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OA/ID Number: 04295
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Folder Title:
Science & Technology [3]

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Withdrawal/Redaction Sheet

(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01a. Memorandum	To: Gary Carver From: Peggy Haggert Re: US-Owned Worldwide Production of Strategic Semiconductor Materials [P.L. 100-180, Sec 276(a)] (1 pp.)	7/11/90	(b)(3)	

Collection:

Record Group: Bush Presidential Records
Office: Economic Policy Council (EPC)
Series: Wethington, Olin, Files
Subseries: Subject Files
WHORM Cat.:
File Location: Science & Technology [3]

Date Closed: 2/2/2010	OA/ID Number: 04295-018
FOIA/SYS Case #: 2005-0336-F	Appeal Case #:
Re-review Case #:	Appeal Disposition:
P-2/P-5 Review Case #:	Disposition Date:
AR Case #:	MR Case #:
AR Disposition:	MR Disposition:
AR Disposition Date:	MR Disposition Date:

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

- P-1 National Security Classified Information [(a)(1) of the PRA]
- P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
- P-3 Release would violate a Federal statute [(a)(3) of the PRA]
- P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
- P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
- P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

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01b. Chart	Sematech chart of production of semiconductor materials [P.L. 100-180, Sec 276(a)] (2 pp.)		(b)(3)	

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Semi-Gas...

(Continued from page four)

that it is against the best interests of the U.S. semiconductor industry and the nation as a whole for Semi-Gas Systems to be sold to a foreign competitor whose apparent intentions are worldwide market domination," wrote Turner Hasty, Sematech executive vice president and chief operating officer, to Hercules Chairman David Hollingsworth in April.

Sematech is concerned the sale would offer Nippon Sanso insight on the consortium's strategies, harming national security and divulging proprietary U.S. technology information.

Officials from Sematech and the Semiconductor Equipment and Materials International [SEMI] contacted Hercules executives and told them of their concern of the proposed sale to a foreign firm.

"We understand that Hercules Inc. has refused to consider a leveraged buyout by Semi-Gas Systems management that would have enabled it to remain an American company," Hasty wrote Hollingsworth. Despite SEMI/Sematech offers to help Hercules find an American buyer, the formal offers "did not even receive the courtesy of an acknowledgement."

The Semi-Gas executive said that Hercules "perceives Sematech as the enemy because [Hercules] wants the money." And, if the Semi-Gas sale proceeds, "the ramifications are that we would become discontinued from Sematech, which would severely hurt our R&D."

Sam Harrell, president of Semi/Sematech, told Hercules executives in January that "a disassociation with Semi-Gas at this time or at any time in the near future would harm Sematech's long-term strategies. As you know, Sematech's charter, as guided by the Defense Department and the U.S. Congress, provides preferential treatment to U.S. vendors/suppliers of semiconductor manufacturing equipment and materials. While our charter allows us to transact with foreign-owned companies, this may only be done as a measure of last resort."

But the sale of Semi-Gas to Nippon Sanso is not a done deal. The Department of Treasury plans to conduct an anti-trust investigatory review within the next three weeks before a deal could be consummated, a source said.

Japanese Control Liquid Crystal Displays

TOKYO—Japan's electronics industry, with government help, is pouring huge sums into liquid crystal displays and hopes to overcome formidable technical barriers that would allow them to develop large displays. "Technically, 40-inch LCDs with quality comparable to today's TVs will be realized in six or seven years," says Eiji Kaneko, director of the Giant Electronics Research Laboratory, a government-sponsored consortium of 17 companies. "We're hopeful they can be commercialized in 10."

Sharp, Hitachi, Hosiden and other Japanese firms this year will invest about \$1 billion to research, develop and set up plants to make LCDs, which are widely used in watches and laptop computer screens. Sharp, which is considered the leader of the pack, plans to invest \$650 million over the next three years.

The only foreign group that is even close to the Japanese in LCD development is IBM, which makes LCDs in a joint venture with Toshiba. "This is a Japan-supplies-the-world market," says Steve Myers, an analyst with Jardine Fleming Securities.

State-of-the-art production models deliver 16 colors on a laptop display. Samples of 14-inch displays with far better picture quality and color comparable to televisions are due out later this year but will cost about \$3,900.

Prototypes of 20-inch LCD screens are expected next year, though commercialization is still three to four years off. Scaling up beyond 25 inches will require technical breakthroughs that many people doubt are possible.

Although research is costly, strong demand for LCD products is fueling R&D spending. Demand is growing rapidly for smaller LCD panels used in portable TVs and VCRs, video telephones, electronic pocket notebooks, laptop personal computers and automobile dashboards.

By the middle of this decade, LCDs should displace cathode ray tubes as the most valuable display technology. By 2000 the LCD business will have grown 10 times to some \$13 billion.

Despite the Japanese blitz, the game is far from over. Active-matrix LCDs may never be scaled up to large sizes at affordable prices. And Japanese companies, along with many in the United States and Europe, continue to explore alternative flat-panel technologies.

But even if other approaches to LCDs turn out to be the screen technology of the future, Japanese firms are likely to dominate. "Whichever way the market moves, they'll have a product," says Myers.

—Steven Brill, Reuters

Coal Production Hits Record High

Production and consumption of coal is hitting a record pace, according to the National Coal Association. NCA's mid-year forecast says coal production will hit just over one billion tons by year end, about 22 million tons over the prior record of last year and the first time ever that production will top the billion-ton mark.

Medtronic To Build Lab In Japan

Medtronic Inc. of Minneapolis, will soon be breaking ground on a technology center in Chitose, on Hokkaido in northern Japan. The center is a "significant milestone in the evolution of Medtronic as a global company," proclaims Winson Wallin, chairman and CEO. The center will manufacture cardiac pacemakers. "As the leader in the Japanese pacemaker market, Medtronic intends to grow from those roots [and] build closer relationships with Japanese physicians," says Wallin.

Du Pont Receives Thallium SC Patent

Du Pont boosted its high temperature superconductivity patent count last week to seven, making it the leading company in the amount of patents granted for the new generation of superconductors. The patent is for a thallium-barium-copper-oxygen superconductor. The composition is similar in structure to a thallium-lead superconductor patent Du Pont received earlier this year, but differs in that the concoction has a single copper-oxygen layer instead of multiple layers. It is superconductive at temperatures in the range of 90 degrees Kelvin.

U.S. Scientists Complain About Employers

After polling 4,300 research scientists, R&D Magazine has found that 48 percent of them feel that they are working for organizations that are "not open to new ideas." This conclusion, says R&D Magazine's editor Robert Cassidy, "is startling because it indicates that the people most responsible for making American strong in technology think the idea-creating system isn't working."

Two-thirds of the scientists are distressed by the way they are treated by management, saying their employers "do not offer researchers the same rewards and opportunities to advance that they offer managers." The poll also indicates that scientists feel that they are kept in the dark when it comes to their company's long-range plans and that they are burdened with red tape in recommending and carrying out research. Fifty-nine percent said their employers failed to effectively communicate their organizational goals.

The survey also found that the scientists love their jobs.

Top 100 Slow R&D Spending

The top 100 spenders on research and development among U.S. corporations increased R&D funding by 8.7 percent last year, down from the 10.7 percent increase in 1988, according to a survey by the publication Inside R&D. The slowdown is attributed to a growing emphasis on pursuing incremental product improvements rather than on basic research targeting big breakthroughs. This trend is the result of companies trying to imitate the

Japanese way of conducting R&D, says Inside R&D. The top 100 U.S. companies in R&D spent \$53 billion conducting their research in 1989, accounting for 77 percent of the total industrial R&D spending.

R&D spending as a percent of sales increased, on average, from 3.67 percent in 1988 to 3.82 percent in 1989. Research spending per employee increased as well, from an average of \$9,010 per employee in 1988 to \$10,500 per employee in 1989.

Top 10 on Inside R&D 100 List

Rank	1989	1988	Company	1989 R&D Spending (\$ Million)	(Increase) from Previous Year (%)
1	1	1	General Motors	5247.5	10.4
2	2	2	IBM	5201.0	17.7
3	3	3	Ford	3167.0	8.1
4	4	4	AT&T	2652.0	3.1
5	6	5	Digital Equipment	1525.1	16.7
6	5	6	Du Pont	1387.0	5.2
7	7	7	General Electric	1334.0	15.5
8	9	8	Hewlett-Packard	1269.0	20.2
9	8	9	Eastman Kodak	1253.0	9.2
10	10	10	United Technologies	956.6	2.6

Source: Inside R&D

R&D Spending by Top 100 Companies by Industry (\$ Million)

Industry (number of companies included)	1989	1988	% Increase
Computers (15)	11,510.4	9,840.5	17.0
Motor vehicles (4)	9,491.8	8,664.5	9.5
Pharmaceuticals (13)	5,688.4	5,068.6	12.3
Electronics (15)	5,280.0	4,779.7	10.5
Aerospace (10)	4,729.4	4,656.5	1.6
Chemicals (9)	4,127.7	3,849.7	7.2
Scientific and photographic equipment (6)	3,917.6	3,264.8	20.0
Telecommunications (2)	2,933.0	2,869.0	2.2
Petroleum (8)	2,055.0	1,918.0	7.1
Industrial and farm equipment (4)	694.0	597.9	16.1

Source: Inside R&D

Semi-Gas Controversy...

(Continued from page one)

The executive said employees of the Massachusetts-based Semi-Gas feel helpless as they sit back and watch the sale of their company to a foreign firm unfold. The final sale is up to parent company Hercules, who is hungry for the cash.

"We're just pawns on the board," he said.

Semi-Gas is the largest supplier of gas handling equipment to the semiconductor industry worldwide, with sales last year of \$20 million. Nippon Sanso plans to acquire the company through its American subsidiary Matheson Gas Products Inc., and came a step closer last week as officials from the government's Committee on Foreign Investment in the United States [CFIUS] said they will step aside and allow the acquisition to occur unless a threat to national security emerges, sources said.

In private meetings in Washington, CFIUS officials met with representatives from Nippon Sanso, Matheson Gas, Hercules and Semi-Gas. CFIUS, which has blocked the sale of only one U.S. company to a foreign firm since its creation several years ago, is not expected to stop the Semi-Gas Systems sale because its sale is not regarded as a national security issue.

CFIUS officials declined to confirm whether the sale of Semi-Gas was under review.

But industry sources told *New Technology Week* that Nippon Sanso intends to finance about half the cost of the sale through a \$10 million cash-loss carryforward recorded by its Matheson subsidiary. Nippon Sanso completed its acquisition of Matheson in 1969.

When Nippon Sanso announced its intentions to acquire Semi-Gas last winter, it triggered widespread opposition in U.S. industry among companies concerned that it was another case of a Japanese firm profiting off U.S. innovation. One of the most outspoken critics of the sale has been the Austin, Texas, semiconductor manufacturing consortium, Sematech. Semi-Gas has collaborated with Sematech for two years on development of its gas distribution technology.

"Sematech feels very strongly

(Continued on page 9)

NEW TECHNOLOGY

Week

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From the Editors of *The Energy Daily and Defense Week*

Monday, July 2, 1990

Volume 4, Number 27

Grumman Pulls Together Maglev Team

BY RICHARD McCORMACK

Grumman Aerospace Corp. has put together a team to pursue magnetic levitation trains. The Grumman team includes Parsons, Brinckerhoff, Quade & Douglas of New York City; General Electric Research and Development Center in Schenectady, GE's Transportation Systems in Erie, Pa., and Inter-magnetics General Corp. of Guildersland, N.Y.

The New York State Energy Research and Development Authority has selected the Grumman team to look into a magnetic levitation system for the state of New York. The project "will support New York State's efforts to become a leader in the application of maglev technology in the upcoming federally supported maglev research and development programs," says the Authority.

(Continued on page 12)

MITI's New Quest For Gigabit Chips

BY SHERIDAN TATSUNO

Japan's Ministry of International Trade and Industry (MITI) has announced plans to begin a 10-year R&D project to develop gigabit (billion bits) memory chips. Slated to begin next March, the proposed project will develop quantum technologies that will allow Japanese chipmakers to produce extremely fine-line memory chips for use in handheld workstations, laptop supercomputers, HDTVs, telephones and other memory-intensive products.

MITI hopes to develop quantum function devices—super-dense, highly functional devices that will go far beyond the one-gigabit level. The project will focus on fine-line quantum devices, quantum dot memories and quantum wave interference devices. MITI will initially develop a fine-line quantum device that connects a source electrode to a

(Continued on next page)

Controversy Erupts Over Semi-Gas

BY LUCY REILLY

Japanese company Nippon Sanso plans to use several million in U.S. tax dollars to finance its controversial, \$23 million acquisition of Semi-Gas Systems Inc., a subsidiary of Wilmington, Del.-based Hercules Inc., industry and government sources said.

"Here we have a successful U.S. company—10 years old—that now has a major share of the industry in the United States and is a key player in the world," said a senior executive of Semi-Gas.

"Comes along a foreign company with money, some of which is taken from U.S. taxpayers, and they're using that to buy our technology and take the profit and the technology overseas. That says to me that the taxpayers are paying, in part, for the acquisition," the Semi-Gas executive said.

(Continued on page 4)

Japan adopts the new process, while the U.S. lags behind.

Plastic Refining: Solid Waste Solution?

BY KIMBERLY DOZIER

Fuji Recycle Industry K.K. of Tokyo is using government-developed technology to turn plastic waste into petroleum products, freeing up incinerators, and making a profit out of a growing waste disposal problem. Japanese and Korean governments are lined up to buy the process, which joint patent owner Mobil Corp. has dismissed as problematic and unprofitable.

The Fuji process is described as a simple one, in which crushed polyethylene plastic—the low-grade plastic used for milk and soda bottles—is heated and broken down into a vapor. A catalyst then reacts with the vapor to break it into naphtha, kerosene and gas oil. The products are condensed into liquids in a cooler and refined.

The technology, under development by the

Government Industrial Laboratory in Hokkaido, Japan, since 1973, was licensed jointly to Fuji Recycle, Mobil Chemical Industries Ltd. and the Japanese Ministry of International Trade and Industry (MITI) in 1987. Fuji Recycle chief executive officer Toshio Hirota told *New Technology Week*.

Fuji Recycle has spent \$5.1 million to commercialize the process and build a pilot-scale facility with an annual capacity of 400 kilograms. An additional \$4 million has been promised from MITI for further research. Mobil and Japan-based Tosoh Corp. are supplying the primary catalyst used in the petroleum reclamation, but have little or no involvement in the commercialization process.

While Mobil is convinced the technology works, the company remains skeptical about the commercial practicality of plastics recycling. "[Fuji Recycling] still

(Continued on page 8)

Confidential

Table 1

Japanese Share of World Semiconductor Materials,
Manufacturing Equipment and Device Markets
(Percent of Value)

Determined NOT to be
National Security Classified Marking
By cap (NLGB) on 1/5/00

	<u>1980</u>	<u>1988</u>
<u>Semiconductor Materials</u>	N.A.	69
---Electrodeposited copper foil	N.A.	92
---Photomask blanks	N.A.	90 (U.S. mkt)
---Photoresists	N.A.	59
---Ceramic packages	N.A.	90+
---Silicon wafers	N.A.	70
	<u>1984</u>	<u>1988</u>
<u>Semiconductor Manufacturing Equipment</u>	26	42 (1989)
---Lithography equipment	N.A.	64
Stepping aligners	38	71
E-beam direct exposure	72	52
Ion beam direct exposure	91	100
---Wafer fabrication equipment	N.A.	44
	<u>1980</u>	<u>1988</u>
<u>Semiconductor Devices</u>	27	51
---DRAMs	39	76
---Fast SRAMs (.70 ns)	N.A.	69
---Microcontrollers	31	68
---ASICs	N.A.	42
Gate arrays	N.A.	60
---EEPROMs	N.A.	40
---Microprocessors	10	23

N.A.-Not available.

Sources: Dataquest, Rose Associates and VLSI Research. Also, "Increasing Sales of Japanese and Western European Lithography Equipment", International Economic and Energy Weekly, January 5, 1990 and Japan's Semiconductor Industry: Attaining Global Leadership, March 1990, Directorate of Intelligence, CIA (NF/NC/PR/ORC).

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Mr. Olin Wethington
The White House

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COMMENTS

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SILICON AND WAFER PRODUCTION

Corporate Rankings (millions of dollars)

1988

1.	Shin-Etsu	JA	\$597
2.	Mitsubishi Metal	JA	\$295
3.	Osaka Titanium	JA	\$277
4.	Komatsu Electric	JA	\$257
5.	Monsanto*	US	\$254
6.	Wacker	WE	\$193
7.	Toshiba Ceramics	JA	\$ 95
8.	DNS	US	\$ 74
9.	Cin. Milicron**	US	\$ 37

*Now owned by Huels (Veba) of West Germany.

**Now owned by Osaka Titanium of Japan.

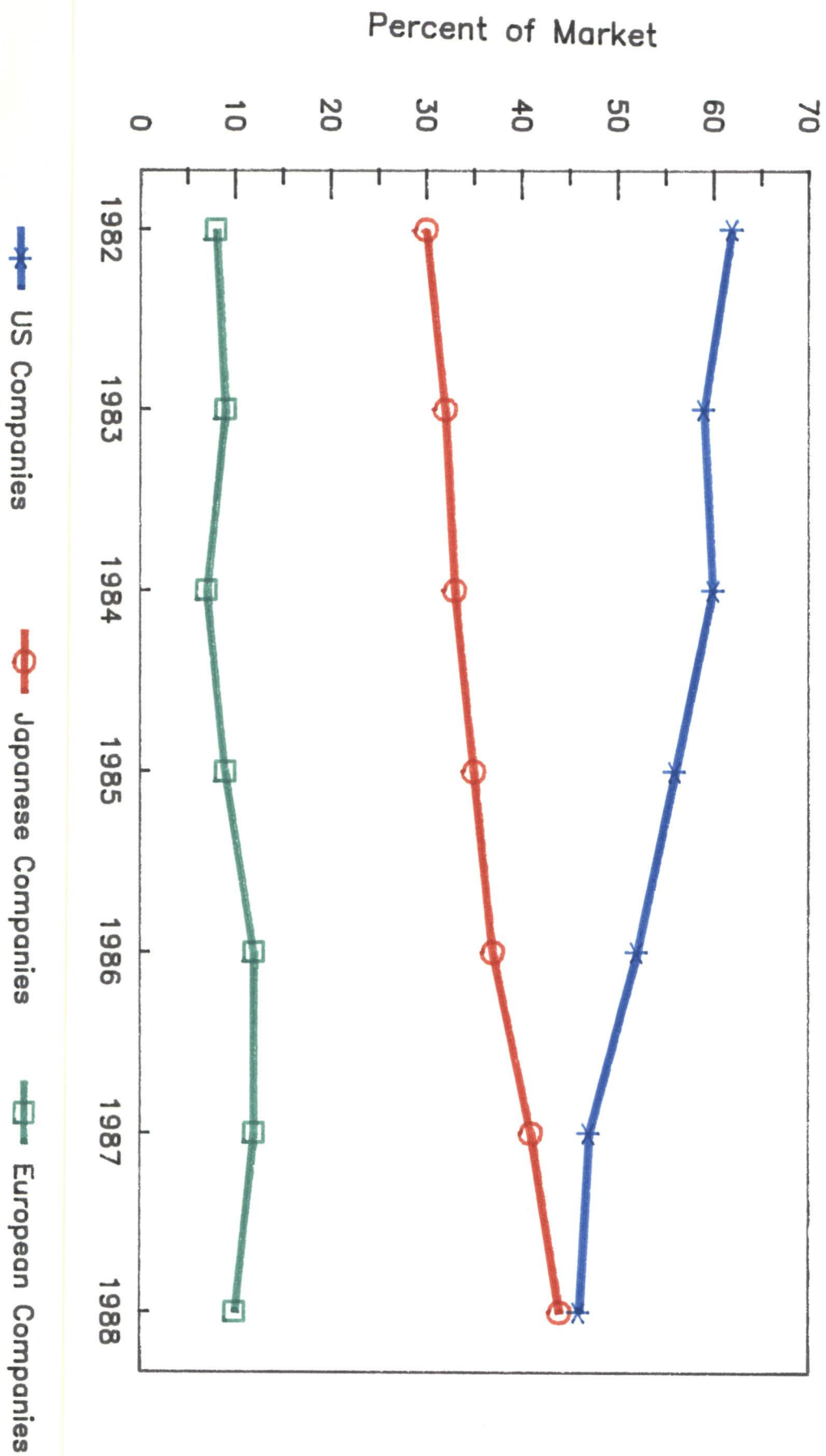
WAFER FABRICATION EQUIPMENT

Corporate Rankings (millions of dollars)

<u>1988</u>			<u>1982</u>				
1.	Nikon	JA	\$486	1.	Perkin Elmer	US	\$152
2.	Applied Materials	US	\$360	2.	General Rad	US	\$150
3.	General Signal	US	\$248	3.	Varian	US	\$ 90
4.	Tokyo Electron	JA	\$239	4.	Applied Materials	US	\$ 69
5.	Canon	JA	\$225	5.	GCA*	US	\$ 64
6.	Varian	US	\$160	6.	Canon	JA	\$ 59
7.	Eaton	US	\$147	7.	LTX	US	\$ 40
8.	Perkin Elmer	US	\$141	8.	Hewlett-Packard	US	\$ 40
9.	Anelva	JA	\$129	9.	General Signal	US	\$ 32
10.	Hitachi	JA	\$113	10.	Nikon	JA	\$ 29

*GCA was purchased by General Signal in 1988.

