NTIA Report 95-318

Dependence on Foreign Sources As It Impacts the U.S. Telecommunications Infrastructure

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May 1995

PREFACE

This study was conducted for the National Communications System (NCS), Office of the Manager, Technology and Standards Office, 701 South Court House Road, Arlington, VA, under Reimbursable Order DNRO 26081. This report provides information that further defines vulnerabilities to the National Security and Emergency Preparedness (NS/EP) telecommunications operations and the capability to respond to mobilization of telecommunications manufacturing facilities required due to natural disaster or other emergency. NTIA Report 94-305 contains the results of an earlier study performed by National Telecommunications and Information Administration (NTIA) in 1992. These studies were performed as a follow up to an initial assessment in 1987 of the telecommunications industry's dependence on foreign sources and the effect of that dependence on a possible need for industry mobilization.

The objectives of this study were, in part, to update the 1987 assessment and to develop a current evaluation of the NS/EP operations' dependence on foreign suppliers of components, subassemblies, raw materials, and other consumable materials used in the telecommunications equipment manufacturing process. This report contains data compiled from reference sources as well as interviews with representatives of Government and industry. Certain commercial products and company names are mentioned in this report to specify and describe some of the information. Such identification does not imply exclusive recommendation or endorsement of the companies or the products by NTIA or the NCS. The views, opinions, and/or findings contained in this report should not be construed as an official NTIA or NCS position unless so designated by other official documentation.

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ACRONYMS AND ABBREVIATIONS

ASIC	Application Specific Integrated Circuit
BXA	Bureau of Export Administration
CPLD	Complex Programmable Logic Device
DoC	Department of Commerce
DoD	Department of Defense
DoE	Department of Energy
DPAS	Defense Priorities Allocations System
DRAM	Dynamic Random Access Memory
DSP	Digital Signal Processor
EPROM	Erasable Programmable Read Only Memory
FCC	Federal Communications Commission
FPLA	Field Programmable Logic Array
HFIA	High Frequency Radio Industry Association
ITA	International Trade Administration
ITS	Institute for Telecommunication Sciences
LAN	Local Area Network
LED	Light-Emitting Diode
MOS	Metal Oxide Semiconductor
NCS	National Communications System
NS/EP	National Security and Emergency Preparedness
NTIA	National Telecommunications and Information Administration

ACRONYMS AND ABBREVIATIONS (Cont.)

PCS	Personal Communications System
PLD	Programmable Logic Device
RBOC	Regional Bell Operating Company
RISC	Reduced Instruction Set Computing
SEM	Semiconductor Manufacturing and Testing Equipment and Materials
SIA	Semiconductor Industry Association
SIC	Standard Industrial Classification
SRAM	Static Random Access Memory
ST^2L	Schottky Transistor-Transistor Logic
T^2L	Transistor-Transistor Logic
TIA	Telecommunications Industry Association
TIM	Telecommunications Industry Mobilization

DEPENDENCE ON FOREIGN SOURCES AS IT IMPACTS THE U.S. TELECOMMUNICATIONS INFRASTRUCTURE

David F. Peach[1]

The ability to rapidly mobilize the telecommunications industry is of concern in National Security and Emergency Preparedness planning scenarios. This report assesses the extent to which the U.S. telecommunications industry is dependent on foreign sources for key components. It concludes that there is a severe dependence on foreign sources for certain types of semiconductor devices as well as many factory materials and other raw materials used to manufacture these devices. This dependence is of particular concern because of the length of time it takes to build a semiconductor factory to replace a lost supply. The long-term impacts of a disruption in supply for semiconductor devices are somewhat mitigated by the fact that most semiconductor factory equipment can be obtained from domestic sources. There is little foreign source dependence for fiber optic and related optoelectronic devices. The report also discusses some of the factors that affect the relative competitiveness of U.S. manufacturers and makes recommendations for improving U.S. firms' competitive position, thereby reducing foreign source dependence.

Key words: emergency preparedness; factory equipment; fiber optics; foreign source dependence; global competition; national security; semiconductor devices; telecommunications

1. INTRODUCTION

The production of telecommunications equipment used for National Security and Emergency Preparedness (NS/EP) purposes in the United States is dependent on components and supplies from vendors operating outside the United States and Canada. The ability to mobilize the manufacturing of telecommunications equipment in response to natural disaster or war is of primary concern. A study of the foreign source dependence vulnerabilities in the process for manufacturing the Class-5 telephone central office switch was completed in 1993 by the Institute for Telecommunication Sciences (ITS) [1]. Certain components were identified that could present a

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barrier to the timely mobilization of Class-5 switch manufacturing. The vulnerabilities included several pieces of factory equipment and several consumable items that are necessary to produce the Class-5 equipment.

The current effort was initiated by the National Communications System (NCS) to assess the vulnerabilities within areas of the telecommunications infrastructure (other than Class-5 switch equipment) that are either key to the NS/EP systems or components in use or planned for procurement by the Government in the 1990s. Specific areas of potential problems (vulnerabilities) include the raw materials and the capability to manufacture certain components or systems. Raw materials, consumables, components, and subassemblies that receive value-added procedures during the manufacturing process are all included in this study. In addition, the factory equipment required during assembly or other value-added manufacturing procedures is considered to be a critical element in the production of the final product.

2. SCOPE OF THE INVESTIGATION

An analysis of the dependence on foreign sources for the entire telecommunications infrastructure is desirable. Due to limitations of funding, the effort was reduced to a study of those lines of telecommunications products (and in some cases components), that are the basis for technology vital to the NS/EP of our country.

The desire to understand foreign source dependence vulnerabilities is based on the possible need for rapid mobilization of U.S. telecommunications factories in the context of NS/EP. A rapid mobilization may mean the need for larger-than-normal quantities of raw materials, spare parts, or the need for additional equipment to provide additional communications capability for U.S. personnel.

The Gulf War of 1990–91 is a prime example of the need for such mobilization. Communications were key to the success or failure of each undertaking during this war. High-tech equipment was requisitioned to outfit the troops as they were scattered throughout the region, increasing the need for a significant amount of additional radios and other telecommunications equipment. Incidents of a similar type can occur without enough warning to adequately prepare for the need. The Department of Commerce (DoC) Defense Priorities and Allocations System (DPAS) Office[2] supported the Department of Defense (DoD) during the Gulf War. The DPAS Office handled 135 cases (91 cases pertained to U.S. forces and 44 cases pertained to allied nation requirements) that required timely availability of industrial resources to meet defense requirements.[3] Six high-priority cases handled by DPAS during Operation Desert Shield/Storm involved foreign suppliers; four Japanese companies and two British companies were lower-tier vendors (subcontractors) to U.S. companies. Each of the companies involved responded positively and was fully cooperative in providing accelerated deliveries of its respective product(s). Each of these cases was a potential problem; however, the prompt attention of the DPAS Office and the positive response of all involved avoided a crisis. All of the cases involved procurement of spare parts for repair of existing telecommunications equipment or purchase of new telecommunications equipment.

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2 The DPAS Office is responsible for establishing a system for obtaining timely delivery of critical industrial products and materials to support current defense requirements and maintaining a preparedness capability for industry to respond to any emergency. The DPAS Office is maintained by DoC, within the Office of Industrial Resource Administration (OIRA).

3 Personal communication, R. Meyers, DoC DPAS Office, July 8, 1993.

In some cases the Government also provides assistance in obtaining supplies in response to mobilization needs after a disaster. The DPAS Office was asked to provide assistance in procuring telecommunications equipment needed during the aftermath of Hurricane Andrew.[4]

Hurricane Hugo in 1990, Hurricane Andrew in 1992, Hurricane Iniki in 1992, the 1991 San Francisco Bay Area earthquake, the East coast blizzard of 1993, and the 1994 Northridge earthquake are examples of recent disasters that required mobilization of the telecommunications industry. Similarly, unexpected failure of large pieces of telecommunications equipment (e.g., the 1988 Hinsdale fire) could create the need to quickly replace components or the complete system. The NS/EP telecommunications needs that could not be met immediately during these disasters ranged from a replacement Class-5 switch (not available off-the-shelf) to a need for telephone poles. In the case of Hurricane Hugo, the immediate supply of telephone poles was depleted early in the hurricane as it passed over the first of three Regional Bell Operating Company (RBOC) territories. The first affected RBOC (Bell South) placed orders for replacement telephone poles. After passing over portions of the Bell South territory, the hurricane then passed over portions of Bell Atlantic territory, and finally over portions of NYNEX territory. An insufficient supply of telephone poles remained to replenish the damaged poles in the Bell Atlantic and NYNEX territories, so a mobilization of this industry (production of telephone poles) was required.

The scope of this study is limited to the high-tech components and systems used in telecommunications devices that are more likely to be in short supply during a mobilization. We have assumed that all lower-technology items can be manufactured by U.S. companies within a reasonable time period. For these reasons the following areas were singled out for this study:

- semiconductor devices
- semiconductor factory equipment
- semiconductor factory materials
- fiber optic products
- wireless products

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4 Personal communication, R. Meyers, DoC DPAS Office, July 8, 1993.

3. LIMITATIONS OF THE INVESTIGATION

The completeness, and to some extent the success, of this study is somewhat limited due to time constraints and the extreme difficulty of obtaining accurate, precise, and current information. In some cases obtaining the correct data is very time-consuming. Some data are considered confidential commercial information by the companies engaged in manufacturing a specific telecommunications system or component and so are unavailable.

The use of a survey was determined not to be an effective approach for this study due to the reluctance of the companies to release data. It was also determined that The Defense Production Act of 1950 (requiring release of data critical to the defense, i.e., for NS/EP purposes) could not be used to collect data for this study because it had temporarily expired during the study.

