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HIGH TECHNOLOGY CONSORTIA: THE FEDERAL ROLE

HEARING
BEFORE THE
JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES
ONE HUNDRED FIRST CONGRESS
FIRST SESSION

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JUNE 8, 1989
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CONTENTS

WITNESSES AND STATEMENTS

THURSDAY, JUNE 8, 1989

	Page
Hamilton, Hon. Lee H., chairman of the Joint Economic Committee: Opening statement.....	1
Levine, Hon. Mel, a U.S. Representative in Congress from the 27th Congressional District of the State of California; chairman, Congressional High Definition Television Caucus; and cochairman, House Export Task Force.....	2
Gomory, Ralph E., IBM fellow emeritus, and president-designate, the Alfred P. Sloan Foundation.....	39
Fields, Craig I., Director, Defense Advanced Research Projects Agency [DARPA], Department of Defense.....	56
Barfield Claude E., director, science and technology studies, American Enterprise Institute.....	65

SUBMISSIONS FOR THE RECORD

THURSDAY, JUNE 8, 1989

Barfield, Claude E.:	
Prepared statement.....	69
Article entitled "It's Still High-Definition Intervention".....	81
Fields, Craig I.: Prepared statement.....	61
Gomory, Ralph E.:	
Prepared statement.....	43
Paper entitled "Turning Ideas Into Products".....	51
Levine, Hon. Mel:	
Prepared statement.....	6
Paper entitled "Consortia and Capital: Industry-Led Policy in the 1990s".....	11

(III)

HIGH TECHNOLOGY CONSORTIA: THE FEDERAL ROLE

THURSDAY, JUNE 8, 1989

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

The committee met, pursuant to notice, at 10 a.m., in room 2359, Rayburn House Office Building, Hon. Lee H. Hamilton (chairman of the committee) presiding.

Present: Representatives Hamilton and Fish; and Senator Bingaman.

Also present: Joseph J. Minarik, executive director; and Louisa Koch, William Buechner, Carl Delfeld, and Lee Price.

OPENING STATEMENT OF REPRESENTATIVE HAMILTON, CHAIRMAN

Representative HAMILTON. The Joint Economic Committee will come to order.

This morning the committee will investigate the Federal role in high technology consortia. There's strong evidence that America's industries face a competitiveness problem. A growing list of industries are seeking Government assistance.

A number of proposals are being put forward but it's not clear to me that these proposals have been carefully thought through.

The committee is very pleased to have Congressman Mel Levine testifying before us this morning as the first witness. Congressman Levine plays a very important role in this arena as chairman of the Congressional High Density Television Caucus and the House Export Task Force, and is chairman of Rebuild America.

After Congressman Levine testifies, the committee is pleased to have a panel of three distinguished witnesses before us today to help us think about these issues. I will introduce those witnesses after Congressman Levine finishes his testimony.

We will turn now to Congressman Levine for his testimony. We are pleased to have you, sir, and any statement you have, of course, will be made part of the record.

STATEMENT OF HON. MEL LEVINE, A U.S. REPRESENTATIVE IN CONGRESS FROM THE 27TH CONGRESSIONAL DISTRICT OF THE STATE OF CALIFORNIA; CHAIRMAN, CONGRESSIONAL HIGH DEFINITION TELEVISION CAUCUS; AND COCHAIRMAN, HOUSE EXPORT TASK FORCE

Representative LEVINE. Mr. Chairman, thank you very much. I'm grateful to you for this opportunity. I will have a prepared statement that I would ask be submitted in the record. I was told that our computers broke in the middle of this exercise and therefore it's only halfway finished and unprintable at the moment.

Representative HAMILTON. When it arrives it will be made part of the record.

Representative LEVINE. We may need a consortia to deal with this concern of ours.

I am delighted that you have called this hearing and I appreciate very much the opportunity to testify on what I believe is one of this Nation's top economic priorities—the need to form high technology consortia in a wide variety of the strategic industries and technologies of the 1990's.

I would like to make three basic points which I believe are essential in this issue.

One, as a result of foreign strategies successfully targeting the key technologies and industries of the 1990's, America's industrial lead is today threatened for the first time since Henry Ford invented the modern assembly line.

Second, American companies cannot compete individually against this foreign targeting and will be increasingly forced to form consortia as well as other cooperative ventures in order to regain technological and industrial parity.

The third point is that once industry has led in creating such consortia, including pledging significant resources from private industry to these consortia, various forms of government assistance will often be necessary in order for the consortia to succeed.

These points let me stress, Mr. Chairman, are not mine alone. As you indicated, I chair a think tank called Rebuild America and recently a group of people involved with Rebuild America as well as several other leading organizations in this country, particularly the American Electronics Association and MCC, the Microelectronics and Computer Technology Corp., got together to put together a white paper entitled "Capital and Consortia, Industry-Led Policy for the 1990s."

That consortia was authored by some of the Nation's major industrial leaders as well as representatives of consortia. I will not list all of them. They will be included in my prepared statement. They included Bob Noyce from Sematech in the Silicon Valley and a number of other very distinguished Americans.

Each of the individuals who signed this white paper has a distinguished career in the private sector and represents companies or industries that are among America's winners, not losers. And they have reached their conclusions reluctantly, if not unhappily.

The careers of the authors of this white paper were working for individual companies and many originally opposed government involvement in private sector activities.

They have had the foresight, however, to recognize the world of the 1980's is fundamentally different from that of the 1960's and 1970's and that targeted American companies now have no choice but to cooperate with each other, as well as the Government, if they are to survive.

I would like to submit their document for the record, Mr. Chairman, and to strongly recommend to the members of the committee that they consider the conclusions of this white paper seriously.

Let me now just briefly summarize these conclusions and also deal with some of the arguments that are frequently made against consortia.

First, the new threat of foreign targeting. Mr. Chairman, there is no question that this Nation today faces an industrial threat without precedent in our history. Foreign targeting of virtually all of our strategic technologies and industries from machine tools to semiconductors to high definition television to superconductors. Foreign governments in Asia and increasingly in Europe have established giant public-private research consortia to commercialize the key industries and technologies of the 1990's from those nations and they have also made available vast direct and indirect subsidies to their companies to commercialize these technologies through a variety of strategies, including public subsidies, protected markets, and loan guarantees.

These strategies have worked so well for Japan that it is today the world's No. 1 financial power, possessing now 9 of the world's 10 largest banks. As a result, Japan's cash-rich private sector is increasingly able to devote long-term, low-interest capital to new industries without public subsidy on a scale undreamed of in this country.

As a result, America's long-term economic health I believe is in serious danger. We have either surrendered or are in danger of losing our lead in scores of key technologies and industries, as was noted by one of the authors of the white paper, Robert Costello, the former Under Secretary of Defense for Acquisition Policy.

Second, companies must form consortia to meet this threat. Even the largest American companies cannot now by themselves meet the threat posed by this foreign targeting. Even IBM, the crown jewel of American industry, recently warned, for example, that the Japanese are outinvesting us in x-ray lithography, a technology critical to producing semiconductor chips exceeding the 64 megabit level. IBM has built the only U.S.-owned synchrotron used in x-ray lithography. Japan has committed to building 19 synchrotron facilities, despite the fact that IBM has the only one that's been built in this country. IBM has called for creating a consortium for x-ray lithography and it has played a key role in creating both Sematech and the superconductor consortium about which Mr. Gomory is testifying later today.

If even IBM is forced to join in consortia to withstand foreign targeting, it is clear that many other American companies will also be forced to do so in the years to come.

Only such cooperative ventures can allow American industry the critical mass of capital, research and development, and personnel needed to commercialize new technologies in the timeframes being achieved by our competitors.

And it is worth clearing up one key misconception here, which is that consortia particularly benefit large companies. The fact is, consortia particularly benefits small companies. Although some suggest that consortia are meant mainly to help large companies, it is in fact the smaller ones that gain most from them. For example, the National Center for Manufacturing Sciences, a consortium of more than 80 companies, reports that its smaller machine tool companies are among the most enthusiastic about the benefits they derive from the consortium.

Mr. Chairman, I have a prepared statement explaining why I believe Government help is necessary for consortia to succeed. I believe that we must pursue an industry-led strategy in which the private sector takes the lead and the private sector commits key resources and key personnel, but I am convinced, for reasons that are outlined in the prepared statement that I will submit for the record, that we simply don't have the ability from a capital investment or a long-term loan point of view for the private sector to go it alone and I believe that once the private sector has taken the lead and invested its own risk capital, if these consortia are going to succeed in meeting the foreign targeting threat, Government help will absolutely be essential.

I am delighted that Secretary Mosbacher has embraced the industry-led strategy concept. It's my hope that he will rethink the "Uncle Sugar" response that he gave to the AEA's proposal, for example, because it will be necessary for the public sector to provide resources once the private sector has taken the lead. This is outlined in some detail in my prepared statement.

Let me just conclude by dealing with three myths that I think have attacked the notion of consortia and should be dispelled and I can deal with each of these quite briefly.

The first myth is the public support for high tech consortia is not an appropriate use of Government funds. Mr. Chairman, the root of our present fiscal crisis is our tendency as a nation to consume more than we produce. Ensuring that we produce more in the 1990's is a key to generating Government income sufficient to meet environmental, social, and defense needs. If we fail to support high tech consortia as a nation through public investment, we could jeopardize our ability to meet all of our other societal needs. When American industry was No. 1, there were better uses for Government funds. Today, however, Government support for high tech consortia is critical as an underlying, underpinning, if you will to the economy which is critical to accomplishing all of the other things that Government needs and wishes to do.

Myth No. 2, public support for high tech consortia requires unwarranted government control of industry. Critics of Government support for consortia seem to assume that Government support inevitably carries with it Government control. Critics seem incapable of imagining there could be a third alternative to either laissez-faire on the one hand, which hasn't worked in the past decade, or a kind of heavyhanded industrial policy on the other, which I believe is unnecessary.

The industry-led policy that I have been suggesting combines the best of our entrepreneurial traditions with the capital needed to compete in today's marketplace. Under this proposal, industry will

take the lead in defining the consortia and in determining which of the key strategic technologies and industries of the 1990's with Government playing a supporting role and this policy is even more important to ensuring, as I indicated earlier, survival of small businesses than of large businesses. Far from constituting unwarranted interference by Government with industry, therefore, industry-led policy is a means by which America's small entrepreneurial base of businesses can be strengthened in the 1990's.

And finally, the third myth is that past business errors preclude future support for high tech consortia.

Mr. Chairman, I have been, as you may know, among those most critical of American business in the past for such errors of judgment as not developing the VCR, for ceding auto market share to the Japanese. The time for fingerpointing, however, has passed. When far-sighted segments of the private sector come forward to form and contribute their own funds to high tech consortia, they deserve our support.

And we need to take particular exception to those who suggest that our high technology industries are coming to Government looking for a handout. High tech consortia are being proposed by the most successful companies in America and the most successful industries in America. The electronics industry, for example, is nine times larger than steel and three times larger than autos. Whatever individual mistakes it has made in the past, it is today America's biggest winner. If the electronics and other high tech industries seek Government support today, it is not because they need or seek a handout, but because foreign targeting has left them with no alternative.

Mr. Chairman, the 1990's will be fundamentally different than the past 40 years. America is challenged as never before in the postwar era and we need new solutions to these new challenges. Support for high tech consortia through an industry-led policy is one such innovative solution and I urge the Joint Economic Committee to endorse it and I thank you very, very much for holding these hearings and inviting me to testify.

[The prepared statement of Representative Levine, together with a white paper entitled "Consortia and Capital: Industry-Led Policy in the 1990s," follows:]

PREPARED STATEMENT OF HON. MEL LEVINE

Mr. Chairman,

I appreciate very much this opportunity to testify today on what I believe is one of this nation's top economic priorities: the need to form high technology consortia in a wide variety of the strategic industries and technologies of the 1990s.

Three basic points, it seems to me, need to be made:

(1) As a result of foreign strategies successfully targeting the key technologies and industries of the 1990s, America's industrial lead is today threatened for the first time since Henry Ford invented the modern assembly line;

(2) American companies cannot compete individually against the foreign targeting, and will be increasingly forced to form consortia and other cooperative ventures in order to regain technological and industrial parity; and

(3) Once industry has led in creating such consortia, including pledging significant funds to them, various forms of government assistance will often be necessary in order for them to succeed.

These points, let me stress, are not mine alone. They were recently made in a White Paper entitled "Capital and Consortia: Industry-led Policy for the 1990s," issued by leaders of some of the nation's major industrial consortia.

The White Paper's authors included: Robert Noyce, the co-inventor of the microprocessor and CEO of SEMATECH; Palle Smidt, a founder and executive vice president of the microelectronics and computer technology corporation (MCC); James Koontz and Ed Miller of the National Center for Manufacturing Sciences, a consortium begun by leaders of the machine tool and other traditional industries; and Mitchell Kertzman and Richard Iverson of the American Electronics Association, which is playing a leading role in creating consortia for High Definition Television and memory chip production; and Robert Costello, who played a major role during the last several years in creating consortia while serving as Undersecretary of Defense for Acquisition.

Mr. Chairman, each of these individuals has a distinguished career in the private sector. They represent companies and industries that are among America's "winners" not "losers." And they have reached their conclusions reluctantly. Their careers were built working for individual companies, and many originally opposed government involvement in private sector activities.

They have had the foresight, however, that the world of the 1980s is fundamentally different from that of the 1960s and 1970s, and that targeted American companies now have no choice but to cooperate with each other, and government, if they are to survive. I would like to submit their document for the record, and to strongly recommend to members of this committee that they consider its conclusions seriously.

Let me now briefly summarize the White Paper's conclusions, and also respond to some of the arguments that are frequently made against consortia.

THE NEW THREAT OF FOREIGN TARGETING

Mr. Chairman, there is no question that this nation today faces an industrial threat without precedent in our history: foreign targeting of virtually all of our strategic technologies and industries from machine tools to semiconductors to High Definition Television to superconductors.

Foreign governments in Asia and, increasingly in Europe, have established giant public-private research consortia to commercialize the key industries and technologies of the 1990s. And they have also made available vast direct and indirect subsidies to their companies to commercialize these technologies through a variety of strategies - including public subsidies, protected markets, and loan guarantees.

These strategies have worked so well for Japan that it is today the world's number one financial power, possessing 9 of the world's largest 10 banks. As a result, Japan's cash-rich private sector is increasingly able to devote long-term, low interest capital to new industries without public subsidy on a scale undreamed of in this country.

As a result, America's long-term economic health is in serious danger. We have either surrendered or are in danger of losing our lead in scores of key technologies and industries as Mr. Costello has noted.

COMPANIES MUST FORM CONSORTIA TO MEET THIS THREAT

Even the largest American companies cannot by themselves meet the threat posed by this foreign targeting.

Even IBM, the crown jewel of American industry, recently warned for example that the Japanese are out-investing us in X-ray lithography, a technology critical to producing semiconductor chips exceeding the 64 megabit level. IBM has built the only U.S. owned synchrotron used in X-ray lithography. Japan has committed to building 19 synchrotron facilities. IBM has called for creating a consortium for X-ray lithography. And it has played a key role in creating both SEMATECH and the superconductor consortium about which Dr. Gomory is testifying today.

We should also restor the civilian portion of overall federal R&D spending to its pre-Reagan historic 50-50 ratio with military R&D spending. If we do so over the next three years, we could generate \$15 billion in potential matching grants for high tech consortia without increasing the federal budget deficit. This was matched by the private sector, it could generate \$30 billion over the next three years for consortia.

Industry should also lead the effort to determine which consortia most deserve government assistance. We have a Defense Science Board, led by private sector individuals, that helps determine U.S. priorities in the defense sector. We propose that a similar industry-led entity be set up by the President to determine investment priorities in the civilian sector.

We also prefer that support for high-tech consortia be led by the Commerce Department rather than the Department of Defense. This is why I support creation of a "civilian DARPA," i.e., an agency in the Commerce Department to commercialize new technologies. But until the Commerce Department has built up its strength, we should at this time encourage a greater use of DOD money for commercialization purposes.

HIGH-TECH CONSORTIA: A TIME FOR COMMON SENSE

Our fundamental need at this time is to reach consensus on the importance of high-tech consortia.

To that end, we should be guided by the kind of Hoosier common sense that built this nation. It is time for all of us to check our ideology and theories at the door, and get down to the practical, pragmatic steps needed to rebuild this nation in the 1990s.

Mr. Chairman, our efforts in Congress should be guided by the real-life experience of top-flight American business leaders who, forced to compete in the realities of today's brutal global market, report that they cannot raise the long-term low-interest capital needed to match their competitors.

The time for academic and theoretical debates over the cost of capital, for ideological debates of the left or right, is past. American industry is under seige, and we need to apply pragmatic, practical solutions toward revitalizing it.

New times, moreover, will demand new solutions. Industry leaders say they need a new "industry-led" policy of support for consortia to survive. If their critics have a better solution, let them put it forward. But if not, let us not pretend that the solutions of the past are adequate to the challenges of the future. We need more common sense and less theory at this point in our history.

To that end, let me try to dispel some of the major myths about support for high-tech consortia that seem to be most in vogue:

Myth #1 - Public Support for High Tech Consortia Is An Inappropriate Use of Government Funds -

Mr. Chairman, the root of our present fiscal crisis is our tendency as a nation to consume more than we produce. Ensuring that we produce more in the 1990s is a key to generating government income sufficient to meet environmental, social and defense needs. If we fail to support high-tech consortia, we could jeopardize our ability to meet our other societal needs.

When American industry was #1, there were better uses for government funds. Today, however, government support for high tech consortia is critical to accomplishing all the other things that government needs to do.

Myth #2 - Public Support for High Tech Consortia Requires Unwarranted Government Control of Industry -

Critiques of government support for consortia seem to assume the government support inevitably carries with it government control. Critics seem incapable of imagining that there could be a third alternative to either "laissez-faire" on the one hand, or a kind of heavy-handed "industrial policy" on the other.

The "industry-led policy" I have described combines the best of our entrepreneurial traditions with the capital needed to compete in today's marketplace. Under this proposal industry takes the lead in defining the consortia and in determining which are the key strategic technologies and industries of the 1990s, with government playing a supportive role. And, as I have noted, this policy is even more important to ensuring the survival of small businesses than larger ones.

Far from constituting unwarranted interference by government with industry, therefore, "industry-led policy" is a means by which America's small, entrepreneurial base of businesses can be strengthened in the 1990s.

Myth #3 - Past Business Errors Preclude Future Support for High Tech Consortia -

Mr. Chairman, I have been among those most critical of American business in the past for such errors of judgement as not developing the VCR, or ceding auto market share to the Japanese.

The time for finger-pointing, however, has passed. It seems to me that when farsighted segments of the business community come forward to form and contribute their funds to high tech consortia, that they deserve our support.

And I think we need to take particular objection to those who suggest that our high technology industries are today coming to government looking for a "handout."

High tech consortia are being proposed by the most successful of our companies and industries. The electronics industry, for example, is 9 times larger than steel and 3 times larger than autos. Whatever individual mistakes it has made in the past, it is today America's biggest "winner."

If the electronics and other high tech industries seek government support today, it is not because they need a handout, but because foreign targeting has left them with no choice.