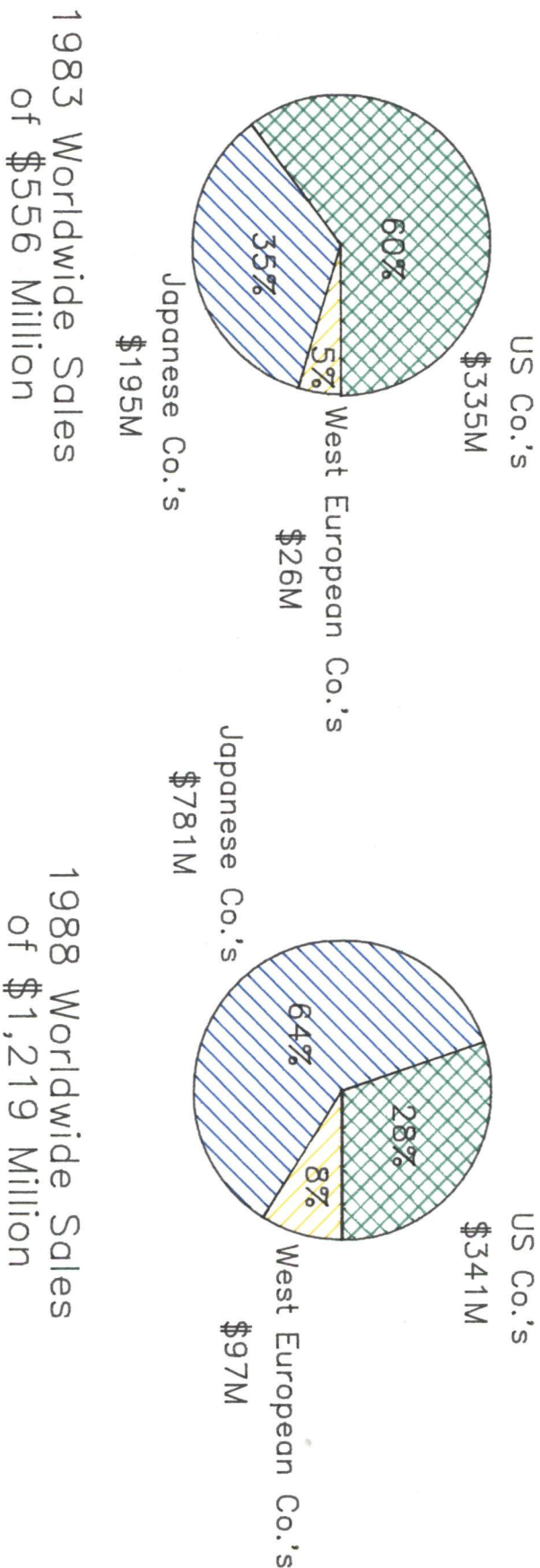
Wafer Fabrication Equipment Market Share



Worldwide Lithography Equipment Market Sales by Country of Origin

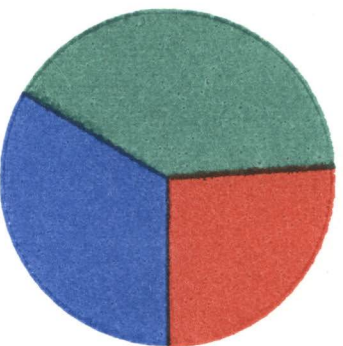
(\$ in Millions)

Figure 4

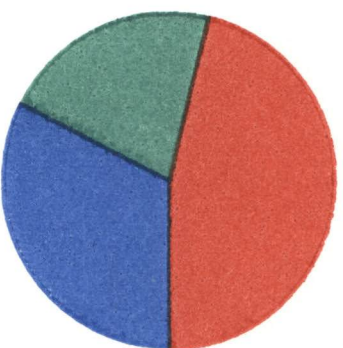


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Regional Shares of Worldwide Automatic Test Equipment Sales



1981



1986

■ Japan 26.1%
■ West Europe* 40.5%
■ United States 33.4%

■ Japan 46.2%
■ West Europe* 21.3%
■ United States 32.5%

* 40.0% and 21.2% of 1981 and 1986 sales, respectively, were of equipment produced by a US subsidiary of a West German firm, Schlumberger. The remainder of West European sales come from the West German firm Siemens.

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**1989 Prime Materials Supplier
Production by Region (\$M)**

		<u>Produced by</u>	<u>Produced in</u>
Silicon Wafers (\$1.709 B)	Japan	68.7%	57.9%
	U.S.	0.0%	29.0%
	Europe	-	11.1%
	Austria	-	-
	France	-	-
	Germany	31.3%	-
	Great Britain	-	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	2.6%
	Hong Kong	-	-
	Korea	-	-
	Singapore	-	-
Photoblanks (\$134 M)	Japan	98.5%	98.5%
	U.S.	1.5%	1.5%
	Europe	-	-
	Austria	-	-
	France	-	-
	Germany	-	-
	Great Britain	-	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	-
	Hong Kong	-	-
	Korea	-	-
	Singapore	-	-
Wet Chemicals (\$374 M)	Japan	48.9%	48.9%
	U.S.	37.2%	38.0%
	Europe	-	13.1%
	Austria	-	-
	France	-	-
	Germany	10.4%	-
	Great Britain	3.5%	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	-
	Hong Kong	-	-
	Korea	-	-
	Singapore	-	-

		<u>Produced by</u>	<u>Produced in</u>
Gases (\$451 M)	Japan	39.9%	29.9%
	U.S.	39.2%	48.6%
	Europe	-	16.0%
	Austria	-	-
	France	7.3%	-
	Germany	7.5%	-
	Great Britain	6.0%	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	4.0%
	Hong Kong	-	-
	Korea	-	-
	Singapore	-	-
Sputtering Targets (\$163 M)	Japan	81.0%	41.1%
	U.S.	3.7%	47.9%
	Europe	-	10.4%
	Austria	-	-
	France	-	-
	Germany	12.9%	-
	Great Britain	2.5%	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	0.6%
	Hong Kong	-	-
	Korea	-	-
	Singapore	-	-
Ceramic Packages (\$1.221 B)	Japan	93.6%	88.3%
	U.S.	5.9%	8.6%
	Europe	-	0.3%
	Austria	-	-
	France	-	-
	Germany	-	-
	Great Britain	-	-
	Holland	-	-
	Switzerland	-	-
	ROW	-	2.8%
	Hong Kong	-	-
	Korea	-	0.5
	Singapore	-	2.3%
Photorealist (\$310M)	Japan	46.1%	50%
	U.S.	41.9%	42.9%
	Europe	6.5% 11.9%	6.5%
	ROW	-	0.7%

Source: Dan Ross & Associates

July 13, 1990

TO: Olin Wethington (FAX: 456-7739)

FROM: Jack McPhee

SUBJECT: Japanese Investment Questions.

This is a recap of material sent to you in answer to your three questions.

1. Japanese purchases from 1980 to 1989 of U.S. semiconductor materials and production equipment firms? The tables detailing Japanese investments in selected U.S. electronics industries: while this may not be the whole story, we are confident that this is a reasonably complete picture.
2. Breakout of ownership by type of production equipment? The charts sent this morning showed ownership by nationality of firm for semiconductor manufacturing equipment overall from VLSI Research and Semi/Semitech. The U.S. "universe" of firms was 340 companies in 1989, corresponding to 46.8 percent. These 340 firms are a very broad group, from those who supply fairly unique components and parts to those who supply complete production equipment systems.
3. Confirm or deny that Japanese firms have bought 33 U.S. semiconductor materials and production equipment firms out of 200 total firms in the last 18 months. We find it impossible to duplicate this ratio from our statistics. Semi/Semitech says that they know of 18 U.S. firms purchased over the last 18 months out of what they feel is the "core" universe of about 150 total. The universe of firms is obviously a matter of definition, the largest of which would appear to be VLSI Research's 340 firms.
4. If you have any other questions, give us a call. (377-0572)

TRANSMITTAL SHEET

TECHNOLOGY ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
Room 4818 Hoover Building
Washington, DC 20230

Tele: (202) 377-1581
(202) 377-5687

Panafax: (202) 377-4817

DATE: 7-12-90

TO: Olin Wethington

AGENCY: _____

TELE: _____

FAX NO. 456-7739

FROM: Deborah Wince-Smith

AGENCY/DIVISION: OTP

TELE: 377-1581

NUMBER OF PAGES INCLUDING COVER SHEET: 10

SPECIAL INSTRUCTIONS/MESSAGE:

Withdrawal/Redaction Sheet (George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01a. Report	Re: [Semi-Gas] (2 pp.)	7/12/90	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Economic Policy Council (EPC)
Series: Wethington, Olin, Files
Subseries: Subject Files
WHORM Cat.:
File Location: Science & Technology [3]

Date Closed: 1/5/2010	OA/ID Number: 04295-018
FOIA/SYS Case #: 2005-0336-F	Appeal Case #:
Re-review Case #:	Appeal Disposition:
P-2/P-5 Review Case #:	Disposition Date:
AR Case #:	MR Case #:
AR Disposition:	MR Disposition:
AR Disposition Date:	MR Disposition Date:

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

- P-1 National Security Classified Information [(a)(1) of the PRA]
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Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01b. Report	Re: Current Information on the Semi-Gas CFIUS Investigation (1 pp.)	7/12/90	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Economic Policy Council (EPC)
Series: Wethington, Olin, Files
Subseries: Subject Files
WHORM Cat.:
File Location: Science & Technology [3]

Date Closed: 1/5/2010	OA/ID Number: 04295-018
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Re-review Case #:	Appeal Disposition:
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AR Case #:	MR Case #:
AR Disposition:	MR Disposition:
AR Disposition Date:	MR Disposition Date:

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FACSIMILE COVER SHEET

**NIST-DOC OFFICE
HERBERT C. HOOVER BUILDING, ROOM 4841
Washington, DC 20230
202-377-4844
FAX # - 202-377-4362**

TO:

NAME OLIN WETHINGTON

ORGANIZATION _____

TELEPHONE NUMBER _____

FROM:

NAME GARY P. CARVER

ORGANIZATION _____

TELEPHONE NUMBER 377-4596

NUMBER OF PAGES 4 **(INCLUDING COVER SHEET)**

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Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
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Record Group: Bush Presidential Records
Office: Economic Policy Council (EPC)
Series: Wethington, Olin, Files
Subseries: Subject Files
WHORM Cat.:
File Location: Science & Technology [3]

Date Closed: 1/5/2010	OA/ID Number: 04295-018
FOIA/SYS Case #: 2005-0336-F	Appeal Case #:
Re-review Case #:	Appeal Disposition:
P-2/P-5 Review Case #:	Disposition Date:
AR Case #:	MR Case #:
AR Disposition:	MR Disposition:
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Loose in original folder



International Trade Administration
Science & Electronics Unit

SARAH COOPER HALL
Industry Analyst

U. S. Department of Commerce
Room H-1015
Washington, DC 20230

(202) 377-2846
Fax # (202) 377-2706

"AN AMERICA THAT CAN COMPETE AND WIN"

by Malcolm R. Currie
Chairman and CEO
Hughes Aircraft Company

Electronic Industries Association
Keynote Address
Washington, D.C.
March 27, 1990

A NEW DECADE

Well, ladies and gentlemen -- we, the U.S. electronics industry -- finally made it through the 1980's. And today we stand at the threshold of the brave new decade of the 1990's -- and in fact, a new century. What will it bring?

The world around us has changed so abruptly, in even one year, that we are still reeling from its possible implications. Certainly our thinking has changed from one year ago. We also know our industry must respond and change. But in what directions? And how can we begin to control our own long-term destiny -- and our vitality -- in a world suddenly overturned? New forces are at work which we scarcely understand. Today we search for positive new policies which can deal effectively with these forces. We face new realities. A new outlook. New industrial structures.

Some would say that, rather than standing at the threshold of a glorious new decade -- our electronics industry actually may be teetering at the edge of a bottomless chasm. I personally prefer to think we're at the bottom of a mountain trail, that we need to patiently climb -- to get back on top in terms of our industrial leadership, our confidence, and our winning.

UNCERTAIN RULES

In any case, I'd say we're just a little punch-drunk coming out of the 1980's -- with some tough fighters still facing us in the ring. One certainly looks like a 500 pound sumo wrestler. Another is a suave but tough European giant. Other young newly developing tigers are standing in line. There is also much confusion on our part on just what the rules of the game we're playing really are. And we have in our corner sponsors who are nice guys but who often seem rather ambivalent whether we win or lose.

But then, by nature, I'm an optimist!

It kind of reminds me of a basketball game we played in Navy flight training many years ago. Ten or twelve players on each side -- 6 or 7 basketballs -- whichever side scored the most baskets in 1/2 hour got liberty that weekend. The only rules were no deliberate eye gouging or kicking in the groin while down. The pure traditionally trained basketball players among us who didn't adapt, who insisted on no double-dribbling or elbowing, came out rather bloody in this new form of basketball. They continually got beat up and lost weekend liberty while complaining that the new basketball rules were unfair.

The theme of this conference -- "Balancing National Security With the Realities of the 1990's" -- is very appropriate and timely. I believe, for reasons that I'll mention later, we have ahead of us the toughest and most complex challenge we've ever faced as an industry.

THE CHALLENGE: TO COMPETE AND WIN

In thinking about what to talk about on this occasion, it's obvious that a number of topics could be included -- all of current and great importance to the defense electronics industry. They involve the impact of a declining defense budget -- the

changing threat -- our international competitiveness -- rapidly changing technology and so on.

So it's fair to tell you where I'm coming from in this talk:

- First, with respect to national security -- I believe that "national security" must inevitably -- and even primarily -- involve our economic security as well as military security. Economic security involves our ability to compete as a nation and to lead in the new kind of world of instant communications -- where economic boundaries are replacing national ones, and with new rules of the game.

National security must involve technology, which has indeed replaced territory as the coinage of national power -- with electronics technology and a powerful electronics industry having an indispensable role in maintaining -- or perhaps recapturing -- our industrial leadership. The health of the defense electronics segment and the electronics industry as a whole -- will be increasingly intimately related in the future.

- Second, with respect to attitude -- I don't know about you, but I'm getting a little impatient with the defeatist and almost fatalistic attitudes that seem to be gaining in some circles. I'm getting a little tired of listening to the litany of our financial disadvantages. Our cultural disadvantages. About competitors who have created new rules of the game involving insidious government-industry partnerships. About foreign ownership and our economic colonization. About how it doesn't really matter as long as we have jobs. About an increasingly arrogant "Japan that can say no". And about unfair protectionism ---- when the constant litany of all these points leads to a seeming acceptance of an inevitable decline in our own industry, especially electronics -- and to the decline and fall of America.

Now these factors and more may all be more-or-less true. But all of our bitching and moaning, our Japan-bashing and now even Europe-bashing don't seem to be helping very much. We're on the defensive while the world around us is changing rapidly and charging along its own path.

In fact, we are the ones who must change!

It's time to get our own act together both nationally and internationally, to recognize and build on our own strength, to get our juices flowing. It's time to address:

"AN AMERICA THAT CAN COMPETE AND WIN"

We must find a way to go from a defensive patchwork mode to a mode that is aggressive and innovative -- to a mode that will permit us to win.

We all know that talking about problems is much easier than constructing solutions. But we must start up that steep mountain trail -- or the consequences for our nation, and for our national security in the broadest sense -- could be disastrous.

At any rate, that's where I'm coming from. I believe we can define a future that lets us compete and win. But we won't get there if we do not face squarely the realities of the 1990's.

REALITIES FOR DEFENSE ELECTRONICS

Let me comment on a few of the realities we are certain to face:

First, as they affect defense:

Declining Defense Budget

- One reality certainly is a declining defense budget that will further add to today's already significant defense industrial overcapacity. I expect DOD's investment account (R&D and procurement), in real terms, to drop to almost one-half its 1985 peak in several years. We must deal with that reality.

Changing Threat

- Another reality that the nature of the threat to our national security will most likely change drastically in magnitude and character. But at the same time we will have to hedge for a while against interim uncertainties; we have no historical precedent for the self-liquidation of a vast empire with its attendant instabilities and potential dangers. We must also actually secure the arms reductions we all hope can happen.

Greater Importance of Technology

- It also seems clear, at least in my view, that technological leadership in defense will assume even greater importance in the future as disarmament agreements drive us toward numerical parity at much reduced force levels. This at a time when our foreign technological dependency is increasing. When it is clear that dual-purpose technologies will increasingly dominate and drive defense capabilities. And when the rate of technological change is faster now than ever. This will certainly be a major challenge for the decade ahead, both in defense and in a general worldwide competitive race. I'll come back to this point.

Phase-down Carefully

- Another very serious reality is the terrible shape the defense industry will be in -- in a few years -- unless the phase-down is executed very thoughtfully and very carefully.

Let me explain --

Part of this situation is due to the accumulated layers of oversight and over-management which have added enormously to costs without commensurate value-added. We've witnessed its impact. The stifling of risk and innovation. The tremendous inefficiencies which add at least 30 percent, probably much more, to the costs of development and production. We can no longer afford this today. We can no longer

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afford to replicate, within the defense industry, the enormous overhead of government. Nor to tolerate projects that often require 3 to 5 times their non-DOD equivalents to execute. To maintain this level of over-management during a phase-down adds an untenable burden to an already costly system.

We also have a now archaic acquisition system which has operated in practice to cause industry to lose money on R&D and then hopefully to generate a reasonable profit on production.

Now you can see that as production levels decline because of the reduced needs of smaller forces, and unless these widely accepted acquisition practices are radically changed, industry will be left in a financially untenable position.

I believe there is a real growing acceptance of the need for a strong and even increased R&D program in the years ahead to help maintain the vital technical leadership in defense I referred to earlier. This acceptance in DOD, and even in Congress, is certainly extremely important and encouraging. However, without acquisition policies and practices which once again allow reasonable earnings on industry's R&D efforts and which turn around the current stifling environment, we will simply be left without the vitality and means to serve the real security needs of the nation looking forward to the decade of the 1990's and beyond.

In this connection also, I'd urge caution against too easily accepting the thesis that we can go into an R&D-only mode in which programs are stopped after prototype feasibility demonstrations and then put on the shelf to create a so-called "ready R&D reserve". As we have repeatedly learned, transition to production and at least limited production itself, is an essential part of the technology development process. The fact is that R&D results have a short shelf half-life; they can't simply be bottled up to be opened at some future date.

As they say, "Use it or lose it".

Another serious concern is the continued loss of our strong and innovative supplier base which makes up the infrastructure crucial to a vital defense industry.

Let me mention also one other fact of life related to the defense industry and acquisition, namely the occurrence of a sudden and drastic overcapacity which will leave industry with a large financial overhang which cannot be instantly accommodated. Large investments that were made in expectation of previously planned defense requirements will go unused. This will present continuing fixed costs which must be written off over a suddenly smaller production base, thus increasing the costs of future business. In fact, those firms which were most responsive to DOD's needs and invested the most to reduce costs, could well end up the least competitive in the anticipated phase-down. They could be the

least able to support DOD's needs in the future. An ironic turn of events -- and a potentially serious problem for the nation.