The extent to which the United States dependence on foreign sources produces vulnerability is complicated by the lack of a defined threat that could sever the supply of needed materials, components, or devices. With the breakup of the Soviet Union and the dismantling of the Berlin Wall, the threat from historic adversaries is thought to be decreased. Other analysts believe the major threat could be from the economic war that they believe is underway or is imminent. For the purposes of this report, the threat will be defined as a disruption of supply.

The lack of a defined threat leads to difficulty in determining whether a given dependence on foreign suppliers is in fact a threat to NS/EP. An example of this dilemma is illustrated in a recent report published by the Department of Commerce, Bureau of Export Administration (BXA) [2], entitled "The effect of imports of ceramic semiconductor packages on the national security." Although over 90 percent of the ceramic packages used in the United States are obtained from Japanese companies, BXA determined that no threat to national security exists because those Japanese companies manufacture a significant amount of the ceramic packages at factories in the United States. This conclusion was reached because there is a domestic source (though foreign-owned) that has been reliable in the past. The report did note that this foreign firm depends on its overseas parent organization for all green tape (i.e., unfired ceramic, and several other critical inputs to the process) for packages produced in the United States.

A second factor that makes it difficult to determine whether a given source vulnerability has national security implications is that the significance of particular components is not always known. The report on ceramic packaging [2] notes that: "As a result of the changing national security challenges facing this country, the Department of Defense is currently unable to identify its exact quantitative requirements for ceramic semiconductor packages during a national security emergency." This is not only true for ceramic packages, but for all of the components or materials that are purchased predominantly from sources outside the United States.

Most of the products that are threatened by a disrupted supply of components or materials are in the high-technology arena. The technology turnover in these areas is rapid, resulting in short-term vulnerabilities in some cases. A good example of this has been the evolution of the Dynamic Random Access Memory (DRAM). Memory sizes have progressed from 64-kb (kilobit) chips to the now commonly used 1-Mb (megabit) or 4-Mb DRAMs. The turnover rate of such technology has decreased to two years or less. An identified foreign source vulnerability for one size DRAM disappears as the next larger size DRAM is used in the design of the next generation of product. The new technology may of course create a new foreign source vulnerability. Because of the inability to isolate one type of DRAM, or Static Random Access Memory (SRAM), or other specific integrated circuit, it was decided to treat the whole group of semiconductors as a “problem” area.

4. SEMICONDUCTOR DEVICES

The U.S. dependence on foreign sources for certain semiconductor devices and components was evident in earlier studies [1, 3]. During the 1992 ITS studies, it was determined that U.S. companies were competitive in supplying all semiconductor devices except DRAM and SRAM devices. In particular, the markets for DRAMs and SRAMs of 4 Mb or more are primarily dominated by sources outside of North America.

4.1 Background Information

Technology turnover in the semiconductor manufacturing business is rapid. Therefore investments in capital equipment and product development are inherently risky—technological innovations may make the products or equipment obsolete before any return on investment can be realized. In the 1980s, the industry began to realize that individual companies and limited partnerships are unable to provide technology leadership because of limited resources and the lack of standards. As a result, in 1987, 11 semiconductor companies and the U.S. Government formed Sematech, a research and development partnership based in Austin, Texas that focuses on improving semiconductor manufacturing technology. For example, Sematech helped the member companies to work together with a standardized qualification methodology for key processing equipment that used the best features of each company's process.

A second consortium, Semi/Sematech, was founded in 1987. This consortium is also based in Austin, Texas and is funded solely by industry funds. Its members are U.S. companies that are suppliers of semiconductor factory equipment and materials, and its mission is to enhance the competitive position of member companies. One way it achieves that mission is by helping member companies work with standards and technologies developed by Sematech.

The worldwide sales of semiconductors have grown over 300 percent during the decade from 1980 to 1990 as shown in Figure 1. During that time, U.S. market share dropped and U.S. companies lost their lead in the semiconductor market. Figure 1 shows that three U.S. companies were among the top five semiconductor producers, and five U.S. companies were among the top ten producers in 1980. In 1990, only two U.S. companies were among the top five producers, and only three U.S. companies were among the top ten producers.

Figure 2 shows the relative market share for manufacturers in the United States, Japan, and other countries between 1982 and 1992. It shows that between 1990 and 1992, U.S. companies regained a slight lead. Some of the credit for the recovery should be given to Semi/Sematech. Normal business cycles are probably responsible for the remainder of the recovery.

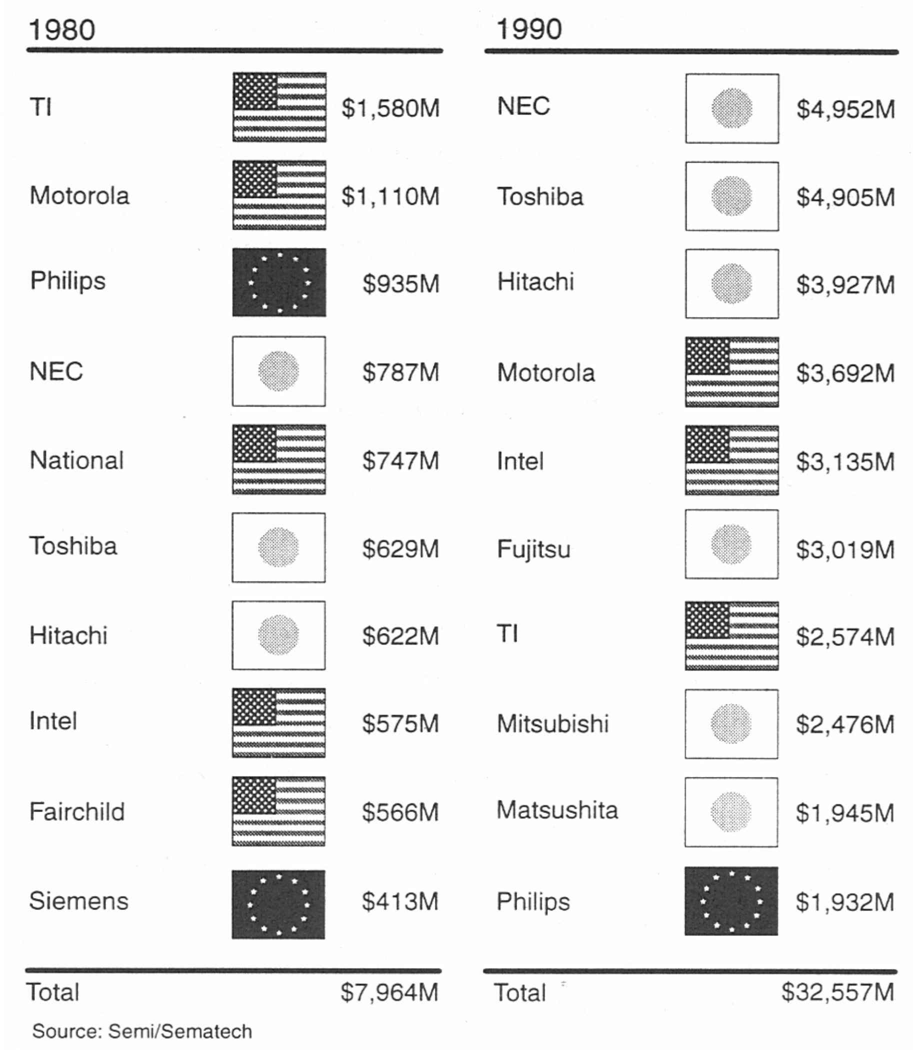

Figure 1. Top ten semiconductor suppliers worldwide.

A recent update from Dataquest, Inc., details the world semiconductor market share by the North American, Japanese, European, and Pacific Rim manufacturing segments. Recently compiled 1992 data show the two largest semiconductor markets (in dollar value) are (1) the DRAM memory (57% of the world market) and (2) the SRAM memory (20% of the world market). The worldwide and North American market share is distributed as shown in Table 1.

Semiconductor component segments that are expected to experience a significant increase in share of the world semiconductor market in the next few years include metal oxide semiconductor (MOS) components. The MOS technology is used to manufacture DRAM, SRAM, and other memory component products. Segments of the semiconductor market that will sustain the greatest growth in the next few years can be determined from Table 2.

