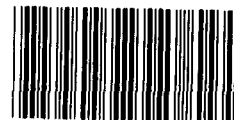


September 1992

FEDERAL RESEARCH

Lessons Learned From
SEMATECH



147834

**Resources, Community, and
Economic Development Division**

B-250107

September 28, 1992

The Honorable George E. Brown, Jr.
Chairman
The Honorable Robert S. Walker
Ranking Minority Member
Committee on Science, Space, and
Technology
House of Representatives

You requested that we annually review SEMATECH, a government-industry research consortium formed in 1987 to further semiconductor manufacturing technology and enable the U.S. semiconductor industry to regain world manufacturing leadership. Our previous reports focused on SEMATECH's technological progress toward strengthening the U.S. semiconductor industry, including equipment suppliers. (See the list of related GAO products at the end of this report.) As agreed with your offices, this report assesses the lessons learned in the first 5 years of the government's participation in SEMATECH that might be applied to other similar government-industry research and development (R&D) consortia intended to improve the competitive position of U.S. manufacturers.

In addition to SEMATECH, the government has entered into, or has considered entering into, other government-industry consortia. For example, consortia were proposed for high-definition television and superconductivity in the 1980s, and in 1991 the Department of Energy joined the Advanced Battery Consortium, which has a 4-year budget of \$260 million. In considering whether to participate in SEMATECH and other consortia, however, the government has not established specific criteria for determining when its participation should appropriately be terminated.

Background

During the 1980s, the U.S. semiconductor industry lost to Japan a significant portion of its market share for semiconductors—components that allow computers and other electronic products to process and store information. In response to this loss, several U.S. semiconductor and computer companies formed SEMATECH in August 1987 to conduct R&D on advanced semiconductor manufacturing. The National Defense Authorization Act for Fiscal Years 1988 and 1989, enacted in December 1987, authorized the Secretary of Defense to make grants to SEMATECH to defray R&D expenses. It was anticipated that the federal government would provide \$100 million per year to SEMATECH over a 5-year period through

fiscal year 1992. In April 1988, the Secretary of Defense delegated responsibility for overseeing SEMATECH to the Defense Advanced Research Projects Agency (DARPA).

SEMATECH is an industry-led consortium; its member companies plan and oversee its R&D program and provide at least half of its annual funding. About 60 percent of SEMATECH's technical staff are member companies' employees assigned to SEMATECH, typically for 2 years. In addition, SEMI/SEMATECH was established to serve as a liaison between SEMATECH and SEMI/SEMATECH's membership of 138 U.S. suppliers of semiconductor manufacturing equipment, processing materials, software, and services. The SEMI/SEMATECH members have one voting member on SEMATECH's Board of Directors. Although not a member, DARPA participates in SEMATECH's Board of Directors and Executive Technical Advisory Board meetings to review technological progress.

Our July 1992 report¹ found that SEMATECH appears to be on schedule for achieving, by the end of 1992, its technological objective of demonstrating the capability to manufacture state-of-the-art semiconductors using only U.S. equipment. According to SEMATECH and several of its members, this capability will enable the U.S. semiconductor industry to reach parity with its Japanese competition in terms of semiconductor manufacturing equipment capability at that time. However, Japanese competitors will continue to have lower manufacturing costs per semiconductor chip because they have a higher yield, or percentage, of chips that meet specifications, according to VLSI Research, Inc., an independent research organization that monitors the semiconductor industry.

Results in Brief

SEMATECH has demonstrated that a government-industry R&D consortium on manufacturing technology can help improve a U.S. industry's technological position while protecting the government's interest that the consortium be managed well and public funds spent appropriately. Overall, SEMATECH has worked well because, among other things, its member companies have led the consortium and members' senior executives have been actively involved in overseeing its activities. On the other hand, SEMATECH might have worked better, in particular, if it had more thoroughly assessed the declining market share of U.S. semiconductor equipment and materials suppliers when the program first began.

¹Federal Research: SEMATECH's Technological Progress and Proposed R&D Program (GAO/RCED-92-223BR, July 16, 1992).