Now all of these problems can at least be alleviated by thoughtful and strong leadership and we should view the period ahead as a tremendous opportunity for constructive change. I want to make it clear that I believe a smaller defense industry is perfectly acceptable as long as it is vital technically and profitable. Certainly an artificial maintenance of the industrial base would not be the right answer. And I want to make it clear that no one is looking for hand-outs. But it will require leadership to navigate through the transition period ahead without crippling our industrial and technology base as we phase down, hopefully to a soft landing.

U.S. Companies Competing Against Foreign Governments

- Still another of the many new defense "realities" we must recognize and deal with is the greatly increased international competition in the defense industry. U.S. policies of the past have aimed at strengthening the industrial and defense capabilities of our allies and friends to counter a perceived massive common threat. U.S. policies have encouraged the build-up of increasingly self-sufficient defense industries in NATO and Japan. These policies were successful in achieving their original purpose. Much technical leveling has taken place in this process. A fact of life is that much defense equipment in Europe and, for that matter, in Japan is now competitive with U.S. industry.

The rules of the game are changing -- even in defense procurement. Our industry is increasingly having to compete against governments in terms of subsidies and guarantees rather than against companies. Maybe I'm just a slow learner -- but I've been in several so-called open competitions recently in which the final outcome has absolutely nothing to do with better price, performance and schedule. Changing rules of the game! European competitors are entering the still-large and important U.S. market as their own markets attenuate with the impending decline of NATO. Competition for third world business is often directly between governments and this comes at a time when our own governmental approval processes often impede rather than help our industry.

Again, this could be helped tremendously by understanding its consequences and by explicit policy changes.

As an aside, my own strong feeling is that we have been too long under the illusion that, in this day and age, we can protect technology and maintain leadership by restrictive protection alone. This simply won't work. Current overly restrictive technology transfer policies don't accomplish much except to damage U.S. industry.

Our ultimate real protection will always rest on investing in technology and innovation and in simply running faster than the other guys, not on trying to hold close something as ephemeral and transitory as technology. But I'll admit that I'm an engineer and may not have the more cosmic perspectives of the economists and lawyers.

Electronic Upgrades For Completely New Capabilities

- Another what I'd call a "reality", at least for defense electronics, is that advanced electronics can be used to tremendously upgrade many current systems, often creating completely new generations of capability to meet new kinds of threats, very efficiently at relatively low cost. I hope this is not lost on our defense planners -- so far, I don't believe it has received enough attention.

SOME POSITIVES FOR DEFENSE

- Finally, as we look forward let us remind ourselves of some very positive "realities" of defense:

The Best Industry

- For example, on the positive side, we have a defense industry that innovates, develops and produces the finest equipment in the world. I assert that it does this very efficiently if looked at on a comparative absolute basis, even in spite of the tremendous inefficiencies imposed by our acquisition system. Our nation should recognize and be proud of this.

DOD, A Prime Force

- Further, since World War II, our Department of Defense really has been a prime force in advancing U.S. technology. This unique role, that evolved as a result of our particular history, should be understood and built on, as I'll discuss.

DOD Develops Large Complex Systems

- And our DOD, together with its related industry, has developed the capacity to envision and to design enormously large and complex integrated systems. We have vaulted to a position of clear world pre-eminence in this. This capability can be a vital link in our future if we properly capitalize on it. World leadership in the creation and management of complexity, of increasingly complex and capable systems, and in a world that will increasingly demand it. An area of tremendous strength.

Well, so far, I've talked about a few of the realities which will affect our defense industry in the 1990's. These realities, or problems, if you will, can be made into opportunities if we are willing to address them head-on and wisely. Certainly they should have profound impact on DOD thinking and planning.

DEFENSE ELECTRONICS DEPENDS ON THE HEALTH OF ELECTRONICS AS A WHOLE

Now I'd like to turn to the broader picture of electronics in general. I've already asserted that, long term, our defense position is dependent on maintaining leadership in electronics and that the strength of defense electronics is, in turn, directly dependent on the health of our electronics industry as a whole. This includes the critical underpinning of basic dual-purpose technologies. We should remind ourselves that in size and volume, defense electronics is a tiny fraction of the total industry. Further, that our national

security in the broader economic as well as in the military sense depends on technological leadership, with electronics arguably as the key factor.

We therefore cannot avoid the issue: How do we climb back on top and compete and win? As I mentioned earlier, this represents perhaps the toughest and most complex challenge we have ever faced.

REALITIES IN A BROADER CONTEXT

Let me start with a few "realities" of the 1990's in this broader context:

- One reality is that we're being massively out-invested. For example, a new wave of Japanese corporate investments this year will add up to over 22 percent of its gross national product, or three times the total U.S. capital investments on a per capita basis. This is in pursuit of a global strategy based on technology leadership including production technology and training.

The level of investment in improved processes has given Japan the ability to shift quickly and maintain leadership in areas when costs and quality improvements become the key to success.

Can we continue to underspend in non-defense R&D? France, Germany, Japan and the United Kingdom will spend 56 percent more than the U.S. for commercial R&D this year. The spending gap increased over the 1980's and continues to grow as we enter the 1990's. And for the first time in 14 years, spending by U.S. companies for corporate R&D has not kept pace with inflation.

- Another reality is that we are being massively out-planned, both in the European and Japanese economic blocs. In the case of Japan, the government has laid out a clear blueprint or vision for the next twenty to thirty years in exquisite detail including critical milestones and initiatives. The plans encompass telecommunications, computers, semiconductors and other critical technologies, as well as conceptual new applications. They also include what to do about education, supporting research, declining industries and even demographics. More importantly, they invest along with industry to reach their ambitious goals.

In Europe, the EC, recognizing the crucial importance of the information technology industry to its future, has already initiated several specific long-range programs such as the 10-year "European Strategy Program for Research and Development in Information Technology" or ESPRIT I and II, for which over \$5.6 billion has been committed. They've developed the idea of cooperation and resource sharing for pre-competitive R&D and for the creation of standards to allow a cohesive European industry to compete in the world market. They are beginning to achieve some impressive results. Another EC-funded program is the "Joint European Submicron Silicon Initiative", or JESSI, funded at \$600 million per year, or three times Sematech. It is aimed at 64 Megabit DRAM's employing quarter-micron technology. Other EC programs include RACE,

"Research in Advanced Communications for Europe", and BRITE, "Basic Research in Industry Technology for Europe". All-in-all, pretty forward looking!

- Still another reality for us is a technical education system which simply will not support our national requirements in the years ahead.

A shortage of 700,000 scientific professionals by the end of the decade. Today vacancy rates in college engineering faculty of 10 percent or more. And one-third of college faculty will retire by the end of the 1990's. A 50 percent drop in U.S. college freshmen majoring in the physical sciences, and engineering. And more than half of the science and engineering graduate students in our great research universities are foreign nationals, most of whom will not remain in the U.S. to enrich our cultural and technical base.

Although we're all aware of this impending crisis, we are far from reaching out for aggressive and realistic solutions.

- Another reality is the so-called globalization of technology. We've heard a lot about this recently. It is facilitated by instant world communications and by changing economic forces which our electronics industry is necessarily trying to respond to. It's following its instincts for survival -- even though some of these may often be short sighted. And it is happening with a swiftness not generally perceived.

I would just comment that in an era when new concepts become globalized almost instantaneously, the premium for reducing concepts and fundamental technology to practice in terms of products and new applications becomes even more important. So we must define technology in a much broader context to include the processes of transformation from concept to fielded applications. Further, this globalization of technology means that many nations can now acquire very advanced weapons.

- Still other "realities" include many continuing forms of protectionism that are a fact of life and will exist in the decade ahead. These protectionist measures, already present in commercial electronics, are spreading to defense. The realities also include the virtual disappearance in the U.S. of many of the basic component industries and technologies on which a vital electronic industry depends, including defense. Further, the realities include the continued fragmentation of our fundamentally important semiconductor and semiconductor-related industries and their lack of critical mass, particularly in light of the escalating costs of research and process development.

THE NEED FOR NATIONAL STRATEGIES

Well what does all this add up to? Certainly we can't hide from these realities. If we really believe that our future security and economic vitality do indeed depend critically on leadership in the broad electronics and information industry then, in light of these realities -- in my view -- we urgently need a set of strong national policies and

actions which can meet these issues head-on and can facilitate positive change. Defense can help play an important role in this process.

This brings up what appears to be a very sensitive issue these days, namely, the total aversion of many Administration officials to discuss anything smacking of the dread term "industrial policy." So let me go ahead and discuss it anyway.

Whether we like it or not, other nations or economic blocs with which we compete in our own markets and worldwide, do have industrial policies both in terms of well articulated competitive strategies and in terms of practices. These include planning, emphasis in critical areas and close government-industry relationships in the form of enabling programs. These nations find our lack of such strategies very perplexing and, for them, comfortable.

Our free-market ideology, without such a national strategy, places us at an enormous disadvantage. The fact is, we're finding out that capitalism and so-called free trade, like ice cream, is coming in 31 different flavors in today's world. The old vanilla flavor we're accustomed to involves a hands-off laissez-faire attitude in free trade and free market forces. It involves governmental policies which abhor choices between industrial sectors and technologies and in providing differential incentives. This vanilla flavor is quite distinct from the many forms of "managed capitalism" and even "managed free trade" versus our "free free trade". Much of the world seems very comfortable with these other flavors and I doubt if we can successfully ram vanilla down their throats.

I would only point out that a determined hands-off policy on some of these issues, in itself, constitutes a powerful form of industrial policy whether we like to call it that or not.

This reminds me of a discussion between some policy makers here in Washington and a Defense Science Board Task Force which I chaired on defense industrial cooperation with the Pacific Rim. This policy group argued philosophically that "it doesn't really matter if Japan has all the electronics in the world -- the U.S. can concentrate on building the best automobile tires in the world and free-markets, in the long run, will take care of everything and even things out". As I recall, this was about the time Bridgestone of Japan took over the Firestone Tire Company.

SOME TECHNOLOGIES ARE MORE CRITICAL

Now I'll admit that I'm not an economist, but I can't quite get interested in a set of theories that tell us there's nothing to worry about. In fact, I think its crazy to think that we can't spell out some of the technologies and industries critical to our future and then to find ways to enable them, to enhance them and to help us compete.

We know what some of these basic technologies are and we know that the industries based on these technologies will be the basis of much of our future national security and economic prosperity but we seem reluctant to make hard choices. For example, I'd like to think that we can choose

- between integrated circuit chips and buggy whips,
- between computers and fast foods, or even

- between complex software and mashed potatoes.

Is it perhaps just possible that the comfortable total free-market economic theories which purportedly explain the past are no longer entirely appropriate to the new realities of instant worldwide communication and technological globalization, of tremendously shortened product life cycles and of the escalation of development and commercialization costs? Perhaps these need some re-examination. And perhaps we should be more willing to experiment and change.

NEED FOR NATIONAL VISION

Well, what should we be doing about all this? From a pragmatic viewpoint, there are a number of things which will help.

First -- and most importantly -- I believe it is extremely important and timely that a coherent technology strategy or vision for the future be articulated at the highest national level. It should state explicitly the importance of technological preeminence, including production technologies, to our national health and security and as a critical national goal. It should constitute a top-level policy direction which can catalyze and guide the many enabling processes and fiscal policies which can then follow.

In my mind, if this constitutes so-called industrial policy, then so be it. We must, it seems to me, have a common forward vision and basis for action.

A BROADER ROLE FOR GOVERNMENT

DOD's leadership in the decades since World War-II has, in effect, constituted much of our U.S. technology policy. The U.S. Government role should now be broadened and be made appropriate for inclusion of worldwide commercial markets and dual purpose technologies versus the monopsonistic government market per se.

I believe, in the 1990's, that the U.S. Government does have a responsibility to become a more powerful catalyst and enabler than in the past. And the DOD can play an important role model in much of this.

Specific enablers for us to compete and win both in national security and in world economic competition include:

- First, fixing our technical education. I will not belabor a subject that hopefully is receiving much attention, except to point out the commitment to education of other nations and that industry has a strong responsibility and role. I think it's time that industry step up and more fully meet these responsibilities in it's own self-interest. We must become more involved.
- Second, while the government admittedly is not equipped to choose and support development of specific products per se, that is, to pick final so-called winners and losers, the support of important generic enabling technologies should be encouraged. Certainly we can define the broad areas of technological importance which, if emphasized, can have an enormous multiplier or domino effect on our future economy.

This support can be achieved, for example, through tax credits, through encouragement of competitive consortia involving both industrial and government contributions, through expanded R&D tax incentives and through credits for technological capital investments in order to achieve the reasonable costs of capital -- low cost patient capital -- that our competitors enjoy. The Electronic Industries Association has made other promising suggestions.

- Third, I would again stress the importance of consciously stimulating true conceptual innovation as well as linear extrapolation of current technologies. One example is in the dimension of complex systems. There are many others revolutionary in nature. We need to continuously look for and encourage imaginative leaps forward in applying technology. This has been and must continue to be a bedrock basis for America's competitive leadership.

And this one doesn't even require direct government investment, only as improved education and a motivational climate and reward for innovation can be helped by government.

We must continually build and retain design capability. Jobs under foreign ownership are not enough.

DOD programs such as MMIC and Mantech can be expanded and used as models. These have been very successful -- they involve the element of collaboration between companies to achieve critical mass, the element of competition and the element of significant private industrial investment. The Senate will shortly begin hearings on extending the 1984 National Cooperative Research Act and to consider the possibility of joint manufacturing ventures as well. It is a much needed discussion.

TIME FOR HARD CHOICES

In short, it is time that some hard choices be made. Making choices is the nature of life. We can't duck them or we are, in reality, choosing to become losers by default.

These kinds of activities, conducted and catalyzed under the banner of a top-down, national technology vision which is articulated at the highest national level, can attack the realities facing us in the 1990's and get us back on a clear winning track. We have the industrial strength, the culture, the innovative adaptability, and the tradition to come back in force -- I believe it is our government's responsibility to help lead the way.

So, Mr. U.S. Government -- including you, Mr. Department of Defense -- we have much to accomplish together as partners rather than as adversaries. Let's join forces creatively in this new world environment which has been thrust on us. Let's find new modes of cooperation -- new strategic partnerships -- appropriate to us rather than copies of others'.

We need you, not as a micro-manager, but as an enabler. And then just get out of the way and see what happens -- I think you'll be surprised!

Summing up, I'm a technologist and an electroniker and am perhaps somewhat biased -- and I thank you for your patience. There is no point in giving a keynote speech

like this without a therapeutic unloading of some frustrations and personal beliefs. But I believe strongly we are in a most critical period. We're in a window of great vulnerability for the defense industry, for our electronics industry at large and for our collective national future. We should project ourselves in our mind's eye to the year 2010 and look back -- and try to imagine in history's perspective what decisions and what actions in 1990 -- or lack of them -- affected the future of a great nation positively or even disastrously at this critical junction.

Let's find new models. And let's not drive into the future just looking through our rear view mirror.

There is no question in my mind that we can compete and win.

Simply stated, it's once again time for enlightened leadership.

TRANSMITTAL SHEET

TECHNOLOGY ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
Room 4818 Hoover Building
Washington, DC 20230

Tele: (202) 377-1581
(202) 377-5687

Panafax: (202) 377-4817

DATE: July 11, 1990

TO: Olin Wellington

AGENCY: The White House

TELE: 456.7968

FAX NO. 456.7739

FROM: a/s Deborah L. Winca-Smith

AGENCY/DIVISION: O.A.S. P.P.

TELE: 377.1581

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Grumman Pulls Together Maglev Team

BY RICHARD McCORMACK

Grumman Aerospace Corp. has put together a team to pursue magnetic levitation trains. The Grumman team includes Parsons, Brinckerhoff, Quade & Douglas of New York City; General Electric Research and Development Center in Schenectady, GE's Transportation Systems in Erie, Pa., and Inter-magnetics General Corp. of Guilderland, N.Y.

The New York State Energy Research and Development Authority has selected the Grumman team to look into a magnetic levitation system for the state of New York. The project "will support New York State's efforts to become a leader in the application of maglev technology in the upcoming federally supported maglev research and development programs," says the Authority.

(Continued on page 12)

MITI's New Quest For Gigabit Chips

BY SHERIDAN TATSUNO

Japan's Ministry of International Trade and Industry (MITI) has announced plans to begin a 10-year R&D project to develop gigabit (billion bits) memory chips. Slated to begin next March, the proposed project will develop quantum technologies that will allow Japanese chipmakers to produce extremely fine-line memory chips for use in handheld workstations, laptop supercomputers, HDTVs, telephones and other memory-intensive products.

MITI hopes to develop quantum function devices—super-dense, highly functional devices that will go far beyond the one-gigabit level. The project will focus on fine-line quantum devices, quantum dot memories and quantum wave interference devices. MITI will initially develop a fine-line quantum device that connects a source electrode to a

(Continued on next page)

Controversy Erupts Over Semi-Gas

BY LUCY REILLY

Japanese company Nippon Sanso plans to use several million in U.S. tax dollars to finance its controversial, \$23 million acquisition of Semi-Gas Systems Inc., a subsidiary of Wilmington, Del.-based Hercules Inc., industry and government sources said.

"Here we have a successful U.S. company—10 years old—that now has a major share of the industry in the United States and is a key player in the world," said a senior executive of Semi-Gas.

"Comes along a foreign company with money, some of which is taken from U.S. taxpayers, and they're using that to buy our technology and take the profit and the technology overseas. That says to me that the taxpayers are paying, in part, for the acquisition," the Semi-Gas executive said.

(Continued on page 4)

Japan adopts the new process, while the U.S. lags behind.

Plastic Refining: Solid Waste Solution?

BY KIMBERLY DOZIER

Fuji Recycle Industry K.K. of Tokyo is using government-developed technology to turn plastic waste into petroleum products, freeing up incinerators, and making a profit out of a growing waste disposal problem. Japanese and Korean governments are lined up to buy the process, which joint patent owner Mobil Corp. has dismissed as problematic and unprofitable.

The Fuji process is described as a simple one, in which crushed polyethylene plastic—the low-grade plastic used for milk and soda bottles—is heated and broken down into a vapor. A catalyst then reacts with the vapor to break it into naphtha, kerosene and gas oil. The products are condensed into liquids in a cooler and refined.

The technology, under development by the

Government Industrial Laboratory in Hokkaido, Japan, since 1973, was licensed jointly to Fuji Recycle, Mobil Chemical Industries Ltd. and the Japanese Ministry of International Trade and Industry (MITI) in 1987. Fuji Recycle chief executive officer Toshio Hirota told *New Technology Week*.

Fuji Recycle has spent \$5.1 million to commercialize the process and build a pilot-scale facility with an annual capacity of 400 kilograms. An additional \$4 million has been promised from MITI for further research. Mobil and Japan-based Tosoh Corp. are supplying the primary catalyst used in the petroleum reclamation, but have little or no involvement in the commercialization process.

While Mobil is convinced the technology works, the company remains skeptical about the commercial practicality of plastics recycling. "[Fuji Recycling] still

(Continued on page 8)

U.S. Scientists Complain About Employers

After polling 4,300 research scientists, R&D Magazine has found that 48 percent of them feel that they are working for organizations that are "not open to new ideas." This conclusion, says R&D Magazine's editor Robert Cassidy, "is startling because it indicates that the people most responsible for making American strong in technology think the idea-creating system isn't working."

Two-thirds of the scientists are distressed by the way they are treated by management, saying their employers "do not offer researchers the same rewards and opportunities to advance that they offer managers." The poll also indicates that scientists feel that they are kept in the dark when it comes to their company's long-range plans and that they are burdened with red tape in recommending and carrying out research. Fifty-nine percent said their employers failed to effectively communicate their organizational goals.

The survey also found that the scientists love their jobs.

Top 100 Slow R&D Spending

The top 100 spenders on research and development among U.S. corporations increased R&D funding by 8.7 percent last year, down from the 10.7 percent increase in 1988, according to a survey by the publication Inside R&D. The slowdown is attributed to a growing emphasis on pursuing incremental product improvements rather than on basic research targeting big breakthroughs. This trend is the result of companies trying to imitate the

Japanese way of conducting R&D, says Inside R&D. The top 100 U.S. companies in R&D spent \$53 billion conducting their research in 1989, accounting for 77 percent of the total industrial R&D spending.

