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NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
 Board on Physics and Astronomy
 Solid State Sciences Committee

FINAL REPORT
 to the
 Air Force Office of Scientific Research
 on the

1993 SOLID STATE SCIENCES COMMITTEE FORUM

Activities for August 1, 1992 to July 31, 1993
 Grant No. F49620-92-J-0455

August 1993

SUMMARY

The 1993 SSSC Forum was conducted under the auspices of the Board on Physics and Astronomy's Solid State Sciences Committee (SSSC) and cosponsored with the National Materials Advisory Board (NMAB), and the Washington Materials Forum. The theme of the Forum, the product of a year-long planning effort, was the Advanced Materials and Processing Program and the Restructuring of Materials Science and Technology in the United States. It successfully brought together experts and policy makers in the fields of solid state science and materials science and engineering to discuss the impact of the AMPP on the field and issues pertinent to the field. Support for the Forum was provided by the Air Force Office of Scientific Research (AFOSR), the Department of Energy (DOE), and the National Science Foundation (NSF).

ORIGIN AND BACKGROUND

The Solid State Sciences Committee (see attached roster) has a long history of annual forums spanning more than a decade. The 1985 Spring Forum was jointly sponsored by the SSSC and the National Materials Advisory Board. It was at this Forum that a consensus developed that a new assessment of the field of materials science and engineering would be useful and timely. As a result, a Committee on Materials Science and Engineering was formed under the joint auspices of the SSSC and the NMAB. The Committee's report, *Materials Science and Engineering for the 1990's*, was featured at the 1989 Forum. The intervening forums focused on the progress of the study in addition to specific areas of the study which were of particular interest to the community. Topics treated at those forums included the following: research opportunities in the field of materials science and engineering, materials science and engineering for the year 2000, and superconductivity. The focus of the 1991 Forum was the federal response to the report *A National Agenda in Materials Science and Engineering: Implementing the MS&E Report*. That report was the culminating activity of the regional meeting process that was initiated, at the request of the Office of Science and Technology policy (OSTP), to follow up the MSE study. The 1993 Forum addressed both the impact of AMPP on materials science and challenges for materials in the 21st century.

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The forum process was originally designed to bring together the scientific community and the policy makers in Washington, DC. At these forums, policy makers are asked to address a general theme and to respond to discussion and to questions from the audience. Additionally, there is usually a scientific or technical theme on which talks are presented. Invitees to these forums include members of the NMAB, past and current members of the Board on Physics and Astronomy and its committees and panels, heads of materials science and engineering departments, and liaisons from materials-related societies.

HIGHLIGHTS OF THE 1993 FORUM

The 1993 SSSC Forum was convened on Tuesday and Wednesday, May 4-5, 1993 by David Litster, Chair of the Solid State Sciences Committee. The Forum was divided into five sessions. (See attached agenda.)

The first session of the Forum included a keynote address by Senator Jeff Bingaman (D-NM). He discussed the evolution of a technology policy in the United States and outlined challenges for the coming years in implementing and building on government-industry partnership programs. The perspective on AMPP from representatives of the federal agencies was provided in the second session. The third session of the Forum focused on the integration of science, engineering, and societal needs in materials. Talks were presented by Al Narath (Sandia), Donald Kash (George Mason University), and Craig Fields (MCC). The final two sessions of the Forum addressed challenges for materials in the 21st century. Speakers were from leading companies in a broad range of materials-related industries as well as national labs and universities. Issues included not only technical challenges, but also challenges for new forms of partnerships and education.

STATUS OF THE PROJECT

A transcription of Senator Bingaman's keynote address was published in the June 1993 issue of the *BPA News*. (A copy of the excerpt is attached.) The SSSC is currently planning the next Forum as a followup to the 1993 Forum and the FY93 AMPP Initiative. A more detailed accounting of the 1993 Forum proceedings will be prepared to distribute prior to the next Forum. [The proceedings have been transcribed and are scheduled for completion during the Winter 1993.] The reports resulting from this effort will be prepared in sufficient quantity to ensure their distribution to the sponsors, to committee members, and to other relevant parties in accordance with Academy policy. Proceedings will also be made available to the public without restriction. The support of AFOSR will be acknowledged in the published proceedings.