SEMATECH's experience suggests that in any future consortia, it is important that

- industry members lead the consortium—including providing at least half of its annual funding—because they can best direct an R&D program designed to address their needs;
- a consortium make a comprehensive assessment of the industry, including supplier segments, and prepare an operating plan that identifies realistic objectives and milestones as a basis for receiving federal funds;
- member companies' senior executives actively participate in establishing R&D priorities and overseeing technological progress to better ensure that the consortium achieves its mission and to increase its visibility within member companies;
- a consortium have a program to improve long-term working relationships between manufacturers and their key suppliers, unless such a program is inappropriate for the industry's structure;
- a consortium emphasize projects that improve an industry's overall efficiency and leverage R&D projects that have industrywide applications;
- because public funding is involved, a consortium consider ways to provide some access to its program for smaller members of the industry that might not have the resources to participate;
- it be understood that improving U.S. manufacturers' technological position will not necessarily lead to more jobs in the U.S. economy because international business relationships are increasingly complex; and
- criteria be established for determining how or when the government should end its funding for a consortium.

Industry Members Can Best Lead a Consortium Designed to Improve Their Competitive Position

In providing federal funding for SEMATECH, the Congress intended that the consortium be industry-led and, to ensure that this happen, limited the Department of Defense's (DOD) ability to modify SEMATECH's R&D program. Companies—not the government—need to lead an R&D consortium intended to improve their industry's competitive position. In establishing SEMATECH, U.S. semiconductor manufacturers responded to a common challenge by Japanese competitors that had aggressively increased their share of the world semiconductor market. SEMATECH's member companies were in the best position to assess their manufacturing weaknesses, establish R&D priorities, and manage a program to develop advanced manufacturing technology. Member companies also have a stake in SEMATECH's success because they provide at least 50 percent of its annual R&D budget.

SEMATECH has shown that member companies can successfully work together in a Japanese-style consortium to develop advanced manufacturing technology. In particular, member companies have shared so-called "precompetitive" information about their manufacturing processes and equipment and provided technical staffing to the consortium. Through SEMATECH's Executive Technical Advisory Board, member companies have tracked SEMATECH's progress and emphasized to SEMATECH's management the importance of meeting milestones, particularly for critical projects. An important aspect of SEMATECH's organization was the involvement of semiconductor equipment and materials suppliers in establishing the consortium's initial R&D program. Furthermore, SEMI/SEMATECH's members have a seat on SEMATECH's Board of Directors.

DARPA has supported SEMATECH's overall mission of improving manufacturing technology because it believes that the nation's security interests are dependent on a strong commercial U.S. semiconductor manufacturing industry. DARPA, which has both the technical and project management expertise needed to monitor SEMATECH's R&D program, has routinely attended management and technical advisory board meetings and encouraged SEMATECH to improve its long-range planning. DARPA also has coordinated SEMATECH's R&D program with DOD agencies that fund other semiconductor R&D, and DOD has assigned employees to SEMATECH.

Comprehensive Planning Is Needed in Developing an Initial Strategy

SEMATECH's initial R&D mission and program (1) overstated what it reasonably could accomplish in 5 years with a \$200 million annual budget and (2) did not adequately consider the rapid loss of market share by U.S. suppliers of semiconductor manufacturing equipment and materials. SEMATECH's initial mission was to enable the U.S. semiconductor industry to regain world leadership in manufacturing by the end of 1992. However, the U.S. semiconductor industry will just reach parity with its Japanese competition in equipment capability and, according to VLSI Research, will continue to have higher manufacturing costs because of Japanese manufacturers' higher yield of semiconductor chips that meet specifications. Although, as one member company noted, aggressive goals are needed to drive SEMATECH's R&D program and motivate workers, such goals set unrealistic expectations against which the consortium's performance is measured.

SEMATECH's initial R&D program, developed during 1987 by executives from several SEMATECH member companies and equipment and materials

suppliers, planned to spend more than 80 percent of the budget internally by building and using a fabrication facility to (1) demonstrate advanced semiconductor manufacturing methods and processes and (2) work with selected U.S. equipment and materials suppliers to improve existing equipment and develop next-generation technology. DARPA expressed concern about the adequacy of SEMATECH's plan and, as a basis for providing funding in May 1988, obtained SEMATECH's commitment to develop a detailed operating plan and to spend at least 20 percent of the budget on R&D conducted outside SEMATECH.

In 1989, SEMATECH and its member companies refocused the R&D program in response to an internal study that found that members planned to purchase from U.S. suppliers less than 40 percent of the equipment needed for their advanced fabrication facilities. Because such low levels of purchases threatened the viability of the U.S. equipment supplier industry, SEMATECH gave higher priority to strengthening suppliers. The consortium correspondingly reduced funding for improving manufacturing methods and processes and dropped such areas as testing, assembling, and packaging final products.