R&D spending as a percent of sales increased, on average, from 3.67 percent in 1988 to 3.82 percent in 1989. Research spending per employee increased as well, from an average of \$9,010 per employee in 1988 to \$10,500 per employee in 1989.

Top 10 on Inside R&D 100 List

Rank	1989	1988	Company	1989 R&D Spending (\$ Million)	(Increase) from Previous Year (%)
1	1		General Motors	5247.5	10.4
2	2		IBM	5201.0	17.7
3	3		Ford	3167.0	8.1
4	4		AT&T	2652.0	3.1
5	6		Digital Equipment	1525.1	16.7
6	5		Du Pont	1387.0	5.2
7	7		General Electric	1334.0	15.5
8	9		Hewlett-Packard	1269.0	20.2
9	8		Eastman Kodak	1253.0	9.2
10	10		United Technologies	956.6	2.6

Source: Inside R&D

R&D Spending by Top 100 Companies by Industry (\$ Million)

Industry (number of companies included)	1989	1988	% Increase
Computers (15)	11,510.4	9,840.5	17.0
Motor vehicles (4)	9,491.8	8,664.5	9.5
Pharmaceuticals (13)	5,688.4	5,068.6	12.3
Electronics (15)	5,280.0	4,779.7	10.5
Aerospace (10)	4,729.4	4,656.5	1.6
Chemicals (9)	4,127.7	3,849.7	7.2
Scientific and photographic equipment (6)	3,917.6	3,264.8	20.0
Telecommunications (2)	2,933.0	2,869.0	2.2
Petroleum (8)	2,055.0	1,918.0	7.1
Industrial and farm equipment (4)	694.0	597.9	16.1

Source: Inside R&D

Semi-Gas Controversy...

(Continued from page one)

The executive said employees of the Massachusetts-based Semi-Gas feel helpless as they sit back and watch the sale of their company to a foreign firm unfold. The final sale is up to parent company Hercules, who is hungry for the cash.

"We're just pawns on the board," he said.

Semi-Gas is the largest supplier of gas handling equipment to the semiconductor industry worldwide, with sales last year of \$20 million. Nippon Sanso plans to acquire the company through its American subsidiary Matheson Gas Products Inc., and came a step closer last week as officials from the government's Committee on Foreign Investment in the United States [CFIUS] said they will step aside and allow the acquisition to occur unless a threat to national security emerges, sources said.

In private meetings in Washington, CFIUS officials met with representatives from Nippon Sanso, Matheson Gas, Hercules and Semi-Gas. CFIUS, which has blocked the sale of only one U.S. company to a foreign firm since its creation several years ago, is not expected to stop the Semi-Gas Systems sale because its sale is not regarded as a national security issue.

CFIUS officials declined to confirm whether the sale of Semi-Gas was under review.

But industry sources told *New Technology Week* that Nippon Sanso intends to finance about half the cost of the sale through a \$10 million cash-loss carryforward recorded by its Matheson subsidiary. Nippon Sanso completed its acquisition of Matheson in 1969.

When Nippon Sanso announced its intentions to acquire Semi-Gas last winter, it triggered widespread opposition in U.S. industry among companies concerned that it was another case of a Japanese firm profiting off U.S. innovation. One of the most outspoken critics of the sale has been the Austin, Texas, semiconductor manufacturing consortium, Sematech. Semi-Gas has collaborated with Sematech for two years on development of its gas distribution technology.

"Sematech feels very strongly

(Continued on page 9)

Semi-Gas...

(Continued from page four)

that it is against the best interests of the U.S. semiconductor industry and the nation as a whole for Semi-Gas Systems to be sold to a foreign competitor whose apparent intentions are worldwide market domination," wrote Turner Hasty, Sematech executive vice president and chief operating officer, to Hercules Chairman David Hollingsworth in April.

Sematech is concerned the sale would offer Nippon Sanso insight on the consortium's strategies, harming national security and divulging proprietary U.S. technology information.

Officials from Sematech and the Semiconductor Equipment and Materials International [SEMI] contacted Hercules executives and told them of their concern of the proposed sale to a foreign firm.

"We understand that Hercules Inc. has refused to consider a leveraged buyout by Semi-Gas Systems management that would have enabled it to remain an American company," Hasty wrote Hollingsworth. Despite SEMI/Sematech offers to help Hercules find an American buyer, the formal offers "did not even receive the courtesy of an acknowledgement."

The Semi-Gas executive said that Hercules "perceives Sematech as the enemy because [Hercules] wants the money." And, if the Semi-Gas sale proceeds, "the ramifications are that we would become discontinued from Sematech, which would severely hurt our R&D."

Sam Harrell, president of Semi/Sematech, told Hercules executives in January that "a disassociation with Semi-Gas at this time or at any time in the near future would harm Sematech's long-term strategies. As you know, Sematech's charter, as guided by the Defense Department and the U.S. Congress, provides preferential treatment to U.S. vendors/suppliers of semiconductor manufacturing equipment and materials. While our charter allows us to transact with foreign-owned companies, this may only be done as a measure of last resort."

But the sale of Semi-Gas to Nippon Sanso is not a done deal. The Department of Treasury plans to conduct an anti-trust investigatory review within the next three weeks before a deal could be consummated, a source said.

Japanese Control Liquid Crystal Displays

TOKYO—Japan's electronics industry, with government help, is pouring huge sums into liquid crystal displays and hopes to overcome formidable technical barriers that would allow them to develop large displays. "Technically, 40-inch LCDs with quality comparable to today's TVs will be realized in six or seven years," says Eiji Kaneko, director of the Giant Electronics Research Laboratory, a government-sponsored consortium of 17 companies. "We're hopeful they can be commercialized in 10."

Sharp, Hitachi, Hosiden and other Japanese firms this year will invest about \$1 billion to research, develop and set up plants to make LCDs, which are widely used in watches and laptop computer screens. Sharp, which is considered the leader of the pack, plans to invest \$650 million over the next three years.

The only foreign group that is even close to the Japanese in LCD development is IBM, which makes LCDs in a joint venture with Toshiba. "This is a Japan-supplies-the-world market," says Steve Myers, an analyst with Jardine Fleming Securities.

State-of-the-art production models deliver 16 colors on a laptop display. Samples of 14-inch displays with far better picture quality and color comparable to televisions are due out later this year but will cost about \$3,900.

Prototypes of 20-inch LCD screens are expected next year, though commercialization is still three to four years off. Scaling up beyond 25 inches will require technical breakthroughs that many people doubt are possible.

Although research is costly, strong demand for LCD products is fueling R&D spending. Demand is growing rapidly for smaller LCD panels used in portable TVs and VCRs, video telephones, electronic pocket notebooks, laptop personal computers and automobile dashboards.

By the middle of this decade, LCDs should displace cathode ray tubes as the most valuable display technology. By 2000 the LCD business will have grown 10 times to some \$13 billion.

Despite the Japanese blitz, the game is far from over. Active-matrix LCDs may never be scaled up to large sizes at affordable prices. And Japanese companies, along with many in the United States and Europe, continue to explore alternative flat-panel technologies.

But even if other approaches to LCDs turn out to be the screen technology of the future, Japanese firms are likely to dominate. "Whichever way the market moves, they'll have a product," says Myers.

—Steven Brill, Reuters

Coal Production Hits Record High

Production and consumption of coal is hitting a record pace, according to the National Coal Association. NCA's mid-year forecast says coal production will hit just over one billion tons by year end, about 22 million tons over the prior record of last year and the first time ever that production will top the billion-ton mark.

Medtronic To Build Lab In Japan

Medtronic Inc. of Minneapolis, will soon be breaking ground on a technology center in Chitose, on Hokkaido in northern Japan. The center is a "significant milestone in the evolution of Medtronic as a global company," proclaims Winston Wallin, chairman and CEO. The center will manufacture cardiac pacemakers. "As the leader in the Japanese pacemaker market, Medtronic intends to grow from those roots [and] build closer relationships with Japanese physicians," says Wallin.

Du Pont Receives Thallium SC Patent

Du Pont boosted its high temperature superconductivity patent count last week to seven, making it the leading company in the amount of patents granted for the new generation of superconductors. The patent is for a thallium-barium-copper-oxygen superconductor. The composition is similar in structure to a thallium-lead superconductor patent Du Pont received earlier this year, but differs in that the concoction has a single copper-oxygen layer instead of multiple layers. It is superconductive at temperatures in the range of 90 degrees Kelvin.

**The
Competitive Status
of the U.S.
Electronics
Sector** from
Materials to Systems



U.S. DEPARTMENT OF COMMERCE
International Trade Administration

The Competitive Status of the U.S. Electronics Sector

From Materials to Systems

A report from

The Secretary of Commerce

to

*The Appropriations Committee
U.S. House of Representatives*

**U.S. DEPARTMENT OF COMMERCE
International Trade Administration**

April 1990

FOREWORD

The issue of the competitive status of U.S. industry vis-a-vis foreign competitors has been under examination for some time. The President's Commission on Industrial Competitiveness defined competitiveness as: "the degree to which a nation can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining and expanding the real income of its citizens." ^{1/}

This definition implies that the competitiveness of nations and companies are intertwined. A government must provide a favorable environment which fosters economic growth, a well-educated work force, and a well-developed infrastructure to support investment and innovation. In order to survive, a company depends upon this larger environment and, in addition, must provide products of high quality and reliability at a competitive price.

This study will examine both of these levels of competitiveness, focusing on the U.S. electronics industries, considered to be one of the leading high technology sectors, and thus a bellwether of U.S. competitiveness.

This effort is the result of a request from the House Appropriations Committee of the U.S. Congress to the Department of Commerce, mandating that it work with other government agencies and the private sector to develop a plan to restore the international competitiveness of the U.S. semiconductor and electronics industries. This document has been seen by nearly 50 representatives in the electronics sector and officials in 10 agencies of the U.S. Government. It represents the first step in this process--a statement on the status of the U.S. electronics sector, the issues facing it, and some options for consideration in addressing these issues.

This report represents the views of the Department of Commerce. It does not necessarily reflect the views of the Administration nor has it received interagency clearance.

This report represents the status of the sector and its associated issues through December 1989.

^{1/} Global Competition-The New Reality, The Report of the President's Commission on Industrial Competitiveness, January 1985, Volume I, page 6.

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EXECUTIVE SUMMARY

The U.S. electronics sector has been historically and remains today the overall leader in the world by many measures. In terms of output, employment, innovation, and technology base, the United States is number one. However, in terms of the growth of these measures and others, such as exports, Japan and Korea are quickly reducing the U.S. advantage. In fact, if current relative growth rates continue, the Japanese will be the world's number one electronics producer and trader by the early 1990s.

U.S. suppliers of a broad range of electronic products have seen their worldwide market shares rapidly decline over the last several years--from silicon wafers and DRAMs (memory chips) to computer displays and telecommunications network switches. The situation is even bleak for some of the newest technologies: X-ray lithography, optical storage devices, and flat panel displays.

Thus, U.S. leadership in electronics is under serious challenge and may very well be eclipsed unless continued tenacity by the U.S. private sector is accompanied by a higher degree of consensus within the industry and improved coordination with academia, federal, state and local governments.

The Importance of Electronics to the Nation

Electronics is the major growth area in the U.S. economy--in terms of employment, output, exports, and innovation. In 1988, the sector employed nearly 2 million workers and shipped \$200 billion in products, of which \$39 billion was exported. Electronic inventions received 40 percent of all patents, and the sector conducted 20 percent of all U.S. industry's research. These facts suggest that any further erosion in this sector's competitive status could have serious implications for the health of the U.S. economy and the standard of living of Americans generally.

Electronics is also vital to the nation's defense and security since our military advantage is based on technological superiority, not the quantity of the weapons in our arsenals.

Causes of the Competitive Challenge

The causes can be found both domestically and internationally. Domestically, the electronics sector is disadvantaged relative to other nations in such areas as the higher cost and lower availability of finance capital, weaknesses in vocational training and science and engineering education, and stricter antitrust laws. Although these issues affect many other U.S. industries, electronics is particularly vulnerable, since the sector is one of the most capital intensive, is extremely dependent on scientists and engineers throughout its operations, and may be forced to move toward joint manufacturing efforts in some products to counter foreign dominance.

Internationally, the sector faces targeting by many foreign governments which have identified electronics as crucial to their economic destinies. They have instituted policies to foster their domestic industries, including restricting domestic markets, funding joint R&D projects, and forcing the transfer of technology from foreign suppliers to domestic firms. Electronics firms have been hurt by unfair trade practices such as dumping and intellectual property rights violations.

In contrast to these foreign governments, the U.S. Government has not had a coordinated set of policies directed at this sector. In general, the United States has followed an ad hoc approach, the effect of which has been to place the U.S. electronics sector at a competitive disadvantage vis-a-vis some of its foreign competitors.

The electronics sector itself is the origin of some of the reasons for its declining competitiveness. As is true of U.S. corporations in general, management of electronics companies has been forced by their equity structure to take a less strategic view of the market than have their foreign competitors, who often emphasize market share over return on investment. The smaller capitalized, entrepreneurial character of companies comprising over 90 percent of the firms in this sector make them more vulnerable to price discounting tactics frequently employed by foreign competitors. Some U.S. electronics firms are not as efficient as their Japanese competitors in transferring research and development results to the market. Moreover, the Japanese lead in manufacturing techniques, giving them an edge in producing low-cost, high-quality products. The Japanese have made substantial market gains through their focus on making incremental improvements on existing products.

There is a lack of consensus on the magnitude of the competitiveness problem, its causes, and there has been much discussion of the appropriate roles of government and industry in addressing the problem.

U.S. Government and Private Sector Actions

The U.S. Government, companies, trade associations, and universities have begun to take steps to enhance the competitiveness of the sector. For example, the Sematech R&D consortium was established, jointly funded by government and industry, to regain U.S. leadership in semiconductor manufacturing technologies. Additionally, the U.S. Government is considering amendment of the U.S. antitrust laws to allow consortia which would cover joint production efforts.

Internationally, the U.S. Government's trade policy activities have focused on countering the targeting efforts of foreign governments through bilateral and multilateral negotiations to pressure these governments to open their domestic markets and to stop trade distorting practices.

Both government and industry have been active in addressing the unfair trade practices of foreign companies in terms of dumping and infringement of intellectual property rights. Despite considerable attention by policymakers, however, challenges to the sector's competitiveness remain.

Recommendations for Additional Action

Unless other steps are taken to address the broad range of issues which affect the competitiveness of the sector, the long-term competitiveness of the U.S. electronics industries could be placed at unnecessary risk. The U.S. Government needs to play an active role, but it is the role of the private sector to chart the course to competitiveness.

DEFINITION OF THE ELECTRONICS SECTOR

"Electronics" has always been an imprecise term, but confusion over its definition has increased as new technologies, products, and applications have proliferated. According to the American Heritage Dictionary, electronics is, "the commercial industry of electronic devices and systems." This definition would include a broad range of products that incorporate some electronic content--from talking teddy bears, to automobiles, to space satellites to supercomputers--both consumer and industrial goods.

This study will concentrate on the industrial segment of this range of products and largely ignore the consumer segment. A variety of studies have been done on this latter segment, including a recent effort from Massachusetts Institute of Technology (MIT). ^{1/} We judged any additional study on our part to be duplicative.

We will concentrate on those industries that are directly involved in the manufacturing of electronic equipment, i.e., primarily the seven industries in the solid boxes in Chart 1: business equipment (including photocopiers), computers, electronic components (including semiconductors), instruments (including automatic test equipment or ATE), semiconductor manufacturing equipment (SME), software, and telecommunications. ^{2/} This collection of industries will be referred to as the electronics sector.

In addition to this study, the Department of Commerce is currently conducting a competitiveness study of the U.S. telecommunications industry as mandated by Section 1381 of the Omnibus Trade and Competitiveness Act of 1988. Many issues unique to the telecommunications industry that have not been addressed in this study on the electronics sector will be examined in detail in the telecommunications report, which is due to be published in fiscal year 1990.

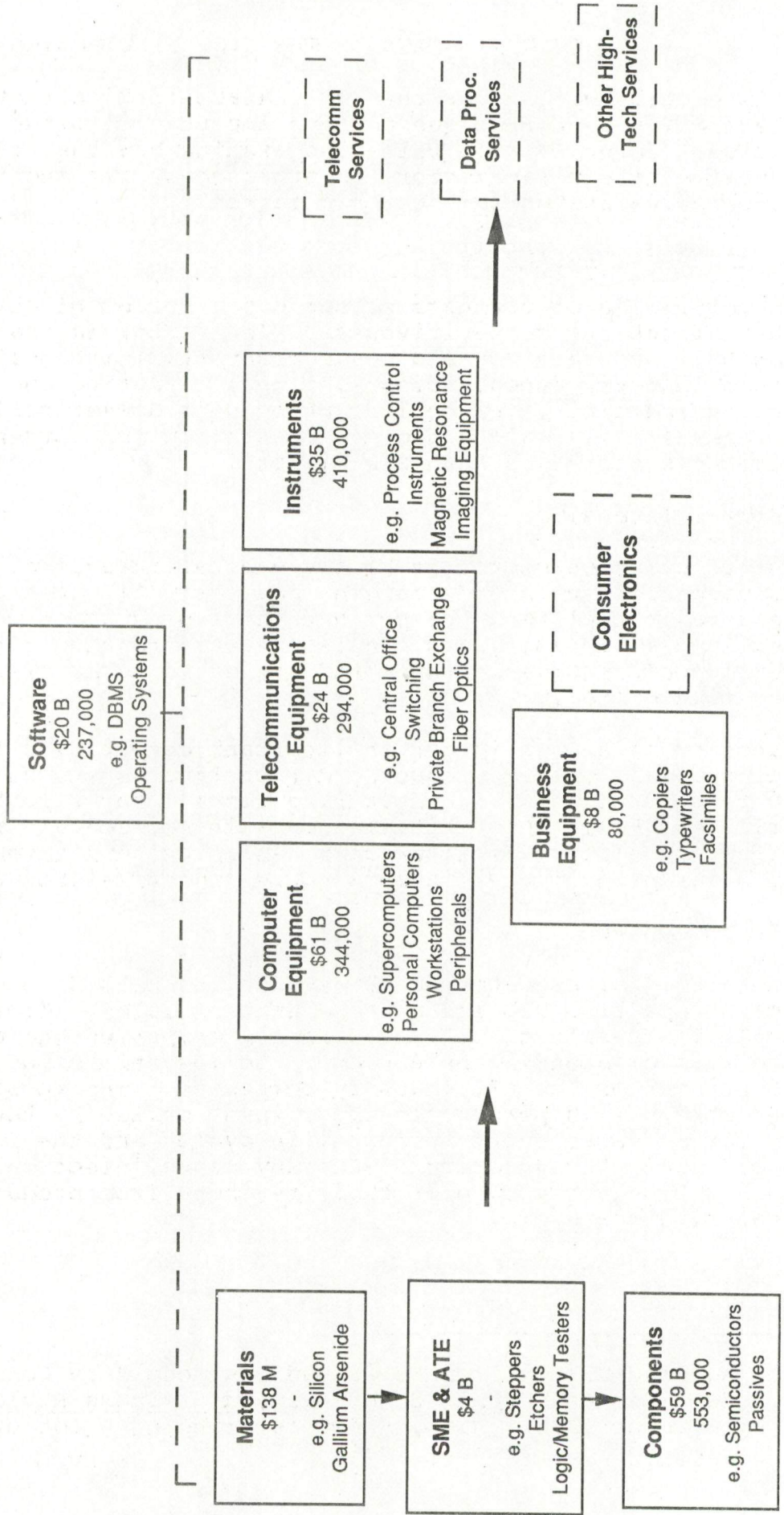
^{1/} The Decline of U.S. Consumer Electronics Manufacturing: History, Hypotheses, and Remedies, The Working Papers of the MIT Commission on Industrial Productivity, MIT Press, Cambridge, Massachusetts, 1989.