Mr. Chairman, the 1990s will be fundamentally different than the past 40 years. America is challenged as never before in the post-war era, and we need new solutions to new challenges. Support for high tech consortia through an "industry-led policy" is one such innovative solution, and I urge the Joint Economic Committee to endorse it.

Thank you.

**CONSORTIA AND CAPITAL:
INDUSTRY-LED POLICY
IN THE 1990s**

Robert Costello, Hudson Institute

Mark Dayton, Rebuild America

Richard Iverson, American Electronics Association

Mitchell Kertzman, American Electronics Association

James Koontz, National Center for Manufacturing Sciences

Rep. Mel Levine, Rebuild America

Ed Miller, National Center for Manufacturing Sciences

Robert Noyce, SEMATECH

Palle Smidt, MCC

CONSORTIA AND CAPITAL: INDUSTRY-LED POLICY IN THE 1990s

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James Koontz is Chairman and CEO of Kingsbury Machine Tool Corporation, located in Keene, New Hampshire, and Chairman of the Board of the NCMS.

Representative Mel Levine (D-CA) chairs the Congressional HDTV Caucus and House Export Taskforce, and is National Chair of *Rebuild America*.

Ed Miller is President of the National Center for Manufacturing Sciences (NCMS), a consortium of companies devoted to improving the state of manufacturing in America.

Robert Noyce is the co-inventor of the microprocessor, a founder of Intel, and currently the CEO of SEMATECH in Austin, Texas. SEMATECH is a consortium of semiconductor companies developing new microchip manufacturing technology.

Palle Smidt is senior Vice-President of the Microelectronics and Computer Technology Corporation (MCC), located in Austin, Texas. MCC is a consortium whose mission is to strengthen America's competitiveness in information technologies.

** The views expressed here are those of the authors of this statement, and do not necessarily reflect the views of the organizations to which they belong. Organizations are listed here for identification purposes only.*

This report was prepared for the "Wake Up America!" conference, held in Washington, D.C. on May 25, 1989, and co-sponsored by the American Electronics Association, the National Center for Manufacturing Sciences, and Rebuild America. For additional copies, please contact Rebuild America at 201 Massachusetts Ave. NE, Suite C-6, Washington, DC 20002 or call (202) 547-1212.

"We do not have the luxury of time. If the United States is to regain the industrial cutting-edge, it must begin now to mount an across-the-board and comprehensive national effort to do so."

-- From "Consortia and Capital: Industry-led Policy in the 1990s"

CONSORTIA AND CAPITAL: INDUSTRY-LED POLICY IN THE 1990s

Precis

During the last several years, American industries have begun to formulate a new "industry-led policy" capable of preserving our industrial leadership against foreign targeting of key U.S. industries for extinction.

Unlike "laissez-faire," this new policy sees individual companies join together and work with government to develop new technologies. But unlike "industrial policy," "industry-led policy" sees *industry* not government take the lead in determining strategic industries.

"Industry-led policy" differs significantly from past national efforts like the Manhattan Project or the space program that were organized by government from the top down. Industry has led the development of this policy through grassroots cooperative enterprises like SEMATECH, the National Center for Manufacturing Sciences, the Microelectronics and Computer Technology Corporation (MCC) and the American Electronics Association's newly proposed strategy for commercializing High-Definition Television (HDTV).

Looking out into the 1990s, "industry-led policy" will require three major elements for success:

(1) **Industry-led consortia** - An increasing number of U.S. industries will be forced to develop cooperative enterprises in the 1990s to survive foreign targeting.

(2) **Cooperation between industry and government** - industry-led consortia will need the same level of support from their government as foreign companies receive from their leaders. Government should only aid consortia to which industry has itself committed significant financial, technical, and human resources. And we need an *industry-led* entity to help establish strategic priorities in the

civilian economy, much as the industry-led Defense Science Board helps establish defense priorities.

(3) **Competitively-priced capital** is the key to success in a world in which foreign competitors enjoy a 4-1 capital cost advantage. America needs to reduce capital costs through such *macro-economic* steps as reducing the budget deficit and providing effective tax incentives for savings and investment. And we need to take such *microeconomic* steps as increasing industry financial commitments to consortia, raising private and public civilian R&D funding, providing matching grants to industry-led consortia, extending loans and loan guarantees, providing direct buys of products made by U.S. consortia, and providing other incentives such as export credits.

CONSORTIA AND CAPITAL: INDUSTRY-LED POLICY IN THE 1990s

Contents

Precis

Introduction: U.S. Lagging in Scores of Technologies	1
I. Why We Need a Strategy: The Threat From Abroad	5
II. Consortia: Industry Must Take the Lead	7
III. Cooperation: National Support Needed	12
IV. Capital: The Key	15
Conclusion: Towards a Revitalized U.S. Industry	21

CONSORTIA AND CAPITAL: INDUSTRY-LED POLICY IN THE 1990s

INTRODUCTION: U.S. LAGGING IN SCORES OF TECHNOLOGIES

There is no longer any serious question that American industry faces its greatest challenge in nearly a century. As a result, America's entire economy and standard of living is at risk. While manufacturing constitutes only 20-25% of GNP and direct employment, it is the driving force of growth and jobs throughout the entire economy. The key to meeting this challenge is to create a new industry-led partnership with government which creates an environment for industrial success, rather than for each party to continue to see the other as an adversary.

Recent studies by the Defense Science Board and former Defense Undersecretary Robert Costello, and a year-long analysis of key industries by MIT, make an especially persuasive case that American industry may be dangerously eroding and hollowing out - to a point that now threatens both our future economic health and national security.

*American industry
faces its greatest
challenge in nearly
a century.*

The *rapidity* with which the United States is losing industrial leadership is particularly disconcerting. Technological change is occurring so quickly, and new technology developments are so interrelated, that our losses in key strategic industries like memory chips and op-

toelectronics threaten our lead in an ever-growing number of other industries.

The rapidity with which the United States is losing industrial leadership is particularly disconcerting.

We do not have the luxury of time. If the United States is to regain the industrial cutting-edge, it must begin *now* to mount an across-the-board and comprehensive national effort to do so.

Much attention has been devoted to the loss of our manufacturing prowess in traditional industries like **machine tools** and **automobiles**. But our loss of leadership in the strategic industries and manufacturing technologies of the 1990s is equally disturbing.

America has virtually lost all of **consumer electronics**, and has devoted far fewer resources than the Japanese and Europeans to developing key new electronics industries like **High Definition Television (HDTV)**. America's share of the global semiconductor market had dropped 20% in the last decade, we have virtually no U.S.-owned ability to produce silicon wafers, our semiconductor equipment industry is steadily losing market share, and we lag badly in developing the X-ray lithographic techniques likely to be used to produce a new generation of microchips.

Leaders in industries from **supercomputers** to **biotechnology** to **optoelectronics** to **robotics** warn that a far greater national effort is needed to ensure that they are not overwhelmed by foreign competition in the 1990s. And a Presidential Commission and Congressional research group warn that we already lag behind the Japanese in developing commercial

applications for **superconductors**, a new technology with immense future implications for transportation, computing, chip production and energy.

In addition to documenting the problems our industry faces, however, it is now time to give more creative thought to *solutions*.

America's greatest strength is its entrepreneurialism and small business innovation. If these strengths are to be preserved, however, we need to develop an "industry-led policy" in which U.S. companies join together and initiate joint strategies to compete against foreign targeting, knowing they can count on as much cooperation from their government as foreign companies enjoy from theirs.

What is needed above all is for industry to take the lead in creating a partnership - between companies, and between industry and government. Only such cooperation can see U.S. companies successfully compete against far larger foreign competitors, backed by the full resources of their governments, banks, and society.

There are three key elements to such an "industry-led policy":

(1) Industry-led **consortia** or other inter-industry partnerships that see U.S. companies work together against far larger foreign competitors - following such successful models as SEMATECH, the National Center for Manufacturing Sciences (NCMS), and the Microelectronics and Computer Technology Corporation (MCC).

We do not have the luxury of time. If the United States is to regain the industrial cutting-edge, it must begin now to mount an across-the-board and comprehensive national effort to do so.

(2) Private-public cooperation which sees industry-led consortia enjoy appropriate support from the government, such as vigorous government action against dumping by foreign companies.

(3) A focus on providing industry with a competitive cost of capital, through *macroeconomic* measures like raising national savings and investment through deficit reduction and tax incentives, and such *microeconomic* steps as support for R&D, and matching grants or loans to industry for developing new technologies and industries.

But our loss of leadership in the strategic industries and manufacturing technologies of the 1990s is equally disturbing.

Such an "industry-led policy" differs both from traditional "laissez-faire" and "industrial policy" approaches as commonly understood.

Unlike laissez-faire, this strategy would see companies cooperate to develop joint strategies and, where appropriate, seek support from the public sector for its efforts.

But unlike an industrial policy which sees *government* pick winners and losers, "industry-led policy" would see U.S. *industry* take responsibility for developing industrial priorities and strategies in the 1990s.

Public funds would only be allocated **after** industry itself had made a significant commitment of both funds and personnel, as has occurred with SEMATECH, the NCMS and the MCC.

And the basis on which these matching funds would be allocated would be established

by *industry* leaders, just as the industry-led Defense Science Board plays a major role in determining defense priorities today.

I. WHY WE NEED A STRATEGY: THE THREAT FROM ABROAD

Many U.S. economists and policy-makers, trained in classical macroeconomic theory, have been slow to awaken to the erosion of U.S. industry. This appears to derive from a lack of understanding of new real-world realities faced by American businesses in today's increasingly global marketplace: foreign targeting of key U.S. industries on a scale without precedent in the history of this nation.

Both Japan and Europe have launched massive efforts to surpass the United States in the key strategic industries and technologies of the 1990s. A recent publication of the American Electronics Association describes the process followed by Japan:

"The pattern is the same, whether the industry is color televisions, automobiles, consumer electronics, or semiconductors:

--identify key technologies.

--close the domestic market to foreign goods in these key sectors.

--force foreign competitors to trade technology for limited market access.

--use the technology acquired and the still largely protected home market to develop economies of scale.

If entrepreneurialism and small business innovation are to be preserved, we need an "industry-led policy."

--through the 'staying power' provided by large vertically integrated companies, sustain the massive short-term losses needed to gain significant worldwide market share."

The key to the success of this process is the fact that our Japanese competitors, and increasingly those in Europe as well, have access to huge capital resources not available to individual American companies. They also enjoy a cost of capital advantage estimated at 4 to 1 over American companies, though in practice this advantage is often even greater.

Such an "industry-led policy" differs both from traditional "laissez-faire" and "industrial policy" approaches as commonly understood.

As a result, foreign countries are able to dump products in the United States at a loss in order to gain market share, a practice against which the average American company cannot compete.

Six Japanese companies invested nearly \$3 billion in new 1 and 4 megabit production lines during the last six months of 1988, for example, at a time when chip demand was soft and several American companies were announcing plans to lay off workers. The Japanese clearly had little expectation of making a short or mid-term profit on their investment, and were instead continuing a policy of taking sustained losses in order to gain long-term market share.

American companies, facing pressures from the stock market and lenders to show a profit far more quickly are unable to compete against such a strategy. Indeed, short-term pressures are such that many American companies today are forced to sell their technology and expertise to foreign buyers for a small portion of the profits

that will eventually be realized when their knowledge is turned into products reaching the marketplace.

It is clear that the old rules no longer apply. Classical economics does not apply to new knowledge-based industries where economy of scale is the main determinant of success. Traditional economics has little to contribute to an American industry facing an entirely new world of brutal competition and foreign targeting. Facing these kinds of foreign practices, the U.S. has no choice but to respond with an industrial strategy of its own.

Dozens of U.S. industries may find themselves forced to form industry-led consortia, cooperate with government, and find new avenues of access to capital, if they are to survive against foreign threats in the 1990s.

II. CONSORTIA: INDUSTRY MUST TAKE THE LEAD

If America is to regain the industrial cutting-edge in the 1990s, U.S. industry must take the lead. America is particularly fortunate in possessing the world's most creative and innovative entrepreneurial sectors, and this strength must be preserved.

It is not appropriate, therefore, to envision a large MITI-like government agency that would allocate capital to selected industries. The key, instead, is for U.S. companies to form consortia that enable them to combine their entrepreneurial strengths with the economy of

scale needed to compete with their larger foreign counterparts. (Note: The term "consortia" is used here to designate a wide variety of cooperative arrangements among companies.)

Public funds would only be allocated after industry itself had made a significant commitment of both funds and personnel.

Such consortia have a long and successful history in this nation. Cooperative efforts date back to land-grant colleges and agricultural extension in the 19th century, the post-war partnership that created the civil aviation industry, and such cooperative research efforts as the Electric Power Research Institute (EPRI) which has made numerous pioneering breakthroughs in energy research.

Particularly encouraging have been the hundreds of joint R&D consortia that have been created in the wake of passage of the 1984 Joint Research and Development Act. Three of these - SEMATECH, the National Center for Manufacturing Sciences and the Microelectronics and Computer Technology Corporation (MCC) - are particularly worthy of mention.

SEMATECH

SEMATECH is a consortium of 14 companies seeking to regain the cutting-edge in semiconductor production. SEMATECH aims to demonstrate capacity for factory-scale manufacturing of equipment capable of producing 4, 16 and 64 megabit memory chips, and other high-volume chip products. It is led by Robert Noyce, co-founder of Intel and co-inventor of the integrated circuit. SEMATECH's budget, half private and half from the federal government, amounts to \$1 billion over 5 years.

Located in Austin Texas, it was recently endorsed by the Advisory Council on Federal Participation in SEMATECH, and is considered to be a success to date.

The National Center for Manufacturing Sciences (NCMS)

The National Center for Manufacturing Sciences is a consortium of 90 companies - from GM and Ford to machine-tool companies around America - that funds manufacturing research in areas like manufacturing processes, production equipment design and technology transfer. It is led by Chairman of the Board James Koontz, CEO of Kingsbury Machine Tool Co., and President Ed Miller. It was originally funded largely from industry sources. Located in Ann Arbor, Michigan, its level of support from member companies has grown steadily.

The Microelectronics and Computer Technology Corporation (MCC)

The Microelectronics and Computer Technology Corporation (MCC) is a consortium of 35 leading electronics companies conducting cutting-edge information technology research in areas like microelectronic packaging, advanced computer architecture, advanced computer technology, software technologies, high-temperature superconductivity, neural nets and optics. It seeks to meet broad industry needs, through application-driven research, development, and timely deployment of

innovative technologies. It was originally funded entirely by industry, seeking help from government only in relaxing anti-trust restrictions on joint research. Its first chairman was Bobby Inman, and it is led today by Chairman and CEO Grant Dove. Its budget has grown steadily to some \$70 million today, and it is located in Austin, Texas.

Consortia: Where We Go From Here

Consortia should not follow a fixed model for each industry. Rather, they should be designed around the needs of each given industry. While the SEMATECH model was appropriate for the relatively mature semiconductor industry, it may not serve as a model for developing High Definition Television (HDTV) since few American companies are today involved in television production.

The consortia formed to date in this nation have been mainly involved in pre-competitive R&D. SEMATECH has gone the furthest along this route, with its goal of making prototype manufacturing equipment.

We must encourage and further such pre-competitive R&D consortia. Many more industries need to be involved. And more funding may be needed.

But it is also necessary to encourage consortia which may go beyond R&D to the promotion, manufacture, and marketing of products.

Consortia enable U.S. companies to combine their entrepreneurial strengths with the economy of scale needed to compete.

Recently, for example, a group of 36 companies organized by the American Electronics Association recommended the formation of a consortium to help create a U.S.-owned HDTV industry in the United States.

The AEA plan calls for industry commitments to HDTV to be matched by \$300 million from DOD and \$50 million from the Commerce Department over the next 3 years plus \$1 billion in low-cost loans and loan guarantees. These funds would be disbursed to companies around America by an industry-led ATV Corporation. The AEA plan provides the advantage of maintaining America's small and entrepreneurial company base, while providing it with the resources required to compete against far larger foreign competitors.

But it is also necessary to encourage consortia which may go beyond R&D to the promotion, manufacture, and marketing of products.

Representative Mel Levine (D-CA) called for a "TV Tech" consortium that closely parallels the AEA proposal. "TV Tech" would be run by American companies, and be empowered to develop a full-blown HDTV industry.

Another example of cooperative efforts going beyond R&D are present plans being developed by the AEA and Semiconductor Industry Association to encourage purchasers and producers of semiconductors to cooperate in an initiative to allow the U.S. to re-enter memory chip production.

Forming such consortia will require restructuring of anti-trust laws to allow industry-led consortia to engage in manufacturing and joint production.

III. COOPERATION: NATIONAL SUPPORT NEEDED

Although industry-led consortia must be at the heart of any effort to regain our competitive edge, they cannot do the job by themselves. Once the private sector has taken the lead to develop industry-led strategies, support from the public sector will often be needed.

The most important role to be played by the public sector is to create an overall environment - including a competitive national savings rate, and good schools - for American industrial efforts.

More direct public support for industry-led policy can take a variety of forms, but should only be accorded to projects to which industry has made a significant commitment of resources and personnel.

Forming such consortia will require restructuring of anti-trust laws to allow industry-led consortia to engage in manufacturing and joint production.

The level of cooperation between the private and public sectors will vary, of course, from project to project. The MCC originally sought federal government help only in relaxing anti-trust restrictions, and state government help in finding appropriate facilities. All funding came from the private sector. The NCMS sought no government help at all in getting started. SEMATECH, as we have seen, involved a 50-50 match from the federal government, and also received help amounting to some 20% of the original costs from state government.

Among the forms of national support for industry-led consortia that should be considered in the 1990s are:

(1) *Anti-dumping assistance* - U.S. industries cannot compete with foreign companies prepared to sell their products below cost in the United States. The U.S. government has to be far more aggressive in preventing dumping in the 1990s if we are to regain our industrial leadership.

(2) *Restructuring inappropriate anti-trust provisions* - Our antitrust laws were drafted long ago at a time when the U.S. was almost wholly concerned with its own domestic economy. Today, U.S. companies find themselves competing against giant foreign combines not affected by our anti-trust laws. We will need to restructure out-of-date restrictions against joint manufacturing, production and product development if U.S. companies are to remain competitive in the global marketplace. Such action will often actually *lower* costs to the consumer by promoting more competition not less.

(3) *Support for pre-competitive R&D* - Action is needed to encourage more R&D, including making the R&D tax credit permanent (and perhaps even increasing it), providing matching grants to R&D consortia, and promoting more effective use of work done by national R&D laboratories. The key is for more R&D priorities to be set by *companies* that are actually seeking to compete in the marketplace, while we continue to support necessary laboratory and academic research.

Once the private sector has taken the lead to develop industry-led strategies, support from the public sector will often be needed.

Both SEMATECH and the National Center for Manufacturing Sciences, for example, contract with university research centers. This helps to ensure that research work done is *useful* to commercializing new products and processes.

It is also important that full support be given to Defense Advanced Research Project Agency (DARPA) efforts to spur commercial research and development.

And greater efforts should be made to build up a capacity within the Commerce Department, e.g. through the National Institute of Standards and Technology, to support industry-led projects aimed at commercializing new technologies.