As a result of this shift in priorities, about 48 percent of SEMATECH's 1991 budget supported external R&D, primarily through contracts with equipment and materials suppliers to improve existing equipment or develop next-generation manufacturing technology. (Correspondingly, SEMATECH currently is using only about 60 percent of its fabrication facility's capacity.) SEMATECH also developed Partnering for Total Quality guidelines designed to change the industry's culture from one exhibiting a competitive, arms-length relationship between semiconductor manufacturers and their suppliers to a culture in which long-term relationships were established.

SEMATECH's experience illustrates the need for (1) thorough planning at the start, including an assessment of the problems and needs of other industry segments, in developing an R&D strategy and (2) collaborating with suppliers to improve the quality of their products and manufacturer-supplier relationships. A careful analysis of the supplier segment would have enabled SEMATECH to allocate resources sooner to critical R&D projects. In addition, SEMATECH might have designed an alternative, lower-cost fabrication facility that focused on individual equipment or processes rather than the entire production line.

Commitment of Member Companies' Senior Executives Is Essential

An important reason for SEMATECH's achievements has been member companies' strong commitment to the R&D program, particularly through their senior executives' involvement in establishing R&D priorities and overseeing technological progress. In particular, SEMATECH's Board of Directors and Executive Technical Advisory Board have emphasized the importance of tracking the progress of ongoing R&D projects and proposed corrective actions when priority projects fell behind schedule. In response to their concerns, SEMATECH has tightened its management controls. In 1990, SEMATECH began using a master deliverables list providing more detailed information than was previously available about each project's definition, objectives, approach, and milestones. These milestones included such key events as defining equipment specifications, delivering equipment to SEMATECH, and completing SEMATECH's characterization and qualification analysis of the equipment. In 1991, to further improve the timely completion of project milestones, SEMATECH reorganized its technical operating divisions by establishing major R&D program, or thrust, areas and removing a layer of management between project managers and the Chief Operating Officer. In addition, SEMATECH has reduced the number of active projects from about 60 projects in 1990 to 37 projects currently and plans to reach a level of about 20 active projects in 1993.

Senior executives also have increased SEMATECH's visibility within the member companies. For example, the commitment of senior executives to SEMATECH has been critical to ensure member companies' willingness to redefine their relationships with key semiconductor equipment and materials suppliers. In addition, senior executives' involvement has encouraged technical employees to apply to be assigned to SEMATECH. In general, the Executive Technical Advisory Board members considered the assignee program very effective; they rated assignees at SEMATECH as of "high" or "very high" quality and believed that the SEMATECH experience made assignees from their companies more valuable employees. Our interviews of 19 of the 79 assignees who returned to their member companies between June 1, 1990, and May 14, 1991, found that almost all of them would accept a position as an assignee if they had to make the decision again. Fourteen of the 19 assignees rated their tour at SEMATECH as a valuable or very valuable experience, and 13 assignees considered the SEMATECH experience as valuable or very valuable for career advancement in their companies.

Improving Supplier Relationships Is Key

An important element of SEMATECH's program has been to change relationships between semiconductor manufacturers and their suppliers

from a traditional adversarial approach to a collaborative approach common in Japan. In June 1990, member companies approved Partnering for Total Quality guidelines that call for members to work more closely with their key U.S. equipment and materials suppliers by (1) sharing strategic goals and plans; (2) giving them greater access to information about the long-term performance of their equipment in a fabrication facility, including the equipment's reliability and any recurring problems; (3) providing them with competitive analysis information; and (4) supporting their product development work. The Malcolm Baldrige National Quality Award Application Guidelines served as a foundation for the partnering guidelines.

Most of SEMATECH's member companies identified the partnering guidelines as one of SEMATECH's most important initiatives. One member noted that many equipment suppliers are small companies that do not have the financial capability to develop and implement world-class reliability, total quality, and customer satisfaction programs.

Executives from 23 of 26 SEMI/SEMATECH members interviewed stated that relations between their companies and SEMATECH's member companies had improved since the guidelines were adopted. Furthermore, executives from 20 of the 26 members believed that relationships between semiconductor manufacturers and their suppliers would continue to improve. (App. II lists the SEMI/SEMATECH companies we surveyed.)