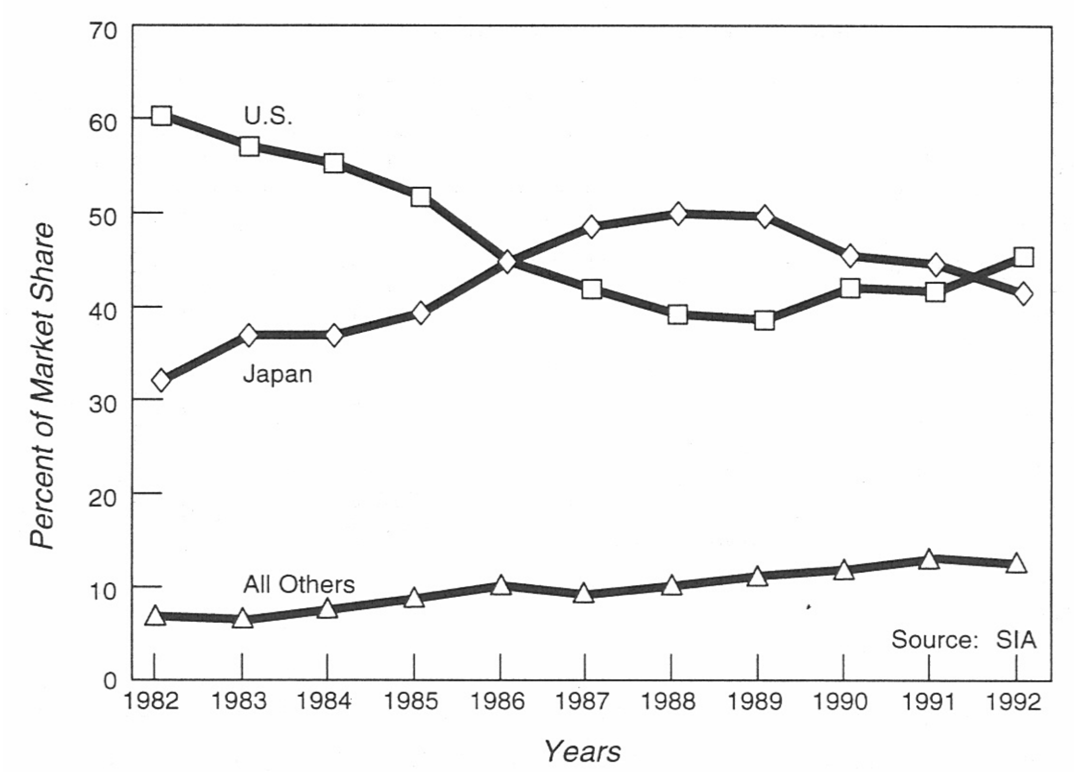

Figure 2. Worldwide integrated circuit market share of the United States, Japan, and all others 1982-1992.

Table 1. 1992 Semiconductor Market Share Distribution

	Worldwide Market Share (%)		North American Market Share (%)	
	DRAM	SRAM	DRAM	SRAM
North American Companies	18.0	23.3	22.9	44.0
Japanese Companies	54.1	61.7	49.4	47.4
European Companies	3.6	1.8	1.7	0.8
Other	24.3	13.2	25.4	7.8

In MOS memory technology, two semiconductor component types showed the fastest growth in 1992—DRAMs and flash memories. It is of concern that these products also attracted the greatest activity in formation of production alliances between large U.S., Japanese, and European companies. In the past, similar alliances have resulted in significant U.S. technology outflow. For example, reduced instruction set computing (RISC) technology was first developed in the United States and was licensed to international partners. Some of these partners then further devel-

Table 2. World Semiconductor Market, 1992–1995

Product	Value (billions of dollars)		Percent	
	1992 *	1995,**	1992*	1995**
MOS Memory	13.8	20.2	24.1	26.1
MOS Microcomponents	12.6	18.4	22.0	23.8
MOS Logic	9.5	13.4	16.6	17.4
Bipolar Circuits	3.0	2.6	5.3	3.4
Analog Circuits	8.3	10.7	14.5	13.8
Discrete devices and optoelectronics	10.0	12.0	17.5	15.5
Total:	**57.2**	**77.3**	**100.0**	**100.0**

* Estimate

** Forecast

oped the technology and became dominant in the field. If a similar scenario develops for MOS technologies, a foreign source dependence for these devices may develop in the future.

Some analysts have conceded the DRAM market to foreign producers; however, three U.S. companies are among the top 15 producers in the world. The supply of DRAMs continues to outpace the demand, and the price continues to fall faster than U.S. companies can reduce costs. The result is a less than favorable competitive position for U.S. companies.

A reverse position exists for flash memories that use MOS technology. Although the flash memory technology is a Japanese invention, U.S. companies command more than 90 percent of the market [4]. However, if the demand for flash memories continues to develop, and if U.S. companies cannot keep pace with the competition's cost reductions, a situation similar to the DRAM scenario could develop.

In the MOS microcomponent category, the fastest growing product types are microcontrollers and microprocessors. Industry analysts expect that the MOS microcomponent market will exceed the MOS memory market in size by the year 2000.[5] Microcontrollers are used in a variety of applications, including consumer electronics, auto parts, robotics, and telecommunications. The DoC estimates that the Japanese have more than 60 percent of the world microcontroller market; the U.S. is second with close to 30 percent [4]. Sales of microcontrollers to the automobile industry rose significantly in 1992 because they are an essential component of antilock brake systems and dashboard instrumentation.

[5] Personal communication, Felling, Dataquest, Inc., San Jose, CA, March 31, 1992.

The DoC also estimates that U.S. companies have more than 80 percent of the world microprocessor market [4]. Three of the top five and six of the top ten companies that produce microprocessors are U.S. companies. Microprocessors are the key semiconductor component for processing information in PCs and computer workstations.

4.2 Summary of Trends

Future trends in the size of semiconductor component consumption in the United States and worldwide are difficult to estimate. A recent analysis[6] is summarized in Table 3 and Table 4. The unknown factor is the future impact of the Asian/Pacific countries other than Japan. Table 3 shows that Japanese suppliers lost worldwide market share between 1989 and 1990, which may have been a factor in the decline of the Japanese economy that began in 1989–90. Table 4 shows erosion of both the North American and Japanese MOS memory worldwide market shares, possibly due to the MOS memory market increase of Asian/Pacific suppliers.

Table 3. Worldwide Semiconductor Market Consumption by Supplier Region (in percent of total market)

Supplier Region/Country	1988 (%)	1989 (%)	1990 (%)
North American Companies	70.3	65.3	68.7
Japanese Companies	20.7	25.5	21.7
European Countries	6.3	5.7	6.2
Other Asian/Pacific Countries	2.6	3.5	3.4

Table 4. Worldwide MOS Memory Market Consumption by Supplier Region (in percent of total market)

Supplier Region/Country	1988 (%)	1989 (%)	1990 (%)
North American Companies	40.1	34.9	34.0
Japanese Companies	49.1	53.1	50.9
European Countries	3.1	2.9	3.9
Other Asian/Pacific Countries	7.7	9.2	11.2

6 Personal communication, Felling, Dataquest, Inc., San Jose, CA, April 1992.

The trends of the semiconductor market for 1993 include a transition from T^2L logic and 1-Mb memory devices to 4-Mb memory devices and the use of more microprocessors and programmable logic arrays. Table 5[7] summarizes these trends.

Table 5. Trends in Use of Semiconductor Devices in 1993

Type of Device	Percent Growth
Downward Trends	
1-Mb Dynamic Random Access Memory (DRAM)	–28.0
Schottky Transistor-Transistor Logic (ST^2L)	–14.0
1-Mb Erasable Programmable Read Only Memory (EPROM)	–17.0
Bipolar Programmable Logic Devices (PLD)	–18.0
Upward Trends	
4-Mb Dynamic Random Access Memory (DRAM)	38.0
32-bit Microprocessors	19.0
Flash Memories	103.0
Complex Programmable Logic Devices (CPLDs) and Field Programmable Logic Arrays (FPLAs)	31.0

4.3 Mobilization Response Timeframes

The NS/EP planners have tried to project their success in terms of the time it takes to recover from a disruption in supply of components or materials. These timeframes are discussed in a previous report [1]. Being able to respond in a timely manner if and when a disruption of supply occurs is of utmost importance to NS/EP planning activities. The appropriate response depends on the product, component, or material involved. In some cases the response can be as simple as redirecting existing inventories of commodities. At the other extreme, if no source exists, the capacity to produce that item may have to be built. For many items this can be a very serious problem. In the case of semiconductors, the lead time for constructing and bringing a semiconductor process facility to full production can be one to two years. Table 6 summarizes the start-up time required to plan, construct, and debug the process for three production scenarios: a low-technology, high-volume process line; a state-of-the-art, low-volume (pilot) process line; and a state-of-the-art,

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[7] Source: Dataquest, Inc., San Jose, CA.

medium-volume process line.[8] The time estimates were based on interviews with Semi/Sematech personnel. Each scenario assumes the need for a usable chip yield of 20% to 30% of chip starts. Constructing a process line for semiconductors, especially a high-technology (very narrow line width) process for a state-of-the-art semiconductor device, requires acquisition of specialized components, nonstandard materials, and personnel with specialized skills. Finally, these materials and personnel need to be coordinated in a production process. In some cases the availability of a particular commodity or skill may be dependent on whether another semiconductor plant is being built elsewhere in the world.

Table 6. Typical Start-up Times for Semiconductor Processes

Production Scenario	Planning Cycle (weeks)	Construction Cycle (weeks)	Process Debug (weeks)	Total Time (weeks)	Yield
Low tech (2-5µ*) High volume $500M investment	10-12	14	10	34-36	20%-30%
State-of-the-art (0.3-2µ) Pilot line (low volume) Variable investment	12	20	16	48	20%-30%
State-of-the-art (0.3-2µ) Medium volume $1B to $2B investment	12	38	16-20	65-70	20%-30%

*µ = chip line spacing in microns

4.4 Foreign Source Dependence

The vulnerability due to foreign source dependence for semiconductor devices is severe, based upon the time that it takes to build additional capacity. The time that it takes to build a process line for state-of-the-art devices that are not already being manufactured (except in prototype quantities) in the United States will be even longer due to the learning curve required to gain experience in full-scale manufacturing of such devices. To reduce our foreign source vulnerability, it is imperative to develop a capability to manufacture all types of semiconductor devices in the United States to avoid the situation in which U.S. manufacturers do not have the experience to develop and operate all high-technology semiconductor processes.

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8 Personal communication, Paiga, Semi/Sematech, Austin, TX, August 12, 1992.

5. FACTORY EQUIPMENT

5.1 Market Share Trends

Until 1990, the U.S. manufacturers' market share of semiconductor factory process equipment was declining. Recently compiled data from Semi/Sematech shows that U.S. companies have again captured over one-half of the world market for semiconductor factory equipment. The current share of the market is above that attained in 1989, as shown in Table 7.