(4) Support for commercialization efforts -

In those cases where the U.S. is committed to creating or supporting an industry to which foreigners are committing considerable resources, such as High Definition Television, it may be necessary to go beyond anti-dumping, anti-trust, and R&D help by providing grants or loans to strategic industries and technologies.

R&D priorities should be set by companies that are actually seeking to compete in the marketplace.

It is highly likely that foreign threats may force a wide variety of U.S. industries to seek public sector support for industry-led strategies in the 1990s, and that priorities will have to be set as to industries to be supported, and the level of support available.

In this instance, it is important that support be prioritized for strategic industries and technologies whose fate is *linked* to the success of a wide variety of other industries, such as

machine tools, semiconductors, superconductors, or HDTV, and/or whose success will have a particularly large impact on economic growth, such as computers and electronics generally.

Such decisions should be insulated as far as possible from special interest lobbying, e.g. by following guidelines established by recognized industry leaders.

America's defense priorities, for example, are significantly affected by the Defense Science Board, a body of top Chief Executive Officers which periodically refreshes its membership. America needs to establish a similar body, e.g. an "Industry Commercialization Board," to help identify strategic industries and technologies in the civilian sector.

Greater efforts should be made to build up a capacity within the Commerce Department to support industry-led projects.

IV. CAPITAL: THE KEY

Foreign Efforts to Provide Low-Cost Capital

Key factors providing foreign companies with far greater access to capital than our own include:

(1) *Multibillion-dollar research consortia* - Both Europe and Japan have launched hundreds of research consortia in old and new industries alike. These consortia are heavily funded by government. For example, government funds provide 50% of Europe's Esprit program for information technologies.

(2) *Government support in manufacturing and production* - The European and Japanese

governments heavily subsidize production of favored projects such as the Airbus.

(3) *Large vertically-integrated corporate structures* - Individual American companies find themselves competing against huge, vertically-integrated companies, which can subsidize losses in one division with profits from another. U.S. merchant semiconductor companies, for example, find themselves hard-pressed to compete against a Toshiba or NEC which is willing to lose money on their semiconductor chips in order to gain market share, knowing they can make up the loss by profits from their consumer electronics or defense contractor divisions.

(4) *Provision of long-term capital by banks* - Japanese banks are far more willing to provide long-term, low-interest capital to their companies than are American banks to theirs. The reasons for this are many, including the fact that Japanese banks (1) can sit on the Boards of Japanese companies, (2) enter into close and long-term relations with their businesses, (3) have accumulated vast capital reserves, and (4) have seen their companies gain market share and profit over the long run from targeted industrial strategies.

America needs to establish an entity comprised of industry leaders to help identify strategic industries and technologies.

(5) *Greater national savings and investment* - Japan's postal service, consisting largely of savings of individuals and households, has assets of close to \$1 trillion, more than those of the 12 largest U.S. banks combined.

As a result of such foreign savings efforts, America's national savings are a small portion

of those of its top competitors. While America's net national savings hit a post-war low of 1.7% in 1986, for example, Japan's stood at 18% and those of France, West Germany, Italy, Great Britain and Japan averaged 10.8% in that same year. As a result, these nations were able to sustain much higher rates of net investment. Japan, for example, invested roughly twice as large a share of GNP in plant and equipment in 1986 than did the United States.

The United States no longer has the luxury of ignoring the cost of capital advantages enjoyed by our competitors. Unless urgent action is taken on both the **macroeconomic** and **microeconomic** levels, foreign capital advantages could reduce the United States to second-rate industrial status within a generation.

U.S. merchant semiconductor companies find themselves hard-pressed to compete against a Toshiba which is willing to lose money on their semiconductor chips in order to gain market share.

U.S. Macroeconomic Action: Raising Savings and Investment

The top priority for ensuring a healthy cost of capital for American industry is reducing the federal budget deficit. No other single action can do more to relieve pressure on interest rates and provide capital reserves that will be needed in the event of a recession in the 1990s.

Urgent action is also needed to provide effective incentives via the tax code, such as through:

(1) action to ensure that **capital gains taxes** incentivize long-term investments, e.g. by implementing a sliding-scale tax that eliminates

taxes on capital gains for productive investments held more than 5 years - perhaps funded by surtaxes on speculative investments;

Foreign capital advantages could reduce the United States to second-rate industrial status within a generation.

(2) incentives to increase savings, e.g. through redesigned *Individual Retirement Accounts* (IRAs) that increase overall savings and do not simply permit individuals to shift savings from one account to another;

(3) redesigned *investment tax credits* that encourage investment in productive plant and equipment;

(4) making the *R&D tax credit* permanent (and perhaps even increasing it); and

(5) reducing incentives for excessive debt by *equalizing the tax treatment of debt and equity*.

U.S. Microeconomic Action: Encouraging R&D and Commercialization

As important as such measures are to raising the overall savings rate, we must also take more direct action to encourage investment in the strategic industries and technologies of the 1990s.

Reducing the budget deficit and redesigning the tax code will take time. We cannot afford to wait. A variety of other measures must be considered:

(1) *Industrial financial commitments* to joint R&D and manufacturing efforts. Industry has made sizable financial commitments to efforts like the MCC, SEMATECH and National Center for Manufacturing Sciences. Efforts should be made to encourage many more such joint funding commitments in the 1990s.

In some cases, this will involve financial commitments to consortia. In others, it will involve the kind of joint efforts presently being developed by the American Electronics and Semiconductor Industry Associations to ease U.S. reentry into memory chip production. Efforts are underway to see purchasers and producers enter into joint agreements guaranteeing a market for memory chips.

(2) *Increased R&D funding* by both the Department of Commerce and DARPA. DARPA's present funding of R&D on key civilian technologies like HDTV, semiconductor chips and superconductors is important, and should be both encouraged and increased.

Capital gains taxes should incentivize long-term investments.

At the same time, however, we must recognize that the Defense Department is not the appropriate agency to fund large-scale civilian R&D efforts in the 1990s. We must begin now to build up a capacity within the Commerce Department, e.g., through the newly-created National Institute for Standards and Technology, to promote needed civilian R&D in the coming decade.

(3) *Matching grants* to consortia through the Department of Commerce. In the event that industry takes the lead in developing joint R&D

The United States still possesses the world's richest lode of technology, creativity and inventiveness. We need a strategy to utilize these strengths effectively.

and manufacturing consortia, and makes a significant financial commitment to them, the Commerce Department should have the resources to provide matching grants. As described above, priorities for disbursing such funds should be determined by industry leaders.

(4) *Loans and loan guarantees* - The federal government should also be prepared to make loans and loan guarantees available to industry consortia developing strategic industries and technologies. Such support should only be given to industries which themselves pledge significant resources to the project, unlike the provision of loan guarantees for synthetic fuels in the late 1970s.

(5) *Direct buys* - John Roach, CEO of Tandy, has proposed that the federal government consider "direct buys" of early products from U.S. infant industries. The FAA, military, and educational institutions, for example, could be encouraged to buy high-resolution displays from a U.S. High Definition TV consortium.

(6) *Other Measures* to promote exports, such as export credits.

CONCLUSION: TOWARDS A REVITALIZED U.S. INDUSTRY

Regaining industrial leadership will not be easy. Many key American industries have eroded so far that it may take as long as a decade for the United States to catch up with its top competitors.

While the path ahead may be difficult however, there is much room for optimism.

The United States still possesses the world's richest lode of technology, creativity and inventiveness. We have the world's largest entrepreneurial and small business sector - which remains the envy of the world. And the American workforce is still the world's most productive, and is being reinvigorated by immigrants from around the globe.

What is needed now is a **strategy** to utilize these strengths effectively. If industry, President Bush and Congress move decisively to develop such a strategy, there is no question that we can enter the 21st century still in the front rank of the world's economic powers, and restore the promise of growth for ourselves and our children.

It is time to begin.

Representative HAMILTON. Thank you very much, Congressman Levine. You've given us an excellent statement, very well presented. It raises the questions for us. We are grateful to you not only for your appearance this morning but for your leadership in this area generally in the Congress.

I have no further questions. If my colleagues have questions to Congressman Levine, now would be the appropriate time. Senator Bingaman.

Senator BINGAMAN. I do not have questions. I appreciate the testimony.

Representative HAMILTON. Congressman Fish.

Representative FISH. I have no questions.

Representative HAMILTON. Thank you very much.

I'll ask the other witnesses to come forward if they would, please. Mr. Ralph Gomory who is IBM fellow emeritus, and president-designate of the Alfred P. Sloan Foundation; Mr. Craig Fields, who is the Director of the Defense Advanced Research Projects Agency at the Department of Defense, DARPA; and Mr. Claude Barfield, who is director of Science and Technology Policy Studies at the American Enterprise Institute.

We have a most distinguished panel to help us with this problem. Gentlemen, we are grateful to you for your appearance this morning. We will hear from each of you. Your prepared statements, of course, will be made part of the record in full. Mr. Gomory, we will begin with you and just go across the panel.

**STATEMENT OF RALPH E. GOMORY, IBM FELLOW EMERITUS,
AND PRESIDENT-DESIGNATE, THE ALFRED P. SLOAN FOUNDATION**

Mr. GOMORY. Thank you very much, Mr. Chairman.

I am very glad to be with you this morning and have a chance to talk about the role of consortia in improving our country's competitiveness. Of course, we are very much involved in that considering the recent announcement about a superconducting consortia.

I'd like to talk about that, but before I get into the superconducting consortia I'd like to say a few words about the role of consortia as I see it.

There certainly are many issues involved in competitiveness, many of them are economic, such as cost of capital. But there are also technical issues, and those are the ones that I want to talk about. So I will be talking about the role of consortia in technical situations.

But even within that, I think there are situations in which consortia are fairly natural and situations in which they are considerably less natural and I'm going to try and make that distinction.

To understand that, I think you have to look at the way that science and technology does in fact contribute to products and I think there are two different ways of looking at it, two different ways that science and technology do contribute.

One is the more spectacular events which most of us have in our minds. Such things as the invention of the transistor, the invention of nuclear fission, leading first to the atomic bomb and later to nuclear power. Or the recent tremendous advances in biotechnology

based on an understanding of the fundamental molecular nature of biology.

Now when these new events come along—and superconductivity is one of these—there is then the effort to seize on this new opportunity and to make it into products. That's one way in which science and technology play a role in bringing in new products.

But there's a whole other thing which I will call the cyclic process or the process of incremental improvement. That is the process by which an existing product—for example, a semiconductor memory chip or an automobile is improved and gets better year after year, not by the introduction of some radical new idea but by a process of successive refinement in which it is redesigned, re-introduced into manufacturing, slightly improved, the design is slightly improved and the process is slightly improved. It's reintroduced in a new form into manufacturing. It's this process of cyclic improvement of the cumulation of small improvements and of manufacturing improvements that has really transformed the car from the Model T to what we have today or has moved the semiconductor memory chip from a bit to a million bits and coming up to 4 million bits.

So we have to bear in mind that there are really two rather distinct things going on here—the introduction of a new idea for the first time, and that's an idea-centered process based on our new knowledge, and there is a product-centered process which is refining the existing product with all the inhibitions that go with that—the need to use the metallurgy that was there before or not to change it too radically, to use if possible the tools that were there before and do the things the people involved in it understand.

Now when we're thinking about competitiveness, we should sort these two out because it certainly is my belief that it is in the second area, refining things that are already understood, that we have had our greatest difficulties. The automobile industry started in the United States. We dominated it. We lost it later not to helicopters but to refined automobiles. Certainly the semiconductor thing started out in the United States. We dominated it. We lost the memory section not to some new concept of memory but to a slightly improved, slightly refined and better manufactured version of the memory.

Now in these two types of activities, the consortia of which we have heard a great deal from Japan which is the VLSI consortia, such as the fifth generation and all of these things, have dealt, as does their present effort in superconductivity, have dealt with the introduction for the first time of new technology and not so much with the rapid refinement of existing product, though that is a key competitive issue.

So having made that distinction, I would say that from my point of view there's quite a natural role for these consortia and there's a great deal of precedent for them in Japan in the introduction of new technology such as superconductivity. Their role in the process of rapid incremental improvement in existing product is much less clear because that's where the differences between the companies would show up—different processes, different products—how do you contribute centrally to all of these? On the other hand, with a

brand new technology, it's much easier to see how that would happen.

So let me now return to the superconductivity consortium. This is a consortium we have proposed to move forward a new technology—high temperature superconductivity. In its proposed form as a starter it involves the Massachusetts Institute of Technology, Lincoln Labs, a government lab, AT&T, and IBM, and we hope very much that we will get other members and especially other industrial members because what we're aiming at here is to try and move this new scientific phenomena, high temperature superconductivity, toward a variety of applications. We think the consortium, one of its key advantages, will be if it succeeds in combining scientific knowledge which is represented in this case by MIT, Lincoln Labs, and also, to a certain extent, AT&T and IBM, with the broad knowledge of what the possible applications are, and for that purpose, additional members would be extremely valuable. They would benefit and the existing members would benefit.

So we hope to have a greatly expanded membership. All the present members bring to this existing research groups and we hope that the MIT part of this and the Lincoln Labs can be supplemented by Government funds.

Putting this consortium together was an educational experience, one which I think others will also go through. We are trying to combine in this consortium organizations with very different backgrounds and very different goals. IBM and AT&T and the other industrial members when they join will be potential users of the new technology. By the way, we believe that those uses are a long way off, at least 7 to 10 years for any significant commercialization.

On the other hand, MIT, another participant, cannot be envisaged even in the very long run as a user of superconducting circuits. So they're merely contributors. To balance the different roles of the participants in this consortium was not a trivial task and I think that's one of the drawbacks that goes with consortia. You have to somehow reconcile the interests of the members.

We expect to create an environment in which the participating researchers will share their results and they will work in a coordinated fashion to advance this new technology and we hope that this consortium will be helpful in several ways.

First of all, as I've really said already, by combining the scientific knowledge and the applications knowledge which we hope to have, it will establish a tighter link between the technology itself and its long-range commercialization.

It will, because of the participation of the university part, be a training ground for scientists and engineers. Because everyone commits to it very publicly, we expect that it will stay in place and it will last the very long span of time that we anticipate will be needed before any benefit comes from this new scientific understanding of superconductivity. Staying in place and stable over a long period of time is a very, very important consideration in these new technologies.

So we think that if we can get this thing going it's going to be a win-win proposition for everyone who's involved.

In summary, I would say that consortia such as the one we are in the process of forming here are certainly not universally useful.

They do seem to have a natural role in the introduction of radical new technologies. We think this is a case of this. We think it's a case in which we need this consortium because we can see that across the ocean similar consortia have formed and they unite on a very stable base the science knowledge and the application knowledge in a way that no other organization in the United States really does.

Thank you very much, Mr. Chairman.

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

PREPARED STATEMENT OF RALPH E. GOMORY

Thank you, Mr. Chairman, for providing the opportunity to appear before your Committee. My name is Ralph Gomory. I am IBM Fellow Emeritus, and President-designate of the Alfred P. Sloan Foundation. Until the first of June, I served as IBM's Senior Vice President for Science and Technology.

I am very glad to be with you this morning to talk about the role of consortia in improving our country's competitiveness. It is particularly timely given the May 23rd announcement of the Consortium for Superconducting Electronics, which is the first consortium resulting from the recommendations of the Committee to Advise the President on High Temperature Superconductivity, a Committee which I chaired.

I will discuss some of those recommendations today, particularly those that focused on the need for cooperative ventures between government, universities and industry in pursuing research and development in superconductivity.

But before turning specifically to the Committee's report and the newly formed Consortium for Superconducting Electronics, I would like to make a few general comments about competitiveness and the possible role of consortia in that arena.

Competitiveness has many aspects. Some are economic, such as the factors affecting the cost of capital, some are sociological, for example education and the work ethic, and some are largely issues of technology and of science. It is only this last category that I will discuss today.

To properly position the role of consortia in these areas, I would like to describe two very fundamental ways of making use of science and technology in bringing out products. Both are critical factors affecting our competitiveness.

First, there is a radical process in science and technology which I call the ladder process. This is the step-by-step reduction to practice of a really new idea. The atomic bomb, the transistor, and biotechnology are examples of this process where radically new technologies have been introduced and then new products have been formed around these radically new ideas. The phenomena of superconductivity would fall into this category, and I do think that consortia are more natural in this area.

A second and more common process is one in which existing products get better and develop additional features year-after-

year. It is a process of repeated incremental improvement and, while the concept may be less exciting, its effects are profound.

It is this process of incremental improvement that -- following the initial great ladder-style invention of the transistor -- has taken us in twenty years from one bit on a chip to four million bits on a chip. I raise the importance of this cyclic development process because in areas where our country has not been competitive, it has lost not to radical new technology but to better refinements, better manufacturing technology, or better quality in an existing product. It is car versus car, not car versus helicopter.

One consequence of this cyclic process is that the speed of the development-manufacturing cycle is vital. If one company has a three-year cycle and one has a two-year cycle, the one with the two-year cycle will have its process and design into production and on the market a year before the other. The one with the shorter cycle will appear to have newer products with newer technologies. While both companies may be working from the same technology base, one will soon develop a commanding competitive edge.

A key factor in the speed of the cycle, as well as in its quality and cost, is the closeness between development and manufacturing. The extent to which research and development is focused on commercial applications and the ease with which a

product can be manufactured will have a direct impact on the speed and cost with which a product can be brought to market, or further refined once it has been introduced.

In this area of cyclic improvement -- dependent as it is on the close tie with manufacturing and with the existing product -- the role of consortia, with the need to tie many manufacturing plants of many companies, and to incrementally improve many existing products of different companies, is less clear.

Returning now to superconductivity and to the superconductivity report. In that report, we point out that Japan has the largest superconductivity program outside of the United States, and that the guiding principal of the superconductivity effort in Japan is to be well structured for commercial applications. This principal is not new. In fact, it follows the Japanese government/industry/academic paradigm of research and development for a commercial purpose.

In the United States, where the bulk of our scientific research is performed by universities or by government laboratories where commercialization is, at best, a secondary consideration, the burden rightfully rests with individual companies to closely monitor new science taking place outside of their own laboratories and to find ways to integrate the new science or technology into future products or product refinements. This separation between universities' scientific

and technological advances and our nation's industries presents interesting competitive challenges.

This comparison with Japanese industry is one of the primary reasons why our Committee on superconductivity recommended consortia on superconductivity to the President. Our recommendations recognize the tremendous strengths in the U.S. of our academic community, our government researchers, and the applications knowledge of our industry.

In the superconductivity arena, the Committee found that those who contribute to the development of superconducting materials and possible applications for them will have a significant lead and a sizeable advantage. It found, further, that efforts aimed at practical applications must be sustained over the next decade or two to attain practical results. Further, in contrast to the Japanese, the group determined that while there is a high level of U.S. activity in superconductivity, most of the work is primarily structured around government rather than commercial application.

Because superconductivity is still very much in the "ladder" stage rather than the "cyclical" stage of development, much of the work will continue to be advanced by scientists. The structure that we have recommended, however, not only promotes the science but improves American competitiveness by enabling the three institutions -- universities, industry and government -- to

work together to develop application objectives and to jointly support them, manage them, and review them for progress.

The goal, therefore, of each of the four to six Superconductivity Consortia that we recommended would be to work on a jointly agreed upon scientific and technical program aimed at advancing superconductivity and its applications.