A Consortium Can Improve an Industry's Efficiency and Leverage R&D Budgets

Because its member companies have accounted for about 80 percent of the U.S. semiconductor manufacturing capacity, SEMATECH is uniquely able to develop industrywide practices and standards that can improve the industry's overall efficiency. For example, SEMATECH has developed common methods for evaluating, improving, and qualifying equipment and associated software. SEMATECH also has begun to develop industrywide standards needed for computer-integrated manufacturing and flexible manufacturing, which member companies believe will yield a high return on investment by enabling them to respond effectively to customers' needs and to substantially reduce manufacturing costs.

Industrywide standards benefit both semiconductor manufacturers and equipment and computer software suppliers, lowering costs by reducing the extent to which suppliers customize products for individual customers. One member company stated that the adoption of industrywide

standards and practices would not have occurred if SEMATECH's members had continued to act alone.

SEMATECH also has leveraged R&D resources within the semiconductor industry, for example, by (1) sharing costs to improve existing or develop next-generation equipment with the supplier company in many cases, (2) using member companies' production lines in certain instances to test the performance of improved equipment and systems, and (3) using Sandia National Laboratories' expertise in manufacturing reliability to assist suppliers and using R&D funded by DARPA as the basis for developing advanced manufacturing technologies. In addition, SEMATECH's member companies, in approving the Partnering for Total Quality guidelines, agreed to work with their key suppliers to develop long-term working relationships, including sharing R&D costs to further improve and develop equipment and materials.

Furthermore, several member companies have stated that one of SEMATECH's most important contributions is as a forum for communications, enabling members to discuss manufacturing problems and solutions. In many cases, member companies have found that they were protecting similar trade secrets and experiencing similar problems. Through discussions, members have better identified the nature of manufacturing problems and the success or failure of approaches taken to fix them. Members also have recognized the importance of improving equipment reliability and using statistical methods for analyzing equipment performance and yield loss.

A Consortium Needs to Consider the Interests of Small Nonmembers

Some critics of SEMATECH have pointed out that its members are among the largest U.S. semiconductor manufacturers, and, in many cases, it has contracted with large suppliers to improve or develop equipment. We obtained the views of senior executives of 10 semiconductor manufacturers that are not members of SEMATECH. (See app. III.) Most of these executives stated that they have not joined the consortium primarily because they are relatively small and do not have the resources to pay SEMATECH's minimum annual dues of \$1 million per year. The 10 nonmember companies generally have received at most only slight benefits from SEMATECH's R&D program. However, 5 of the 10 executives told us that SEMATECH is improving the competitive position of the U.S. semiconductor industry to a moderate, great, or very great extent.

It is unclear whether reducing SEMATECH's minimum dues would encourage smaller U.S. semiconductor manufacturers to join. The President of VLSI Research pointed out that unless SEMATECH provides specific competitive benefits to member companies, it will face a "free-rider" problem in that nonmembers are able to receive benefits comparable to those received by SEMATECH's dues-paying members. One way to provide smaller companies with some access to SEMATECH's program might be to establish an "associate" program that would enable them to participate in certain parts of the consortium's program. Four executives of nonmember companies said that SEMATECH could help their companies most by providing information about their R&D program and/or access to seminars, workshops, and technical papers.

Members' International Relationships Make Benefits to the U.S. Economy Difficult to Measure

In authorizing federal funding for SEMATECH in December 1987, the Congress found that federal assistance for an industry R&D consortium on semiconductor manufacturing technology was in the national economic and security interests of the United States. The formation of SEMATECH responded to the rapid rise of the Japanese semiconductor industry, which replaced the U.S. industry as the world leader in semiconductor production in 1985, and to concerns about U.S. dependency on foreign sources for advanced semiconductors that are critical components of the weapons systems that have given DOD a technological edge in war.² Advocates of federal funding also pointed out that semiconductors are the foundation of the U.S. electronics industry, which employed 2.4 million workers and had shipments of electronic products valued at about \$310 billion in 1991.

Since the Congress authorized funding for SEMATECH, the international semiconductor industry has become increasingly complex. To better compete in foreign markets, several SEMATECH members are building advanced fabrication facilities in Europe and/or Asia. In addition, several U.S. semiconductor manufacturers in recent years have entered into strategic alliances with Japanese and European competitors to improve their access to foreign markets and/or reduce the costs associated with designing future generations of semiconductor chips and building advanced fabrication facilities. (Table 1 shows several key agreements involving SEMATECH's members that have been publicized since January 1990.)