^{2/} The following SIC codes (Standard Industrial Classification) are covered: business equipment -- SIC 3574, 3579, 38612; computers -- SIC 3573; electronic components -- SIC 367; instruments -- SIC 382; software -- SIC 7372; telecommunications equipment -- SIC 3661, 36621.

The U.S. Electronics Sector

Total Electronics - 1988

Revenues: \$202 Billion
 Employment: 2 Million Persons



I. CURRENT STATE OF THE U.S. ELECTRONICS SECTOR

This section will cover the key characteristics that make the electronics sector unique and its importance to the U.S. economy and national security. It will also examine how the U.S. sector compares to similar sectors in other countries and the sector's competitive status in the world market.

A. Key Characteristics

Summary: The electronics sector has a number of characteristics that affect its competitiveness. The sector is characterized by capital, and research and development (R&D) intensity, cross-industry dependencies, a global marketing and production base, increasing firm-level collaboration both domestically and internationally, and a high concentration (95 percent) of companies with assets of less than \$10 million.

Capital Intensive

The electronics sector is highly capital intensive, exceeding all manufacturing by a wide margin (see Chart 2). Although the sector is a major employer, the percentage of production workers has declined in recent years, replaced by increasing automation to remain competitive in the world market in terms of price, quality, and time of delivery.

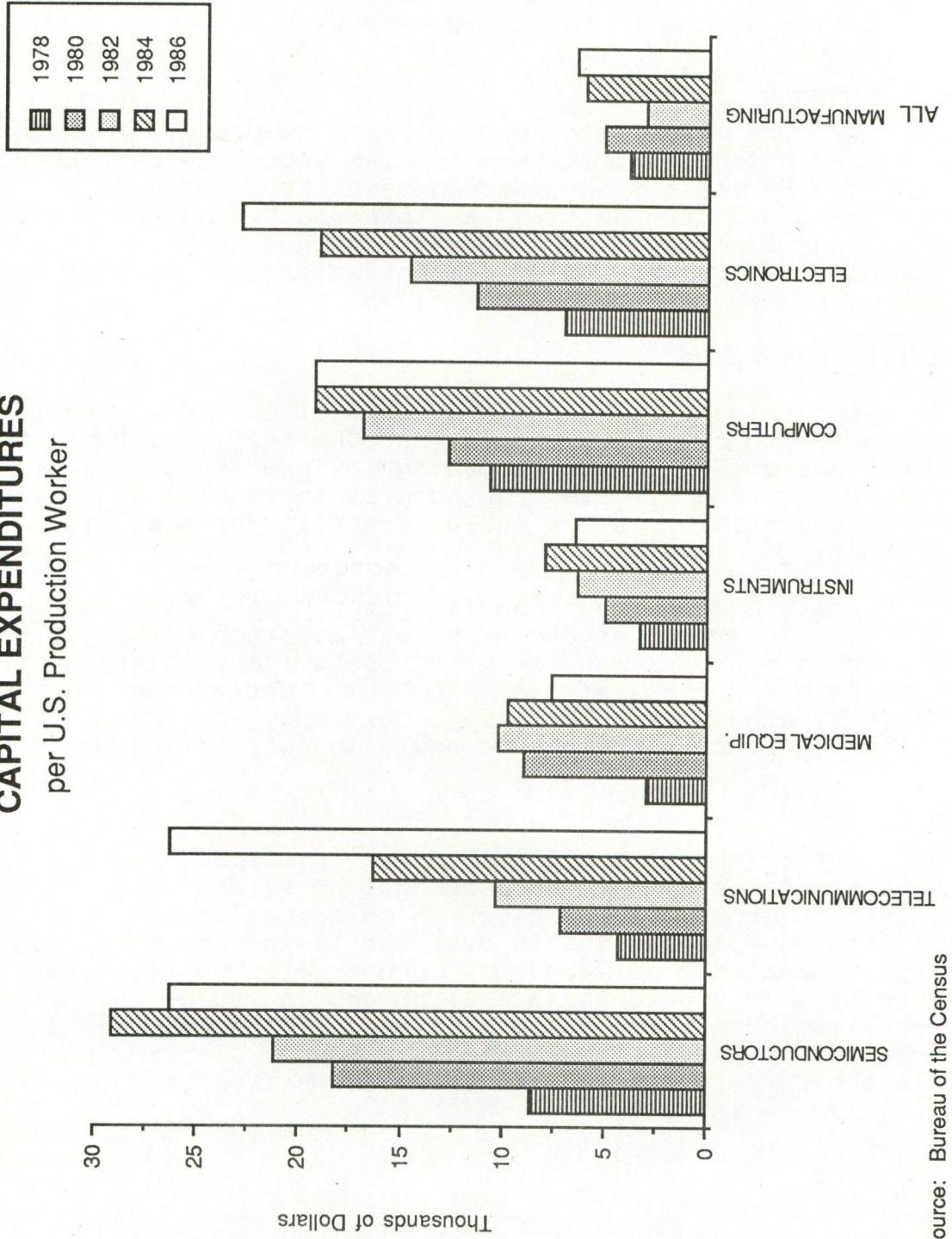
Labor costs are no longer an important competitive factor, since, for most electronic products, direct labor costs only represent 5 to 10 percent of total manufacturing costs. Any slight advantage that still exists in the Far East and Latin America has reportedly been offset by higher administration, shipping, and inventory costs, and by lower productivity in some newly industrialized nations. ^{1/}

R&D Intensive

The electronics sector is the leader in the U.S. economy in the amount spent on R&D and as a percent of sales. Table 1 shows that by 1987 a sample of U.S. electronics companies had more than doubled the rate of spending on R&D over the 10-year period, accounting for 20 percent of the all industry composite. The relatively higher percentage (7.9 percent in 1987) spent on R&D by the electronics sector reflects short product life cycles and the resulting need for rapid product development. In many cases, electronics companies gain a high percentage of their revenues from products that are less than five years old.

^{1/} "Manufacturing Offshore is Bad Business," by Constantinos C. Markides and Norman Berg, Harvard Business Review, September-October 1988. Also, "ADDS is Bringing A Lot of It Back Home," Electronics, January 1989.

Chart 2
CAPITAL EXPENDITURES
 per U.S. Production Worker



Source: Bureau of the Census

Table 1 Comparison of R&D Spending by Selected Industries

<u>Industry Sector</u>	<u>1977</u>		<u>1987</u>	
	<u>Value (\$ M)</u>	<u>Percent of Sales</u>	<u>Value (\$ M)</u>	<u>Percent of Sales</u>
Electronics	4,240	3.7	10,645	7.9
Aerospace	972	3.5	3,865	4.4
Chemicals	1,665	2.5	4,168	3.7
Automotive	3,719	2.4	8,653	3.5
Manufacturing	1,428	2.6	1,463	2.3
All Industry Composite	18,048	1.9	54,267	3.4

Source: Derived from "R&D Scoreboard" for the years 1977 and 1987, in Business Week, July 3, 1978 and June 20, 1988.

Cross-Industry Dependencies

The industries within the U.S. electronics sector are linked technologically and economically with companies having close working relationships. For example, manufacturers who produce ultra pure silicon wafers in the materials industry must work closely with makers of semiconductor manufacturing equipment (SME), automatic test equipment (ATE), and semiconductor devices to ensure that such products as dynamic random access memories (DRAMs) can be produced cost effectively in high volume. The suppliers of the various "downstream" systems products--computers, business equipment, and telecommunications equipment--will design these memory chips into their latest products and will depend on the "upstream" suppliers for reliable, high-quality chips at competitive prices. Software is an overriding product that is necessary to make all digital electronic systems function. Software is found in virtually all these products whether embedded in the circuitry of the chips or recorded on magnetic disks or tape.

A technological or business development in one of the electronics industries can have a profound effect on others. The most recent example of this interdependence was the DRAM shortage beginning in 1987 (see case study on memory market in Appendix A), which involved the shortage of 256K and 1M memory chips from Japanese suppliers and which found many U.S. system-level suppliers facing squeezed profit margins and lost sales.

Broad Product Range

Products in the electronics industries cover a wide range, from those that are sold in the millions of units and that are very price sensitive to those whose annual sales number in the hundreds and for

which price is secondary to performance. Commodity items, such as many semiconductors, are similar from one manufacturer to another in terms of function, design, quality, and process technology. These items are often purchased in large quantities, with competition centering on price as the major factor in a purchaser's decision. Profit margins can be razor thin for such products.

At the other extreme are products, such as supercomputers, that may cost as much as \$10 to \$25 million per system, but the sale of which is contingent on the overall level of performance of the hardware, including the type and variety of software available. While competing systems might have a theoretically higher raw processing speed, their ultimate utility for real world tasks can be severely limited by a lack of proper software. In fact, at the electronic systems level, the availability of appropriate software to run the machines is a major competitive advantage of U.S. suppliers.

Global Production and Marketing

Since their commercial beginnings, companies in the U.S. electronics sector have had a major presence overseas. U.S. electronics companies are leading employers, manufacturers and exporters in Europe, Japan, Canada, and many of the developing countries.

This strong foreign position can be seen by examining the overseas position of the largest industry in the sector, computer equipment. Table 2 shows the relative proportions of five major overseas markets served by U.S. computer exports and by U.S. overseas subsidiaries. These figures highlight the importance of foreign investment to the U.S. computer industry. In 1986 these five markets had a total value of about \$47 billion, of which U.S. firms supplied \$21 billion or 45 percent. U.S. exports represented about \$9 billion of the \$21 billion, leaving \$12 billion supplied from overseas production facilities of U.S. computer firms. Thus, U.S. overseas investment was the source of more than 60 percent of the value of U.S. computer shipments to these markets. Less than 40 percent of U.S. computer shipments was represented by U.S. exports.

Increasing Collaboration

The U.S. electronics sector has had a history of collaborations among both domestic and foreign firms with complementary product lines. These collaborations have taken several forms: joint ventures in R&D, manufacturing, or sales; distribution and marketing agreements; technology licensing agreements; and outsourcing (purchasing foreign designed and developed parts and components).

Overseas, U.S. electronics firms have often been required to forge such links to avoid market restrictions imposed by foreign governments. In addition, as foreign electronics firms have advanced relative to U.S. suppliers in terms of delivering products competitive in technology, price, and quality, U.S. electronics companies have come to depend on them to remain competitive in

Table 2 U.S. Trading Patterns in Leading Computer Markets-1986

<u>Country</u>	<u>Total Market</u> (\$B)	<u>Total U.S. Share</u>		<u>Total U.S. Export Share</u>	
		(\$B)	(%)	(\$B)	(%)
Japan	15.0	3.3	22	1.2	8
West Germany	10.0	5.8	58	2.3	23
United Kingdom	8.1	3.2	40	1.9	23
France	8.7	4.8	55	2.0	23
Italy	4.8	3.8	79	1.2	25
Total	46.6	20.9	45	8.6	18

Source: Various, including official foreign government data.

certain markets. Some of the more recent agreements have resulted from the need to share the growing costs and risks of R&D, to broaden product lines, and to obtain manufacturing capabilities not available in-house. The long-term cost of some of these linkages has been the more rapid diffusion of U.S. technology to foreign concerns, many of which have emerged as major competitors in the world market. Several studies have documented this phenomenon. ^{2/}

During 1980-86, the pace of these major collaborations accelerated substantially as shown in Table 3. The data cover the semiconductor, computer, and telecommunications industries, but the activity was greatest among semiconductor firms. Japan was the leading country with which U.S. companies forged alliances, reflecting the growing competitive prowess of Japanese semiconductor suppliers over this period.

Japanese firms have established collaborative links with foreign partners, but are perceived as having been largely successful in acquiring advanced technologies without surrendering their own to

^{2/} See, for example, Made in America: Regaining the Productive Edge, The MIT Commission on Industrial Productivity, 1989; Microelectronics Manufacturing Technology: A Defense Perspective: Final Report of the Defense Microelectronics Technology Base Project, Institute for Defense Analyses, April 1988; "The Japanese Challenge in High Technology" by Daniel I. Okimoto in The Positive Sum Strategy: Harnessing Technology for Economic Growth, National Academy of Sciences, 1986.

Table 3 Alliances Between U.S. and Foreign Electronics Firms

<u>Year</u>	<u>Joint Venture</u>	<u>Marketing/ Distribution</u>	<u>Technology Licensing</u>	<u>Technology Development</u>	<u>Out-Sourcing</u>
1980	4	1	4	2	2
1986	24	27	31	19	4

Source: Merger Yearbook, Cambridge Corp.; Mergers and Acquisitions, Gee and Co.; Dataquest; and Business International.

major competitors. The Japanese strategy in entering many of the electronics markets has been to begin with original equipment manufacturer (OEM) agreements, thus gaining marketing assistance and establishing a reputation for a product. The companies eventually withdraw from the OEM arrangements and establish their own brand name operations.

Source of New Firm Growth

The electronics sector is a major source of new firm creation and is composed of a high percentage of small firms.

From 1977 through 1985 (the most recent year available), the number of manufacturing firms in this sector nearly doubled to over 17,000 (see Table 4). Enterprises with total assets below \$10 million constituted 95 percent of this total, underlining the fact that the

Table 4 Number of Enterprises in the U.S. Electronics Sector

<u>Year</u>	<u>Manufacturing</u>			<u>Software</u>	<u>Total Software Firms</u>
	<u>< \$10M</u>	<u>Assets >\$10M</u>	<u>Total</u>	<u>Software Products</u>	
1977	8,738	348	9,086	-	-
1979	-	-	-	1,095	1,915
1980	11,537	434	11,971	1,225	2,200
1981	-	-	-	1,605	3,919
1982	11,923	585	12,508	1,879	4,340
1983	-	-	-	2,250	4,850
1984	-	-	-	2,500	5,250
1985	16,579	912	17,491	2,488	5,192
1986	-	-	-	2,705	5,422

Sources: Manufacturing: Almanac of Business and Industrial Financial Ratios, Leo Troy, Phd., 1980, 1984, 1986 and 1988 editions; software: Input in the Association for Data Processing Services Organizations (ADAPSO) annual reports 1980-1987.

sector has a predominance of small, entrepreneurial companies that have been a key source of innovation and new products. The size and behavioral characteristics of these firms allow them to respond quickly to market opportunities, but their smaller size makes them vulnerable to price competition from larger competitors. Table 4 also shows the growth in software suppliers over this same time period, to over 5,000 companies by 1986.

B. Importance of Sector to the National Interest

Summary: The U.S. electronics sector is the major growth area in the U.S. economy. In terms of increases in shipments, productivity, exports, and employment, electronics leads all other sectors. It is also highly innovative and a major source of new firms and products that are critical to economic growth and national security.

Production and Trade Leader

Although relatively young, electronics has become as important a barometer of the economic health of the nation as any other major sector. As shown in Chart 3, electronics' average annual growth rate of 11 percent in output since 1977 has been more than twice that of automobiles and chemicals, and three times that of textiles and wood products. Only aircraft, another high technology sector, had a growth rate comparable to electronics. But in 1987, electronics had reached \$200 billion in shipments, compared to \$75 billion in aircraft.

Substantial gains were made in productivity during 1977-86. Value added per production worker hour increased by two and one-half times in electronics versus the doubling of this measure in all manufacturing.

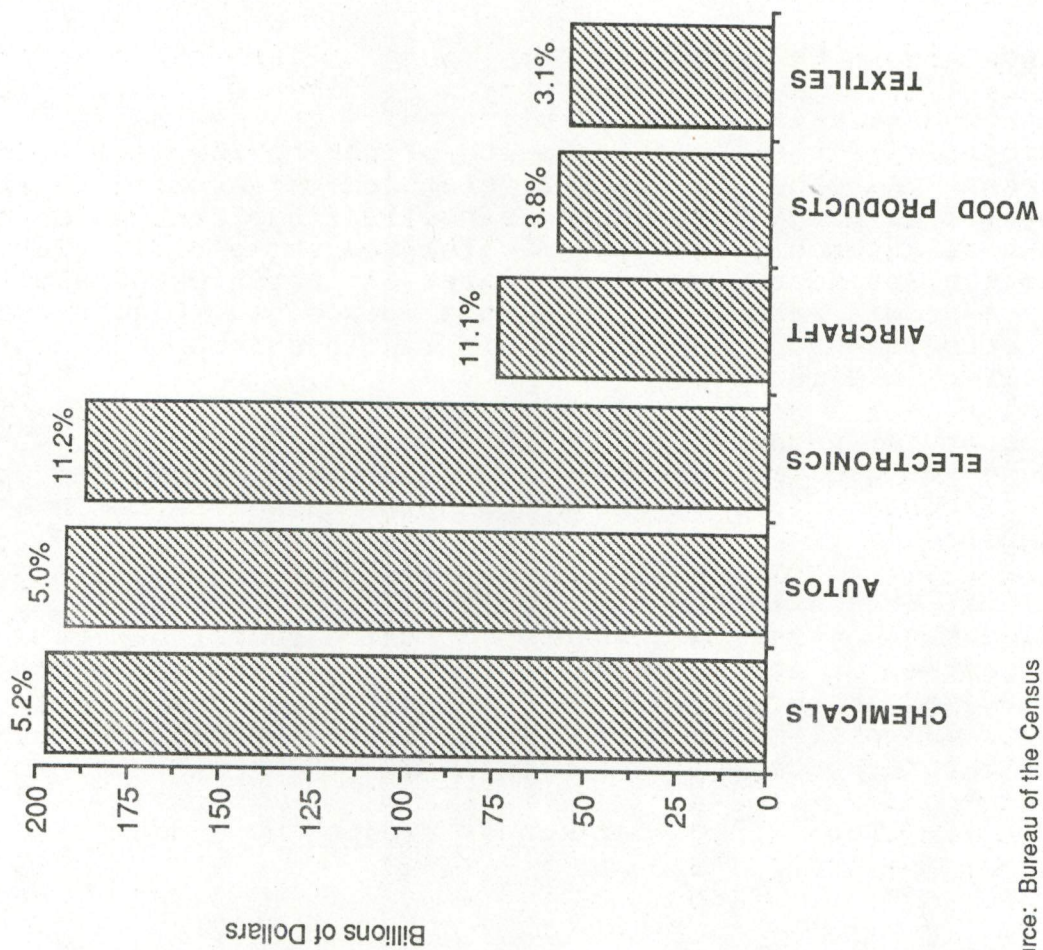
Similar trends in terms of the level and increase in exports are evident. Not only does the electronics sector export a high percentage of its output--25 percent--but the value of exports has increased at an average of 18 percent a year since 1977, reaching about \$39 billion in 1987. This growth even outpaced that of aircraft exports as seen in Table 5.

Table 5 Comparison of Exports by Industry Sector

	<u>1977</u> ((\$B)	<u>1987</u> ((\$B)	<u>Annual</u> <u>Growth</u> (%/yr)
Aircraft	7.1	22.2	12.1
Automobiles	2.7	2.7	0.0
Chemicals	12.9	32.0	9.5
<u>Electronics</u>	<u>7.6</u>	<u>38.8</u>	<u>17.7</u>
Textiles	1.3	1.7	2.7
Wood Products	1.7	3.4	7.2

Source: U.S. Bureau of the Census.

Chart 3
**1987 Shipments and 1977-87 Growth Rates
of Selected U.S. Industries**



Source: Bureau of the Census

In terms of the jobs created in the last decade, the electronics sector leads all others. The electronics sector directly employs about 9 percent of the manufacturing work force, having grown at an average of nearly 3 percent a year since 1977. This increase has meant the addition of nearly 600,000 new jobs over the 10-year period to a level of more than 2 million workers. Worth noting is that these figures do not include the indirect effect electronics has had on employment in many other industries that use the output of this sector for their own livelihood. Examples would include data entry personnel, software programmers, and systems analysts who make up the internal data processing staff of many large organizations, as well as staff supporting telecommunications systems in these firms.

Leader in Innovation

The electronics sector is the leader in innovation in the United States, as measured by the number of patents granted per year.

The rate at which new products are developed in the electronics sector outstrips that of any other industry sector in the economy. Table 6 shows that U.S. patents awarded to electronics inventors were 36 percent of all patents awarded in 1986 (the most recent year available), up from around 30 percent 11 years before.