With this result in mind, on May 23rd the Massachusetts Institute of Technology, the Lincoln Laboratories, AT&T and IBM announced the establishment of the Consortium for Superconducting Electronics. Additional industry, university, and government participants in this consortium will be sought, as will support over three years from the Defense Advanced Research Projects Agency (DARPA). This support would supplement the approximately \$10 million a year in staff and facilities being provided by the initial four participants. Our recent meeting on this subject with the Director of DARPA, who will testify later this morning, was productive.

This Consortium is particularly interesting because in forming it, to date, we were able to surmount control of work issues and intellectual property issues that arose between very different organizations, companies like IBM and AT&T, who are potential users of new knowledge, and MIT and Lincoln Lab which tend to have a different structure and goals.

We will create an environment where the researchers, though remaining in their present locations, openly share information with each other.

They will be pursuing efforts in four targeted areas: (1) signal distribution and conditioning networks (i.e., interconnects); (2) junctions and Superconducting Quantum Interference Devices; (3) advanced devices and integrated circuits; and (4) high temperature materials and technology.

The formation of the Consortium for Superconducting Electronics should be helpful in a number of ways.

1. Through the interaction of the consortium participants, it establishes a much tighter linkage between the technology and its commercialization.
2. It will provide valuable training for scientists and engineers.
3. It will provide a stable base upon which to perform work over the many years we think will be needed for significant commercialization.
4. And, with the participation of secondary members in the Consortium, it will provide an environment for resource constrained small and mid-sized companies, colleges and government laboratories to participate in world-class research and development, and bring together a wider view of possible applications.

It seems to me it is a win/win proposition for all involved.

In summary, while consortia such as the one we have just announced are not universally useful, they do seem to have a natural role in enabling the commercialization of new technologies that have a long time horizon in their movement into product. Certainly this area is only a small part of the American competitiveness problem. But it could be an important one in the long run.

To the extent Congress can provide an economic and legal environment where such consortia can be employed, and assist in the funding of those that are vital to our national interests, it can only help American competitiveness.

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Ralph E. Gomory

Turning Ideas into Products

It is the speed of the development and manufacturing cycle that appears as technical innovation or leadership.

Events of the past 40 years have demonstrated in unforgettable ways that science, in addition to being a stimulating intellectual pursuit, has enormous practical power. This power has been made evident to everyone.

It was evident first in the stunningly sudden appearance of the atomic bomb—the practical result of the gradual buildup of knowledge about the atomic structure and the nucleus over the previous 40 years.

A second example of the practical power of science was the appearance and rapid evolution of the transistor—again, the result of a steady buildup of scientific knowledge (this time, about quantum mechanics and solid-state physics) since the 1920s. Today, this development, in the form of silicon chips, is rapidly transforming the world around us.

A more recent example is the spectacular scientific success of molecular biology and its practical ramification—biotechnology—which seems well on the way to affecting living beings themselves in a profound and transforming fashion.

Scientific versus Product Dominance

Since World War II, the United States has been the dominant scientific power of the world. But, to the surprise of many, automobiles, steel, and semiconductor memories have shown us that dominant science does not automatically mean dominant *industry*—even in the most high-technology areas. But we should realize that it never did. Long before, as well as after, World War II—before the world was devastated and the other industrial nations weakened—the United States was the dominant industrial power of the world. In the 1920s, for example, the United States produced more than twice as much iron, steel, and electricity as France, Germany, and Britain combined (and also more than twice as much per capita). It was on this kind of massive and efficient industrial base that were built the overwhelming air and sea armadas of World War II. All of this was done on a negligible U.S. science base. The capital of science in the early 1900s was Europe. One could say with some truth that we were the “Japan” of that period.

To understand why dominance in science does not necessarily mean dominance in products—and how the United States today can continue to excel in generating new scientific ideas, but not so much in generating competitive products—we need to think more concretely about the connection between science and products. We

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THE BRIDGE

12

need to realize that the dominance of science and scientists in creating the atomic bomb, the transistor, and biotechnology provides an example or paradigm for the introduction of radically new technology, but not a paradigm for the more ordinary process of product improvement.

Two Different Development Processes

The radical process I have been talking about so far (that produces, for example, a transistor), I call the "ladder" process. It is the step-by-step reduction to practice of a new idea. That new idea being dominant, the product forms itself around the new idea or new technology. And those who understand this idea or technology (often scientists) play the dominant role. However, there is another (indeed, much more common) process of innovation, which I will call, in contrast to the ladder, the "cyclic development" process, or the process of repeated incremental improvement. In this type of improvement process, an existing (not new) product gets better and develops new features year after year. Though that may sound dull, the cumulative effect of these incremental changes can be profound.

It is this process of incremental improvement that — following the initial great ladder-style invention of the transistor — has given us every year larger and better computer memories. In the past 20 years of incremental improvement, we have come from one bit on a chip to 1 million bits. Incremental improvement is also the process that each year gives us higher-resolution display screens, quieter and better quality printers, and so on. This process of gradual improvement is enormously important. Most products sold today were here in slightly inferior form last year, and most competition is between variants of the same product. Competition is usually my auto against your auto — not my auto against your helicopter. In areas where the United States has not been competitive, it has lost — insofar as technical factors are concerned — usually not to radical new technology but to better refinements, better manufacturing technology, or better quality in an existing product.

Characteristics of Cyclic Development

One important point to realize is that the world of incremental product development is, by definition, a world built around the existing product — not, as in the ladder process, around a new idea. The people who know that existing product best, and who decide what happens

next, are the ones already involved with it. And what they can do to improve the product is strongly affected by what it already is.

A second point to be aware of is the cyclic nature of the process. In the world of computers, printers, and displays, while the current version of a product is in manufacturing, a development team is working on the next product generation. For example, manufacturing could be making 256-kilobit (K) memory chips, while development is working on the process, other refinements, and the design for a 1-megabit chip. When they are ready, the megabit chip is introduced into manufac-

The product engineers themselves must be well informed on the relevant science and technology. . . .

turing, which gradually builds up production and phases out the 256K chip. Then the development process starts over again on a 4-megabit chip. A similar cycle of improved product and new production applies to most products in my industry, and to the products of many other industries as well.

Speed Is Crucial

One consequence of this cyclic process is that the speed of the development and manufacturing cycle is crucial. If one company has a three-year cycle and one has a two-year cycle, the company with the two-year cycle will have its process and design into production and in the marketplace one year before the other. The company with the shorter cycle will appear to have newer products with newer technologies. But, in fact, both companies will be working from the same storehouse of technology. It is the speed of the development and manufacturing cycle that appears as technical innovation or leadership. And it takes only a few turns of that cycle to build a commanding product lead.

A key factor in the speed of the cycle, as well as in its quality and cost, is the relationship between development and manufacturing. Design for manufacturability results

in a rapid start-up of production. Likewise, close ties between manufacturing and development translate into early knowledge of technical problems, into speed of introduction, and into quality. And the lack of these ties does the opposite. Another common feature of this development and manufacturing cycle is its relative imperviousness to ideas coming from *outside itself*.

Getting Ideas into the Cycle

If you want to get new ideas into the cycle from the outside, there is a right moment. You need to propose them at the *beginning* of the cycle: halfway through is too late. If you propose a better print-head one year into a two-year printer development and manufacturing cycle, the proposal is useless. Furthermore, even when the new concept is available at the start of the cycle, it will need to be pretty well fleshed out and tested so that the development team can expect to finish their work on the idea in time. Another complication is the fact that the product is often too complicated, or uses processes that are too complex, to be understood completely. Examples are electroplating baths of unknown composition or effects, reactions of ions in a plasma with surfaces, or even the vibrations and other factors affecting the flight of a read-write head over a magnetic disk.

Often in development and manufacturing, you do not know exactly how something works, but it worked last time. In this situation, small evolutionary changes are clearly more acceptable than large radical changes. All these things are manifestations of the fact that the existing product is there and is being refined by new ideas. The product, its complexities, what the development and manufacturing teams know or do not know . . . these are the factors that often dominate. And these factors often are understood only by the development teams themselves. This is nothing like the transistor ladder paradigm, where a whole new device is built around a new idea. All of these facts weigh heavily against ideas from the outside, and even more against ideas at a university level of development.

Keeping Well Informed

If new ideas are difficult to get into the cycle from the outside, then those people who are part of the cycle and who understand the present state of affairs in detail must themselves be the bearers of new ideas. This means that the product engineers themselves must be well informed on the relevant science and technology, for they are often

the only route in for new ideas. And if they are not up to date about what is happening technically in other companies or in universities, a high level of technology in the infrastructure will go to waste—or, more likely, will be seized on by a competitor. The travel-to-meetings budget, reading the technical literature, being a part of the overall engineering community—all of this is not a frill, nor is it an indulgence to the professional ambitions of the engineer. It is a *necessity* if we are to compete with those who do make these efforts, and thus are better able to incorporate change into their own complex product worlds.

Factors in Effective Competition

Our most effective foreign competition to date has been characterized by

- ‡ Tight ties between manufacturing and development;
- ‡ An emphasis on quality;
- ‡ The rapid introduction of incremental improvements often known to all in the development cycle of a preexisting product; and
- ‡ A tremendous effort, by those actually in the product cycle, to be educated on the relevant technologies, on the competition's products, and on what is going on in the world.

These are the things at which the United States, too, must excel. Much of what needs to be done in U.S. industry emerges from a better understanding of the cyclic development process: closer ties to manufacturing, design for manufacturability, a rapid design cycle, and ensuring the technical up-to-dateness of the engineers themselves. Another thing that emerges from this picture is the self-contained nature of the product development world, and the factors that make this world relatively hard to affect from outside itself.

What about Outside Factors?

Nevertheless, let us look briefly at several elements outside the development and manufacturing cycle. The first is the important area of the company's own in-house research organization.

An organization for research (as opposed to development) in industry must be closely tied to the product improvement cycle if it is to succeed. Only through close ties to development and manufacturing can it understand the progress of the cycle, present new steps at the appropriate time, and have them fleshed out enough to be acceptable. Familiarity at a personal level also helps to

THE BRIDGE

14

build this acceptability. All of this is much harder to do from a university base and even harder from government laboratories as they are now constituted.

Second, cooperative intercompany research (not development and manufacturing) can sometimes help — especially if it is performed by temporary groups made up of people who afterward return to their home companies with new knowledge, and there reenter the cycle. Further considerations include reform of the educational system, strengthening the national science base, and so on. These things are all good and help build a strong foundation — a strong infrastructure. But they are unlikely to affect the development and manufacturing

cycle itself in the short run. Their effect will be less direct and more long term. Indeed, it may be that governmental policies in this area need to be formulated with the properties of the development and manufacturing cycle in mind.

The United States has been very successful at the science and scientist-dominated "ladder" type of innovation, where a wholly new idea moves from research into a wholly new product. But there is no escaping the fact that we must learn to succeed also in the rapid, cyclical, engineer-dominated process of incremental product improvement. Neither process is a substitute for the other. We need both.

Representative HAMILTON. Thank you, Mr. Gomory.
Congressman Fish.

Representative FISH. Mr. Gomory, I'd like to get a clear understanding of what a consortium is. In 1984, we passed a joint R&D bill. We have legislation pending now which would extend that, the relaxation of antitrust laws to joint production. Some would go even further, to marketing.

Is that a consortium when people have since 1984 gotten together in joint R&D operations?

Mr. GOMORY. I'm not sure I quite follow. This particular consortium that I'm talking about, Congressman Fish, I think you would regard as a research consortium. The work that will be done in the consortium will be understanding materials and so forth. It will be guided by the desire to reduce all that to practice in the long term. So we will be working on materials that we hope some day will make wires that will conduct current without loss.

When we get to the point where that seems doable in a practical sense, which I believe is a considerable number of years away, that knowledge will then be exploited by the participants of the consortium as individual companies. So this consortium does not envisage using the knowledge in the consortium per se, but that knowledge will be passed through to the member companies who will then do production. That's the answer I'd give you.

Representative FISH. More generally, why was it necessary for your committee on superconductivity to recommend consortia on superconductivity to the President? Why did you not go ahead and just do it?

Mr. GOMORY. As individual companies?

Representative FISH. No, as a group. Why was it necessary to recommend to the President—there must be some barrier other than money.

Mr. GOMORY. You mean why don't we just get the people together to do it without asking the Government for support? That's a very reasonable question and I hope you don't mind if I give you a somewhat extended answer because it opens up several very important points.

I think, had there been only industrial participants, Congressman Fish, we could have done that because in this case the industrial participants are not asking for any money. But we did hope to involve the existing natural advantages of the country. One of the existing natural advantages of the country is the tremendous research base that exists in the universities. This is unlike Japan which doesn't have that. The university structure in Japan is relatively weak. The companies are relatively strong. In the United States we have a natural advantage in these tremendous research universities, which by the way have to a considerable extent in the past been Government funded to do that research.

We wanted to exploit that. We wanted to exploit the existence of Lincoln Labs, which does do in fact pioneering work in superconductivity. So we wanted to add to what were purely company resources which would have been something we could put together without these Government-sponsored entities as an additional source of strength basically. And it is that that introduces the Government element, Congressman Fish.

Representative FISH. So there's no legal barrier that you know of?

Mr. GOMORY. No, not at this level that I know of, Congressman Fish.

Representative FISH. Thank you.

Representative HAMILTON. Mr. Fields, please proceed.

Mr. BARFIELD. I know you don't want to get off on this, but if I understood the point you were making you would have to make a distinction between the rationale for a consortia related to production and the public policy issues it presents. These are different it seems to me. We can talk about this latter, but since it's been raised, particularly since you talked about barriers—and the rationale for public support of a research consortia. I think we will agree on that. It is when you get into coproduction or some sort of joint arrangement for production you really raise questions of anti-trust that have already I think been by and large solved in the research areas.

Representative HAMILTON. Thank you.

Mr. Fields, you may proceed.

STATEMENT OF CRAIG I. FIELDS, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY [DARPA], DEPARTMENT OF DEFENSE

Mr. FIELDS. Thank you.

As you know, DARPA is heavily involved in the area of consortia right now, so I'm going to try to bring an air of reality to some of these topics that you've raised and questions that you've raised.

We support Sematech, the microelectronics semiconductor production consortium. We also support the MCC, the microelectronics and computer technology consortium. We support currently three—actually they're in contracting—three consortia concerned with the high temperature superconductors such as you just heard a bit about. We are heavily involved at the moment in the development of a new consortium in the area of optical electronics.

So far our support of these consortia has been in a sense by ourselves within the Federal Government, but we're in discussion with other departments within the Government, like the Department of Commerce, about jointly funding such consortia.

For 30 years we've been supporting and forming teams and partnerships to do work in technology. We haven't used the word "consortia," but in fact the teams and partnerships that we've helped to arrange are consortia from my point of view.

Sometimes the organizational form has looked like a prime contractor with many subcontractors. Sometimes it's taken the form of a number of contractors with cross-licensing agreements and linked work statements that we've arranged. Sometimes there have been other organizational forms, occasionally called centers of excellence or interdisciplinary teams.

The reason I'm raising this is to say that this kind of work is business as usual for us. In fact, there's almost nothing that's going on in my Agency that isn't the support of a team of one sort or another, some called consortia and some not.

The reasons for forming these are varied. Sometimes it's to get skills and talents together that otherwise you wouldn't have. Sometimes it's to save money by reducing redundant investment. That money can be used to provide a longer term focus for R&D or do more and shorter term R&D or to be invested in production facilities or marketing or to service debt.

Sometimes the purpose is to establish standards and protocols and interfaces and common modules and components, again to help an industry. There are many motivations.

The reason I've gone through this background, 30 years of background, is not to try to establish my credentials or DARPA's credentials, but to say that this is good but not new. Thus when people criticize consortia and say that they are as yet unproven I think that is false. There is just ample evidence over our 30-year history that establishing teams like this, which are joint Government-industry activities can be very, very successful.

What I'd like to do at this point is to try to turn to some of the questions that you raised, keeping in mind that there is no necessary logical link between the idea of a consortium and the idea of Federal funding. Most consortia—there are probably about 150 in operation that I know of today—aren't federally funded. Some are, but most aren't. And the Government funds a great deal of R&D at organizations that are not consortia, although typically that's not DARPA's style.

So with that as a logical background, if I can just go through briefly the questions that you raised in your letter of invitation. No. 1, does the United States benefit from high technology consortia? Absolutely. There's a great deal of evidence from a number of our past programs as well as our existing activities that a good deal of work has come out in a very timely manner and in a very cost-effective manner. There's simply no question there.

No. 2, what will they contribute to the U.S. economy? Well, that's a little more difficult question because as you know, success in the laboratory, research and development, does not itself assure success in the marketplace. You have to invest in manufacturing capacity. You have to invest in marketing. You have to be able to deal with issues of competitive pricing. You need to access worldwide markets. And you have to be protected against unfair practices like dumping, and so on.

So just by themselves, R&D consortia are not going to solve the problem. You'll see this theme coming up again and again in my remarks. They are an absolutely necessary component, but they are not a sufficient component. More coordinated activity is needed.

The next question, what are their limitations? Well, since no two consortia that I know are alike, I don't think there are inherent limitations in the notion of teamwork and partnership. Obviously, you can do better or worse and some things succeed and some things fail. It might fail because of lack of talent or just limitations in the physics of what you're trying to do. But I don't think there's anything particularly deep in the issue of are there fundamental limits of consortia.

Next question, what lessons can be learned from consortia forms in other countries? Well, we are pretty heavily involved in knowing

about consortia in other countries. We send teams to Europe and to Japan every month or two to find out what's going on. I even have some ex-graduate students working in Europe at several consortia.

There are lots of lessons to be learned. I don't want to go into a critique of individual foreign consortia, since I don't think that's appropriate for me as a Federal official. However, the critical point is that the lessons to be learned are just common sense. If you don't have stable funding, if you don't have adequate funding, if you don't have the best people, if you don't have good ideas, you're not going to succeed. And I could go on and on. These are cliches, but they are true.

Next question, should the U.S. Government play a role in supporting consortia? Well, first of all, we already do. The real issue here, which I'll get back to later and the one that I think is fundamental to your concerns, isn't supporting consortia or other organizational forms. It is, should the U.S. Government play a more effective role in dealing with issues of competitiveness and economic strength. Consortia are a means to that end. They are not the end by themselves. Let me leave that aside for just a minute.

What type of support is most appropriate? Well, funding is the traditional sort. From our point of view, that means cost sharing for high-risk work. Cost sharing reduces the effective investment risk on the part of the partners in a consortium or other kind of team, but there are other kinds of help that we give right now, routinely, that have nothing to do with money.

We consider it our job to form links between members in a team and between that team and other groups working in the DARPA sort of community, in order to help them. For example, in the work that we are now about to begin supporting in high-definition displays, we will be making available to the participants in that work, chipmaking facilities, design tools, software production tools, and things that come out of our many other programs. We support 300 or 400 companies now, giving them opportunities they otherwise just wouldn't have available. That is part of our value added and that is what we routinely do.

What is the proper role for DARPA or other defense agencies in promoting commercial revitalization? Well, that is easily the most difficult question on the list that you sent to me, and so I am going to be able to give you just a partial answer. Right now we do support a great deal of R&D in industry. That is our normal job and a lot of that spills over into the commercial sector in areas of advanced materials, computers, telecommunications, robotics, manufacturing technology, and so on. I hope that is our proper role, because we have been doing it for 30 years, and we hope to continue and expect to continue.