Table 7. U.S. Manufacturers Share of the World Semiconductor Factory Equipment Market

Year	Percent of Market
1989	47.8
1990	43.9
1991	46.6
1992	50.5

The previous progressive loss of the U.S. market share for factory equipment is shown in Figure 3.[9] The substantial lead that the U.S. manufacturers enjoyed in the early 1980s has been lost, but seems to be on the recovery track at the present. This turnaround began about 1990, as illustrated in Figure 3, shortly after the formation of Sematech and Semi/Sematech.

As early as 1979, the semiconductor industry recognized that rapidly escalating research and development costs, resource limitations, and the nature of global competition in the semiconductor field required an industrywide approach to coordinate and support long-range technology development. It was clear that independent and redundant efforts by U.S. semiconductor companies, the DoD, and processing equipment and materials suppliers would be insufficient to provide technology leadership. These conclusions were echoed in a Defense Science Board study on dependence of supply for critical semiconductor components for defense. Leadership of U.S. companies in the global equipment market was very good in 1980, as illustrated in Figure 4; however, the picture was changing and would change significantly by 1990.

A true indicator of the current reliance on foreign sources for semiconductor factory equipment would be an actual analysis of a recently capitalized fabrication plant. One recently completed plant is the Motorola MOS 11 plant completed in 1992 in Austin, TX. Early in the planning

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9 Source: VLSI, a market research firm located near San Jose, CA.

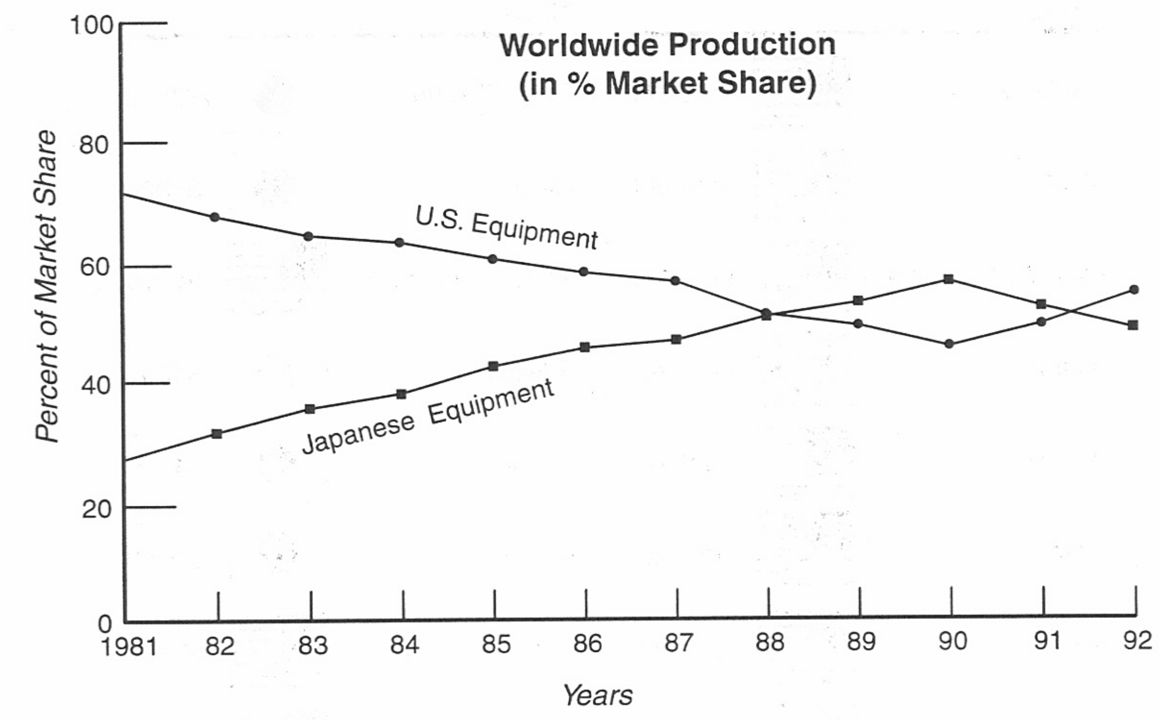

Figure 3. The global semiconductor process equipment market.

cycle for the MOS 11 plant, a Senior Vice President at Motorola indicated the benefit of Sematech in their planning process. This Vice President is quoted as saying:

"Sematech has had a significant impact on MOS 11. When we first started planning for the facility a few years ago, we anticipated that the majority of the equipment would have to be sourced outside the U.S. Things have changed over the last couple of years, largely through the help of Sematech and through a lot of work on the part of individual equipment manufacturers. When MOS 11 actually opens, it will contain about 80 percent U.S.-manufactured equipment."[10]

After the plant was completed, actual procurement summaries indicate that 85 percent (dollar amount) of the process equipment was purchased from U.S. sources.[11] This is an indication that U.S. equipment is adequate for deploying a state-of-the-art semiconductor production facility. Discussions with representatives of Semi/Sematech and Sematech during preparation of this report revealed that the industry is fraught with opinions that U.S.-made semiconductor factory equipment is of lower quality than foreign-made equipment. These opinions are thought to be a

10 Source: Presentation to Sematech by T. George, Vice President, Motorola, Inc., December 1991.

11 Personal communication, Farr and Paiga, Semi/Sematech, Austin, TX, August 12, 1992.

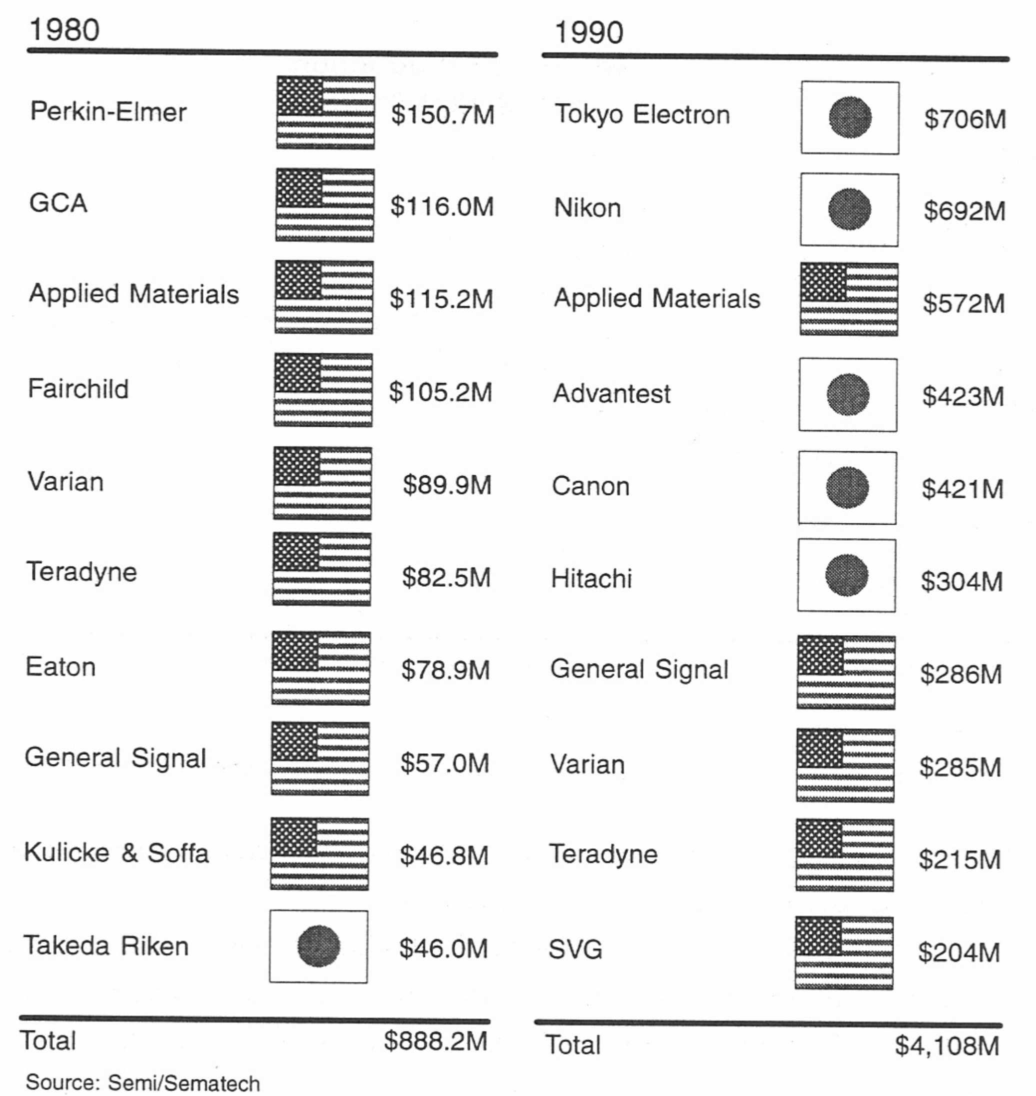

Figure 4. Top ten semiconductor factory equipment suppliers worldwide.

result of negative experiences with U.S.-made equipment in the early 1980s, along with very effective promotion from foreign equipment manufacturers.

5.2 Foreign Source Dependence

Semiconductor factory equipment can largely be obtained from sources in the United States. This fact helps to mitigate our vulnerability due to dependence on foreign sources for semiconductors. Since U.S. companies can produce all of the required semiconductor devices in prototype quantities, the ability to obtain needed factory equipment is a major factor in determining the true vulnerability for these devices.