²See Report of Defense Science Board Task Force on Defense Semiconductor Dependency, Department of Defense, Feb. 1987.

Table 1: Recent International Alliances to Develop and/or Manufacture Advanced Semiconductor Chips

Year	Companies	Purpose
1992	IBM, Toshiba, and Siemens AG	Joint development of 256-megabit DRAM ^a
1992	Advanced Micro Devices and Fujitsu	Joint development, manufacturing, and marketing of flash memory chips ^b
1992	IBM and Toshiba	Technology sharing for flash memory chips
1992	Micron Technology and NEC	Mutual supply and marketing of DRAMs
1992	Intel and Sharp	Technology sharing and mutual supply for flash memory
1991	Texas Instruments and Hitachi	Joint development of DRAMs
1991	IBM and Siemens	Joint development of DRAMs
1990	Advanced Micro Devices and Sony	Sharing of very large-scale integration technology
1990	AT&T and NEC	Design, technology, and production of micro controllers

^aDynamic random access memory (DRAM) chips are currently the most common type of memory chip.

^bA flash memory chip retains information when a computer's power is turned off.

Source: Integrated Circuit Engineering Corporation and The New York Times.

In addition, many U.S. semiconductor equipment suppliers have developed sales and service networks in Japan, which purchased 42 percent of the world's semiconductor manufacturing equipment in 1991. SEMATECH's contracts to improve existing equipment or develop next-generation technology initially required that equipment suppliers give member companies exclusive rights to purchase new or improved technology for 1 year. However, SEMATECH revised this clause in 1991 to reflect U.S. equipment suppliers' needs to compete worldwide to succeed. Under the new clause, member companies have the more limited right to order and receive the technology first, while the supplier can sell a product worldwide—including to SEMATECH members' Japanese competitors—when it is ready for market.

One result of the increasingly complex international business relationships in the semiconductor industry is that the benefits of continued federal funding for SEMATECH become less clear. In particular, while SEMATECH's efforts may benefit U.S. employment in the \$10 billion semiconductor

manufacturing equipment segment, it is more difficult to assess SEMATECH's effect on U.S. employment in the \$60 billion semiconductor manufacturing segment. As a result, SEMATECH's success may not lead to substantially more jobs in the U.S. economy, although SEMATECH officials believe that it could be expected to retain high-value-added jobs in the United States.

Criteria for Terminating Federal Funding Have Not Been Established

The Senate and House Committees on Armed Services and the House Committee on Appropriations have reported on defense authorization and appropriations bills for fiscal year 1993, respectively, and have recommended to continue the \$100 million grant to SEMATECH. No specific criteria have been established for determining when federal funding should appropriately end.

DARPA believes that industry should bear the primary responsibility for ensuring continued support for SEMATECH because it is an industry-led consortium addressing industry needs. Accordingly, DARPA has proposed phasing out funding specifically designated for SEMATECH by providing it \$80 million in fiscal year 1993 but awarding \$80 million annually in subsequent years to microelectronics manufacturing R&D projects considered to best address DOD's needs for high-performance information systems. Shifting funding for semiconductor manufacturing technology to a project basis beginning in fiscal year 1994 will enable DARPA to support R&D it considers most important, including aspects of SEMATECH's R&D as well as projects with universities and individual businesses. SEMATECH officials expressed concern that DARPA's proposal would shift the focus of SEMATECH's R&D from technologies that could be implemented in 2 or 3 years to longer term R&D that would not be implemented until 10 years after the project was completed.

Alternative criteria for terminating federal funding for SEMATECH might include the following:

- Assess whether (1) U.S. semiconductor manufacturers have reached parity with their Japanese competitors in equipment capability, manufacturing costs, and yields and (2) planned R&D projects potentially have a high return on investment. For example, member companies believe that SEMATECH's computer-integrated manufacturing and flexible manufacturing programs, which are only in the early stages of development, have a high payback because they can reduce manufacturing costs, improve yields, and respond effectively to customers' needs.

- Assess whether continued federal funding is likely to substantially benefit the U.S. economy by retaining or increasing manufacturing jobs. However, as previously noted, the increasingly complex business relationships in the semiconductor industry make any assessment of this criterion difficult.
- Continue federal funding as a matching grant, but annually reduce the government's percentage of support from the current 50-percent level.
- Continue to support the consortium until one of its largest members decides to withdraw because it is no longer receiving sufficient benefits. This option was suggested by SEMATECH officials.