Attachments

- (1) Roster of the Solid State Sciences Committee
- (2) Agenda of the 1993 SSSC Forum
- (3) Excerpt from June 1993 issue of *BPA News*

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**1993 Solid State
Sciences Committee
Forum**



*The Advanced Materials and Processing Program
and the Restructuring of Materials Science and
Technology in the United States:
From Research to Manufacturing*

Jointly Sponsored by the Solid State Sciences Committee, the
National Materials Advisory Board, and the
Washington Materials Forum*

* The Washington Materials Forum (WMF), organized in 1991, is a consortium of professional societies with an interest in materials science and technology. The WMF consists of the Materials Research Society; American Physical Society; American Chemical Society; American Ceramics Society; American Vacuum Society; ASM International; The Metals, Mining, and Materials Society; Society of Photo-Optical Instrumentation Engineers; Society for Hybrid Microelectronics; Mineralogical Society of America; Federation of Materials Societies; the Electrochemical Society, Inc.; American Institute of Chemical Engineers; and the American Society of Mechanical Engineers.

1993 Solid State Sciences Committee Forum

The Advanced Materials and Processing Program and the Restructuring of Materials Science and Technology in the United States

National Academy of Sciences Auditorium

May 4, 1993

Session I: Welcome and Keynote Address

- | | | |
|------|---|---|
| 0830 | Welcome and Introduction | Robert M. White, Vice Chair, NRC
Jim Williams, Chair, NMAB and David
Litster, Chair, SSSC |
| 0845 | Keynote Address
(Topic: New Forms of Cooperation and
Impact on Competitiveness) | Senator Jeff Bingaman (D, New Mexico) |
| 0915 | Questions from the audience | |

Session II: Perspective on the Interagency Advanced Materials and Processing Program (AMPP) from the Federal Agencies

- | | | |
|------|--|--|
| 0930 | Advanced Materials and Processing:
The Federal Program in Materials
Science and Technology | Lyle Schwartz, Director, Materials Science &
Engineering Laboratory, NIST, and
Chair, COMAT |
| 1000 | National Science Foundation | William Harris, Asst. Director for
Mathematical and Physical Sciences |
| 1030 | Department of Energy | Will Happer, Director, Office of Energy
Research |
| 1100 | Advanced Research Projects Agency | Gary Denman, Director |
| 1130 | National Aeronautics and Space
Administration | Daniel Goldin, Administrator |
| 1200 | Panel Discussion | Above plus Bill Appleton, Praveen
Chaudhari, Henry Ehrenreich, Merton
Flemings, Bob Laudise, David Litster ⁺⁺ ,
John Poate, Jim Williams ⁺⁺
[⁺⁺ =Co-chairs of Panel] |
| 1230 | Questions from the audience | |
| 1300 | LUNCH | |

Session III: Integration of Science, Engineering, and Societal Needs in Materials

- | | | |
|------|--|---|
| 1430 | National Laboratories: Their Role in
US Economic Security | Al Narath, Sandia National Laboratories |
| 1515 | Government Technology Policy: What
Should It Do? | Donald E. Kash, George Mason University |
| 1545 | BREAK | |
| 1600 | Role of Consortia in US Industrial
Competitiveness | Craig Fields, MCC |
| 1630 | Discussion and Closing Remarks | Jim Williams, David Litster |
| 1700 | RECEPTION | |

1993 Solid State Sciences Committee Forum

National Academy of Sciences Auditorium

May 5, 1993

Session IV: Challenges for Materials in the 21st Century

0845	Welcome and Introduction	Jim Williams, Chair, NMAB; David Litster, Chair, SSSC; John Poate, WMF
0900	Motorola: Cooperative Efforts in Microelectronics in the US	Tommy George, Motorola
0930	IBM: The Technology Value Chain: Evolution and Implications	Jim McGroddy, IBM
1000	AT&T Bell Laboratories: The Changing Role of Industrial Research	William Brinkman, AT&T
1030	BREAK	
1100	Boeing: Engineering Needs in Structural Materials	Don Lovell, Boeing
1130	General Electric: High-Strength Light-Weight Materials for Transportation	Jim Williams, GE
1200	Hewlett Packard: Emerging Technologies in the US Optoelectronics Industry	Roland Haitz, Hewlett-Packard
1230	LUNCH	

Session V: Challenges for Materials in the 21st Century (Continued)