6. FACTORY MATERIALS

Consumable materials are a necessary part of any factory process. Raw materials that receive "value-added" procedures or process modification are also critical to the manufacturing process. A lack of any one of the many materials used can preclude the manufacturing of one or more products. This study concludes that the United States has a significant vulnerability because of the extent to which our manufacturers are dependent on foreign sources of certain materials.

6.1 Significance of Factory Materials

The study performed in 1987 [3] did not examine whether any raw materials or consumable materials used in factories were obtained from foreign suppliers. In the DoC/NTIA study performed in 1992 [1], it was first determined that several consumable materials used in telecommunications equipment factories were being supplied primarily by foreign companies. The present study confirms the results of the 1992 study and also concludes that U.S. manufacturers are dependent on foreign sources for "starter" materials, a mix of consumable and raw materials and certain other value-added materials, for making components and devices (e.g., semiconductor devices, liquid crystal displays, flat panel displays). The Wall Street Journal has referred to the problem of foreign source dependence for materials as "chokepoints" that pose a "hidden vulnerability" for the computer maker [5].

Whether these supplier concentrations, from either a foreign or domestic source, are viewed as a vulnerability depends on the likelihood of a disrupted supply. The NS/EP planner must consider possible disruptions due to natural disasters, equipment failures, human error, and sabotage. The only real insurance against a lost supply is to develop diverse sources for all critical materials that can be identified.

A recent example illustrates the problems that can arise when diverse sources are not available for critical materials. One Japanese company, Sumitomo Chemical, provides over 50 percent [6] of the world requirements for epoxy resin, which is used in semiconductor manufacturing.[12] Over 90 percent of the world requirement for epoxy resin is supplied by Japanese companies. A July 1993 explosion within the Sumitomo plant curtailed production, and as a result has slowed several semiconductor manufacturing plants that rely on this source of resin. A shortage (real or

[12] The epoxy resin is a necessary raw material used in the fabrication of a temperature-stable and evacuated capsule (package) for microchips.

imaginary) of DRAMs has resulted, and the price of these chips has escalated to as much as 150 percent of the price just prior to the explosion.

6.2 Examples of Foreign Source Vulnerabilities

The time allotted for this study did not allow for the identification of all the materials that have disproportionate portion of their supply coming from foreign sources for even one manufacturing process. A few of the "chokepoints" in the semiconductor process have previously been identified [5], and a summary of the most obvious instances of foreign source vulnerabilities in the manufacturing process for microprocessors is presented below.

- **ceramic packages—**70% of the world market comes from a single supplier, Kyocera Corp., at a plant in Kokubar, Japan. Used to encase microprocessor chips for insertion in other devices.

- **magnetic ferrite**—45% of the global market share comes from TDK Corp., at a single plant in Kofu, Japan. Used to make the read/write magnetic "head" needed to source and sink data in a PC's disk drive.

- **dicing saws—**70% of the saws come from Disco Corp., which manufactures saws at two factories in Japan. Used to dissect a finished wafer into microprocessor chips that can be packaged for use.

- **"steppers"—**50% to 70% are made by Nikon Corp., at a single factory in Japan's Saitama Prefecture. Used to precisely locate the placement of each layer as it is applied in the microprocessor chip manufacturing process.

- **photomasks**—40% of the world market comes from Dai Nippon Printing Co. at two factories in Japan. Used as a stencil-like outline on the silicon wafer during the making of a microprocessor chip.

- **ultraviolet light bulbs**—70% of the bulbs are made by Ushiro Inc., at a plant in Harima, Japan. Used during the process of applying the layers on a wafer during the manufacturing process for a microprocessor chip.

- **quartz plates—**Two-thirds of the world's supply of blank quartz plates used to make photo masks are made by Hoya Corp., at two locations in Japan.

- **epoxy resin—**50% of the epoxy resin is supplied by one company; 90% of supply is from Japan. Used in production of capsules for holding microchips.

6.3 Relative Position of U.S. Materials Suppliers

As part of this project, Ms. Peggy Hagerty of Semi/Sematech presented an analysis of the U.S. semiconductor materials suppliers' position in the worldwide marketplace to ITS personnel in Boulder, Colorado on October 8, 1993, and to NCS personnel in Reston, Virginia on April 8, 1994.

Ms. Hagerty noted that materials manufacturers are typically subsidiaries of larger companies. During the widespread corporate downsizing of the 1980s, many corporations divested themselves of their materials divisions, often selling these operations to foreign buyers.

Table 8[13] shows the total 1992 sales for the top ten worldwide semiconductor materials suppliers as well as the percentage of corporate sales derived from the materials operations. Table 9[14] shows the same information for the top ten U.S. semiconductor materials suppliers. The total sales derived from materials operations is much smaller for the U.S. suppliers than for the top ten worldwide suppliers (eight of which are Japanese). Excluding the two dedicated materials manufacturers (Photronics and Komatsu Electronic Metals), these tables show that the materials operations of the top ten U.S. firms represent on average 3.64% of total corporate sales, while among the top ten worldwide suppliers, these sales represent on average 32% of total corporate sales. These data indicate that semiconductor materials manufacturing is not given the same attention in the United States as in Japan.

Table 10 shows the 1990 worldwide market share by region for several commonly used semiconductor materials. The numbers given in the table are approximate and are taken from graphs shown in Ms. Hagerty's presentations. The United States leads in only one category. In six categories, the U.S. market share is less than 5%.

Mr. Clay Prince of Sematech also participated in the briefings to ITS and NCS in October, 1993 and April, 1994. During the briefings, he discussed the strategic importance of materials production for the electronics industry. His position was that the materials industry is the root of wealth creation and that the United States is not developing an electronic materials infrastructure, with the result that the United States is dependent on foreign sources for vital materials.

Mr. Prince also discussed Sematech's plans for addressing the issue of foreign source dependence for critical materials. These include mapping the materials used in electronic devices and identifying potential bottlenecks to production and delivery of these materials. The mapping process is intended to be ongoing, to incorporate information on new technologies and new

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13 Source: Rose Associates.

14 Source: Rose Associates.

Table 8. Top Ten Worldwide Semiconductor Material Suppliers

	1992 Worldwide Semiconductor Materials Sales ($M)	% of Total Corporate Sales	Products
Shin-Etsu Chemical	1188	33	Wafers, resins
.Kyrocera	890	26	Ceramic packages
Huls (MEMC)	530	9	Wafers
Hoechst (Wacker)	510	2	Wafers, chemicals
Shinko Electric	505	80	Leadframes, ceramic
fi)ai Nippon Printing	450	5	Leadframes, masks
Osaka Titanum	446	86	Wafers
Mitsubishi Mtl.	433	5	Wafers, wire, targets
NGK Spark Plug	390	42	Ceramic packages
Komatsu Electronic Metals	385	100	Wafers, gas
Total	5727		

Table 9. Top Ten U.S.-owned Semiconductor Material Suppliers

	1992 Worldwide Semiconductor Materials Sales ($M)	% of Total Corporate Sales	Products
Air Products	160	5.3	Gas, chemicals
DuPont	140	0.4	Photomasks, gas, chemicals
Rohm & Haas	120	4.3	Photoresist, mold compound
National Semi (DCI)	120	7.0	Leadframes
Dow-Corning	100	5.6	Polysilicon, silicone
Ashland Oil	75	0.8	Chemicals
Praxair	70	2.7	Gas
Olin	65	2.8	Photoresist, chemicals
Photronics	42	100.0	Photo masks
Dexter	40	4.0	Mold compound, epoxies
Total	932		

Table 10. Approximate 1990 Market Share for Semiconductor Materials, by Region.

	U.S.	Japan	Europe	Other
Silicon wafers	0	66	27	8
Sputtering targets	2	77	20	2
Gas products	28	35	25	13
Wet chemicals	38	36	10	17
Headers	*	33	18	48
Photoresist	42	46	12	0
Leadframes	9	62	12	16
Photo blanks	1	99	0	0
Die attach materials	27	17	29	27
Multilayer ceramic packages	*	95	*	5
Bonding wires	11	73	3	14
Molding compounds	15	76	*	7
Cerdip	8	88	*	4

* Market share for a few, small suppliers is included in the “other” category.

generations of existing technology. Sematech also plans to work with industry to minimize critical materials vulnerabilities.

6.4 Foreign Source Dependence

U.S. manufacturing facilities assume significant risk by relying on foreign suppliers for materials required for producing telecommunications products. Interruption of supply is a very real possibility, as illustrated by several examples in this report. As a result, the NS/EP infrastructure is vulnerable and the ability to mobilize is not assured.

The stability and viability of our manufacturing capability derives from the availability of materials to build quality products. As mentioned in Section 10 of this report, U.S. companies are divesting themselves of low-profit materials production operations, and companies in Japan are seizing the opportunity to invest in these operations. Enterprises in other parts of the world (i.e., Korea, China, Taiwan, the European Community, and the former Soviet states) are following Japan’s example.

7. FIBER OPTIC PRODUCTS

7.1 Projected Growth Rates

The worldwide growth rate for fiber optic products, as projected by KMI Corp., remains strong: the compound average growth rate is estimated at 59 percent for the six-year period 1992 through 1998.[15] The North American market is projected to grow 13 percent during that period; while the emerging markets (including South America, Eastern Europe, India, and Indonesia) are expected to grow at a rate of 24 percent. The growth rate projected for the United States and Canada ensures a continuing demand for products to support this technology. The NS/EP requirement will only increase, and as a result will increase our sensitivity to foreign source dependence of our fiber optics product factories.