Table 6 Patents Granted to U.S. and Foreign Inventors

Industry Sector	1975			1986		
	Total Patents	U.S. Share (%)	Foreign Share (%)	Total Patents	U.S. Share (%)	Foreign Share (%)
Electronics	21,353	66	34	25,724	53	47
Machinery	15,648	63	37	13,766	50	50
Chemicals	10,806	59	41	7,804	54	46
Fab. Metal	6,064	72	28	5,769	59	41
Rubber/Plast.	2,931	66	34	2,856	56	44
Motor Veh.	3,163	66	34	2,809	47	53
Drugs/Med.	1,067	55	45	1,411	49	51
Stone/Clay/Gl.	1,375	65	35	1,352	53	47
Other	3,500	83	17	3,240	55	45
Total	72,000	65	35	70,860	54	46

Source: Derived from Science and Engineering Indicators-1987, National Science Foundation.

Source of Critical Products

The products and services of the electronics sector are increasingly vital to a broad range of industries in the U.S. economy and, in fact, are critical to their long-term growth. They are also critical to national security. The use of electronics technology has spread widely to disparate sectors of U.S. business and industry. Manufacturers are increasingly turning to sophisticated instrumentation, computers, software, and advanced communications systems to lower their costs and increase their efficiency. Similarly, firms are incorporating electronics technology into the design of their products. Automobiles, for example, have increased the value of their electronic components substantially. In 1988, electronic sub systems represented more than \$800 of the price of the average car, double that of 1982. As products incorporate larger amounts of electronics technology, the dependence of manufacturing upon the electronics sector grows stronger.

Electronics technology has become central to the service industries as well. A wide variety of transportation, legal, financial, and research firms have invested heavily in advanced computers, electronic business equipment, software, and telecommunications for day-to-day operations.

A strong, technologically superior industrial base is a key element of national security. The future of the U.S. electronics sector, as one of the key high technology sectors, is particularly important to the United States since the country's military advantage is based on technological superiority, not quantity of weapons. As the Defense Science Board stated in its study of the U.S. industrial base, "These challenges (to U.S. technological leadership) must be met by new policies which link military and industrial strategy to assure the existence of the industrial and technological resources on which our military strategy relies." 3/

C. The Competitive Status of the U.S. Electronics Sector

Summary: The U.S. sector is still the largest in the world in terms of production, exports, and employment, but each of these indicators is growing faster in other countries. Although the U.S. electronics market is the largest in the world, imports have risen substantially, displacing domestic production. U.S. firms have overall technological leadership, but face strong competition from the Japanese. In addition, they are losing world market share to their foreign competitors across the broad spectrum of the sector, from materials to systems.

3/ Final Report of the Defense Science Board 1988 Summer Study on the Defense Industrial and Technology Base, Office of the Under Secretary of Defense for Acquisition, Volume I, Oct. 1988, \pg.1.

Comparisons Between Countries

In Table 7, the U.S. electronics sector is compared with those in seven countries (Brazil, India, Singapore, South Korea, Taiwan, France, and Japan) and one regional group, the European Community (EC). Together, these entities represent about 95 percent of the world's electronics manufacturing. The countries are ranked from one (highest) to nine (lowest) in terms of parameters covering electronics: production, domestic consumption, trade with the world, employment, and technology base (infrastructure). These factors were chosen because they represent common development goals of most countries and can be objectively measured.

Production: The data in Table 8 show that the United States for 1988 had the largest electronics manufacturing sector in the world, with about 38 percent of world output. Japan and the EC followed, with 26 and 24 percent, respectively. These three entities represented 88 percent of the world's total. The figures in Table 8 cover domestic production only. If output from overseas subsidiaries could be broken out from these production figures, the U.S. electronics sector would show a larger production share worldwide.

Table 7: Ranking of Electronics Sectors in Selected Countries

	Ind	Brz	Sng	Twn	Kor	Frn	Jpn	EC	U.S.
PRODUCTION*									
Volume	9	8	7	6	5	4	2	3	1
Growth	3	5	2	4	1	7	6	8	9
CONSUMPTION*									
Volume	9	7	8	6	5	4	3	2	1
Growth	2	4	3	5	1	7	6	8	9
Imports/Cons.	6	8	1	2	3	4	9	5	7
TRADE WITH WORLD*									
Exports	9	8	6	5	7	4	1	3	2
Export Growth	5	9	4	2	1	6	3	8	7
Trade Balance	7	5	3	2	4	6	1	9	8
Trade Improvement	6	7	4	2	3	5	1	8	9
EMPLOYMENT*									
	7	4	9	8	5	6	3	2	1
TECHNOLOGY BASE									
	9	8	7	5	6	3	2	4	1

* Does not include data on the software industry.

Source: U.S. Department of Commerce.

Table 8 Comparing Electronics Sectors in Selected Countries

	INDIA	BRAZIL	SINGAPORE	TAIWAN	S.KOREA	FRANCE	JAPAN	E.C.	U.S.	WORLD
PRODUCTION										
Value (\$M, 1988)	2,314	3,876	7,651	7,890	9,103	24,175	127,208	115,136	186,232	486,718
% of World Total (1988)	0.5	0.8	1.6	1.6	1.9	5.0	26.1	23.7	38.3	100.0
CAGR, Real (1984-88)	23	11	23	15	24	6	8	6	1	4
Production/GDP (% 1987)	1.7	1.0	28.6	10.0	6.0	2.6	4.6	2.6	3.9	n.a.
Export/Production (% 1987)	3	13	145	89	80	45	39	24	20	n.a.
CONSUMPTION										
Value (\$M, 1988)	2,680	4,175	3,456	4,848	7,604	25,639	93,002	124,255	187,913	470,498
% of World Total	0.6	0.9	0.7	1.0	1.6	5.4	19.8	26.4	39.9	100.0
CAGR, Real (1984-88)	20	13	14	10	22	7	9	5	3	5
Consumption/GDP (% 1987)	0.8	1.2	14.4	6.2	5.1	2.7	3.3	2.7	3.9	n.a.
Import/Consumption (% 1987)	27	21	193	76	67	51	9	33	22	n.a.
TRADE WITH U.S.										
Exports (\$M, 1987)	17	90	3,580	3,742	2,673	758	15,428	5,807	n.a.	32,342
Export Growth (CAGR, 1980-87)	11.4	7.9	24.2	31.6	31.9	13.3	27.5	15.0	n.a.	19.3
Export/Import Ratio (1987)	.06	.19	2.0	2.95	1.87	.25	3.78	.36	n.a.	n.a.
Change in E/I Ratio (1980-87)	-.02	.05	.99	1.67	.98	.08	2.29	.13	n.a.	n.a.
Trade Balance (\$M, 1987)	-253	-373	1,792	2,473	1,243	-2,308	11,344	-10,207	n.a.	n.a.
% of U.S. Trade (1987)	0.4	0.8	7.8	7.3	6.0	5.6	28.5	31.9	n.a.	100.0
TRADE WITH WORLD										
Exports (\$M, 1987)	84	338	7,012	7,297	5,349	10,811	38,331	26,688	35,418	167,507
Export Growth (CAGR, 1980-87)	12.9	-2.0	21.5	28.2	29.8	10.7	22.2	8.3	8.6	12.1
Export/Import Ratio (1987)	.06	.27	1.24	1.74	1.07	.91	6.12	.69	.88	n.a.
Change in E/I Ratio (1980-87)	-0.6	-1.5	.32	.66	.35	-.05	3	-.24	-.92	n.a.
Trade Balance (\$M, 1987)	-1,357	-924	1,337	3,113	348	-1,060	32,063	-11,760	-4,795	n.a.
% of World Trade (1987)	0.5	0.5	3.8	3.4	3.1	6.8	13.3	19.5	22.6	100.0
EMPLOYMENT										
Total (000, 1986)	200	257	71	194	254	230	1,201	1,454	1,776	n.a.
CAGR (1980-86)	n.a.	n.a.	-2	2.6	9.8	4.1	9.6	1.5	1.3	n.a.
TECHNOLOGY BASE										
Telephones/1000 Pop. (1986)	4	84	417	228	186	620	558	520	791	n.a.
Scientists & Engineers (000, 1986)	100	33	2	42	47	102	575	468	787	n.a.
Scientists & Eng./IneersM Pop.	128	230	923	2,149	1,116	1,840	4,712	1,443	3,230	n.a.
U.S. Patents Granted (1963-87)	36	75	21	248	68	12,731	57,374	69,812	294,103	444,250
% of Total Patents Granted	0	0	0	.1	0	2.9	12.9	15.7	66.2	100.0
MACRO ECONOMIC DATA										
GDP (\$B, 1987)	255.1	326.0	19.9	74.0	121.3	878.3	2,374.6	4,255.0	4,484.3	n.a.
GDP/Capita (\$, 1987)	326	2,304	7,654	3,794	2,881	15,797	19,448	13,137	18,393	n.a.
Population (M, 1987)	781.4	141.5	2.6	19.5	42.1	55.6	122.1	323.9	243.8	4,917.0

*EC data exclude Portugal and Greece

CAGR = compound annual growth rate

Sources: U.S. Department of Commerce, United Nations, International Monetary Fund, and Elsevier Science Publishers.

In terms of growth rates since 1984, the picture is quite different. The United States fell to last place, with an average of only 1 percent per year, compared with 8 and 6 percent for Japan and the EC, respectively. In short, if Japan and the United States maintained their respective growth rates, Japanese electronics production would surpass that of the United States in 1994. The newly industrialized countries-- (NICs) South Korea, Taiwan, Singapore, Brazil, and India--all had double digit average growth rates, although from much smaller bases.

Several factors contributed to the relative decline in the growth of U.S. shipments of electronic products. In addition to some softness in the U.S. market, the growing strength of the dollar until 1985 compared with other foreign currencies weakened overseas demand for U.S. products. Finally, foreign competition increased, in terms of price, reliability, and level of technology.

Trade: Japan not only was the leading electronics exporter in volume (\$42 billion) in 1987, but also outstripped the United States in export growth by a ratio of 3 to 1. Although representing about 23 percent of the world's electronics trade in 1987 (the most recent year available across these countries), the United States had a \$4.8 billion trade deficit and ranked last among the selected countries in terms of the rate of improvement in its balance of trade. The EC had the highest deficit, \$11.8 billion. Only the Pacific Rim countries, led by Japan's \$32.1 billion, had trade surpluses.

While U.S. electronics exports grew substantially from 1980-87, with some impetus from a weakening dollar, their growth was outstripped by that of U.S. electronics imports, contributing to several years of multibillion dollar trade deficits.

The principal source of these imports was the Far East. Some of this deficit was attributable to the movement offshore of U.S. production, some to outsourcing by U.S.-based firms (including affiliates of foreign companies) from both U.S. overseas subsidiaries and foreign suppliers.

Consumption: The United States also had the largest electronics market in 1988, with a 40 percent share of world consumption. Japan and the EC followed with 20 and 26 percent, respectively. As in the case of production, other markets have been growing faster, placing the U.S. market in last place in terms of growth. Also, the figures show that the U.S. production base has lost competitive ground to imports.

These figures show that Japan and Europe taken together surpass the U.S. market in value, underscoring the fact that U.S. electronics companies must not only compete successfully in their own market, but in these overseas markets as well if they are to survive. The sector cannot depend only on its domestic market for future growth. Flowing from this is the implication that these foreign markets must

be free of trade and investment barriers for U.S. electronics firms to compete fairly.

Employment: The United States has the largest electronics work force, but electronics employment in other countries, such as Japan and Korea, has grown more rapidly. While employment in the U.S. electronics sector has shown steady gains, growth since 1982 has slowed. Within this overall growth, the number of production workers remained virtually unchanged, reflecting the movement to offshore production and the increasing use of automation.

Technology Base: A country's physical and human infrastructures are vital to the support of a high technology sector, such as electronics. As a proxy for the physical infrastructure, telephones and computers per capita will be compared. The rationale is that these products are fundamental elements of an environment that provides not only communications, but also the computational resources to design, develop, and manufacture sophisticated product technologies. The United States leads in physical infrastructure, while Singapore, with its high concentration of foreign operations, is the leading developing country.

In terms of the human infrastructure, the situation is different. While the United States has the largest number of scientists and engineers of any country (787,400), according to U.N. data, Japan has the highest concentration of scientists and engineers (4,712 per million of population). Korea has the largest number of scientists and engineers among the NICs. From 1974 to 1984, the number of research scientists in Korea increased 16 percent a year compared with only 6 percent growth in India. Growth rates are lower in the industrialized countries.

The number of U.S. electronics patents granted from 1963 to 1987 was used as the proxy for these countries' technological know-how. Patents awarded by the United States usually reflect the most advanced technologies developed worldwide and the technological prowess of competitors in the U.S. market. As expected, the United States has the predominant share, although this has declined from 80 percent of the total prior to 1974 to 55 percent in 1987. There has been a significant surge recently in the number of foreign-owned patents granted, with most of these going to Japan. Taiwan has the largest number of patents (1 percent of the total) among the developing countries; however, data show that relative latecomers, like South Korea, have increased their activity substantially in recent years.

The Japanese have more than doubled the number of U.S. electronics patents they were awarded when compared with the mid-1970s, and their patents have been cited more frequently than those of their U.S. counterparts. Japanese companies also held the top three positions for U.S. electronics patents received in 1987 (see Table 9).

Table 9 Top Ten Firms Awarded U.S. Electronics Patents in 1987

<u>Rank</u>	<u>Company</u>	<u>Country</u>	<u>Number of Patents</u>
1	Canon	Japan	847
2	Hitachi	Japan	845
2	Toshiba	Japan	823
4	G.E.	U.S.	779
5	Philips	Netherlands	687
6	Westinghouse	U.S.	652
7	IBM	U.S.	591
8	Siemens	West Germany	539
9	Mitsubishi	Japan	518
10	RCA	U.S.	504

Source: The Structure of the Japanese Electronics Industry,
 Dodwell Marketing Consultants, Tokyo, Japan,
 December 1988.

Specific Electronics Technologies

This downward trend in the U.S. share of patents is reflected in the declining capabilities of U.S. firms relative to the Japanese in the research and development phases of bringing key electronics technologies to market. In process materials, U.S. firms lag behind the Japanese in nearly all areas. Their Japanese competitors are now the dominant suppliers of high-quality semiconductor materials and the only source of ceramic packaging materials and quartz glass for mask blanks.

U.S. companies also trail in many processing equipment technologies, particularly those required to produce sub-micron semiconductor devices.

At the component level, U.S. firms lead only in microprocessors and custom/semicustom logic and are behind in several key memory technologies and optoelectronics. The United States has seen its lead eroded in many systems-level products. In the computer area, U.S. firms are roughly at parity with the Japanese in hardware design although they still have a slight, but dwindling, advantage in the development of parallel, multiprocessor systems. 4/

In telecommunications, a panel of government and industry experts reported in 1986 that the United States had generally lost ground to the Japanese in advanced research and product development in

4/ Microelectronics Manufacturing Technology: A Defense Perspective: Final Report of the Defense Microelectronics Technology Base Project, Institute for Defense Analyses, April 1988.

telecommunications wire and radio systems. But the United States remained strong in basic research on networks and networking subsystems. 5/

World Market Shares

The declining competitive position of the United States relative to Japan in the research and development of these technologies already has begun to be reflected in a comparable erosion of U.S. worldwide market shares of these products. Table 10 shows that dramatic erosion occurred from 1984 to 1988 in the share of worldwide shipments of U.S. companies across a broad range of major products corresponding to many of these technologies.

Another perspective can be seen by narrowing the view to computers. Chart 4 focuses on five leading foreign markets for computers--France, Italy, the United Kingdom, West Germany, and Japan. The graph shows that over the 1977 to 1986 period, U.S. computer companies, while showing revenue growth, lost market share to local and third-country suppliers in all five markets. The loss was particularly startling in Japan, where the U.S. market share dropped from about 50 to 22 percent over this period.

At the company level, a view of the market status of the top 100 computer firms in the world is provided in Table 11, which is an analysis of data from Datamation magazine's annual survey. Estimates place the top 100 firms as representing about 85 percent of the worldwide revenues from rental and sales of computer equipment, software, data processing services, maintenance and after-sales services of companies. The number of U.S. companies in the Datamation 100 dropped by 11 from 1983 to 1987, while European companies gained 3 slots and Japanese firms gained 8. The reason for the U.S. losses can be seen in the growth column, which shows that, in terms of worldwide revenues, the groupings of both European and Japanese computer companies grew respectively 60 and 160 percent faster over this period than the grouping of U.S. computer firms.

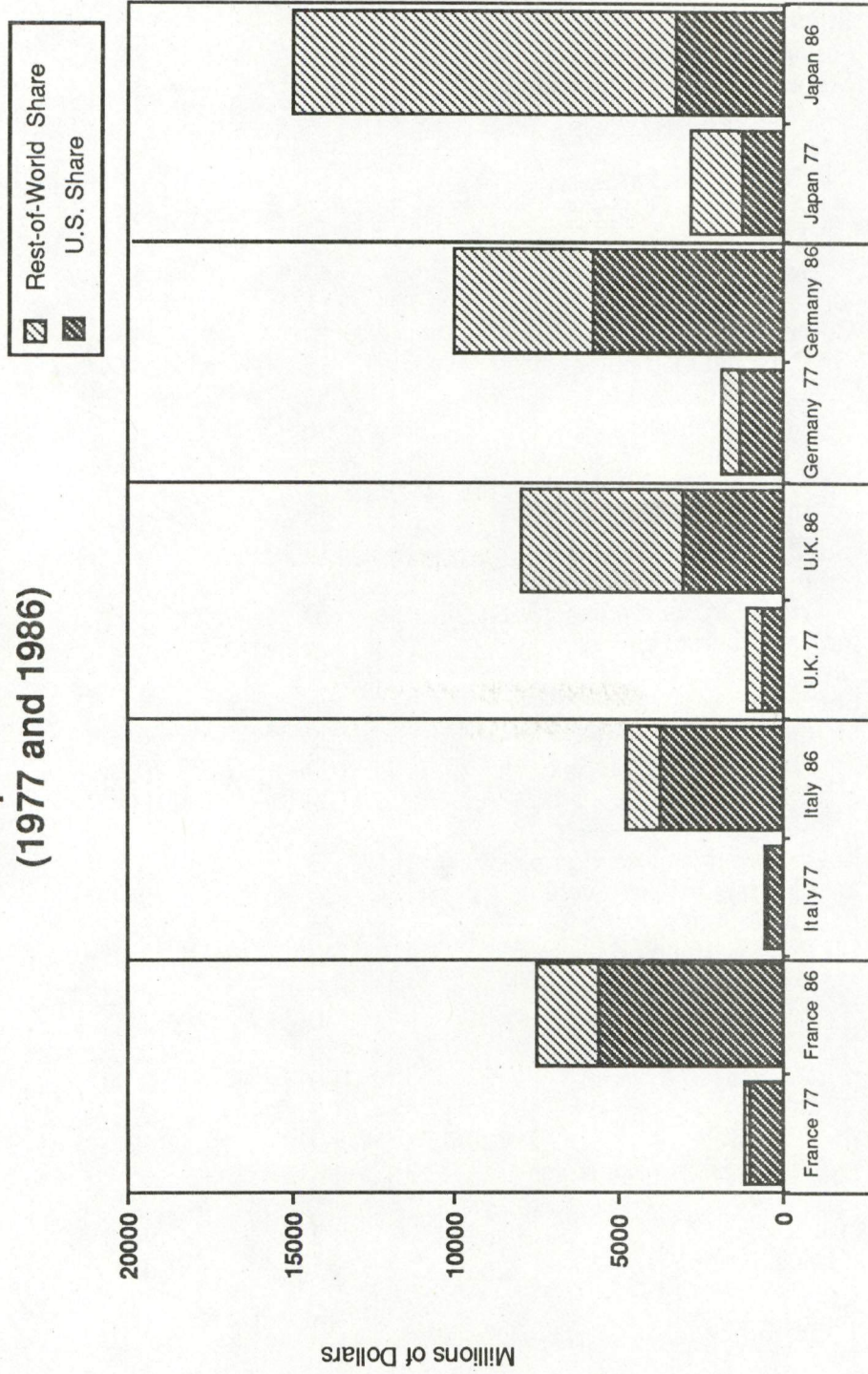
5/ JTECH Panel Report on Telecommunications Technology in Japan, Science Applications International Corporation, May 1986.