1400	Technology Transfer Activities in Government Laboratories	Panel: Bill Appleton, ORNL; Dan Arvizu, Sandia; Roger Lewis, DOE
1445	The Changing Climate for Precompetitive R&D Collaboration	John P. McTague, Ford Motor Co.
1515	BREAK	
1530	University Research in Tomorrow's Environment	Venkatesh Narayanamurti, UC Santa Barbara
1600	Engineering Education in the 21st Century	Raymond Orbach, UC Riverside
1630	Discussion and Closing Remarks	Jim Williams, David Litster, and John Poate
1700	ADJOURN	

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The Board on Physics and Astronomy is a continuing interdisciplinary body with expertise spanning the various subfields of physics as well as astronomy and astrophysics. It serves as a focal point in the National Research Council for issues connected with these fields. The activities of the Board are supported by funds from the National Science Foundation, the Department of Energy, the Department of Defense, the National Aeronautics and Space Administration, and private and other sources.

Board Meets (continued from Page 1)

ported on a program initiation meeting that he chaired on optical sciences and engineering that was held at the Academies' Beckman Center on the campus of the University of California at Irvine. A proposal for a major study of this field emerged from that meeting. A full report of the meeting appears in another article in this issue of *BPA News*.

The January issue of *BPA News* reported on hearings on the changing environment for research in physics and astronomy that the Board held last October. Those discussions led the Board to propose to its parent Commission on Physical Sciences, Mathematics, and Applications a convocation that would ad-

dress this issue within a broader context. The Commission is now planning a meeting of some 40 policy makers and researchers to be held in August in the Washington area to discuss the issues and to formulate plans to extend the dialog more widely. These plans were discussed during a joint meeting of the BPA and the Board on Mathematical Sciences.

The open session of the Board meeting closed with a presentation entitled "Frontiers of Optical Science and Engineering: Communications, Displays, and Storage" from Richard Slusher of AT&T Bell Laboratories. Dr. Slusher is a member of the Committee on Atomic, Molecular, and Optical Sciences and was a participant in the program initiation meeting on optical science and engineering. ■

1993 Solid State Sciences Committee Forum. Keynote Address

New Forms of Cooperation and Impact on Competitiveness by Sen. Jeff Bingaman

What I would like to do this morning is, first, describe the evolution of technology policy over the past half dozen years, and second, outline the challenges of the coming years in implementing and building on government-industry partnership programs put in place over the last few years.

Evolution of a Technology Policy

For several decades after World War II, the Department of Defense was clearly the world's dominant customer for advanced technologies ranging from computers to aircraft. This was no longer true, and for the first time in 50 years foreign dependence was emerging as a potential national security threat.

Technology had gone global. If we were to maintain technological superiority in our weapons systems, DOD had to begin adjusting to the new realities of worldwide technology development. This appeared to be particularly true with regard to technologies with commercial applications.

Interest in the impact of these trends and DOD's efforts to adjust to them led me to develop a statutory requirement for an annual Defense Critical Technologies Plan. Prioritization of defense R&D seemed to be the first logical step in developing a new approach. In 1989 we received the first annual plan, which identified 22 critical technologies for the Department. The trends were becom-

ing clear: (1) dual-use technologies dominated the list; (2) commercial applications led defense applications in those areas; and (3) the U.S. was no longer dominant, with Japan ahead on 6 of 22 technologies.

From an economic perspective, it was clear that every advanced industrialized nation was making a commitment to technology development not for national security reasons but because they saw it as central to economic growth. Even more so today than six years ago, global competition prevents any one country from dominating all technologies of economic or military significance. But it is crucial that we maintain a strong technology base in this country and seek to ensure that U.S.-based firms are among the global leaders in the highest-leverage technologies and industries.

From a defense perspective, we need to do so simply to stay abreast of rapid technological developments which could result in unforeseeable future threats to our country. Technology is the currency of national power, and we need to constantly replenish our stock of this currency to ensure the qualitative superiority of our weaponry.

At that time, we saw that economic security and national security were rapidly converging, and it became very clear that the Defense Department's efforts to nurture criti-

cal technologies needed to be integrated into a broader national effort. What followed over the next five years was a series of efforts, which I am sure most of you are familiar with, aimed at the development of a national technology policy.

These efforts were characterized by:

1. Fostering government-industry partnerships in DOD and the Department of Energy laboratories in dual-use critical technologies where U.S. industry could both contribute to defense needs and benefit from federal investments.