There are some roles that probably are not proper, given DARPA and the Defense Department's current charter and scope. I don't expect to see us trying to do commercial revitalization in areas like clothing, agriculture, and so on. Agriculture is actually in reasonable shape. But the really interesting questions are in intermediate category. Intermediate category is concerned with defense dependence on foreign sources for critical technology—semiconductors, electronics, advanced materials, manufacturing tools, and so on.

What we are now starting to face—we started to face it in 1987, looking at semiconductors is the degree to which the Defense Department can be comfortable in achieving and assuring national security, if we are dependent on foreign-owned sources whether the sources are located in the United States or located abroad. And I don't think we have solid answers to that question and that issue as yet. How dependent do we want to be? Do we want to trust in COCOM agreements to assure that our trading partners don't give technology to our military adversaries. That is always the concern on something we just have to pay attention to.

If we are going to be concerned, what particular technologies or industries do we want to focus on? I tend to focus on advanced materials, manufacturing technologies, computers, and semiconductors, areas where there is tremendous defense importance. The technology is moving very rapidly, so if you are a year or two behind, you are in big trouble, and also areas where there is a lot of leverage of those things on almost everything else. So you get leverage from your investments.

If DOD is going to be involved in trying to achieve a degree of independence for national security, is it possible to do that without looking at the larger commercial interests? In areas like semiconductors, where there is a huge economy of scale in mass production, it may not be possible to achieve Defense's goals without looking at the larger picture. If Defense is going to look at the larger picture, should we pay the whole bill or just part of the bill, since it really is an economywide question. You know, the budget in the Defense Department is not in the best of shape at the moment for, I think, understandable reasons. We can't afford to do everything. If we are going to pay only part of the bill, who pays the other part? Who is going to take the leadership role?

DOD and perhaps DARPA has a tremendous track record of dealing with these things. Perhaps we should not. These are just very serious and deep issues that I can't myself provide answers to.

Next issue. If the Government is going to provide direct financial support, how should it decide which consortia merit funding? We apply the same criteria to choosing among consortia as to deciding whether to fund the consortia or another organizational form. It is a question of quality, quality of ideas, quality of people. Do we need R&D done of that particular sort? There is nothing unique in that question. It is just standard business practice for us. Should foreign firms be allowed to join consortia receiving Government support? If so what criteria should be used to admit them? This is a very tricky issue.

Well, first of all, you appreciate that the whole question of what's a foreign firm is as yet unanswered. It is a question of location, of production and assembly, location of R&D, nationality of the people involved in the work, loading stock ownership, and licensing policies. There are just a large number of factors, and they trade off. Would you rather deal with a firm that had production in the United States and R&D abroad or R&D in the United States and production abroad? I don't know how to handle those things with simple-minded rules. Every case requires its own examination.

But leaving the issue of definition aside, foreign participation is a question, and I will tell you what we now do; namely, in every

single case we try to say will the participation of the foreign organization be of net benefit to the United States, as we now support foreign organizations in a number of international programs. In some cases, it makes sense. In some cases, it doesn't.

Many of our international programs with our NATO allies make a great deal of sense, because it means that we can have shared costs for development. It means that we can have smaller inventories, fewer kinds of things and thus save money there.

In the case of dual-use technology, computers and semiconductors, supercomputers and so on, it is more problematic, and typically, we have not been supporting foreign firms in those areas, because we didn't see a way that there was a net benefit to the United States. But it is the question, is there a net benefit, which is the real issue? In some cases there will be and in some cases there won't be.

Then the last question you gave, should consortia be allowed to produce products or be confined to research and development? Well, again, I am not an attorney, and I don't want to deal with issues of antitrust. You know, there the concerns are fixing prices, restraint of trade, and so on. When you look at this in the context of a global marketplace, it is very hard to see how U.S.-only consortia could have the power to really fix prices and to really restrain trade, but that is something that has to be dealt with by the Justice Department, and it is that kind of issue.

So to sum up here, there is absolutely no magic in the word "consortia," but they are an excellent idea and an increasingly important idea because of the cost of R&D, you need to join together, and we consider it routine business practice to do this kind of work and will continue.

The question that really has to be faced is the one I raised earlier and said I would get back to, a more effective Government role vis-a-vis international competitiveness. As you know, we now do a lot of things. If you look at our Tax Code, the special provisions; if you look at the Omnibus Trade bill, and the 139 sections of that bill that deal with particular industries. The question is, we want to do a better job, which may or may not cost more money, a separate issue entirely. And there my focus is, frankly, an organizational one; namely, who's in charge? I mean, whose job is it to figure out what to do and what to do better?

Right now, those responsibilities are spread throughout the Government, and it is rather difficult to make progress that way.

Those are my remarks and thank you very much.

[The prepared statement of Mr. Fields follows:]

PREPARED STATEMENT OF CRAIG I. FIELDS

Mr. Chairman and Members of the Joint Economic Committee, I appreciate the opportunity to meet with you to address issues concerning high technology consortia. DARPA is deeply involved in such consortia, probably more so than any other part of the Federal Government. We are responsible for Federal participation in the industry-government consortium Sematech which is successfully developing manufacturing technology for leading edge semiconductor production. We support the Microelectronics and Computer Technology Corporation, or MCC, the first of the large scale high technology consortia, in developing advanced production technology for high performance electronic systems. We are supporting three consortia concerned with developing technology for the new high temperature superconductors. And we are deeply involved in the formation of a consortium for optoelectronics technology.

For thirty years we have supported and organized partnerships and teams -- not formally called consortia -- of cooperating groups performing high technology research and development. Sometimes these organizations have taken the form of a prime contractor, with a number of subcontractors in a close knit organization; other times these organizations have taken the form of a coalition of contractors with interlocked work statements for the sharing of R&D results, and cross licensing agreements for the use of intellectual property. Performers have included companies, universities, and Federal laboratories or National laboratories. You've heard phrases like "interdisciplinary teams" or "centers of excellence" sometimes applied to these partnerships.

The motivations for such teamwork vary. Sometimes the purpose is to assemble disparate skills and talent not found in a single company or university in order to do interdisciplinary R&D. Sometimes the purpose is to save money by eliminating or reducing redundant investment - the organizations involved agree to cooperate in some areas and compete in other areas, instead of bearing the burdensome expense of competing in all areas. The money saved can be used to do a greater variety of short term R&D; or to support a longer term focus on R&D; or to invest in production facilities so as to better capitalize on R&D; or to reduce debt, or whatever. Sometimes the purpose is to establish common standards, protocols, interfaces, modules and technology components. And sometimes the purpose, particularly of Defense support, is to establish a multi-vendor competitive industrial base for critical technology.

My purpose in mentioning this history and variety is not to establish DARPA's credentials, and my own, for addressing high technology consortia, but to point out that we are not discussing a new phenomenon. We are discussing an increasingly important phenomenon. R&D is getting to be so expensive that cost sharing is a necessity; and, R&D is getting to be

so interdisciplinary that no individual organization has the depth and breadth to go it alone

You should also realize that there is no logical connection between the notion of a consortium and the notion of Federal support for R&D. Many consortia receive no Federal funds, and most Federal support for R&D does not go to consortia. At DARPA we apply exactly the same decision criteria to supporting consortia and to supporting other kinds of organizations.

With this as background, I would like to answer the questions you posed in your letter of invitation to appear before your committee.

Does the United States benefit from high technology consortia? The answer is unambiguously yes. New technology is being developed in record time, e.g. at Sematech, and at a cost to the members -- including the Federal Government -- that is significantly lower than by other means. I see no evidence that there is any lowering of quality or competitive spirit among the participants, a speculation sometimes voiced.

What will they contribute to the US economy? This is very hard to answer. Success in R&D is necessary for, but not sufficient for success in the marketplace. You also need investment in factory capacity to capitalize on the R&D; investment in marketing; and, an environment for fair trade, open markets and fair pricing world-wide. The best I can say is that I think we are a lot better off with consortia than without consortia.

What are their limitations? No two consortia are exactly alike, and as I have indicated there are many other partnerships that are functionally equivalent to consortia but called by different names. In that context I don't see any inherent limitations in consortia. Of course, any organization, including consortia, can fail for many reasons - not enough quality personnel; technical failures limited by physics; inadequate or unstable funding, and so on.

What lessons can we learn from consortia formed in other countries? I am quite familiar with the inner workings, the successes and failures, of a number of high technology R&D consortia in individual European countries, in the European Community and in Japan. That familiarity comes from personal visits, study teams DARPA routinely sends abroad, government-only sources, and even former students of mine who are employed in such consortia abroad. As a Federal official I don't think it would be proper for me to review those efforts one by one. The lessons learned are obvious -- you fail if you don't have clear goals and focused management, if you don't have good technical ideas and the very best scientific and engineering talent, and if you don't have adequate and stable

funding, be it from private or public sources.

Should the US Government play a role in supporting consortia? As I indicated, I apply exactly the same criteria in deciding whether to support R&D through consortia or through other means.

What type of support is most appropriate? Funding is the traditional means. In many consortia the Federal funding is matched with private funding. In DARPA we add value beyond just funding by creating and managing technical links among the participants in our very large and varied, both vertically and horizontally integrated, R&D program, involving over 300 companies.

What is the proper role for DARPA, or other defense agencies, in promoting commercial revitalization? I would like to re-phrase your question. Can the DoD assure National security if it is dependent on foreign owned and controlled sources -- perhaps located in the US, perhaps located on foreign soil -- for the critical components and subsystems, like electronics, of its weapons systems? Under those circumstances, can the DoD comfortably rely on the COCOM agreements to assure that our military adversaries are limited in their access to advanced technology? If the DoD needs to assure technology independence for some critical components and subsystems, what are they and what needs to be done? Can such technology independence be assured for DoD without commercial revitalization in those areas? If not, can that commercial revitalization be assured by DoD alone, or will it require the cooperative action of other Departments of the Federal Government? Should DoD pay the whole bill for such technology independence, or should the cost be shared with other parts of the Government? Regardless of who pays the bill, should DoD, and perhaps, within DoD, DARPA, lead the effort, since it has a stronger track record of experience than anyone else in industrial base development? As you can see, these are questions for the President, the Cabinet and the Congress.

Is Sematech a good model? Sematech is a good consortium -- they are on schedule, within budget, producing results they promised -- but they are only one good model. Every consortium has, and should have, its own organizational form.

If the government is going to provide direct financial support, how should it decide which consortia merit funding? There are really two questions here. What R&D does the Government want? For Defense that is a matter of identifying the technology needed for national security. What is the best way to get the required R&D? Again, my approach to choosing among consortia, or between consortia and other organizations, is based in an unbiased manner on the usual management criteria - quality of people and

ideas, technical and management approach, cost and schedule, business policy issues like licensing, and so on.

Should foreign firms be allowed to join consortia receiving government support? If so, what criteria should be used to admit them? Again, there are two issues here. First, what is a foreign firm - foreign location of production, foreign location of R&D, foreign nationality of management, foreign nationality of workers, foreign sourcing of components and materials, foreign ownership of voting stock? No firm is fully foreign or fully American, but how do we trade off the various factors? At DARPA we don't have any simple-minded rules but judge each case on its own merits. Second, should the Government support R&D involving foreign firms, in consortia or outside of consortia? The fundamental question is whether such support provides net benefit to the US. We now support some foreign firms in international programs with our military allies, with goals of cost sharing, providing unique skills or technology, or achieving common technology among allies to reduce costs and increase interoperability. But we have not as yet significantly supported foreign firms in the development of so-called dual use technology -- technology critical for defense and also central to the civilian industrial base -- because we did not see a net gain for the US.

Incidentally, on a related subject, please realize that international technology exchange agreements may appear to be attractive in providing a level playing field in intellectual property, leaving aside for the moment who originally paid for the intellectual property. However, if one of the parties in such an agreement has significantly greater capability than the other to capitalize on intellectual property in the business arena, a level playing field in the lab may translate into a very unequal situation in the marketplace.

Should consortia be allowed to produce products or be confined to research and development? As I am not an attorney, I don't want to get into issues of anti-trust law. However, it is my understanding that the intention of such laws was to curb price fixing and to avoid restraint of trade and competition. Since we are now operating in a global marketplace, with the US sometimes a modest player and a player which more or less maintains an open and fair marketplace, it seems unlikely that a US consortium could be very successful in fixing artificially high prices or restraining competition. So I would lean toward allowing consortia to produce and even market products, although I don't want to comment on the legal issues associated with whether the anti-trust statutes need to be changed or just clarified, and I am not proposing Government support for consortia that produce and market products in pursuit of profit.

Thank you for giving me the opportunity to address your questions about high technology consortia.

Representative HAMILTON. Thank you very much, Mr. Fields. Mr. Barfield, please proceed.

STATEMENT OF CLAUDE E. BARFIELD, DIRECTOR, SCIENCE AND TECHNOLOGY STUDIES, AMERICAN ENTERPRISE INSTITUTE

Mr. BARFIELD. Thank you very much, Mr. Chairman. In the interest of economies of scale, I would like not really to go over much of what is in my prepared statement but to add just in 5 or 6 or 8 minutes a few other points related to other questions that I didn't cover in my prepared statement.

I guess that I was invited as the skeptic here, so I am happy to say that given Hobart Rowan's column this morning in the Washington Post where he referred to consortia as a euphemism for cartel, I can appear something as a moderate, I don't think that all consortia necessarily lead to cartels, though I think there is a problem down the line to some degree.

I would like preliminarily to refer back to Representative Levine's comments. While I think the public role and the role of consortia either private or public is important, I would have to start by saying something that I would say were we talking about trade policy. Often trade policy—in this case to some degree direct or targeted—R&D policy is not nearly so important to the kinds of overall concerns it seems to me Congressman Levine raised as macroeconomic policy. The key, it seems to me, since he raised the issue of U.S. competitiveness and the trade deficit, the answer to those questions to overall and long-term U.S. competitiveness relate to issues of U.S. productivity, education, tax policy, budget policy, and deregulation. In other words, creating a business environment. And just as I think the recent trade bill will probably not help us in terms of competitiveness, so I think any R&D policy we are talking about this morning, though I think R&D is quite important, certain that it is done by the private sector and indeed much that is done by the public sector is not as important as larger economic policies of the U.S. Government.

Now let us talk, second, to the question of consortia and public support. There I will refer to my prepared statement where I preliminarily noted that there are a number of linkages that firms make and universities and nonprofit organizations make, and they have proliferated in the last 10 to 15 to 20 years. I think a point to note at the outset is that the role of the Government is not, it seems to me, very much bound by the particular form, and that is, it seems to me that the criteria that one will end up setting up as to what the Government does vis-a-vis consortia may not be very different from the way you would set up something as just a linkage between a particular set of firms or even an individual firm. There may be a reason for the Government to support a particular firm if it has an idea.

There may be reasons, even though the example is a very bad one, given what seems to have happened, for the Government to support a particular university. And that has just happened, cold fusion, you know, even though the end doesn't seem to be very good.

In other words, the reason for Government funding, it seems to me is, by and large, independent of the particular organization. I also would say that I think that though times change and particular forms of organization change, I guess I should refer back to something Mr. Fields said. I think he is right. DARPA and other Government agencies have been supporting what now are called consortia for a long time. So we just have a new name for Government support. It reinforces the point I make about organization not making that much difference.

It seems to me that, to get back to the rationale, that the Government exerts its force best in two areas. One, basic research and second, and this has come more to the fore, and we can talk more about this, generic research or research that is just not free flowing to gain knowledge across the board but is aimed at a particular set of problems that cut across issues in a particular area.

The nature of combustion, for instance, in relation to automobile engines or something like that, that one particular company or an industry could not see the payoff in economic terms, that the social benefits were much larger possibly than the private benefits to a particular set of firms, and there you will probably have some market failure, and there is a rationale for public support.

Beyond that, whether you are talking about a consortia or individual company of whatever form, I think you begin to get into difficulties and the consortia movement has fanned back and forth.

Let me note a couple of things about other facts or factors we have to keep in mind in relation to Government support, whether it is consortia or individual companies.

Every year there are over 200,000 new businesses started in the United States. Certainly, there is no way that the rationale couldn't be made, or the fiscal or natural resource could be put from the public side to those businesses, and then you have to decide how and under what conditions one would want to support a particular industry or a particular business. Obviously, and I raise this because we have had, as part of the last year, a set of propositions but forward that there are certain industries that are more important than others, that are strategic or critical.

I would suggest that most economists will argue that it is very difficult, if not impossible, to judge what is or is not important. So when you go beyond a certain point, beyond basic or generic research, when you are making judgments that get into prototype or demonstration development, you really are at sea. And what is likely to happen—I am being very brief here, so we can discuss this later—is that corporations or the businesses or the sectors with the largest political clout are likely to get the most funds. This is not likely to be based on any particular rational criteria.

A second point to note is that when you get closer to actual commercialization, we have a very efficient and effective venture capital set of funds in the United States. There are over \$30 billion to be devoted today to venture capital for new startups or for existing businesses who want to go into a new particular venture. And I think that that is the place that beyond a certain point the private sector should be directed. And one of the problems that you face—again, I am being brief—with the rationale that has been presented for consortia, is that I think the political process has reversed what

should be happening. In other words, there is a tendency, and I will take the HDTV as an example. I will come back to that, because the plan that we have now before us for the corporations and the particular sector to come to the Government first and without having seen or given a particular rationale that there is any particular market failure here—and again, I will have to say depending on what it wants. And I just will make one other point about that.

There are some 36 corporations in the HDTV coalition. I just did a back of the envelope calculation about the cash sales of the top 15. It is a \$192 billion business. Now depending on what they want from the Government—again, to go back to the distinction between, let's say, some basic research or generic research vis-a-vis product development. It seems to me that there are a lot of resources in that area for these companies first to invest on their own, and then if there is some need maybe later to come back to the Government.

But what we have before us with high definition television is a wide scale plan which asks for not only direct funding of research subsidies but for loan guarantees and direct loans. We can come back to that in some detail later.

That leads me to the second point I want to make and that is I think we have to connect U.S. research policy or science or technology policy with other policies. And again, let me just take—I don't mean to pick on the HDTV people, but as I say, there we have a full plan. In relation to high definition television, rebuild America, and Mr. Noyce, who is part of Sematech, but who has spoken about high definition television as well as Sematech, have advocated over the last few weeks and months, the following kinds of Government help or Government regulations: that you think about licensing only technology to U.S. companies, that you think about a guaranteed market. I have mentioned product loans and loan guarantees. The forced purchase, only if the Government gave money to the advanced television corporation of U.S. semiconductor chips, direct subsidies, the potential, at least, of excluding foreign corporations.

This is probably not an exclusive list, but the point of that is that many of the individual suggestions that I have listed fly in the face of U.S. trade goals and U.S. international economic goals which are for more open markets and for allowing our corporations to invest freely and to decide on the basis of market judgment where they will invest and put production facilities.

Let me just take a couple of examples. We have been at odds and will probably go to the mat at some point if something is not done about it in the near future with the makes of at least \$12 million to \$15 million and are probably much more than that when you get in kind and other kinds of help from the Government. And we have argued that that is an unfair subsidy and that it is hurting our corporations. I think we should be very careful when we think about plans that would then lead us in the direction of subsidy on anything, a subsidy on production or guaranteed loans, or closed markets. As I say, we can come back to that.