In the United States, the cable lengths are getting shorter as fiber deployment moves from long-haul to feeder to distribution, and then to the drop.[16] Figure 5 illustrates the change in types of installation from 1992 to 1998. Installations will require almost exclusive use of single-mode fiber through the 1990s (92.7% single-mode in 1990 vs. 92.2% single-mode in 1998).[17]

7.2 Fiber Optic Cable Needs

As the demand for video-to-the-home increases with the proliferation of cable services, certain experts are attempting to analyze the capability of our nation's fiber cable capacity. Mr. Peter Scovell, Managing Director of Optoelectronics at Northern Telecom, estimates that we must plan to provide a minimum capacity of 40 to 50 gigabits per second of data throughput by the end of the decade (Figure 6).[17] Currently, companies are preparing to deploy systems that will increase our capacity to 10 gigabits per second. Whatever the increase may be, experts in industry agree that the demand for more capacity will increase in the future, increasing the demand for

15 Kessler Marketing Intelligence (KMI Corporation), Newport, RI, The 16th Annual Newport Conference on Fiberoptics Markets, October, 1993.

16 The "drop" is the relatively short cable required to connect a residence from the "curb" to the wall outlet. The term "distribution" refers to the cable used to distribute service along a street, in a neighborhood, from the central office. A "feeder" is the somewhat longer cable that provides the fiber optic backbone to the central offices.

17 Source: KMI Corp., The 16th Annual Newport Conference on Fiberoptics Markets, Newport, RI, October, 1993.

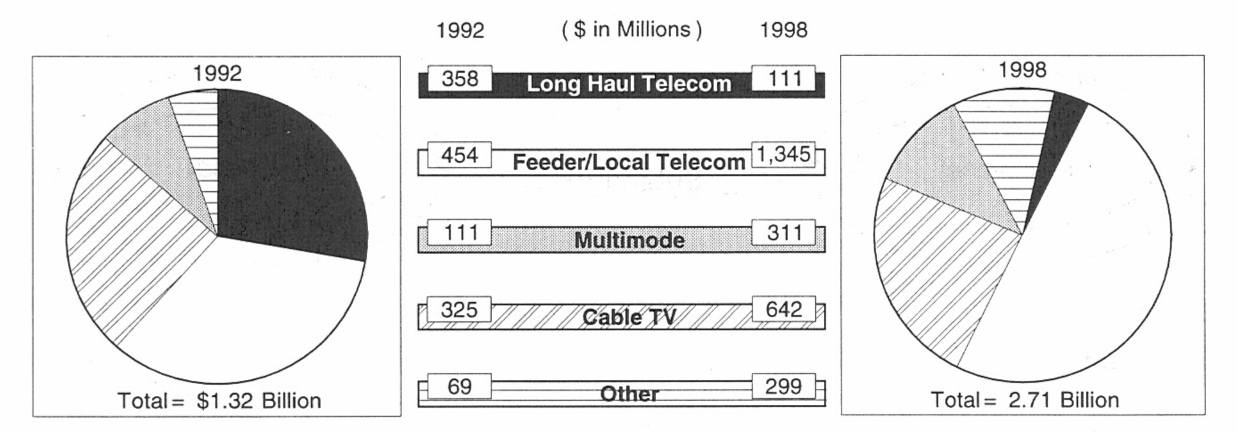

Figure 5. U.S. fiber optics market by application sector, 1992 and 1998.

high-tech fiber optic components, especially devices that increase the data transmission rate through existing fiber optic cable.

7.3 Other Fiber Optic Component Needs

The key components of any fiber optic system are the optoelectronic components, and the transmit and receive devices required to send information (data, video, etc.). At present, this area is of little concern; however, as the demand for these devices increases, additional capacity for production will develop, possibly overseas. For the NS/EP planner, this could be a problem.

7.4 Foreign Source Dependence for Optoelectronic Devices

In 1993, the BXA at the DoC conducted an assessment of six technologies deemed critical to the national security of the United States. Optoelectronics, which includes equipment used in fiber optic transmission systems, was among these technologies. BXA conducted a survey to determine U.S. companies' strength in the world marketplace for these devices. The companies were asked to rate themselves relative to their Japanese and European competitors. The results are summarized in a Department of Commerce International Trade Administration (ITA) report [7]. As a group, the responding companies believed that they were ahead of their Japanese and European competitors in the areas of technology, price, and quality. However, they believed that they were behind these competitors in terms of government support.

Another good indicator of the strength of U.S. companies' position in the competitive arena can be obtained by assessing the shipments of fiber optic components to users outside the

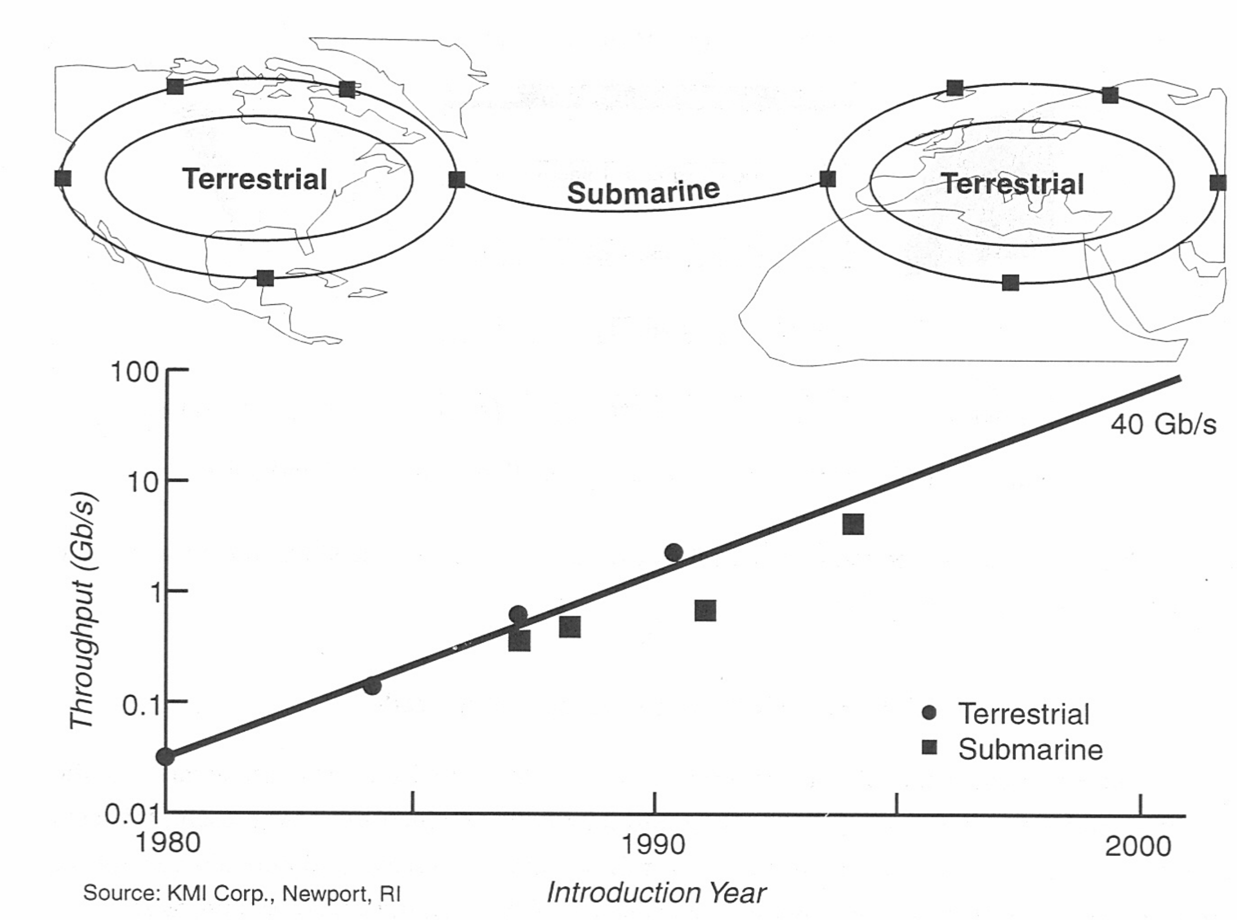

Figure 6. The looming fiber optic capacity crunch.

United States. A summary, based on the The Bureau of the Census findings, is provided in [7]. These data are included as Table 11. This summary shows that export of optical sensors, optical emitters, and light-emitting diodes (LEDs) has begun to increase, after a slight decrease in 1991. Based on this analysis, the ITA concluded that national security is not in danger due to shortages of these components. However, it should be noted that this study did not analyze the availability of raw materials and consumable materials required to manufacture these devices.

Ultimately, the strength of U.S. manufacturing is determined by the amount of R & D dollars that can be dedicated to preparing future technology. One measure of R & D investment in this industry is to assess the amount that industry is receiving from the U.S. Government. ITA has summarized data [7] that are presented here in Table 12. These data show that Government funding for optoelectronic research fell in the early 1990s. If this loss was not offset by an increase in

Table 11. U.S. Shipment of Fiber Optic Equipment (in millions of dollars)

Product	1990	1991	1992	1993 *
Optical Fiber	$394.7	$462.7	$509.0	$552.1
Fiber Optic Cable	789.6	733.7	807.1	892.3
Fiber Optic Systems and Equipment	892.2	1,011.6	1,112.7	1,246.2
LEDs	39.8	39.7	40.4	42.1
Optical Sensors and Emitters	81.9	74.1	81.5	83.7
Fiber Optic Connectors	17.6	73.1	80.4	88.6
Total	**2215.8**	**2394.9**	**2631.1**	**2905.0**

* Estimated

private-sector funding, the United States may not be spending enough on research and development to maintain its competitive position in this field.