Conclusions

SEMATECH has shown that a government-industry R&D consortium can help improve a U.S. industry's technological position by developing advanced manufacturing technology. Whether this can be replicated and what conditions would lead to this result in other cases is uncertain. Particular strengths of SEMATECH are that (1) its member companies have formulated the objectives, managed the R&D program, provided most of the technical staff, and paid at least 50 percent of the annual costs; (2) members' senior executives have been actively involved in establishing R&D priorities and overseeing the consortium's progress; (3) equipment suppliers are primary beneficiaries of its R&D program through equipment improvement and development contracts and efforts to improve long-term working relationships between semiconductor manufacturers and their key suppliers; and (4) the consortium is improving the U.S. industry's efficiency by developing industrywide standards and practices and leveraging R&D resources. SEMATECH might have improved its initial manufacturing R&D program by more thoroughly assessing the declining market share of U.S. semiconductor equipment and materials suppliers and by more realistically aligning its overall mission with the funds available to accomplish it.

No criteria have been established for determining when the government should end its funding for SEMATECH. While DARPA's proposal focuses on DOD's national security needs, alternative criteria might be whether (1) the U.S. industry has achieved parity with foreign competitors in manufacturing technology or (2) continued federal funding is likely to substantially benefit the U.S. economy. Another option is to reduce the government's percentage of support each year once the period that it initially committed to provide funding has ended.

Matters for Congressional Consideration

SEMATECH has done many things well; however, it could have done some things better. Therefore, in considering any future support for consortia, the Congress may wish to consider each of the eight lessons learned that this report identifies. Among other things, the Congress could consider requiring that, as a basis for receiving federal funds, the consortium (1) prepare an operating plan with milestones for critical elements of initial projects and (2) develop a program to improve members' long-term working relationships with their key suppliers. In addition, the Congress may wish to establish specific criteria for determining when federal support for SEMATECH—and any future consortia—should appropriately be terminated.

Agency Comments

We discussed the contents of this report with officials from DARPA's Offices of the Comptroller and Electronics Systems Technology and SEMATECH. DARPA officials agreed with the thrust of our eight lessons learned from SEMATECH's experience and with our matters for congressional consideration. While generally agreeing with our lessons learned, SEMATECH officials stated that our matters for congressional consideration neglect the necessity for flexibility in a consortium's response to changing environments, citing its decision in 1989 to alter its R&D program to give critical attention to equipment suppliers. While we agree that a consortium needs flexibility, we continue to believe that a consortium needs to develop an initial operating plan with realistic objectives and milestones on the basis of a comprehensive assessment of the industry. This plan can be modified subsequently as needed to respond to a changing environment. In addition, both DARPA and SEMATECH provided some clarifying information to improve the report's technical accuracy, which we incorporated as appropriate. However, as requested, we did not obtain written comments on a draft of this report.

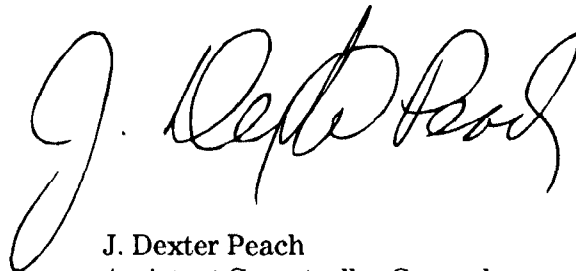
Scope and Methodology

This report builds on our previous reports assessing SEMATECH's progress in strengthening the U.S. semiconductor industry by developing advanced manufacturing technology. To update information provided in our September 1990 report on U.S. semiconductor equipment and materials suppliers,³ we contacted 26 of the 31 SEMI/SEMATECH members we had previously surveyed. We also obtained the views of 19 former assignees at SEMATECH about the value of their experiences and the effect the assignment might have on their careers. These assignees had returned to

³Federal Research: SEMATECH's Efforts to Strengthen the U.S. Semiconductor Industry (GAO/RCED-90-236, Sept. 13, 1990).

their parent companies between June 1990 and May 1991 upon completion of their tours. In addition, we interviewed executives of 10 U.S. semiconductor manufacturers that are not members of SEMATECH to obtain their perspectives on SEMATECH's benefits to their companies and to the U.S. semiconductor industry. We conducted our review between June 1991 and August 1992 in accordance with generally accepted government auditing standards.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will provide copies of this report to the Secretary of Defense; the Chief Executive Officer of SEMATECH; and the Director, Office of Management and Budget. We also will make copies available to others upon request. This report was prepared under the direction of Victor S. Rezendes, Director, Energy and Science Issues, who can be contacted at (202) 275-1441. Major contributors to this report are listed in appendix IV.