2. Developing national policies and institution toward critical technologies through the creation of a (1) National Critical Technologies Panel chaired by the White House Science Advisor; (2) a requirement that the Federal Coordinating Council on Science, Engineering, and Technology develop strategic plans in each of the national critical technologies, just as it had done in the High-Performance Computing Initiative championed by then-Senator Gore; and (3) establishment of a Critical Technologies Institute to assist the Science Advisor in both efforts.

The Advanced Materials and Processing Initiative being discussed today is one result of these requirements.

I cannot tell you that these efforts have all been neatly coordinated and smoothly built one on the other. For those who followed technology policy formulation in Washington, it must have appeared that we were taking one step back for every two steps forward, particularly during the ideological gridlock of the last few years. But a general consensus began to emerge, and Congressional efforts culminated last year in a broad-based Defense Reinvestment and Conversion initiative. The Clinton-Gore campaign was reaching similar conclusions, as outlined in their position papers from last fall, and their efforts began in earnest in February with the release of the administration's technology policy.

These initiatives—the defense reinvestment package and the Clinton technology

policy—are part of a long-term, fundamental shift in federal technology policy, one that will profoundly change the way the federal government pursues research and development. Erich Bloch has referred to these changes as a "paradigm shift," in reference to Thomas Kuhn's description of how scientific theories evolve through the slow accumulation of data followed by a rapid shift in the ground rules. In my view this is an apt analogy. The ground rules shifted rather abruptly with the end of the Cold War, and we will be figuring out how to operate under the new paradigm for some years to come.

The Challenge

We need to figure out how government and industry can cooperate for competitive gain. It is obvious to me that we need a strategy for creating high-wage jobs and technological leadership for the country in the future, and cooperation will be a major part of that strategy. The imperative to focus on this today

is economic, but in the long run it is also required by our national security needs.

The mix of firms and industries that make up our industrial base is constantly in flux. We see the so-called "downsizing" of many of our best known corporate giants (General Motors, IBM, the Bell Companies and many others). We also see new firms and entire industries emerging and providing high-wage employment both here and overseas in the semiconductor and software development industries, as well as in areas such as advanced materials and biotechnology.

The questions which arise as we view this are:

1. Will the new mix of jobs provide us with our fair share of high-paying employment?
2. Will the new mix of technological and industrial capabilities that we have meet our long-term national security needs?

Put another way: Can we have an economy which enhances our standard of living and provide for our future security needs by doing so? See "Sen. Bingaman's Keynote Address" on Page 10

Task Group on AXAF Releases Report:

SCIENTIFIC ASSESSMENT OF THE RESTRUCTURED PROGRAM FOR THE ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)

The following report was prepared by a task group chaired by Arthur Daviden of Johns Hopkins University.

Summary

The Task Group on AXAF (TGA), a joint panel of the Space Studies Board and the Board on Physics and Astronomy, found that the restructured AXAF program—consisting of AXAF-I, to be launched into a high-Earth orbit in 1998, and AXAF-S, to be launched into a polar, low-Earth orbit in 1999—is fully capable of meeting the primary scientific goals of the former AXAF program. Although the need to reduce substantially the total cost of the program has led to shorter mission lifetimes, the expected increase in operating efficiency partly makes up for this shortfall. The TGA concludes that the revised AXAF program continues to meet the scientific expectations set forth in previous NRC reports, which have recommended AXAF as the highest-priority, new, large-scale program in astronomy.

Thus the TGA urges NASA to proceed with the implementation of the restructured AXAF program and to make every effort to ensure the launch of both AXAF-I and AXAF-S before the end of this decade.

Background

In a letter dated September 15, 1992, from Joseph K. Alexander, Assistant Associate Administrator for Space Sciences and Applications, to Louis J. Lanzerotti, Chair of the Space Studies Board, NASA asked the National Research Council (NRC) to evaluate the scientific content and the expected scientific return of the restructured AXAF program. In response to this request the Space Studies Board and the Board on Physics and Astronomy jointly established the Task Group on AXAF (TGA) as a subpanel of the newly formed Committee on Astronomy and Astrophysics. Arthur F. Daviden, of Johns Hopkins University, was appointed Chair of the TGA.

See "AXAF" on Page 8

"Some are ... critical ... including such areas as development of a national information network and the need to spur private R&D investments through changes in the tax laws."—
Sen. Jeff Bingaman

AXAF from Page 9

will be operated independently. Perhaps the most serious loss in this regard involves the capability of fielding new instrumentation that might have capitalized on future technological advances or been designed specifically to follow up earlier AXAF discoveries. It seems likely, however, that alternative, post-AXAF mission scenarios could prove equally effective as platforms for fielding new instrumentation, perhaps even in a more cost-effective manner.