Second, we are also not just in the unfortunate super 301 but in other bilateral negotiations again and again going to the mat with other countries on performance criteria for investment. The list

that I have just given you that has been suggested for HDTV is performance criteria that we are fighting around the world to stop because they are hurting our corporations.

So the bottomline, I think, is that we have to be very careful in that what we do in relation to, whether it is technology policy or whether related to consortium or other, that we do not, on the one hand, take away from our corporations what we try to give them on the other.

I think I will just leave it there, and we can discuss this matter more fully. Thank you.

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

PREPARED STATEMENT OF CLAUDE E. BARFIELD

Industrial Consortia

Mr. Chairman, I am happy to accept your invitation to appear before the Joint Economic Committee this morning to discuss issues related to the role of high-technology consortia. I should like to note at the outset that as a nonprofit and nonpartisan research institution, the American Enterprise Institute takes no policy stands and thus the views expressed in my testimony are my own.

It is my understanding that you would like to spend most of the time in discussion, so I shall keep both my written statement and my oral remarks quite brief. My written statement consists of a discussion of the positive aspects of consortia, as well as potential limitations; in addition, I should like to introduce an article I wrote for the Wall Street Journal which gives my views on the political context in which the consortia phenomenon--particularly for HDTV-- has emerged.

The emergence of new peers and fierce competition in the international marketplace has highlighted the importance of an effective and efficient R&D investment mechanism for long-term national competitiveness. Firms have been forced to re-evaluate "go it alone" practices and prompted to reduce unnecessary duplication of research results and choose from an array of collaborative arrangements to pursue their strategic objectives.

Research consortiums are only one in this spectrum of

potential arrangements which include cross-licensing, technology exchanges, joint R&D ventures and second sourcing. Chart 1 illustrates the extensive network of U.S.-Japanese interfirm alliances stretching across industrial sectors. Motorola is one example of how an individual company can enter into a variety of public and private collaborative arrangements in order to enhance their competitiveness in key product lines. As chart 2 shows, Motorola as of 1986 had technical ties to a number of foreign firms (and through them to foreign research associations) and to U.S. private and public R&D programs.

Chart 1

Analysis of Three-Hundred-Twenty-four Interfirm Technology
Agreements, 1980-82

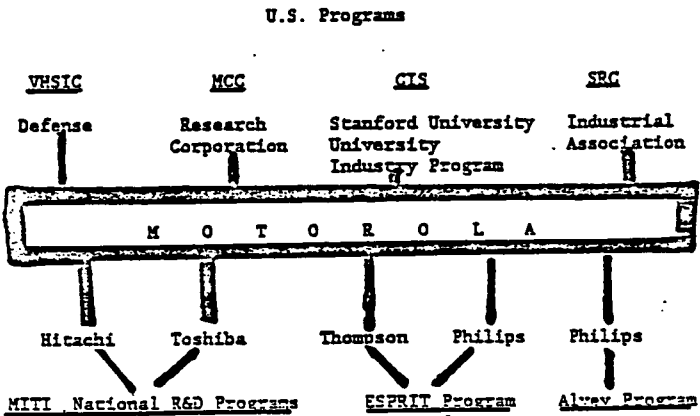
TOTAL NUMBER OF COMPANIES AND U.S. - JAPANESE AGREEMENTS BY INDUSTRY SECTOR

<u>Industry Sector</u>	<u>Number of companies</u>	<u>Number of Agreements</u>
Aerospace	2	4
Automotive: cars, trucks	2	3
Automotive: parts, equipment	3	5
Building materials	4	4
Chemicals	28	62
Conglomerates	8	10
Drugs	33	53
Electrical	3	16
Electronics	7	10
Food, beverage	4	4
Fuel	9	16
Information processing: computers	6	21
" " : office equipment	1	1
" " : peripherals, services	4	4
Instruments	4	5
Machinery: farm, construction	3	3
Machinery: machine tools, industrial, mining	32	32
Metals, mining	3	3
Misc. manufacturing	6	9
Oil service and supply	1	4
Semi-conductors	7	18
Steel	11	17
Telecommunications	3	9
Tires and rubber	2	2
nec construction, engineering	16	18
TOTAL	202	324

Source: Lois S. Peters, Technical Network between U.S. and Japanese Industry, Rensselaer Polytechnic Institute, March 1987.

Chart 2

**Participation of Firms With Technical Ties to Motorola
in National R&D Programs and Motorola's
Participation in U.S. Programs**



1. VLSI
2. Fifth Generation Computer Project
3. Optoelectronics
4. New Function Elements

Japanese National
R&D Programs

European
National R&D Programs

Source: Lois S. Peters, Technical Network between U.S. and Japanese Industry, Rensselaer Polytechnic Institute, March 1987.

Economics of Consortia

For collaborative arrangements between more than two firms research consortiums are an attractive mechanism to decrease the cost to an individual firm from performing research whose results can be used simultaneously by other firms without permission or compensation to the innovating firm. If these market-failure problems are ignored then the net result will be an inadequate level of investment from society's perspective. Research consortiums are particularly useful for high tech industries due to the large percentage of sales devoted to R&D and the increasing difficulty of recouping individual firm investment costs due to shorten product cycles and globalization of information markets.

There are, however, limitations on the effectiveness of consortiums beyond areas of pre-competitive research as numerous economists and industry analysts have noted. The problem of cooperation between consortium members who are also rivals is just as problematic for corporations in industrial R&D consortiums as it is for military allies in joint R&D efforts like the FSX. Also, the economic rationale for public support weakens as a consortium's objectives approach the market place since the individual firm's problem of capturing benefits for exclusive use is likely to be less severe.

Consortia are also not appropriate for every industry. As the recent report on federal participation in Sematech noted, clear common technology objectives are necessary for the creation

and cohesiveness of the consortium. Given the variety of proposed HDTV standards and contending private agendas currently making the rounds of the FCC and Congress, the prospects for an effective HDTV consortium -private or public-seem remote. Irrespective of all the fanfare, in the absence of common ground an actual industry-led approach in HDTV is unlikely.

Overall, consortiums are a useful tool that have emerged as international trends have forced changes in both private and public paradigms of behavior. These changes via the consortium framework have important benefits and limitations that should be recognized.

More specifically, a research consortium can reduce an individual firm's cost from investing in a technology whose benefits spill over to other industry participants free-of-charge. In the absence of cooperation, an individual firm covers the full cost of technology investment but captures only part of the benefits since the knowledge produced is intangible and assignment of property rights is inherently difficult. Employee mobility and reverse engineering also contribute to this leakage of benefits and reduced incentive to undertake R&D. Consortiums are a response to this traditional free-rider problem which has been aggravated by the globalization of the information market. Through up front R&D cost sharing, members spread out project costs in new or leaky technology and restore technology investment incentives.

Second, a research consortium can realize the beneficial

sharing of research results that would otherwise be in the interest of the individual firm to restrict. Research has "public good" qualities in the sense that simultaneous use by different parties is possible without adding to cost. This unique quality means that wide-spread dissemination of research results would be socially desirable, but not optimal at the individual firm level. Consortiums address this divergence in social and private returns by facilitating the spread of results at least to a subset of the market while sharing the building costs of a common technology base.

A third related and much acclaimed benefit of consortiums is the potential to match scale advantages of foreign competitors by making more efficient use of investment resources devoted to common technology objectives. This potential to avoid unnecessary duplication is derived from ability of member firms to use research results simultaneously. The opportunity for cross-fertilization of ideas due to complementary skill and experiences of members further enhances the efficiency of research activity. If invested in a diverse portfolio, the pooling of technological resources also permits reduction of individual firm portfolio risk and a longer term perspective than an individual firm could afford with respect to large or risky projects. The importance of risk sharing via consortiums is dependent on existence of imperfect capital markets that preclude efficient allocation of risk by investors themselves in portfolio decisions.

Consortiums are also a particularly useful mechanism for encouraging process oriented innovation which has been largely underfunded by both private and public sectors. Research in process innovations has been identified by the NSF, the CBO, and a variety of industry analysts as a gap between public sponsorship of basic R&D and individual firm research focused on product development.

There is, however, a down-side to consortiums that cooperation may facilitate collusion to slow the pace of innovation. Members would have a collective incentive to restrict the use of results in order to preserve a technology monopoly for as long as possible. Provided independent R&D is not precluded by the consortium arrangement, the common cartel policing problem will limit the potential for effective collusion. All the fuss over the Texas Instruments-Hitachi business alliance to jointly develop 16-megabit memory chips demonstrates the potential difficulty of retaining information within the bounds of a consortium such as Sematech.

The principal problem associated with consortiums is the prospect of immediate competition between members in the use of results which will tend to undercut a firm's incentive to participate in or conduct real research. To the extent that non-members have significant market share or member firms are in different end-product markets, the incentive to undertake common research is partially reinstated. This was the case for both MCC and Sematech with non-member foreign chip firms having a

significant market presence and small aggressive domestic firms vying for larger shares.

In addition, the scope of consortiums is limited by incentives of private members. Based on the Japanese experience and the logic of competitive dynamics, several industry analysts and economists have noted cooperative R&D tends to differ from internal R&D. In particular, "break-throughs" will be rare since firms will be firms with incentives to keep strategic information from each other and share only non-threatening information which will not alter the competitive balance. Keeping consortium objectives at least several steps removed from marketplace is, thus, one tool for "keeping the peace." The usefulness and limitation of cooperative R&D was recently summed up by one leading Japanese industrialist who was quoted as saying "the best experimental results are negative... we don't spend our money on unprofitable avenues and have nothing to fight about with our competitors."

As with scope, competitive dynamics will also tend to limit the effective size of consortiums. The larger the consortium, the more illusive a consensus on agenda and increased likelihood that the purpose of venture will be defeated. This is likely to be a particular problem with HDTV.

As a result of competitive pressures, consortiums can be expected to be most effective in terms of encouraging and improving efficiency of technology investment when the focus is on basic or generic research, or common technological problems.

As objectives approach the marketplace, problems of appropriation are less severe and cooperation will be more difficult. With high tech fields in particular, both the growth of the global market and the rise of the multinational corporation complicate the task of defining common domestic needs. IBM has recently encountered this problem with the exclusion of foreign companies in Sematech which is now a convenient excuse for Europeans to block IBM participation in the European version of Sematech-JESSI.

Public Support

The argument for consortiums is not ipso facto an argument for public funding. If effective, consortiums will work to correct market failures that would otherwise limit an individual firm's incentive to perform socially desirable investment. The proper public role in this process is as a mediator in planning stages, a monitor for barriers to socially-desirable cooperation and for anti-competitive practices, and if necessary as a catalyst in terms of limited funding in areas where a clear market failure is likely-i.e. basic and generic research. If support extends beyond these functions, despite the best intentions, Congress risks getting caught in pork barrel politics while trying to decide which consortiums to fund and which industry guides to follow through the famous black box of technology and innovation. Capital markets may very well be imperfect, but the prospect for objective review and informed

choices in the halls of Congress is even more imperfect.

I should like to close with two quotations from a former OMB official:

A problem that we faced throughout last year's budget and that we will face in this year's budget and clearly in coming year's budgets is what should the federal government support beyond basic research. The economic argument for investment in basic research is clear and unassailable.... (But) the further one gets towards classical, commercial development, the more problems... OMB has institutionally...with federal expenditures. There is clearly a grey area in which we begin to leave federal and public expenditure investments, which we are certain yield a public return, and we begin to enter into investment about which we have many more doubts.

.....

There is very clear evidence that on the far end of the R&D spectrum...we do in fact replace the private sector if we are not careful. I have seen it happen, I have had private coalitions come to me and argue that they needed a particular kind of commercialization project-not because they could not fund it, but because some other group had received funds by the federal government; therefore, it was comparatively disadvantageous for them to do it out of their own equity. The less we are cautious about that, the more we will wind up with federal government simply replacing investment and private innovation.

These cautions come not from a rigidly ideological Reaganite nor even from a Ford administration conservative-they were made in 1978 and 1980 to the leaders of the U.S. scientific and high technology community by Bowman Cutter, the top OMB science and technology policymaker in the Carter administration. I believe they illustrate that though the particular institutional forms and arguments change, the issue of the proper federal role is not new in this decade and the historical experience of both

Democratic and Republican administrations is relevant to the current debate.

Both the Ford and the Carter administration faced intense pressure for the government to go beyond its historic postwar role as the patron of basic science and fund large-scale demonstrations and production projects in the name of U.S. "Energy Independence." The Ford administration beat a gradual retreat, but the Carter administration (over the protests of its OMB and environmental appointees) folded and allowed the creation of the \$88 billion Synthetic Fuels Corporation. This hearing is not the place to recount the sorry record of synfuels, but it should give pause before the United States embarks on another program of huge subsidies because of an alleged national crisis.

It's Still High-Definition Intervention

By CLAUDE BARFIELD

The drive to create a U.S. high-definition television industry has brought together some strange bedfellows: the traditional industrial-policy promoters from the left; industry executives, whose corporations will directly benefit from large subsidies and trade protection; and the Pentagon, which, starting from a legitimate concern over the defense industrial base, has strayed far from its competence or mandate. In the name of national security and an anachronistic economic nationalism, this alliance has conceived a witch's brew of proposals for massive public-sector intervention.

HDTV is in many ways an odd sector to choose to revive industrial-policy proposals. To some, HDTV is merely a television picture twice as sharp as existing sets; to others, it represents a vast new array of digital technologies that will emerge from the convergence of the computer, telecommunications and entertainment industries.

An Unlikely Setting

In all scenarios, a fierce struggle looms among existing and emerging economic and political interest groups, which include the major networks, TV producers, cable broadcasters, satellite companies, computer companies, AT&T and all the Baby Belts, domestic (only one, Zenith) and foreign television manufacturers, and heave knows how many other smaller interest groups—each with its own goals and alliances. Such a marketplace of private agendas is an unlikely setting for the efficient use of public resources or the mantle of trade protection.

Congress is, however, charging ahead on HDTV, and the reaction of the Bush administration—to come in a national plan from the Commerce Department in July—will give a clear signal about the degree to which the new administration's approach will differ from the strongly anti-industrial policy stance of the Reagan administration.

Because industrial-policy proposals got a bad name in the early 1980s, enthusiasts for direct and extensive government-sector intervention have come up with a new slogan: "industry-led industrial strategy." If, they argue, will avoid the old pitfall of having the government "pick the winners and losers."

Minimal scrutiny reveals that the "new" industrial policy looks very much like the old. As with traditional industrial

policy, the current proposals proceed from the assumption that the market will not allocate resources in a manner that will enhance its competitiveness. Thus, an aide to Rep. Edward Markey (D., Mass.), a leading proponent of HDTV, recently told an industry group: "There is a serious weakness in the basic structure of U.S. capitalism... It is not allocating capital on the basis of U.S. economic strength."

In addition, there is the belief that the "United States must take control of the sectoral composition of its future economy." In the words of Alan Wolff, a Washington trade lawyer who is a leading pro-

HDTV is an odd sector to choose to revive industrial-policy proposals. A fierce struggle looms among existing and emerging economic and political interest groups.

ponent of the new strategy. In this context, HDTV is seen as a model for other major efforts—for superconductors, advanced materials, automated machinery, lasers, supersonic aircraft and a "food chain" of electronic industries and technologies: semiconductors, X-ray lithography, supercomputers and other digital electronic technologies.

At this point, the new industrial-policy enthusiasts attempt to distinguish their proposals from earlier plans—industry, they say, not the government, will formulate the competitive strategies, through a series of consortia. The problem is that while industry may "pick the winners," the government is still expected to provide the resources and policies to ensure that the winners are winners.

With Sematech, the first public-private consortium (semiconductor manufacturing technology), the subsidy will run to at least \$300 million over five years. For HDTV, proponents are now asking for the public to fund a large share of billions of dollars of development costs. In addition, they want revision of antitrust laws to allow joint manufacturing production, low-cost government loans and a guaranteed market. Government thus is not only the catalyst but the funder and protector.

Bater the Pentagon. While many industrial-policy strategists from the left routinely decry the lead role of the Defense Department, it is clear that national-security fears are central to the new strategy. The rush to provide a huge subsidy for the semiconductor industry would not have

succeeded without a Defense Science Board report that asserted that virtually all future U.S. war-making capability was dependent on the chip industry. Recently, the Defense Advanced Research Projects Agency (Darpa) jumped in with an announcement that it will fund at least \$30 million in grants to HDTV joint ventures. These will advance Darpa's mission in support of "high risk, long range" research.

Sematech and the Darpa HDTV involvement represent an ominous trend, and a perversion of the Defense Department's highly successful role since 1945 as a pub-

lic Godfather to the U.S. science and technology enterprise.

The extraordinary success of the science-military partnership was based on two characteristics of Defense Department patronage: 1) Key Defense Department scientists were among the most imaginative, far-sighted and flexible instruments for basic science funding in the government; and 2) the department kept a fixed eye on the defense goals of its technology mission and did not attempt to enter the labyrinth of market economics. Unfortunately, both of these fundamental pillars of the Defense Department science and technology enterprise have been fundamentally altered.

The department's overall funding of basic research as a percentage of total defense funding has declined from 3.2% in 1965 to an estimated 1.2% in 1990. Further, since 1980, the basic research share of the Darpa budget has decreased by about two-thirds. This means that scientific seed corn for future advanced defense technologies has been persistently underfunded. Further, since basic research ultimately produces substantial payoffs for civilian sectors as well, this underfunding undoubtedly has been detrimental for overall U.S. competitiveness.

In addition, the Defense Department has increasingly expressed support for industrial policy and technology-commercialization proposals that it has little competence to evaluate and that often merely advance the goals of special interests to raid the public treasury. Over the

past few months, Darpa representatives have laded the agency for guaranteed markets for HDTV, mandated U.S. production, mandated use of U.S. semiconductor chips and microprocessors in new television equipment, and exclusive licensing to U.S. companies. These policies constitute a dream list for industrial-policy advocates and professional special interests, and are all across purposes with U.S. trade-policy goals to end subsidies, beat back spurious infant-industry arguments and keep markets open for investment.

Before committing scarce public resources and revising regulatory practices for HDTV or any other technology program, the Bush administration should set forth stringent criteria and high thresholds for government intervention.

First, the administration should act to reverse the pernicious tendency for industry to come first to Washington before attempting to tap private investment sources. The leaders of the purported "strategic" industries should be reminded that the U.S. has the largest and most efficient venture-capital market in the world.

In addition, if it gives support to private industrial consortia, the government should resist large jump-sum subsidies, as occurred with Sematech. Public funds should be spread widely and limited to basic and generic research: a 10% limit for federal involvement in consortia seems a reasonable starting point.

Back to the Barracks

U.S. regulatory policy should certainly be used to advance national interests (standards are a critical factor in HDTV development), but the government should resist wholesale abandonment of the antitrust laws for manufacturing. Similarly, calls for guaranteed markets, discrimination against foreign-owned companies and exclusive licensing of technologies should all be rejected. They directly conflict with U.S. international trade goals and will inevitably work against U.S. national and corporate interests.