Table 10 U.S. Share of Worldwide Electronics Markets
(1984 and 1987)

	Percent		Worldwide Market (\$B)
	1984	1987	
Silicon Wafers	85	22	\$ >.01
Automatic Test Equip.	75	68	1.2
Semiconductor Mfg. Equip.	62	57	6.5
Microlithography Equip.	47	35	2.0
All Semiconductors	54	41	\$38.1
ASICs	60	50	7.3
DRAMs	20	8	3.4
Microprocessors	63	47	1.7
Computers	78	69	\$121.0
Personal Computers	75	64	47.2
Laptop Computers	85	57	1.6
Supercomputers	96	77	1.1
Computer Subsystems			
Displays	11	8	8.2
Flat Panel Displays	25	15	2.4
Floppy Drives	35	2	2.5
Hard Drives (up to 300 MB)	73	65	8.2
Hard Drives (up to 40 MB)	70	60	2.3
Dot Matrix Printers	10	8	4.8
Software	70	72	\$44.5
Operating Systems	90	90	16.4
Data Base Mgmt. Systems	100	95	2.8
Spreadsheets	100	100	0.9
Telecommunications Equip.	33	32	\$88.0
Central Office Switching	30	24	4.8
Fiber Optics	75	50	3.0
Private Branch Exchange	29	26	7.8
Data PBXs	100	36	0.2
Facsimile	30	25	3.1
Key Telephone Systems	28	22	5.7
Voice Mail Systems	100	100	0.6
LANs	100	98	2.4
Data Modems	49	37	3.2
Statistical Multiplexors	94	35	0.5
Instruments	52	46	\$48.9
Medical Equip.	35	41	12.3
Photocopiers	40	36	\$13.4
Consumer Electronics	19	12	\$37.2

Source: Science & Electronics, U.S. Department of Commerce

Chart 4
**U.S. Share of Selected International
 Computer Markets
 (1977 and 1986)**



Source: Various U.S. Government market studies

Table 11 Datamation 100 Results - 1983 and 1987

	<u>Number of Companies</u>		<u>Total Revenues</u>		<u>Percent Growth Per Year (%) *</u>
	<u>1983</u>	<u>1987</u>	<u>1983</u>	<u>1987</u>	
U.S. Companies	71	60	\$87B	\$132B	10.8
European Companies	19	22	\$12B	\$35B	17.5
Japanese Companies	8	16	\$9B	\$40B	27.9

* Growth rates were calculated in native currencies: dollars, yen, and European currency units.

Source: Derived from Datamation magazine.

II. ISSUES FACING THE U.S. ELECTRONICS SECTOR

The sections of Chapter I highlighted key characteristics and trends in the U.S. electronics sector, some of which implied strength and others weakness. New firm creation, high rates of innovation, shipment and employment growth, and a worldwide production and marketing base were indicators of a strong, vital sector. But higher growth rates in other countries in production, consumption, and employment; an eroding trade balance and technology base; and a diminishing share of worldwide markets point to a weakening position.

Few observers believe that the sector is a terminal case at this point. But from materials to systems, the sector is under serious challenge from foreign competitors, often with the assistance of their governments. The private sector must lead in addressing these challenges, but there are also areas where government policy can help ensure improved competitiveness.

The issues range from "national," issues which affect most industries--such as the lack of sufficient low-cost capital--to "sectoral" issues, which are more industry-specific problems--such as the targeting of the electronics sector by foreign governments.

National Issues

Capital costs
Federal budget deficit
Taxes
Savings
Exchange rates
R&D tax credits
Education and the work force
Antitrust laws
Short-term corporate view

Sectoral Issues

Lack of consensus on issues facing sector and solutions
Research and development
Unfair international trade practices
Intellectual property rights
Export regulations
Growing dependence on foreign suppliers
Increased foreign investment in the sector
Export financing

The following pages will briefly examine each of these problems as they relate to the U.S. electronics sector.

A. National Issues

1. The Cost and Availability of Capital

The cost and availability of finance capital 1/ are important to the competitiveness of U.S. industry generally and to the electronics sector in particular, given its capital intensity. These factors not only affect the overall growth of net investment, but also the speed with which an industry can modernize in response to competitive challenges. Although debate continues over the nature and degree of difference between the cost of capital in the United States versus other countries, U.S. industry speaks with virtually one voice that this difference continues to exist and that it is a significant burden to improving industrial competitiveness.

Cost of Capital

Several recent studies have indicated that the real cost of finance capital during the 1980s may have been more than twice as high in the United States than in Japan and 30 percent higher than in West Germany.

When comparing the United States and Japan from 1972 to 1985 (the most recent year available), the United States was seriously disadvantaged relative to Japan in the net real cost of capital for equipment, fixed assets, and research and development (R&D) projects. The largest cost-of-capital differential was in R&D projects, reflecting the fact that R&D has been significantly more expensive to perform in the United States than in Japan. The smallest gap between both countries was in the real cost of equipment, which resulted from the existence of the investment tax credit through 1985 in the United States. Repeal of this credit and an increase in the capital gains tax on investment contained in the 1986 Tax Reform Act have reportedly widened the real cost of capital differential. 2/ Two Stanford University economists, Douglas Bernheim and John Shoven, have estimated that the cost of capital disadvantage with Japan may now be at least 3 to 1. 3/

The high cost of capital in the United States has adversely affected the rate of investment in manufacturing and productivity

1/ The cost of capital is the least return that satisfies the need to cover taxes, the interest required by lenders, and the dividends and capital gains required by equity holders. From The Cost of Capital in the United States and Japan, George Hatsopoulos and Stephen H. Brooks, 1987.

2/ Hatsopoulos and Brooks, pp.26-31.

3/ Statement of Mark Shepherd, Jr., Chairman of Texas Instruments, before the U.S. Senate Finance Committee on February 3, 1987.

growth in this country. A study prepared by the Organization for Economic Cooperation and Development (OECD) in 1987 showed that, although manufacturing gross investment per worker in the United States recovered in 1985 to its pre-1980 peak level, this investment in constant dollars was little more than half of the \$6,000 invested in each worker by the Japanese.^{4/} Moreover, the rate of growth of Japanese manufacturing investment has increased much faster than the U.S. rate since 1978.

The high cost of capital and the low rate of capital formation in the United States are attributable to several causes. Most economists agree that the federal budget deficit is a fundamental cause. The capital required to continue to finance this deficit has placed the federal government in the role of a competitor with the private sector for a limited pool of funds, driving up the cost of capital and reducing funds available to U.S. industry for investment. Economists have also blamed the structure of the U.S. tax system, which encourages borrowing and consumption rather than savings and investment. This has resulted in a very low savings rate and a smaller pool of funds available for investment.

Relative to foreign competitors, the higher cost of capital in the United States has a rippling effect, raising costs for U.S. firms all along the spectrum of business functions, from R&D through marketing. By contrast, studies have shown that because Japanese firms benefit from high debt-to-equity ratios and a cost of capital considerably lower than in the United States their costs and risks are lower, permitting them to take a longer term view. Because of this they are reportedly able to employ strategies such as forward-pricing to gain market share, while U.S. firms must focus on short-term profitability at the expense of market share (see discussion under "Short-Term Corporate View" on page 30). Many in the electronics sector feel that this differential poses serious long-term problems for this capital intensive sector, since the firms with the lowest cost of capital can be expected to be the eventual winners.

Venture Capital

Capital problems also plague the newest companies in the U.S. electronics sector due to changes in funding by and attitude of U.S. venture capitalists. Along with private investors, venture capitalists have long been major financiers for start-ups, the source of much innovation in the United States. They have generally provided not only cash but also management expertise and contacts for additional funding later on. However, as Table 12 shows, venture capital funding of the U.S. electronics sector peaked in 1984, with the computer hardware and software industries receiving more than half of these investments. Since then U.S. venture capital funding has shifted away from electronics to consumer- and medical/health-related industries.

^{4/} Hatsopoulos and Brooks, pg. 34.

Table 12 Shares of Venture Capital Funding by Industry

Industry	1980		1982		1984		1986		1987	
	(\$M)	(%)	(\$M)	(%)	(\$M)	(%)	(\$M)	(%)	(\$M)	(%)
Computers	283	26	774	43	1200	40	812	28	975	25
Communications	127	11	180	10	450	15	464	16	585	15
Other Electronics	107	10	234	13	390	13	377	13	351	9
Subtotal	517	47	1188	66	2040	68	1653	57	1911	49
Other Industries	583	53	612	34	960	32	1247	43	1989	51
Total	1100	100	1800	100	3000	100	2900	100	3900	100

Source: Venture Economics, Incorporated.

Venture capitalists have now become much more selective and cautious in their approach to U.S. electronics firms. They have been dissatisfied with their overall rate of return on investments in many of these companies over the past few years and view electronics start-ups as less attractive because they are taking longer to mature and are more capital-intensive than they were in the early 1980s. Their ceiling of \$35 million on a typical investment is considerably less than what most start-ups currently need to survive. In addition, U.S. venture capitalists are very demanding. They usually want a high percentage of the ownership and may expect as much as a 60 percent compound annual rate of return on investment.

Because of these requirements, electronics start-ups have increasingly turned in recent years to well-financed foreign investors such as the Europeans and the Japanese who offer funds at relatively low interest rates and ask for less ownership than U.S. venture capitalists. However, the transfer of advanced technology to potential competitors is often the price that they have to pay for foreign money. A number of promising start-ups that have been unsuccessful in their funding search have filed for bankruptcy or have been absorbed by larger U.S. and foreign firms before they have had a chance to bring their products to market.

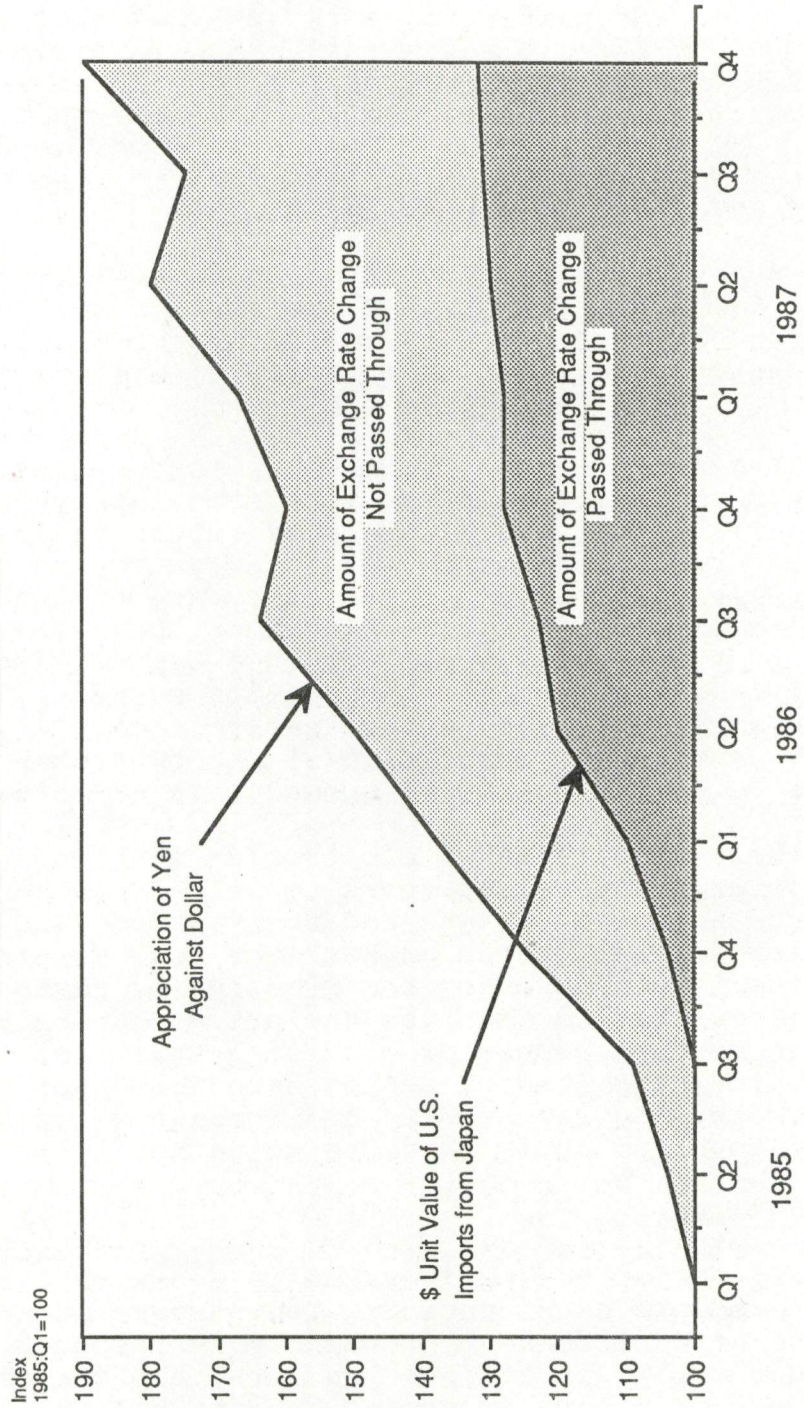
2. Exchange Rates

Since the U.S. dollar peaked in value in February 1985, imports of electronics products have continued to increase in nominal value. While exports have increased, presumably in response to the effect of the cheaper dollar in overseas markets, the corresponding fall-off expected in more expensive imports has not materialized. Chart 5 shows that at least part of the reason in the case of

Chart 5

Yen Appreciation and Pass-Through in Dollar Import Prices - Quarterly

1st Quarter 1986 - 4th Quarter 1987



Source: Trade & Information Analysis, USDOC

Japanese imports can be traced to Japanese firms not passing through the full yen appreciation to U.S. buyers. ^{5/} By the end of 1987, only 33 percent of the yen's appreciation since the first quarter of 1985 had been passed through on U.S. imports from Japan. In those import categories covering electronics products, the pass-through was even less. For example, in the category containing consumer electronics and electronic components, the pass-through by the end of 1987 had only totaled 6 percent. This low percentage was attributed to Japanese firms reducing prices on videocassette recorders (VCRs), since the pass-through was 23 percent, if the large category for these products is excluded. The categories containing photocopiers, instruments and medical equipment also showed a pass-through of only 6 percent.

While Japanese imports showed a 33 percent pass-through due to the appreciation of the yen, U.S. imports from the world showed a 42 percent pass-through due to foreign currency appreciation. Thus, electronics products did not show appreciable price increases due to a weaker dollar, and demand from U.S. buyers continued to buoy U.S. electronics imports. The ability of foreign firms to absorb the increased costs due to currency appreciation stymied the use of exchange rates as a tool to improve the U.S. electronics trade balance.

3. R&D Tax Credits

The R&D tax credit was introduced by Congress as part of the Economic Recovery Tax Act of 1981 (ERTA) to increase R&D spending and, as a result, to stimulate industrial innovation. Although viewed favorably within U.S. industry, the credit has certain features that have generated a great deal of controversy since it went into effect.

As enacted, the credit was designed only as a temporary tax benefit. It has been extended periodically and is scheduled to expire on December 31, 1990. Furthermore, the benefits of the credit have been gradually diluted by reducing it from a 25 to 20 percent credit and by adding a 50 percent deduction disallowance. Nevertheless, the credit has proven effective in fostering growth in R&D. Industry has lobbied vigorously over the past several years to have the credit increased once again and made permanent. In support of this position, the American Electronics Association (AEA) cites recent findings of two Brookings Institution economists who note that U.S. R&D spending from 1980 to 1986 nearly doubled to \$60 billion and estimate that the R&D tax credit actually boosted private sector research expenditures during this period by 7 percent over the amount they would have spent without the benefit of the credit.

^{5/} From: "U.S. Import Prices and the Pass-Through of the Change in the Yen/Dollar Exchange Rate," Victoria Hatter, ITA, February 1989.

The question of eligibility has created some concern within industry. The intent of the tax break was to encourage innovation, but a firm must be in the process of carrying on a trade or business, i.e., selling products and incurring tax liabilities, in order to be eligible to take advantage of the credit. These eligibility requirements exclude highly innovative start-ups that may take several years to turn their research into marketable products and reach profitability. Start-ups are also the companies that need the credit the most.

Many companies in the electronics sector are still uncertain about what is covered under the tax credit. In the area of product technology, it is clear that expenses related to the development of a working prototype are covered. These expenditures are defined in the ERTA as researchers' wages, research supplies, rent for equipment, and 65 percent of contract research. Direct purchases of R&D plant and equipment do not qualify, but are eligible for accelerated depreciation. By contrast, nonexperimental product development (i.e., incremental product improvements) and non-laboratory process technology (i.e., improvements in factory floor processes) may be ineligible for the credit. The R&D tax credit is one area in which the U.S. electronics sector has a competitive disadvantage relative to the Japanese.

Software development was initially another grey area under the tax credit. The Internal Revenue Service (IRS) originally took the position in draft regulations issued in 1983 that most software development costs would be ineligible for credit consideration. However, based on published IRS revenue procedures, it was clear that software development costs would be treated like hardware development costs for purposes of the Section 174 deduction election. Most software companies have assumed that at least a portion of these same R&D expenses would qualify for the credit.

Congress clarified the software credit issue in 1986 by including language in the legislative history of the Tax Reform Act of 1986 defining those software development costs that would qualify for credit consideration. In general, costs incurred in the development of software that is to be sold, leased, or otherwise licensed may be eligible. These costs will be evaluated on a basis similar to that used for hardware development costs. Costs incurred in the development of software to be used in-house (except for use in other qualified R&D) will be subject to separate rules. The IRS is drafting interpretative regulations.

Another feature of the R&D tax credit that has sparked industry opposition is the incremental base period used to evaluate R&D increases. Critics claim that it has reduced the incentive effect of the credit for some firms since current expenditures on R&D automatically increase the base for each of the next three years and, in turn, raise the amount by which a company will have to boost R&D spending in those years to receive additional tax credits. Particularly disadvantaged are companies that may have large

absolute R&D expenditures, but which are increasing at a low rate. In certain circumstances, such as an economy-wide slowdown, this feature may act as a disincentive by encouraging firms to reduce or postpone R&D spending so they can obtain future tax credits when the outlook improves.

H.R. 3150, introduced in the House of Representatives on August 4, 1989, would make the tax credit permanent. Passage of this legislation would demonstrate to the industry that Congress appreciates the competitive challenges facing the industry.

Besides the R&D tax credit, industry favors making the Basic Research Credit permanent in the future. This tax benefit was enacted by Congress under the 1986 Tax Reform Act to encourage strong private sector support for basic research at universities and nonprofit research centers. Industry also supports modification of Treasury regulations (1.861-8 allocation rules) on the treatment of U.S. R&D expenses that were imposed in 1977. These regulations require a firm to allocate a substantial portion of its U.S. R&D expenses to foreign income even when the foreign country does not allow a deduction for the expense. This places U.S. industry at a disadvantage competitively with companies in nations that have no such requirement for this kind of R&D allocation. Moreover, they have the effect of creating an incentive for U.S. firms to transfer their R&D operations and related jobs overseas.

4. Education and the Work Force

The education of today will shape the worker of tomorrow. There is concern that the U.S. educational system is not adequately preparing students for current and future jobs. This is of particular concern within the electronics sector, which is in the forefront of the economy's growth.

The Work Force Equation

In order to have a competitive electronics sector, educated workers must be available. One can summarize the process of producing a skilled worker by considering the following factors:

Demographic Trends	+	Industry Sector Demand	+	Education and Training	=	Skilled Workers
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By having a clear vision of who will make up the work force and what skills the electronics sector needs, the nation can work towards formulating and implementing an educational policy that can shape the worker of today and tomorrow. Education and educational assistance are tools that can be used to attract and retrain the current and future work force.

Demographic Trends

The U.S. work force is changing with more women and minorities entering the ranks. Some of the demographic changes occurring in

the United States are summarized in Workforce 2000, a study conducted for the U.S. Department of Labor. According to this study, by the year 2000 the following demographic trends will be taking place:

- o the population and the work force will grow more slowly;
- o the average age of the population and the work force will rise and the pool of younger workers entering the labor market will shrink;
- o more women will enter the work force, although the rate of increase will taper off;
- o minorities will be a larger share of new entrants into the work force;
- o immigrants will represent the largest share of the increase in the population and the work force.