Table 12. Federal Government Funding of R&D for Optoelectronic/Photonic Technologies (in millions of dollars)

Agency	1991	1992	1993
DoC	$1.2	$1.0	$0.8
DoD*	86.8	70.9	71.9
DoE	26.5	28.4	28.1
NASA	4.4	4.9	5.2
NSF	23.4	27.0	32.7
Total	**142.3**	**132.2**	**138.7**
Annual Increase	**—**	**–10.1**	**6.5**

* Excludes classified research

7.5 Foreign Source Dependence

The United States currently has a good competitive position in the fiberoptics and optoelectronics market. However, there are indications that optoelectronics research and development in the United States may not be keeping pace with that in other countries. If this trend continues, a foreign source dependence for these devices may develop in the future.

8. WIRELESS PRODUCTS

The growth of wireless personal communications systems (PCS) has been launched by the tremendous success of cellular radio telephone. The PCS architecture has taken on greater definition in 1992 and 1993. This service is being defined as a family of services that will encompass both existing services such as cellular communication and emerging wireless services, many of which are awaiting frequency spectrum allocations before they can be realized. A recent DoC publication has defined the PCS family of services, as shown in Table 13 [4].

Table 13. PCS Family of Services

Existing Services	Emerging Services
Enhanced Cellular	Advanced Cordless
Enhanced Paging	Wireless Business Service
Enhanced Specialized Mobile Radio	Telepoint
	Mobile Satellite
	Data PCS
	Wireless LANs
	Personal Telecommunicators

The common denominator of all the PCS services is a capability for persons or devices to communicate independent of location. The Federal Communications Commission (FCC) is proceeding toward a goal of completing the rules for licensing PCS. As a highly segmentable industry, PCS may evolve first for office buildings and high-density pedestrian applications that cannot be served on a large scale by cellular communications. Interest is high and the technology will most likely develop in the future, requiring that numerous high-tech products be integrated into the NS/EP scenario by NS/EP planners.

8.1 Factors Affecting PCS Development

The key factors determining the development of the PCS technology and the proliferation of PCS products will be:

- timely Government licensing
- adequate frequency spectrum
- access to capital funds

- the formation of strategic alliances to meet the full range of PCS needs
- appropriate pricing and distribution strategies
- phone number and address definition and availability required to facilitate portability

The success that Government and industry have in implementing these factors will determine the growth of this emerging technology, its inclusion in the NS/EP plan, and ultimately the vulnerability due to dependence on foreign sources.

8.2 Foreign Source Dependence

Because PCS products are built around semiconductors (e.g., microcontrollers, digital signal processors (DSPs), flash memories, DRAMs, SRAMs, EPROMs, ASICs) the foreign source vulnerability discussed in Sections 4 through 6 would of course apply to the PCS industry as well.

9. FACTORS AFFECTING THE RELATIVE COMPETITIVENESS OF U.S. MANUFACTURERS

9.1 Industry Views on Competitiveness

Continued growth of the U.S. companies supplying factory equipment, materials for manufacturing, semiconductor devices, or telecommunications products depends largely upon the competitive edge that U.S. companies can maintain. U.S. companies have been able to compete and have increased their share of the market for semiconductor factory process equipment, in spite of the significant disadvantages of operating in the United States compared to operating in Japan. Two areas of concern that are frequently mentioned by U.S. companies are the R&D tax write-off schedule and the depreciation schedule. A comparison of U.S. and Japanese depreciation schedules for a typical piece of semiconductor manufacturing equipment (wire-bonding equipment) is shown in Figure 7. The U.S. companies must depreciate their assets over four to seven years, usually using a straight-line method, as illustrated by Figure 7, while Japanese companies are allowed to depreciate their equipment over three or four years, and if the equipment is used more than eight hours per day, Japan allows an even more rapid depreciation [8].

However, some analysts maintain that product performance and technology, financial viability, and the health of the market are the primary factors that determine whether a U.S. company can be competitive in a particular market. A good example is the Semiconductor Manufacturing and Testing Equipment and Materials (SEM) member companies. The factors that led to competitiveness of SEM companies in the semiconductor market [8] are:

- the development of stable sources of financing for R&D
- the success of cooperative relationships with domestic and foreign customers
- the growth of the domestic market for SEM products
- the ability of U.S. SEM firms to establish a presence in foreign markets

The size of the company appears to be another element in determining whether a company can succeed in a particular market, according to Semi/Sematech. Smaller companies are less likely to attract sufficient capital to purchase the state-of-the-art equipment required to build a high-technology factory. Large firms and nationally owned (Government-owned or substantially subsidized) firms tend to be immune to this problem because they can raise the capital necessary to compete in the high-technology arena.

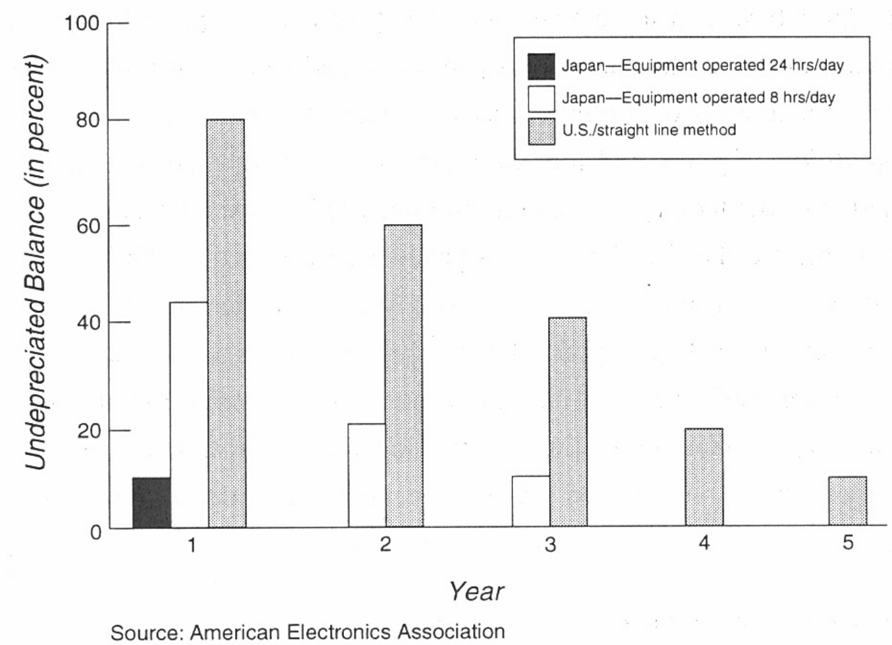

Figure 7. Wire bonding equipment: total 1990 income tax depreciation schedules for United States and Japan.

Based upon the fact that factories in different parts of the world operate under quite different rules and restrictions (determined by the individual country's laws), and that some of these rules seem to favor the factories outside of the United States, one could surmise that the playing field on which we play the economic game is not level. However, there are other factors that affect the competitive position of a U.S. company than those mentioned above. These factors include the operational costs associated with operating the factory, the time to prepare a new product for production, and the level of investment for the factory [9].

9.2 Another Perspective on Competition

An analysis by Womack et al. [9] illustrates other differences that may have a significant effect on the competitive position of U.S. companies. This study identified two types of production philosophy: (1) mass production, as developed by Henry Ford, and used successfully by manufacturers such as Ford Motor Co., General Motors, and Chrysler; and (2) lean production, as developed in Japan and used successfully by companies such as Toyota and Nissan for manufacturing automobiles in Japan and the United States.

Mass production originated with the Model T Ford, based upon Henry Ford's twentieth design of the Ford automobile [9]. Ford had finally achieved two objectives: a car that was designed for manufacture, and a car that could be driven by people without special skills. As related by Womack and his colleagues, the key to mass production was not—as many people then and now believe—the moving or continuous assembly line, *rather, it was the complete and consistent interchangeability of parts and the simplicity of attaching them to each other* (emphasis added). Automation of the factory was also important, and became a standard that factories of the world sought to duplicate. The heyday of mass production was in the 1950s.

Lean production began to evolve as a result of a conclusion in the early 1950s by Toyota Motor Company's engineer, Eiji Toyoda, and his production manager, Taiichi Ohno, that mass production could never work in Japan [9]. The formulation and perfection of lean production continues even today. Typical lean production features include just-in-time manufacturing, more efficient use of factory space, minimized on-site inventory of materials and components, and a commitment to reduce defects. Lean production requires

- human effort in the factory
- manufacturing space
- investment
- engineering hours
- time to develop new products

The analysis performed by Womack shows that lean production techniques have achieved almost a 2:1 advantage in “assembly hours” and “assembly space” required per car, and an advantage of approximately 3:1 in “defects” per car. Womack states that in terms of manufacturing space, the lean production factory was 40 percent more efficient, and its parts inventories available at the work station were a tiny fraction (two hours vs. two weeks) of those for a typical mass production factory.

The quality-enhancing ideas developed by W. Edwards Deming in the 1950s appear to have been the seed for the development of “lean production” techniques. The ideas of Deming have been summarized by the Associated Press [12] and are presented in the fourteen points below.

1. Create constancy of purpose.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.

4. Cease doing business on the basis of price tag alone.
5. Improve constantly and forever the system of production and service.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear so that everyone may work efficiently.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations, and targets.
11. Eliminate numerical quotas.
12. Allow pride in workmanship.
13. Institute a program of self-improvement.
14. Put everybody in the company to work to accomplish the transformation.

The implementation of these ideas is probably the key to the success of the Deming philosophy and the success of lean production. While more widespread adoption of lean production in the United States may improve the competitive position of U.S. manufacturers, it would also heighten the vulnerability due to foreign source dependence because of the low inventories of raw materials and subcomponents at lean production factories.