Finally, the Pentagon should be sent back to the barracks with the reminder that the department that gave us the high-tech 500 toilet lid is the last place one would look for guidance through the uncharted maze of market economics.

Mr. Barfield is director of science and technology policy studies at the American Enterprise Institute.

Representative HAMILTON. Thank you very much, gentlemen, for your excellent statements.

We will begin now with questions. We will follow the 10-minute rule, and the Chair recognizes Senator Bingaman.

Senator BINGAMAN. Thank you, Mr. Chairman. Let me start with the philosophical issue that we all come back to here. That issue is to what extent can Government wade in and identify an industry that is important to us either in a national security sense or economic sense and take steps to assist that industry.

I think I agree with Mr. Fields in the area of just supporting research. We have supported research for a very long time. We need to continue, and we clearly have done that, whether the research is to be done by individual companies, by individual universities, individual laboratories, or a consortia of those.

I think the question arises when we move from research closer to a product or a process that is commercially available. For example, Mr. Fields says that it is his view that new materials are a crucial area for us to concentrate on in technology development for national security purposes.

Is it enough for us to say that the role of Government is to see to it that the research is done so that those new materials can be produced, and then it is up to the private sector from then on? That commercialization is not our problem? Isn't it a problem if the production of those new materials occurs overseas entirely, and if we are dependent upon overseas sources to purchase those new materials to put in our weapons systems or use throughout our economy?

Mr. Barfield, is it your view that we should stop at the step of doing the research and not worry about the commercial application or the application of that research in weapons systems?

Mr. BARFIELD. Well, you have no mixed up weapons systems and materials. I think you would have to take it on a case-by-case basis as to what is the material, where is it that we would second source it, what can we do in the United States.

Let me turn that around to you for just a minute. I think we are in a time, and it will be increasingly true for the United States, that we will not be No. 1 or sometimes even No. 2 or No. 3 in everything, whether it is technology or particular products.

In the basis of defense, we cannot just go out, and I am not suggesting that Mr. Fields is suggesting this, and begin to subsidize or in some way try to force production of particular products just because we don't have them here. What I would suggest is that I have no one answer to that question. You would have to take it on a case-by-case basis. By and large, however, I think that the Government would be chasing its tail if it tried to force production of something that we just do not have a comparative advantage or are not capable of doing. There are other means, by the way. If there is a particular material, or if there is a particular technology that the Defense Department thinks is key to U.S. security, even a free marketer like myself would say they ought to go ahead and build it.

Senator BINGAMAN. You say we should take it on a case-by-case basis and the Government should make the decision on each case—

Mr. BARFIELD. That's right.

Senator BINGAMAN [continuing]. So that you are not opposed to the Government stepping in and saying in this case it is so important to us militarily—

Mr. BARFIELD. If the case is made, yes. I have no problem with that.

Senator BINGAMAN [continuing]. That we have a production capability here, that we will use Government funds and other resources available to us—

Mr. BARFIELD. Absolutely.

Senator BINGAMAN [continuing]. To ensure that production remains here.

Mr. BARFIELD. I think the issue becomes more complicated, and I will take Sematech as an example. I think the thing that disturbs me about Sematech, besides the fact that I think the Government need not have invested as much as it did, and I am thinking as a taxpayer. I just think that the investment was too large. I say that because—again and again I was on a Council of Competitiveness Task Force that took a look at what the Government role in consortia was a couple of years ago just as this was forming. And if you ask the companies, if you really press them, and we talked to a number of them, they basically said that if the Government didn't come into Sematech, they would do it. There were the funds to do it. Whether or not that is the case, I do not know. I do not think that necessarily you had to have a 50-50, as we ended up with, and that seems to have become a number that is bandied around.

But let me go through the history there. What happened was that the companies, rightly or wrongly, had not been able to build political support for a Government subsidy until you weighed in with the Defense Science Board Report which argued in ways that I don't agree with, that somehow all of the United States' warmaking capability was dependent on semiconductors and D-RAMS. Then it rushed through very quickly, I think, without a lot of thought, and my worry is that once the national security issue is raised, you tip the political balance. We can't talk about, it seems to me, these questions of science and technology without thinking in the matrix of a highly developed special interest group system. And when you add in the problem, and I am not suggesting that people are always patriotism as a foil, but it does introduce, it seems to me, a complication up here for the Congress in the passage and in the push for Government support.

Senator BINGAMAN. Well, I would agree with you that it does. There is no question that to the extent that people believe that our capability in the defense sense is dependent on the development of new technologies in a particular area, then clearly, they are more willing to support that development with Government funds. And I think that is appropriate myself. I don't think that is a foil. I think that is an appropriate decision to come out of the political process, but that may be a difference of opinion that we have.

Let me ask Mr. Fields the question of who should be involved in these things and the issue of whether foreign participation is appropriate. Is it enough to just say the test should be whether in each case there is a net benefit to the United States? Is that the test that is applied by foreign countries? Do they use that same test or do they have, in some cases, a blanket prohibition against

U.S. firms participating in research consortia? And if they do have a blanket prohibition against U.S. firms participating in research consortia, should we have a similar reciprocal prohibition, even though, on a case-by-case basis, we might conclude otherwise?

Mr. FIELDS. Well, there are foreign consortia in which American companies participate. There are foreign consortia in which American companies are not allowed to participate. So I don't know that I could really apply the term "blanket prohibition" across the board. Furthermore, I have no means of knowing the motivations of the foreign governments and companies as they make their decisions.

By using the guideline that I stated, which is not a rule; namely, we will look at each case and see whether there is a net benefit to the United States, puts more of a burden on us. We have to be thoughtful. We can't just use a simple-minded rule. But it seems to me the right way to do it. In some of our programs, we are supporting, for example, a small superconductor firm in France or an infrared focal plane array firm, a small one in Great Britain, there is a net benefit to the United States. Wasn't the first thing we tried to do or the second or third, but after a point, it is the right thing to do. But by applying that rule, I think, you know, you get what you want to get, and I think that that is the way we are going to have to proceed.

Senator BINGAMAN. Mr. Gomory, let me ask about your idea of the superconductivity consortium. You indicated that you would hope to use taxpayer funds for a portion of it, and that the research benefits would be available to the member companies and not to others. Is that a decent deal for U.S. taxpayers? I mean, what should the taxpayer expect to get back other than the sure confidence that someone in the United States is benefiting?

Mr. GOMORY. In any case, it is very hard to confine all the benefits of a consortium to consortium members. So a lot of the information must inevitably be published, but what you get from being a member is sort of the hands-on experience. You can publish yourself to death. You won't know as much as the people who are creating to it. And so we will advantage those U.S. firms that participate.

Now I think it is probably advantageous to the United States to be a player in whatever comes out of superconductivity. So I would say that's the advantage that we see in the United States that we will be stronger in this area than if we don't do this, and if we watch, say, the Japanese march away with it. That is what I would see as the U.S. benefit.

Senator BINGAMAN. Let me ask you one other question about your distinction between using consortia for the development of a new idea and using it for the incremental improvements. You indicated that Japan has used it for the former and not for the later. I gather that you would say that with something like Sematech, Japan would not have done with a consortia and that in that case perhaps we should not have gone forward with a consortia, because that was not a new idea. Nobody came to the Congress and said we have a new idea. They essentially came to the Congress and to the administration and to the Defense Science Board and said on this incremental improvement of manufacturing processes, we are

going to lose our shirt and lose the ball game unless we get our act together as an industry, and we need some Government help.

Mr. GOMORY. Let me go ahead and answer what I think is an extremely penetrating question. There are real distinctions, I think, between the commercialization of a new idea and the incremental improvement. And one that is worth remembering is the difference of scale involved, right? I think this is a very important point. The whole effort in high temperature superconductivity in the United States is probably on the order of \$100 to \$150 million. And in Japan about the same size. To put together a consortium with a going rate of \$15 million, you are putting together an object that is 10 percent of everything that is happening. Once you get into a highly developed industry and try and affect the ongoing incremental improvement process, you are usually dealing with an industry that exists on a scale of \$20, \$30, \$40, \$50, or \$100 billion and to affect that becomes less likely and much more expensive. So if you are at the very peak of the pyramid of something new where there is very little resource invested, you have much more of a chance of affecting that with a relatively small scale consortium than when you try to deflect the course of an industry which is going on at \$100 billion.

I think to begin with, there is a certain plausibility that it is easier, as the Japanese have done with their consortia to have an effect at the early stages, and this may not be research. It may be directed research. I think we have to have a more complex model than just research and manufacture. There are in between stages, and it is important to work on them.

Now to return to the question of Sematech. I would say that Sematech is an experiment for the reasons which you point out, because it is trying to do something which doesn't have many precedents. So I think the success of Sematech will depend to considerable extent on their ability to single out from the mass of manufacturing processes which go into making a semiconductor chip a few key elements that are common and so to speak, to substitute by means of discovery of these common elements the missing central idea, and whether that will come about is an open question, in my mind.

So I would say, yes, Sematech is much more experimental than the sorts of things that I am talking about.

Representative HAMILTON. Congressman Fish.

Representative FISH. Mr. Barfield, in current high tech consortia proposals, do you think that the small- and medium-sized businesses are being treated fairly, or do you fear that large firms will end up with the bulk of Federal financing?

Mr. BARFIELD. I actually cannot answer that. In terms of those that are being funded. Mr. Fields, since he was talking of it, they fund quite a number. If public money is not being asked for, that is really not an issue, in the sense that the consortia can get together and it can be small and large firms. My understanding, but I would defer to Mr. Gomory, as he may know more about Sematech, is that while there has been a little griping from some of the small companies, the semiconductor manufacturing companies, it hasn't emerged as a major issue there. I would not challenge that, though

I have heard small companies gripe about it. But I don't think overall it would be fair to say that has become a major issue.

I would guess that there are general rules about small business in R&D contracts that the Federal Government has, I do not know how they would apply to consortia.

Representative FISH. In the text of your statement, you raised the down sides of consortia. You fear that they may facilitate collusion to slow down the pace of innovation and then the prospect of immediate competition between the members in the wings there.

Is this based on speculation, or do you have, from your examination—

Mr. BARFIELD. Well, there have been a number of studies of the way the Japanese have handled these questions and other countries, and I think, by and large, most economists who have looked at this would say that. There are a couple of things that I mentioned in there. One, at the far end, if you get into production you always have a problem of monitoring, whether it is on a national level or to get a semiconductor pact, you have to monitor it on an international level. Collusion.

Second, you would normally not expect, and this was not so much a negative, it was just that you had to realize the limitations—of great breakthroughs. You don't get companies really presenting their most important and far-reaching ideas. What has happened in Japan where they use consortia quite a bit is that you get incrementalism. Also, the Japanese and American economists who study this say that by and large, what you get is more exchange of information than anything else. They keep up to some degree about what they are doing, but they do not share greatly new ideas. That is just an inherent limitation of the companies getting together.

Representative FISH. It is stock in trade, isn't it?

Mr. BARFIELD. That's right. There is nothing unusual about that, what one would expect.

Representative FISH. Yes. Mr. Fields, isn't the issue—I am talking now about the FCC's role—of transmission standards set by the FCC most important in respect to HDTV? How can companies assess their potential returns or begin an investment before they know what the standards will be that will be applied to them?

Mr. FIELDS. Well, it is certainly true that the FCC is responsible for choosing transmission standards. They have the option of choosing transmission standards, not only for terrestrial broadcasts but also for other media as well as satellite broadcasts, but they are not at the moment exercising that option so far as I know. There is no question that the uncertainty about what the FCC is going to do is an impediment, in that it does raise risks for companies. It is not the largest impediment. There are other impediments associated with the cost of manufacturing capacity, the cost and risk associated with R&D, uncertainties about trade issues, and so on. So I would say that this was sort of a medium-sized factor and not a large factor compared to some others.

Representative FISH. Finally, Mr. Gomory, this gets into, you know, how far the Government is going to get involved here. If we do fund high technology consortia, can the Government avoid en-

tangling itself in questions of coordination, questions of allocation of roles, matters that really are best left to the market.

Mr. GOMORY. Well, Congressman Fish, I certainly agree those are matters that would be much better left to the nongovernmental elements. I think it is very difficult to get into, take the concrete thing that we have been wrestling with the superconductivity. The companies, MIT, Lincoln, have definitely been able to work out a very good technical plan that we all believe in, and we are going to march that forward now. Is it possible for the Government to put in money to support this without trying in some fashion to materially alter that plan? I believe it is.

Representative FISH. You believe it is possible?

Mr. GOMORY. I believe at that level it is possible, yes.

Representative FISH. Well, gentlemen, I am going to yield back my time to the chairman. Had he returned a moment later, I would have adjourned this meeting and taken the gavel for the first time in my 20 years in this institution, but now the chairman is back. Thank you very much for your presence.

Representative HAMILTON. Thank you, Congressman Fish.

Let me begin with a very basic question. Do you all think that there is something seriously wrong with American industry?

Mr. GOMORY. Can I respond to that?

Representative HAMILTON. Yes.

Mr. GOMORY. I don't think there is the slightest doubt about that, Congressman Hamilton.

Representative HAMILTON. You think we have a real competitiveness problem out there?

Mr. GOMORY. Well, I would say, you know, without getting in any theory, as a person who has visited Japan fairly regularly since about 1974 or 1976, I can no longer remember which, and watched them in the fields in which I am quite experienced, watched their meteoric progress by seeing it with my own eyes, I think we definitely have a major competitiveness problem.

Representative HAMILTON. Do you agree, Mr. Fields?

Mr. FIELDS. There is no question about that.

Representative HAMILTON. No doubt. Mr. Barfield.

Mr. BARFIELD. Well, I do, but I would have to say what is that competitiveness problem?

Representative HAMILTON. OK. Go ahead and tell us.

Mr. BARFIELD. It seems to me that in the last 10 years—I assume you are talking about manufacturing. American corporations have gone through a wrenching process of adjustment, and I think that has been and is paying off. Now this cannot keep them nor should it keep from the meteoric rise of Japan, Korea, and any other nation. We have a new set of competitors and kicking ourselves in the butt in some ways the best way to get forward. But I think that by and large when you look over the last 10 years, given some major macroeconomic mistakes that the companies have had to live with, in terms of budget and tax policy, at least until quite recently, we have done quite well. Manufacturing productivity has come strongly back. We are now exporting, are in the midst of an export boom that is across the board. We are at full capacity. Now I am not wanting to be Pollyanna—

Representative HAMILTON. Are we doing so well, Mr. Barfield, that we do not need to worry from a Government policy standpoint?

Mr. BARFIELD. I am not arguing that. I am just saying I am trying to get some perspective about what we need to worry about and what we do not need to worry about. I think we need to worry about such things as our education system, of getting our macro-economic house in order. Those kinds of things.

Representative HAMILTON. That is where you would focus your efforts, and you would not worry about this industrial policy we have been talking about here.

Are you offended by Mr. Fields' efforts?

Mr. BARFIELD. No, I am not offended either personally or institutionally by Mr. Fields' efforts.

Representative HAMILTON. Well, obviously, I don't mean that on a personal basis, but let's take a look at it. Here is DARPA involved in superconductors. Mr. Fields, how big is your agency?

Mr. FIELDS. It is about 150 people, about \$1.2 billion a year.

Representative HAMILTON. OK. You have 150 people over there. They are all good people. Mr. Fields is an outstanding person. DARPA is involved in superconductors, semiconductors, artificial intelligence, computers, high definition television, and the machine tool industry; right? Other things as well?

Mr. FIELDS. Many other things.

Representative HAMILTON. Many other things.

What do you think about that?

Mr. BARFIELD. Well, it depends on what they are doing and how they are involved. I think one of the things that does disturb me is the following: I think that rightly or wrongly—I am a pragmatist about such matters. I think that for whatever reasons we came out of the Second World War and the decade after the Second World War with the Defense Department having the most far-sighted, intelligent, and incredible support for basic science in the United States. I don't see any reason—and as long as—and even beyond that—as long as we were going to compete with whoever the enemy was on the basis of technology versus numbers we needed that, and we still do need that. I think that that is a capability, institutionally, and with the various leaders that we have had over the 20 years in the Defense Department, Democrats and Republicans, continued support for basic science. We should keep that support and shore up.

One of the problems, however, that does disturb me is that increasingly in the last, well, 15 years and certainly in the last 10 years, the basic research portion of the Defense Department budget has gone down dramatically. I think that will hurt us or is hurting, will hurt us in the future, both in our defense capabilities as well as over the long range on our U.S. competitive capabilities for the following reason. I think product development, and I will get to the other side of this in terms of what disturbs me about Mr. Fields'—basic research is by and large fungible, and though one can argue that increasingly—

Representative HAMILTON. Mr. Barfield, let me interrupt you. Are you for or against the Government subsidizing superconductors?

Mr. BARFIELD. I am not for the Government subsidizing, if you mean product development. I am for consortia that Mr. Gomory talked about—

Representative HAMILTON. Are you for or against the Government subsidizing semiconductors, using subsidies in the broadest sense?

Mr. BARFIELD. No. If by that you mean product development.

Representative HAMILTON. And how about advanced materials, manufacturing materials?

Mr. BARFIELD. You will get a straight no answer for anything that has to do with product development. The distinction I have been trying to make—

Representative HAMILTON. Between research and product development.

Mr. BARFIELD. Exactly.

Representative HAMILTON. Are you involved in product development, Mr. Fields?

Mr. FIELDS. Not in our development—

Representative HAMILTON. You are only involved in research?

Mr. FIELDS. We do research and development technology.

Representative HAMILTON. So, Mr. Barfield, you support all the things that DARPA is doing?

Mr. BARFIELD. Well, there are a couple—let me just raise a couple—

Representative HAMILTON. They are all research, he said.

Mr. BARFIELD. I would say this.

Representative HAMILTON. He said they're all research.

Mr. BARFIELD. Well, I would say let's just take an example, and I will defer to—let Mr. Fields answer this.

It seems to me that the DARPA contracts, for instance, in the high definition television field that are about to be let, are contracts for products that have been described, at least by the companies, as prototype development. That is, that you will have a product within the next 3 to 5 years. I see no reason for the Government subsidizing that. If there are particular problems further out that relate to defense and even broader about the science of this or there are particular scientific hurdles or even generic technology hurdles that the companies wouldn't do, then certainly there is a role, but it seems to me that the closer you get to what is basically commercialization, and I think in this case, it seems to me from what I have read, this is fairly close, that I see no reason for us subsidizing it. That is a subsidy.

Representative HAMILTON. Mr. Fields, I am interested in who makes these decisions. I mean, why do we pick out these particular technologies to support, even in a research capacity, like semiconductors, artificial intelligence, computers, and high definition television? Who makes that decision?

Mr. FIELDS. Well, in the last analysis, the Director of DARPA makes the decision.

Representative HAMILTON. You make it?

Mr. FIELDS. That's right. We get input from the Joint Chiefs of Staff, we get input from the services, we get quite a lot of input from the Congress, we get input from the Defense Science Board, input from the CINC's and from the Director of Defense Research

and Engineering, and of course, my bosses can overrule the decisions and the Congress can choose to appropriate money in different ways.

Representative HAMILTON. Are you comfortable with that way of doing things?

Mr. FIELDS. This has been working very, very well. Independent of ideology we have, I think, a rather substantial track record that this system works.