The restructured AXAF mission maintains essentially all of the outstanding scientific capabilities of the baseline mission. The angular resolution of AXAF-I is more than an order of magnitude better than that offered by any other mission under development or even in the planning stages. The U.S. investment in high-precision x-ray optics makes AXAF-I unique in its capabilities to undertake x-ray investigations on the largest scales and at the

earliest epochs of the universe.

Similarly, the broad-band, nondispersive spectroscopy enabled by the development of the micro-calorimeter (the XRS) is maintained in the restructured mission. AXAF-S will provide a combination of high sensitivity and high spectral resolution in the important energy region above 4 keV that is unavailable with any other planned missions. Its capabilities for high-resolution spectroscopy of extended sources are particularly notable and unique in comparison with those of dispersive spectrometers.

The restructured AXAF program continues to provide unmatched angular resolution, spectral resolution, and sensitivity that will make it the centerpiece of international efforts in x-ray astronomy for the foreseeable future. When the AXAF-I and AXAF-S spacecraft are launched at the end of this decade, they will provide unique capabilities permitting major advances in our understanding of the universe.

Senator Bingaman's Keynote Address (from Page 3)

tinuously creating high wage jobs in the process of modernizing itself to create new technology and new products?

One way to look at the challenge is to identify some of the key factors in developing a national technology infrastructure which will sustain our ability to compete in the global market.

National Technology Infrastructure

Some essential components of a national technology infrastructure are:

1. Scientific and Engineering Education
2. Government-Industry Partnership
3. A Network of National Laboratories
4. Setting Technical Standards
5. Foreign Technology Monitoring
6. Technology and Trade Policy Coordination

1. Technological and Engineering Education

There are several aspects of education that I would like to address. First, education for scientists and engineers should be aimed at developing future technologies. In the last couple of years, we have been developing a manufacturing engineering education program. This program is an effort within the

Defense Department to provide matching grants to colleges and universities to support and develop programs in manufacturing engineering. Increased support for university programs was a recommendation in the OTA report on the state of US manufacturing "Making Things Better".

\$25 million was authorized and appropriated for this program in FY92 and FY93. None of the 1992 funds were expended because of a lack of Bush Administration support for the program. We expect a solicitation to be released from ARPA in March, along with solicitations for other programs included in the defense conversion package approved last year.

Secondly, education is needed for the skilled technicians required to insure our manufacturing strength. \$5 million was appropriated for FY93 for the Manufacturing Experts in the Classroom program, which is primarily aimed at two-year colleges and vocational education institutes. This program would help to bring experienced manufacturing personnel into the classroom to better tie technician training programs to industry needs.

Thirdly, we need to promote general technological literacy for the population.

2. Government-Industry Partnerships
Policies in this area should depend heavily

References

1. Committee on Space Astronomy and Astrophysics, Space Science Board, *A Strategy for Space Astronomy and Astrophysics for the 1980's*, National Academy of Sciences, Washington, D.C., 1979.
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5. Astronomy and Astrophysics Survey Committee, Board on Physics and Astronomy, *The Decade of Discovery in Astronomy and Astrophysics*, National Academy Press, Washington, D.C., 1991. ■

upon industry initiatives, should focus on the commercialization of products, and should help to facilitate the integration of defense and non-defense firms. Partnerships designed to accomplish these goals are the central feature of the defense reinvestment and conversion package passed as part of the FY93 Defense bill.

The package included \$305 million for government-industry partnerships in critical technologies, including \$30 million for partnerships in materials synthesis and processing, as well as \$200 million for federal-state partnerships in manufacturing and technology extension.

A major challenge for this year is effectively implementing these efforts. ARPA and the Interagency Technology Reinvestment Project organized to implement the partnership programs are to be commended for their efforts thus far. The process they have developed serves as a model for interagency technology cooperation.

I will be the first to say that we do not know if industry will be interested in all of these programs. The political situation last year somewhat precluded a more bottom-up approach, and we hope to learn enough from the implementation process, and industry input as that process goes forward, to make any

changes that might be needed. In my view the importance of the Technology Reinvestment Policy lies in the lessons we will learn as we figure out how to operate effectively under the new paradigm.

