology.

REPRESENTATIVE HAMILTON. Admiral Inman.

ADMIRAL INMAN. Mr. Chairman, my disappointment, having great respect for Dr. Weidenbaum, is that when in spite of a wonderful staff and a lot of hard work, we have not written a report that can be clearly understood as to our intent. We set out to create greater efficiency and effectiveness from an existing government structure, and the thought that this was somehow a charter to grow the government, I believe, is uniformly anathema to the view of all of the participants in the study.

We also suffer from, and this is probably directly my fault, needing to read this report in parallel with "Gaining New Ground." They were both being produced at the same time, and I chaired both. "Gaining New Ground" was an effort to get the private sector to focus on their view of the issues and the needs, and this was a parallel issue to say how do you retune what government is doing to better and more effectively address industry's concerns that are laid out in "Gaining New Ground." Perhaps, in the articulation of it later, we'll be able to get the two to marry together. Obviously, your hearing is at least a help in starting that process.

Thank you.

MR. BRANSCOMB. This country finds itself with enormous opportunities in a rapidly changing world. I think the big problem we have is trying to understand the nature of how the relationship of government to the private sector needs to change. We don't want a MITI in this country. There is no other country that I know of that provides a prototype or model for the relationship of government in the private sector that we want here. We need a uniquely American one.

I think this Committee, and this is a particularly important Committee to do it, serves this country very well by trying to explore these issues and, most importantly, trying to get at least one level below the ideological level of labels and sound bytes that make this debate very difficult to have.

There is a piece of a chapter in the forthcoming book that I mentioned earlier, "Beyond Spinoff," that describes how hard it is for government to do a good job of dealing with civilian technology, particularly. It is very difficult, and the Commerce Department is struggling to learn how. I don't think we ought to multiply their budget by a factor of 10 every year. I think they need encouragement, and they will find their way. They need a sympathetic hearing from both the Congress and the business community, and I think they're getting it.

I'm quite optimistic about the future, but we have a lot to learn about new ways of doing things. We're going to have to drop some old labels, but keep the legitimate ideas that are fundamental to our political and economic system.

MR. WEIDENBAUM. May I offer an olive branch. In my forthcoming book, which my full statement draws upon, I quote——

REPRESENTATIVE HAMILTON. We're going to have to have a lot of additional hearings if we're going to cover all these new publications coming out.

[Laughter.]

MR. WEIDENBAUM. By all means. I quote admiringly from the writings of both Admiral Inman and Professor Branscomb.

REPRESENTATIVE HAMILTON. That's a good note to end on.

Thank you, gentlemen, for your contributions, and we'll conclude.

[Whereupon, at 11:25 a.m., the Committee adjourned, subject to the call of the Chair.]

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