10. SUMMARY OF FINDINGS

Telecommunications technology is fast-changing, experiencing turnover in a matter of months. A company that wishes to participate in this industry must be capable of sustaining the capital investment required to compete by continuously altering market position and modifying its manufacturing processes to remain efficient as the market for products changes and the process technology evolves. The ability to compete is determined by two factors: the vision to offer the right products to fulfill the customer needs and the resourcefulness to implement the most efficient and cost-effective manufacturing techniques in a timely fashion.

U.S. companies continue to be both inventors of technology and implementors of manufacturing process techniques. In some cases a technology (or product) invented in the United States has been more efficiently or more quickly implemented by a foreign company. Frequently the U.S. inventor has not been properly recognized or compensated for the intellectual rights; however, creation of properly constructed alliances with foreign entities has reduced the outflow of technology without compensation.

U.S. companies try to position themselves for maximum profit and a low-risk future, responding to the demands and requirements of their investors and stockholders. These two attitudes determine and sometimes limit the products and processes that a company is able to pursue. For example, the pursuit of maximum profit frequently precludes the manufacture of commodities requiring a high investment and yielding a low return on investment. Many manufacturing organizations consider this to be a “dirty” business (a high-overhead business fraught with regulations, such as those of the Environmental Protection Agency). Frequently, the only company that can be successful in manufacturing such products or commodities is the company that owns the intellectual property rights (patents, etc.), since the profit margin can be less than the royalties demanded by the patent holder.

U.S. companies have successfully improved their competitive position through the development of industry associations and partnerships in certain industries. Examples of successful partnerships in the semiconductor industry include: Sematech, Semi/Sematech, and the Semiconductor Industry Association (SIA). Other successes in improving U.S. firms’ competitive position have been demonstrated by the formation of the Land Mobile Radio Industry’s organization, Associated Public Safety and Communications Officials, Inc. (APCO 25) under the sponsorship of the Telecommunications Industry Association; and the High Frequency Radio Industry’s Association (HFIA) under sponsorship of the Armed Forces Communications and Electronics Association. These organizations, sometimes referred to as the “The American Keiretsu,” [10] if properly structured and managed, can provide a competitive edge for the member companies. The Keiretsu system practiced in Japan involves partnerships between the banking industry, manufacturing industry, and users.

Statements of findings, supported by facts and data provided earlier in this report, are included here in summary:

1. It is difficult to identify and respond to foreign source vulnerabilities for raw materials, process consumable materials, components, and subassemblies that affect the telecommunications industry because of the rapid technology turnover in this industry. By the time a vulnerability for a given item is recognized and a domestic source for the item is developed, the item may no longer be needed by the industry. Domestic sources for all items vital to the telecommunications industry must be developed with long-term goals and commitment.

2. A partnership must be formed between manufacturing companies that have a foreign dependence problem and a U.S. company that can develop a local source for the item(s) purchased from foreign sources. These partnerships are referred to as "The American Keiretsu" [10].

3. The U.S. semiconductor device industry is stronger than it was in the 1980s, the ability to compete is proven, and the U.S. semiconductor makers are in command of the market for a majority of end-product devices. However, the dependence on process materials (i.e., gases, photolithography items, raw and processed silicon, chemicals, and other consumable materials) from foreign sources is becoming greater.

4. Telecommunications end-product and component manufacturers are concerned about their reliance on foreign supplies of key components or materials used to build their products [11].[18]

5. Most product production processes are reliant on one or more foreign sources for supply of one or more components, subassemblies, raw materials, or consumable material commodities [11].

6. The implementation of "lean production" at some factories in the United States has likely increased the exposure to interruption due to a disrupted foreign supply. The compression of the inventory supply pipeline within the manufacturer's process facility has compounded the vulnerability due to reliance on foreign suppliers. Frequently, the end-product manufacturer does not know the quantity or the location of raw material supply available to his factory because that responsibility has been transferred to the supplier. That supplier may be a foreign

[18] The referenced article in *The Atlantic Monthly,* entitled "Looking at the sun," cites a report performed by the U.S. Office of Technology Assessment that concluded that several steps in the semiconductor process were dependent solely on Japanese suppliers.

entity or may be dependent on a foreign supplier at a lower tier for supply of a raw material.

7. U.S. manufacturers are capable of manufacturing or supplying every essential component or material required to produce telecommunications products. The reasons why there are no U.S. manufacturers producing certain products are numerous. These reasons usually stem from an insufficient return-on-investment, which is a result of one of the following factors:

    - inability to compete due to labor costs in the United States
    - inability to compete due to cost of conforming to Environmental Protection Agency regulations
    - inability to compete due to cost demanded by proprietary rights (patent) owners
    - inability to compete due to manufacturing costs (higher than foreign competitors) resulting from U.S. tax law structure
    - an unwillingness to sell below cost for an extended period [11].

8. Some U.S. manufacturers have been purchased by foreign organizations as a result of insufficient return-on-investment.

9. The formal association of U.S. manufacturers for the purpose of improving the members' competitive position in the marketplace has proven to be beneficial for several industries.

10. Foreign investors have seized investment opportunities in the United States. There is an indication that there has been strategic positioning of these investments in a way that could provide control of selected processes. For example, in a typical semiconductor process, foreign suppliers are the only source for certain process equipment and materials.

11. REFERENCES

[1] D.E. Peach and M.D. Meister, "An assessment of the U.S. telecommunications industry dependence on foreign sources as it impacts the U.S. telecommunications infrastructure," NTIA Report 94-305, NTIS Order No. PB 94-204757, April 1994.

[2] U.S. Department of Commerce Bureau of Export Administration, "The effects of imports of ceramic semiconductor packages on the national security," NTIS Order No. PB 93-192441, August 1993.

[3] National Communications System, "Final report of the joint industry-government telecommunications industry mobilization (TIM) group, Volume II: Telecommunications industry mobilization (TIM) subject reports," NCS Report 792/5, October 1987.

[4] Department of Commerce, International Trade Administration, *U.S. Industrial Outlook*, U.S. Government Printing Office, Pittsburgh, PA, 1993.

[5] D.P. Hamilton, "Chokepoints—computer makers face hidden vulnerability: Supplier concentration/Many of their crucial parts and materials are made by just a few factories/Tracing the PC's ingredients," *Wall Street Journal,* August 27, 1993.

[6] "Memory-chips supply is hit by Japan blast," *Wall Street Journal*, July 21, 1993.

[7] A.J. Mocenigo, "A competitive assessment of the U.S. fiber optics industry," U.S. Department of Commerce International Trade Administration, NTIS Order No. PB 94-134806, January 1994.

[8] United States International Trade Commission, "Global competitiveness of U.S. advanced-technology manufacturing industries: Semiconductor manufacturing and testing equipment," September 1991.

[9] P.W. Womack, D.T. Jones, D. Roos, and D.S. Carpenter, *The Machine That Changed the World: The Story of Lean Production*, New York: HarperCollins Publishers, 1990.

[10] D.M. Burt and M. Doyle, *The American Keiretsu*, Burr Ridge, IL: Irwin Professional Publishing, 1993.

[11] J. Fallows, "Looking at the sun, a case of Japanese success and American failure that can't be explained by American economic rules. Could the rules be wrong?," *The Atlantic Monthly,* November, 1993.

[12] Associated Press, "Deming, a Management Innovator, Dies at 93." *Daily Camera*, Boulder, CO, December 21, 1993.

FORM **NTIA-29**
(4-80)

U.S. DEPARTMENT OF COMMERCE
NAT'L. TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

BIBLIOGRAPHIC DATA SHEET

	1. PUBLICATION NO.	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE
Dependence on Foreign Sources as it Impacts the U.S. Telecommunications Infrastructure

5. Publication Date

6. Performing Organization Code
NTIA/ITS.N1

7. AUTHOR(S)
David F. Peach

9. Project/Task/Work Unit No.

8. PERFORMING ORGANIZATION NAME AND ADDRESS
National Telecommunications and Information Admin.
Institute for Telecommunication Sciences
325 Broadway
Boulder, CO 80303-3328

10. Contract/Grant No.

11. Sponsoring Organization Name and Address
National Communications System
Office of the Manager, Technology and Standards Office
701 South Court House Road
Arlington, VA 22204-2198

12. Type of Report and Period Covered

13.

14. SUPPLEMENTARY NOTES

15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The ability to rapidly mobilize the telecommunications industry is of concern in national security/emergency preparedness planning scenarios. This report assesses the extent to which the U.S. telecommunications industry is dependent on foreign sources for key components. It concludes that there is a severe dependence on foreign sources for certain types of semiconductor devices, as well as many factory materials and other raw materials used in manufacture of these devices. This dependence is of particular concern because of the length of time it takes to build a semiconductor factory to replace a lost supply. The long-term impacts of a disruption in supply for semiconductor devices are somewhat mitigated by the fact that most semiconductor factory equipment can be obtained from domestic sources. There is little foreign source dependence for fiber optic and related optoelectronic devices. The report also discusses some of the factors that affect the relative competitiveness of U.S. manufacturers and makes recommendations for improving U.S. firms' competitive position, thereby reducing foreign source dependence.

Key words: emergency preparedness; factory equipment; fiber optics; foreign source dependence; global competition; national security; semiconductor devices; telecommunications

17. AVAILABILITY STATEMENT	18. Security Class. *(This report)*	20. Number of pages
☒ UNLIMITED.	Unclassified	45
☐ FOR OFFICIAL DISTRIBUTION.	19. Security Class. *(This page)*	21. Price:
	Unclassified	

*U.S. GOVERNMENT PRINTING OFFICE:1995-673-018/00105