J. Dexter Peach
Assistant Comptroller General

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Abbreviations

AT&T	American Telephone and Telegraph Company
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DRAM	dynamic random access memory
GAO	General Accounting Office
IBM	International Business Machines Corporation
R&D	research and development
SEMATECH	SEmiconductor MANufacturing TECHnology
SEMI	Semiconductor Equipment and Materials International

SEMATECH's Original Member Companies

Advanced Micro Devices, Inc.
American Telephone and Telegraph Company (AT&T)
Digital Equipment Corporation
Harris Corporation
Hewlett-Packard Company
Intel Corporation
International Business Machines Corporation (IBM)
LSI Logic Corporation^a
Micron Technology, Inc.^a
Motorola, Inc.
National Semiconductor Corporation
NCR Corporation^b
Rockwell International Corporation
Texas Instruments, Inc.

^aWithdrew from SEMATECH in 1992

^bNCR Corporation has been acquired by AT&T.

SEMI/SEMATECH Companies GAO Surveyed

ADE Corporation
AG Associates
AMRAY, Inc.
Applied Materials
Applied Science and Technology, Inc.^a
Asyst Technologies, Inc.
ATEQ Corporation
Bio-Rad Laboratories, Inc.
Brooks Automation
BTU Engineering Corporation
Eaton Corporation
GaSonics
GCA^a
General Signal Corporation
Genus Incorporated
Hampshire Instruments, Inc.
KLA Instruments
Lam Research Corporation
Lucas Laboratories, Ltd.^a
Novellus Systems Inc.
Olin Corporation
Optical Specialties, Inc.
ORASIS Corporation^a
Peak Systems, Inc.
Prometrix Corporation
Shibley Company
Silicon Valley Group, Inc.
Thesis Group, Inc.
Ultratech Stepper^a
Varian Associates
Wilson Oxygen & Supply Company

Note: The 31 equipment and material supplier companies we contacted in the first half of 1990 represented 22 percent of the total of 142 SEMI/SEMATECH companies as of January 30, 1990.

^aCompanies participating only in GAO's 1990 survey. We did not include these companies in our second survey because one company had gone out of business, one company had been acquired by a non-SEMI/SEMATECH company, an executive for one company stated he could not contribute to our survey because his company had not had much contact with the SEMATECH program in over a year, and two companies are divisions of General Signal Corporation, which we contacted.

Semiconductor Manufacturers That Are Not Members of SEMATECH Surveyed by GAO

Analog Devices, Inc.^a
Burr-Brown Corporation
Cypress Semiconductor Corporation
Dallas Semiconductor
Integrated Device Technology, Inc.^a
International Microelectronic Products
Performance Semiconductor Corporation
Sierra Semiconductor Corporation
Waferscale Integration, Inc.^b
Xilinx, Inc.^a

^aMember of the Semiconductor Industry Association.

^bAssociate member of the Semiconductor Industry Association.

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Related GAO Products

Federal Research: SEMATECH's Technological Progress and Proposed R&D Program (GAO/RCED-92-223BR, July 16, 1992).

Federal Research: Assessment of the Financial Audit for SEMATECH's Activities in 1990 (GAO/RCED-92-97, Apr. 9, 1992).

Federal Research: SEMATECH's Efforts to Develop and Transfer Manufacturing Technology (GAO/RCED-91-139FS, May 10, 1991).

Federal Research: Assessment of the Financial Audit for SEMATECH's Activities in 1989 (GAO/RCED-91-74, Apr. 30, 1991).

Federal Research: SEMATECH's Efforts to Strengthen the U.S. Semiconductor Industry (GAO/RCED-90-236, Sept. 13, 1990).

Federal Research: Assessment of the Financial Audit for SEMATECH's Activities in 1988 (GAO/RCED-90-35, Feb. 16, 1990).

Federal Research: The SEMATECH Consortium's Start-up Activities (GAO/RCED-90-37, Nov. 3, 1989).

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