Representative HAMILTON. I have an article here that was written sometime ago by Charles Schultze. He was Budget Director many years ago, and he says this:

One thing the American political system cannot do well at all is to choose among particular firms, industries and regions, cold-bloodedly determining on grounds of economic efficiency which shall prosper and which shall wither.

What do you think of that?

Mr. FIELDS. There are two separate issues here. One is using individual firms; the other is choosing areas. The areas we choose to work in like advanced computing or artificial intelligence are areas where there is a tremendous defense need for better performance and there are some good technical ideas. If you just have one versus the other, you can't do it.

Representative HAMILTON. You reject the idea that you are involved in an industrial policy?

Mr. FIELDS. I don't want to use inflammatory phrases like that. [Laughter.]

Representative HAMILTON. That is an inflammatory phrase.

Well, I noticed Congressman Levine used an interesting phrase, "industry-led policy." How about that one?

Mr. FIELDS. I don't quite understand how things work differently on my side of the river than your side of the river. When I am back on my side of the river, we try to develop defense policy and make choices and have priorities and on this side of the river comparable actions are criticized as developing industrial policy and picking winners and losers. So this asymmetry has always left me a little mystified.

Representative HAMILTON. You reject the idea that you are involved in the business of picking winners and losers.

Mr. FIELDS. It is based on technical merit and the probability they can actually achieve the goals.

Representative HAMILTON. Yes, but you say you don't fund one company or another, but you certainly fund one industry or another, don't you?

Mr. FIELDS. Well, we actually fund one company or another—

Representative HAMILTON. You do that too?

Mr. FIELDS. Well, there is no choice. What is the alternative? As I said, there were two issues. One is choosing the area in which you want to work and the other is what is the best way to get that work done. So certainly, we will choose to fund one proposal versus another, as does the National Science Foundation, the Office of Naval Research, the Department of Energy, and so on and so forth.

Mr. BARFIELD. But picking the winners and losers in the context that you have raised it, however, has to do with industries or sectors of industries.

Representative HAMILTON. As do what?

Mr. BARFIELD. Industries or portions of industry. And the Government when it makes a choice beyond basic or generic research is certainly doing that, and is what Charles Schultze was talking about.

Representative HAMILTON. Yes. Would you agree with Mr. Schultze's comment?

Mr. BARFIELD. Absolutely. I am glad it was a Brookings economist.

Representative HAMILTON. Do you think we are doing that?

Mr. BARFIELD. No.

Representative HAMILTON. We're not.

Mr. BARFIELD. Except to that there is no conscious policy, and I will be the first to admit that there are public policies that affect industries, whether it is tax policy or some industry may get a subsidy for the savings and loans. We have just bailed those guys out. I wouldn't call it picking a winner; it is picking a loser there.

Representative HAMILTON. No.

Mr. BARFIELD. But the point is that I do not doubt that there are Government policies that do that. What I think Mr. Schultze was saying was that over time there are two things that will happen. Economists can't give you very good criteria and the political process, even if you had the criteria, would not allow you to pick what would really be the winner.

Representative HAMILTON. You talk about political clout in your prepared statement.

Mr. BARFIELD. Yes. This is a system that in the matrix of a political system.

Representative HAMILTON. Why should the Defense Department be picking these particular industries?

Mr. FIELDS. Again, you've asked two questions, and I have to separate them.

Why does Defense do it? And then a question—

Representative HAMILTON. You have a knack of rephrasing my questions all the time! [Laughter.]

Mr. FIELDS. Sorry, Congressman Hamilton.

Representative HAMILTON. It's OK. You may do it better. Go ahead and answer your questions. [Laughter.]

It's always a lot easier to answer your own questions than somebody else's. [Laughter.]

Mr. FIELDS. DOD's investment strategy in investing in one industry or one technology or another industry and another technology is based on what we think we need to provide national security, and that is the way we have been doing it since World War II, and I think it has worked astoundingly well. There are always ways to improve efficiency and effectiveness, and we try to all the time. That's not the point.

The other point you raised is one of exclusivity. Should DOD have the exclusive role in choosing industries in a larger sense than just DOD needs.

I am certainly not accepting that at all. The fact is that there are interests that are not defense interests. Other parts of the Government have responsibility for dealing with those things. To the

extent they are or are not dealing with those things are really concerns you should address to them.

Representative HAMILTON. I am interested in your criteria. Why do you pick any of these areas and not the others?

Mr. FIELDS. Well, let me go back over the three criteria briefly, because that is the statement of the reasons. We have to do things where the technology that we are going to invest in makes a big difference for defense, because I can't afford to invest in things that will make a small difference for defense. That is one criteria—the performance.

Second, I have to deal with things where there is rapid change, because what we are trying to do is maintain leadtime, and the nature of national security is leadtime over adversaries.

Then the third issue is this one of leverage. I can't afford to do everything, so I am trying to find those things where if we invest in that area it affects a lot of other things.

In the case of semiconductors, it is perfect in all three of those criteria. There isn't any defense weapons system that I can identify, and perhaps Mr. Barfield can identify, that isn't dependent on the performance of electronics for its effectiveness.

Representative HAMILTON. I want to go back to this point and make sure I understand it. You only involve yourself in research.

Mr. FIELDS. We do research and development, what DOD calls 6-1 and 6-1 research.

Representative HAMILTON. Now what does "development" mean?

Mr. FIELDS. Development means a little further stage of maturation.

Representative HAMILTON. Does it include developing a prototype?

Mr. FIELDS. In some cases we will develop a prototype as a concept demonstration, but not as the final product. That's not our role.

Representative HAMILTON. And you don't get into the question of production at all?

Mr. FIELDS. Production is not our job.

Representative HAMILTON. Mr. Gomory, are you satisfied with the way things are operating in this area?

Mr. GOMORY. Yes. I think that is fine, but I would like to put a little perspective on it. If we are interested in the industrial competitiveness issues rather than the defense one, I think it is very helpful to deal with these research questions, and I want to come back to that in a moment, but we have to keep remembering that our real difficulties against the competition have not been inadequate research, but they have been, are closely related to manufacturing and to product development, and the effect that we will have by any of these research type consortia will be limited. Nevertheless, put in that perspective, I would very much support the kind of things that by and large DARPA has done in the past and that we are proposing in the area of superconductivity.

I do think that at times the terminology here is confusing, because the words "research and development" have long since lost whatever meaning they may ever have had, and they mean absolutely different things to everyone who uses them. I think that the novel element, therefore, in what we and others are now thinking

about can't be captured by those words. I am going to try to make a distinction.

The Government of the United States for a long time has funded what we would call basic research. That means discovering the basic properties of materials, the kind of work that led, in the case of superconductivity, to the discovery of superconductivity. Where are the molecules? Why do the electrons flow the way they do?

Representative HAMILTON. Mr. Fields, how would you describe the research you are sponsoring, is it basic or applied?

Mr. FIELDS. Some of it is basic, some of it is applied.

Representative HAMILTON. You go into applied research. OK. Excuse me.

Mr. GOMORY. Beyond that, there is, just as your remarks suggest, something else which is applied research, and that is what we are going to try and do in this consortia. I think it is appropriate to support this, and that would be—hey, let's take these materials, but hey, if you want to make a wire out of them today, they are useless, they'll break. First, they won't carry enough current. Second, if you try and bend them, they will just fly all over the place in pieces. So let's get on with developing the properties that in the long run would enable us to make a wire.

Representative HAMILTON. There must be 10,000 firms out there that would like to get some Federal help on research; right?

Mr. GOMORY. I am sure there are. I think, generally speaking, firms will accept money.

Representative HAMILTON. You probably know that, Mr. Fields, don't you?

Mr. FIELDS. All true.

Representative HAMILTON. You cut a lot of them out, I guess, don't you?

Mr. FIELDS. Yes.

Representative HAMILTON. I was interested in your comments, Mr. Gomory, on the consortia and the people participating in the consortia—MIT, Lincoln Laboratories, AT&T, and IBM. Those are all pretty big actors in the world of research and production, aren't they?

Mr. GOMORY. Yes, sir.

Representative HAMILTON. Now suppose there is a small company that wants to get into that consortia with you—

Mr. GOMORY. Yes.

Representative HAMILTON [continuing]. And they are a good enterprising company. Are you going to let them in?

Mr. GOMORY. Absolutely.

Representative HAMILTON. Anybody that wants to can join?

Mr. GOMORY. Well, we can't let anybody in, because there would be too many members, so we have to work out some rules, but very definitely—

Representative HAMILTON. Who works the rules out?

Mr. GOMORY. The members of the consortia, presumably.

Representative HAMILTON. Now are you going to work those rules out to your own benefit?

Mr. GOMORY. I don't think that will be the exclusive criterion,

Congressman HAMILTON. I think that when we wrote the—

Representative HAMILTON. You're not going to work them out against your benefit, are you?

Mr. GOMORY. I think this is probably a case where the country and the members are liable to benefit from our progress.

Representative HAMILTON. I don't disagree with that. I just wonder about people not included in the consortia.

Mr. GOMORY. Could I comment on that?

Representative HAMILTON. Sure.

Mr. GOMORY. First of all, the committee report did not ask for a consortium. It encouraged many consortia, and it did not ask for a consortium made up for people like IBM and AT&T. OK. So when we set out to start this thing, we very much had in mind, first of all, the addition of other companies, and second, which I think would be even more significant, the formation of many other consortia even in the field of superconductivity.

For instance, we are only confined to one branch of the technology without even going into it. We did this, and I can speak very strongly for my own motivation in this matter, to break the ice. OK. We wrote a report, and we were damn sure nothing would happen. So we said, let's do one of them and let's hope that others will follow.

So nothing is going to prevent other people, in my opinion, from doing the same thing. If so, it will be very beneficial.

Representative HAMILTON. Suppose you come up with something in your consortia that is really valuable in terms of production or research, and you said something about sharing. Do you mean by that the results of your research are going to become public?

Mr. GOMORY. We pretty much are going to have to have an open publication policy because of the participation of MIT. So whatever is publishable or is a normally publishable thing will be published. That is our intent. It is also a fact, though, that the members will know more than is being published, just as when you do something you know more than when you describe it.

Representative HAMILTON. And if that consortia comes up with some patents, you would have them exclusively, wouldn't you?

Mr. GOMORY. Yes.

Representative HAMILTON. And they would be partially funded by Federal money; right?

Mr. GOMORY. Absolutely.

Representative HAMILTON. And is there any public interest in those patents?

Mr. GOMORY. Yes. Not in the patents, but in the fact that these companies and this group will do better.

Representative HAMILTON. It doesn't bother you that you get that patent through public money in part, and yet the patent rebounds to your benefit—

Mr. GOMORY. No—

Representative HAMILTON [continuing]. And not to the public's benefit?

Mr. GOMORY. I think that you, if I may say, you are making that distinction between ours and the public's. I think that it is very hard at the same time to contend that you are trying to help the companies compete and yet if you help them, that that doesn't re-

dound to the public benefit. I think that is a fundamental difficulty.

Mr. BARFIELD. I would like to make two comments about that, one to Mr. Gomory and then, I think, say that you have raised a legitimate question.

It seems to me that from the public point of view, from the Congress' point of view and the administration's point of view and where the role of public resources go, it is, the Federal funds should be spread widely, and you should not—you can get away from some of the problems you raised, whether it is political clout or whatever, in this case, they don't have any political clout, because you don't know what is going to happen, by spreading funds widely, and that is particularly true when you are talking, as again, I think I said, without knowing all the details of this consortia, it sounds to me as if it is an excellent candidate. Whether you can give that much money or not, I can't speak. But the questions you raise, it seems to me, or the problems that you raise can be alleviated somewhat by, as I say, spreading the public funds widely. There should be a number of consortia, given the state of the art in superconductivity today, and I would support that across the board.

In the question of patents, there may be patents down the road in this consortia. I can't speak to the individual case, but given the kinds of issues that they are dealing with, it does not look like there will be a lot of them, but that does become an issue. It seems to me to the degree the Federal Government gets involved further down the process of large infusions of Federal funds which become subsidies, it seems to me, that we're close to private development.

Representative HAMILTON. How many consortia are we supporting today?

Mr. FIELDS. Well, I think we are talking about something like a half dozen.

Representative HAMILTON. Not very many.

Mr. FIELDS. Not very many, and there are about 150 consortia that I know of.

Representative HAMILTON. And the Federal Government is only involved in six of them?

Mr. FIELDS. Oh, a half dozen, eight, something like that.

Representative HAMILTON. Now consortia allow firms to pursue their research agenda more cheaply, is that the basic point?

Mr. GOMORY. Well, I think that is a real point, but I think that very often there are other considerations that are even more important. I think that the notion that we were advocating here was not only the cheapness notion but the fact that if these consortia, and we advocate several, are formed, that they would link the application knowledge of many companies, who themselves would not be able to afford a scientific base, with the existing scientific base in universities. So that the notion was rather of combining disparate knowledge or disparate skills than it was cheapness, so to speak.

Representative HAMILTON. The 1984 National Cooperative Research Act relaxed a number of antitrust restrictions to allow cooperative research and development ventures.

Is that act working pretty well?

Mr. FIELDS. Yes. It works fine.

Representative HAMILTON. Does it need to be changed in any way?

Mr. FIELDS. Not for R&D consortia.

Representative HAMILTON. Do you think there need to be any changes in our antitrust laws at this point?

Mr. FIELDS. That is very unclear. I have spoken to a number of attorneys, and I have received an equal number of opinions on that subject. So I really can't address that directly.

Representative HAMILTON. Do the others have any views on that?

Mr. BARFIELD. Well, I would say certainly I think we are not to the time that one could say there should be a sweeping exemption from production, even though we are dealing in some cases in world markets. You might want to think about allowing either the Antitrust Division of the Justice Department or the FTC to take things on a case-by-case basis.

Representative HAMILTON. So you would provide antitrust waivers for production?

Mr. BARFIELD. If you were going to do that, I think that would be the way to go, and I am not an expert on it, but I just don't think the case has been made for the wholesale—

Representative HAMILTON. Yes. Now the industries you have selected, Mr. Fields, are high-technology industries, aren't they?

Mr. FIELDS. Yes; that is our investment.

Representative HAMILTON. Why should high technology be given preference?

Mr. FIELDS. Well, the industries we choose are the ones that we choose in order to get performance for national security. The fact is that we don't—just to take a comic example, we just don't need better military uniforms than we have now in order to—you know, by and large, in order to achieve better national security, and we do need better sensors and electronics and better ceramics and so on. So that is a sort of natural consequence. In doing that, we support both big companies and small companies. About 60 percent of our contracts go to small businesses, not the large businesses, in fact.

Representative HAMILTON. The American Electronics Association has recently proposed that Congress enact a billion dollar program of Federal loans, loan guarantees, and research grants to promote high definition television.

How do you all feel about that? That involves more than research—loans, loan guarantees? Do you have any reaction to that?

Mr. GOMORY. I don't feel I have any particular expertise on it.

Mr. BARFIELD. Well, I was deferring to my colleague because I am already on the record about that. I think one would have to make a clear distinction about what the American Electronics Association is proposing as a consortia and what Mr. Gomory has talked about. There you really do get a full scale, it seems to me, because there are trade policies involved here and production—a question that you really ought to raise—I mean, you should raise it here. There should be a real debate on that.

Representative HAMILTON. Yes.

Mr. BARFIELD. I think I would oppose it, but the great thing about it, it has laid out for you the full panoply of what would be possible. For a variety of reasons in this case I think it is not a good idea, not the least of which, for a consortium, given the con-

tending political and regulatory and economic forces involved, it is impossible for me to think that it could really work at this point.

Representative HAMILTON. Yes.

Mr. GOMORY. Can I comment on one answer—a lot of the questions have gone to how do you choose industries and things like that. Now what I am going to say is certainly not a way of selecting, I think it is a way of rejecting certain industries. There are only some industries, at least to my knowledge, where there is any leverage there. In other words, we really believe that with a small number of millions, and I said with an “m” and not a “b,” you can make a difference in high temperature superconductivity. The same might be true in a few other areas, but you can’t make out a case that super high tech is a high leverage item in everything. There are just certain areas that are moving and certain areas that are not.

Representative HAMILTON. Mr. Fields, one of the things that strikes me about the areas that you have chosen to support is that not only do they have very broad military ramifications, but they also have very profound impact on the civilian economy.

Mr. FIELDS. Yes, they do.

Representative HAMILTON. How does that affect your thinking? I mean, you are making a decision based on military criteria. Your criteria are that you need to identify technologies that strongly influence the performance of the DOD system. Nobody is going to quarrel with that. That is a function that ought to be carried out, an important function. And yet your decision has a very big impact on the civilian sector, manufacturing tools. Nothing is more basic in production and manufacturing today than the manufacturing tool industry.

Mr. FIELDS. That’s right.

Representative HAMILTON. Right?

Mr. FIELDS. Absolutely.

Representative HAMILTON. So, it has a profound impact. I wonder whether the Defense Department is the right place to make those decisions. You are saying to me that you are making the decision on the basis of the defense needs of the country.

Mr. FIELDS. I think that the public should be pleased that they are getting such double duty, if you like, for the investment, and they are getting the national security, whatever quality and quantity they want, can afford, but then as this sort of second benefit, and by second, I don’t mean it is less important, but another benefit, the effect on the national economy. That effect isn’t the reason we choose things.

We wouldn’t choose one thing versus another for that reason. On the other hand, it is real. It is very large, and I just think that the civilian sector should be pleased by the consequence, not dismayed by it.

Representative HAMILTON. Do you work with the Commerce Department in making a judgment like this? You make a judgment that you are going to help the machine tool industry. You make that judgment principally on defense criteria, but do you check with the civilian side at all? Do you work with the Commerce Department, for example, on that decision?

Mr. **FIELDS**. Let me answer that question and not rephrase it. We work with any number of Federal agencies, not from the point of view of their helping us make our decisions, except where they are requested, but in fact, to make sure they know exactly what they are doing so they can comment on it. We have very, very good relations with the new staff that has joined the Commerce Department, the Secretary, Wayne Berman, Janice Socholski, Deborah Winn Smith, Dennis Closky, who just came from the Defense Department, and so on. We have very good relations with the National Science Foundation and meet with them very frequently, with NASA as well.

So I think that there is a lot of coordination and communication, and there is a formal body that does this, known as the Federal Coordinating Council on Science, Engineering and Technology, the so-called FCCSET Committee. We deal with almost once a week now.

Representative **HAMILTON**. Mr. Gomory, if the Federal Government contributes to your consortia, should the Federal Government sit on the board that makes the decisions for the consortia?

Mr. **GOMORY**. Gee, I—is that the way we have it—I guess the answer is we are going to do that, but I think—

Representative **HAMILTON**. You are structured so the Federal Government participates?

Mr. **GOMORY**. Yes.

Representative **HAMILTON**. Who participates? DARPA?

Mr. **GOMORY**. A DARPA representative, along with the representatives of all the other sponsors, so to speak.

Representative **HAMILTON**. Yes.

Mr. **GOMORY**. We feel that as a sponsor, they should participate.

Representative **HAMILTON**. Well, this has been a good session. This is a difficult issue and your insights into it have been very helpful. I appreciate your testimony very much.

The committee stands adjourned.

[Whereupon, at 11:45 a.m., the committee adjourned, subject to the call of the Chair.]