Industry has a large role to play. The key to partnerships is industry input, and the materials industry, as a pervasive supplier rather than a high-profile, finished product industry, has a more difficult challenge than many other sectors in getting federal attention. What is needed is a consensus position that the varied materials companies in the U.S. can advocate to Congress and the Administration. SACMA and USACA recently took a strong step in that direction with the release of their joint agenda. This effort needs to be expanded to include other materials organizations to the extent possible.

More needs to be done in the technology area as well. Materials road maps need to be developed to help guide federal materials R&D and the Advanced Materials Processing effort within FCCSET in particular. The Semiconductor Industry Association 15-year road map is a model for the type of industry efforts required to truly bring the federal research establishment into partnership with industry.

3. Integrating the National Laboratories

The Department of Energy and Department of Defense laboratory systems are unique research resources that need to be integrated into a national technology infrastructure. In facilities, equipment, and personnel, these laboratories have unparalleled capabilities. These capabilities developed out of national security needs that are not as pressing today as they were during their buildup. However, many of the concerns that led to the development of laboratory facilities will remain in the future. Just as special efforts will be required to maintain a robust defense industrial base, special efforts must also be made to maintain the facilities and people at the core of the DOD and DOE research base.

The question is how to sustain these critical research capabilities with a declining defense budget. In my view, the labs need to be integrated into a national technology infrastructure that serves the national technology base. In my view, this would involve the establishment of national user facilities and pilot centers, and broad, generic cooperative

agreements with particular sectors in addition to the CRADA activity they are currently involved in.

The DOE laboratories have a wide range of unique facilities, equipment, and expertise in the area of advanced materials, and our challenge is to make that expertise available to U.S. industry to support competitiveness. Again, industry has a large role to play in this effort, and again, the SIA semiconductor road map serves as a model. SIA has taken its road map to the DOE laboratories and asked how the labs could help. Working together, the DOE labs and the SIA have identified some areas of emphasis for the labs and have begun to flesh out cooperative research programs. A similar effort within the materials industry would be very beneficial.

4. Setting Technical Standards

A fourth issue we face is the development of an effective and timely mechanism to define technical standards so that products may be readily commercialized and used.

In the advanced materials industry in particular there is a great need for timely standards development. As the largest buyer of advanced materials, the Defense Department has in the past set *de facto* standards through its purchases. As the defense budget declines and commercial applications of advanced materials increase, DOD can no longer play this role.

The government needs to help fill that vacuum, but not through a government standard setting effort—the result would be too slow and too limited to be effective. The government needs to provide support to industry in the form of a standards infrastructure that facilitates the setting of industry-developed standards in an agile environment in a way that can speed the application of new materials in the market.

5. Foreign Technology Monitoring

We need to help industry in defining what government can do to monitor technological development in other countries. One way we have tried to address this is through the U.S.-Japan Management Training Program, an initiative that provides grants to colleges and universities to develop programs that teach Japanese language, culture, and business practices to scientists, engineers, and managers. This initiative is modeled after the

MIT-Japan program, which for many years was the only effort of this kind in the U.S. There are now eight university programs receiving funding under these programs.

We need to do a much better job of learning from others in all areas of technology development. A better integrated government-supported information services for industry and government would address that need.

6. Enforcement of Trade Provisions

We need to look at enforcement of our trade laws so as to insure that there are adequate and equal incentives for job creation here in the United States. The Motorola philosophy has been that the company needs to compete in Japan if it is to be competitive in the United States. If we cede the Japanese market to Japanese companies, those companies will eventually compete here, and the lack of competition in their home base will be used to its full advantage.

This philosophy has been proven true many times in many sectors, most often to the detriment of our country. In my view the federal government needs to recognize this fact up front and do a better job of supporting industry efforts to break into foreign markets in high-tech areas.

Concluding Remarks

There are obviously a great number of other issues we must address in adjusting to the paradigm shift. Some are just as critical as the ones I have mentioned, including such areas as development of a national information network and the need to spur private R&D investments through changes in the tax laws.

Ultimately the U.S. standard of living and our technological and industrial strength will be determined by the success of private firms in our economy, but that success can be substantially promoted or retarded by the policies we adopt in government.

The job of designing and refining these policies to meet the change in requirements of economic competition is a complex undertaking. But the fact that it is complex does not mean we can shirk the responsibility.

The 21st century will demand no less sophistication of us than we will find exhibited by our competitors. The job is to bring government and industry together into a partnership that can meaningfully address the challenge of retaining our industrial strength. ■