Industry Sector Demand

Workforce 2000 also identifies the fastest-growing jobs and the educational and skill requirements needed to fill them during the 1984-2000 period. Jobs falling under the electronics sector, including computer and mathematical scientists, engineers, technicians, and marketing, sales, and managerial positions are projected to grow at an average rate of 46 percent, higher than the 25 percent growth rate of all occupational categories. These jobs will require higher levels of education and skills, including language, math, and reading.

Education and Training

Educational trends indicate that a decreasing number of students are specializing in science and engineering. U.S. electronics firms may find it more difficult to keep up with their international competition as a result of this trend. The National Science Foundation has estimated that by the year 2000 the United States will produce 400,000 fewer scientists and engineers than the country needs.

The National Science Board's (NSB) publication Science and Engineering Indicators - 1987 points to inadequacies in the academic performance of students, the teaching force, and the curriculum in pre-college science and mathematics. Achievement in these disciplines among minority groups and females lags substantially behind white males. Yet, minority groups and females are expected to constitute the bulk of the labor force by the turn of the century. Moreover, U.S. high school students overall are less skilled in science and mathematics than students in competitive countries, especially Japan.

The number of noncertified teachers in certain fields of science and mathematics is high, and the supply of new teachers in this field is diminishing. Teaching methods often do not stimulate students to learn science and mathematics, and thus students often avoid taking these subjects. In many states, school systems offer a wide range of nonscientific and math electives that students may substitute for these courses.

Enrollment levels for full-time undergraduates in engineering have been decreasing. Any increase in full-time graduate enrollments has been largely due to growth in the foreign student population. In 1986, foreign graduate students represented 44 percent of full-time graduate enrollments in engineering in all institutions. In the same year, foreign graduate students made up 39 percent of full-time students in science and engineering. ^{6/} Doctorates awarded in science and engineering continue to increase but remain below the peak years of 1972 and 1973. These increases are wholly accounted for by foreign citizens.

Continuing education and vocational training programs are inadequate in the United States, according to the MIT study Made in America: Regaining the Productive Edge. Formal educational institutions provide most of the specialized skills needed in the workplace while on-the-job training involves little more than quick task-related instructions. As a result, U.S. workers have limited skills and have minimal input into improving the manufacturing process. By contrast vocational training in Japan and West Germany occurs within corporations and emphasizes the development of both general and specialized job skills. It is also extensive in character, ranging from apprenticeships to job rotations, off-the-job training, correspondence courses, and participation in quality circles. These programs give workers broad experiences and skills that allow them to deal flexibly with a variety of manufacturing tasks, unforeseen production problems and technological changes. Their impact on industrial performance has been significant. Studies have shown that Japanese and West German workers make greater contributions to labor productivity than their U.S. counterparts.

5. Antitrust

On October 11, 1984, the President signed the National Cooperative Research Act of 1984, which amended U.S. antitrust law to permit joint R&D projects in the private sector. ^{7/} As a result, 125 consortia have notified the Department of Justice and the Federal Trade Commission of their intent to collaborate in R&D. Some of

^{6/} Figures are from the National Science Foundation. Science includes physical, environmental, mathematical, and computer sciences.

^{7/} See "The Antitrust Laws Have Been Changed to Encourage Cooperative R&D," Office of Productivity, Technology and Innovation, U.S. Department of Commerce.

these are in the electronics area, the most publicized example being the Microelectronics and Computer Technology Corporation, based in Austin, Texas.

The act implicitly acknowledged the existence of a competitive, global marketplace, of which the U.S. market represents only one piece. The law substantially reduced the incentive for unwarranted private antitrust suits by specifying the applicability of the rule of reason and by reducing treble damages to actual damages in the event that anti-competitive activity is found. But other problems plague U.S. industry that suggest the need for additional amendments to U.S. antitrust law. Commerce Secretary Robert Mosbacher articulated the concerns behind the administration's support for antitrust relief in his July 26, 1989 testimony before the House Committee on the Judiciary. He stated:

The enactment of remedial legislation would also strengthen competition by eliminating a substantial competitive disadvantage that prospective American coventurers face vis-a-vis their foreign counterparts. European or Japanese firms that seek to establish joint production ventures need only obtain clearance from national or European antitrust officials. Once they obtain such clearance, they do not face the uncertain prospect of unwarranted private antitrust suits--private treble damage litigation is not authorized under European or Japanese antitrust law. Indeed, even suits for single damages are rarely brought. As a result, potential American coventurers today face greater antitrust uncertainty than potential European or Japanese coventurers. Antitrust reform would help eliminate this unwarranted disparity and thus level the international competitive playing field.

Antitrust concern has become particularly evident in the electronics sector recently, with the joint efforts on the part of the American Electronics Association (AEA) and the Semiconductor Industry Association (SIA) to stimulate U.S. companies' reentry into DRAM (memory chip) production. Since a new semiconductor fabrication facility costs approximately \$250 million for 1MB devices and \$350 million for 4MB DRAMS, few U.S. semiconductor companies can afford to make such investments on their own. With this in mind, the SIA sent to its membership in May 1989 a \$1 billion preliminary business plan to establish a joint producer-user consortium to manufacture 4MB DRAMS, called U.S. Memories. Although this effort has failed for a number of reasons, unless current antitrust law is amended, other joint-manufacturing consortia are subject to the possibility of third-party antitrust suits.

6. Short-Term Corporate View

Stockholder equity is an important source of funds for U.S. companies, and this is equally true in the electronics sector. With this dependence comes a requirement that short-term profits be

maximized, which usually translates to businesses looking at their operations with a short-term tactical view. Under these circumstances, a long-term strategic approach is usually difficult to take. However, many foreign companies, particularly Japanese firms, have close relationships with major domestic banks which allow the firms to take a longer term view.

Table 13 summarizes a survey taken of Japanese and U.S. corporate executives that ranked their respective corporate objectives. The ranking validates the preceding statements. Japanese executives place market share and return on investment as their first and second objectives, whereas U.S. executives are primarily concerned about return on investment and share price increase, with market share in third place. Japanese executives place share price increase in last place, reflecting their relatively weak dependence on stockholder equity.

Table 13 Ranking of Corporate Objectives-Japan vs. U.S.

	<u>U.S.</u>	<u>Japan</u>
Market Share	3	1
Return on Investment	1	2
Ratio of New Products	7	3
Rationalization of Production and Distribution	5	4
Improve Product Portfolio	4	5
Increase Equity ratio	6	6
Improve Company's Image	8	7
Improve Working Conditions	9	8
Share Price Increase	2	9

Source: Kaisha by Abegglen and Stalk.

The remaining major difference between the two groups is the placement of the ratio of new products, which the Japanese place high on the list in third place and the U.S. executives rank as number seven. This last comparison is not entirely reflective of the U.S. electronics sector, since it has had and continues to have a high rate of new product introductions, from chips to systems.

B. Sectoral Issues

Issues at the industry and company level will be examined in this section, focusing on those issues that are closely tied to the electronics sector.

1. Lack of Consensus

Industry observers in both the U.S. Government and private sector considering the competitiveness of U.S. industry are roughly divided into two camps.

One camp is composed of those who believe that significant problems exist that are threatening the sector's future viability and that extraordinary measures must be taken to avoid a crippling of the sector or its total disappearance. This group feels that many other nations are not playing the international trade game by the same rules and that U.S. firms do not enjoy the proverbial "level playing field." It says foreign governments are acting unfairly to nurture their domestic electronics industries to the disadvantage of U.S. suppliers. The group argues that U.S. firms cannot overcome the advantages that their competitors have by reason of the government aid of their competitors, the use of unfair trade practices such as dumping, and violations of intellectual property rights. While no champion of government intervention, the group believes that restricted or targeted foreign markets run counter to free trade principles and should be addressed at the governmental level, through an aggressive use of U.S. trade laws as well as through selected changes in domestic policies and laws.

The other camp believes that while U.S. leadership has slipped, such erosion is a normal evolution stemming from growth in the world economy since the Second World War. It also believes that free trade is a compelling ideal, generally accepted worldwide, admittedly with some deviations toward restricted trade. The second group, while condemning unfair trade practices, argues that the U.S. electronics industries, like other U.S. industries, suffer from problems of their own doing, including poor management practices and lower product quality, and that solving these problems, plus "trying harder in the world markets," will assure their long-term health. A corollary of this position is that U.S. firms have to "run faster" and stay ahead of their competitors through increased R&D and new products. This second group also argues for as little U.S. Government involvement as possible, allowing market forces to determine the ultimate result, which they feel will be in the best interests of the consumer. The U.S. Government should not try to influence the outcome, even if, in the extreme, it may mean the U.S. electronics sector is "hollowed out" ^{8/} and only acts as a distributor of foreign-manufactured products.

2. Research and Development

As mentioned previously, the U.S. electronics sector is the nation's leader in both the level and rate of R&D spending. R&D has been the key to the growth of the U.S. electronics sector and will continue to be in the future.

^{8/} The term was borrowed from a Business Week article, March 3, 1986, and refers to companies which do little or no manufacturing, but perform other profit-making functions, such as distribution.

The Roles of the U.S. Government and Industry

While the U.S. Government played an important role in fostering the development of the electronics sector, most of the funding and procurement were directed toward military and national security purposes. Although debate continues over the degree to which R&D directed toward these purposes results in commercial spin-offs, most observers agree that such a structure is not an efficient mechanism by which to translate laboratory results into marketable products.

The preponderance of electronics R&D has been funded by and performed by the U.S. industry for some time. As shown in Table 14, since the mid-1970s, U.S. industry has been responsible for roughly 70 percent of the R&D funding in electronics. This figure is somewhat higher than the all-industry average in the United States, which was about 65 percent over this same period. This high percentage of R&D funding by industry and the military focus of U.S. Government R&D have meant that R&D for marketable products has been largely the responsibility of U.S. industry (for further discussion, see Appendix F). Electronics R&D performed by industry has been generally uncoordinated, with few joint efforts between companies until recently. Much of this R&D has been necessarily focused on the near term.

Table 14 Value of U.S. Electronics R&D by Funder
1977-86
(\$B)

	<u>77</u>	<u>78</u>	<u>79</u>	<u>80</u>	<u>81</u>	<u>82</u>	<u>83</u>	<u>84</u>	<u>85</u>	<u>86</u>
Industry	4.6	5.4	6.4	7.8	9.0	10.7	12.6	14.8	16.0	15.8
Government	<u>1.8</u>	<u>1.9</u>	<u>2.3</u>	<u>3.0</u>	<u>3.1</u>	<u>3.7</u>	<u>4.3</u>	<u>5.2</u>	<u>5.9</u>	<u>6.3</u>
Total	6.4	7.3	8.7	10.8	12.1	14.4	16.9	20.0	21.9	22.1

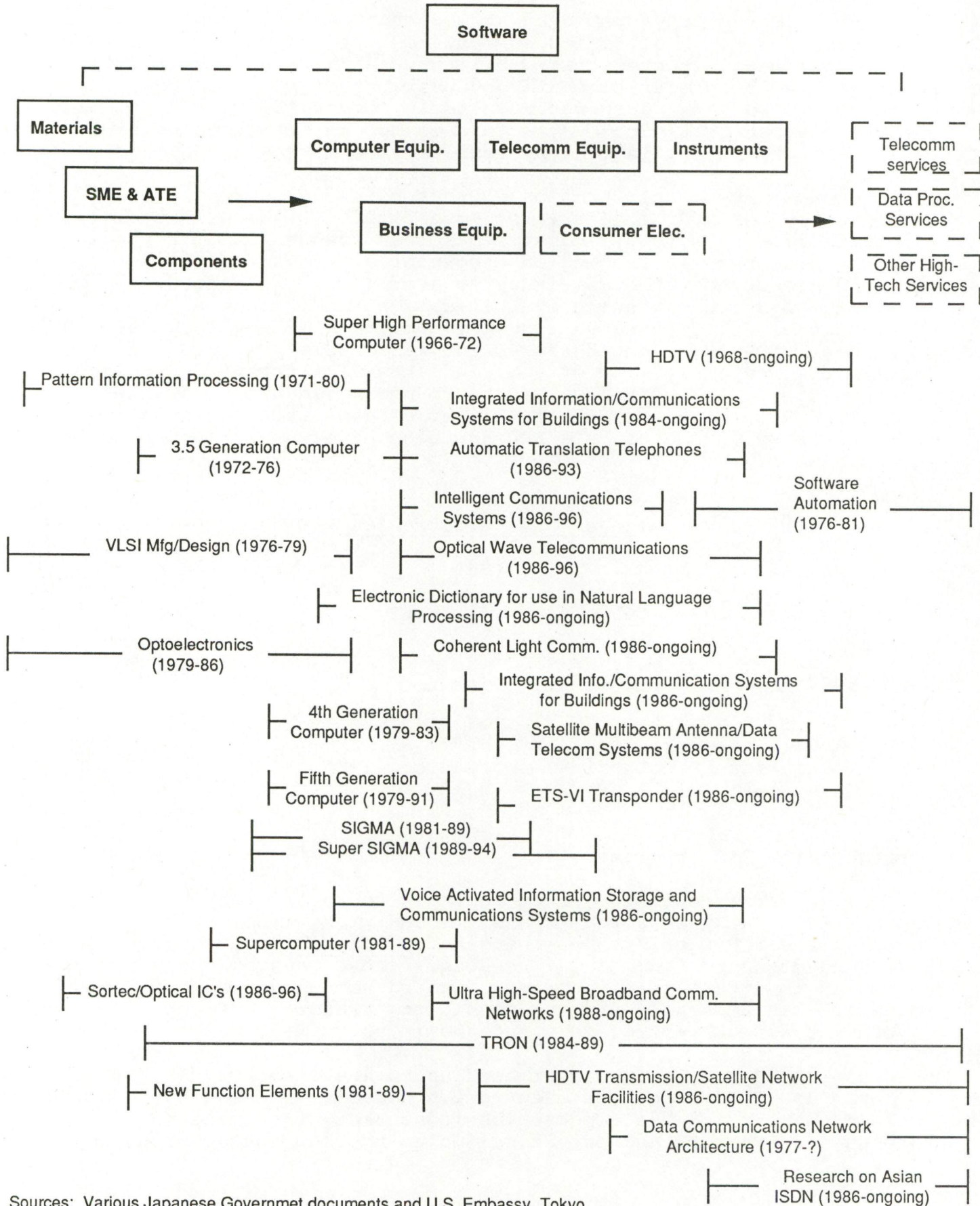
Source: American Electronics Association, 1989.

Foreign Joint R&D Programs

The U.S. experience is in direct contrast to the history of R&D in Japan and recently in Europe where, in addition to companies focusing their R&D efforts on the market, the respective governments have funded R&D for commercial reasons. These governments also have played an important role in bringing coordination and a long-term focus to this R&D and improving technology transfer between government and university labs and the industry.

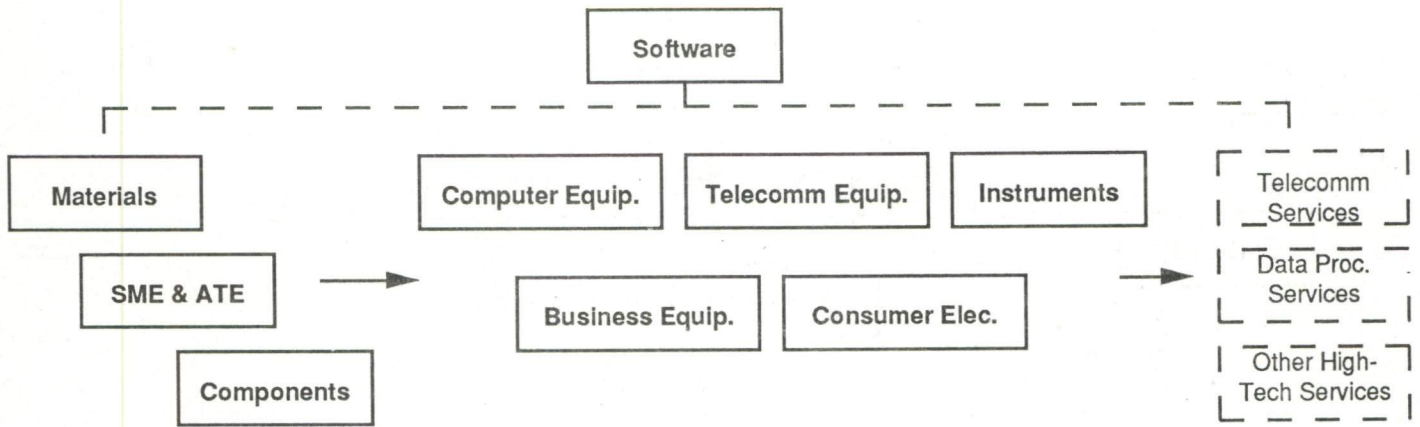
Charts 6 and 7 show joint government and private sector R&D projects in Japan and Europe for the electronics sector. The R&D has covered a broad spectrum of the electronics industries, from materials through end products and services, including the manufacturing

Japanese Joint Research and Development Efforts



Sources: Various Japanese Government documents and U.S. Embassy, Tokyo

European Joint Research and Development Efforts



| Distributed Computing System |
U.K. (1984-86)

|----- ESPRIT Phase I (1984-88) -----|

|----- ESPRIT Phase II (1989-94) -----|

|----- RACE (1988-93) -----|

|----- EUREKA (1985-Ongoing) -----|

| BRITE/EURAM |
(1989-92)

| SUPRENUM |
W. Germany

| Joint Optoelectronic Research Scheme |
(1982-ongoing) U.K.

| LINK (1988-93) U.K. |

| LINK |

|----- ALVEY (1983-88) U.K. -----|

|----- Transputer (1987-91) U.K. -----|

|----- MEGA Project |
W. Germany/Netherlands

Sources: Dr. Jacob Blackburn, U.S. Embassy, London; U.K. Government documents; and the European Economic Commission

processes involved. The bulk of these foreign R&D activities have been directed toward the development of commercial products.

How successful have these joint R&D efforts been in advancing these countries' commercial interests? In the case of the programs in Europe, which have only dated from the mid-1980s, there has not been sufficient time to judge the success of such programs as ESPRIT (European Strategic Program for Research in Information Technology), although commercial products have begun to appear in the market as a result of these joint efforts. But in the case of Japan, where the chart shows joint efforts dating from the 1950s, judgments can be made. There is a very strong correlation between joint R&D projects and the subsequent market success of Japanese electronics firms. Few would reject the view that the VLSI (Very Large Scale Integration) manufacturing and design project from 1976 to 1979 catapulted Japanese semiconductor and semiconductor manufacturing equipment firms into world prominence in the 1980s (see Appendix I, country profile on Japan--Computer Hardware).

Similarly, the many joint projects in the computer area--"3.5 Generation Computer (1972-76)," "4th Generation Computer (1979-1983)," and the "Supercomputer (1981-89)"--have allowed the Japanese to offer very competitive mainframes and supercomputers. Fujitsu has claimed that the ability of its newest generation supercomputer, the VP 2000, to process tasks in parallel was aided by its participation in the Supercomputer Project sponsored by Japan's Ministry of International Trade and Industry (MITI). Furthermore, the recent supercomputer announcements from Fujitsu and Nippon Electric show that the impressive performance claims for the systems are due in part to equally impressive high-speed semiconductor logic and memory devices. There has been a vital synergism between the R&D at the component level and that at the systems level, which will increasingly allow the Japanese to make major inroads into systems markets worldwide.

The Japanese and Europeans have learned how to form joint efforts quickly. Within a matter of weeks after the spate of successful experiments in raising the temperature of superconductive materials, the Japanese and Europeans had formed R&D consortia to explore this key technology.

But these joint R&D efforts are not the whole story in Japan. The National Science Foundation has published figures comparing corporate non-defense expenditures for electronics R&D as a percent of gross national product in the United States and Japan. From 1980 to 1984 (most recent year available), Japan's private sector increased its relative level of R&D spending on electronics (0.38 to 0.66 percent), outpacing the U.S. increases (0.41 to 0.55 percent).

U.S. R&D Weaknesses

The U.S. electronics companies are seen as not being as efficient as their Japanese competitors in transferring R&D results to the

market. In addition, many U.S. firms do not seek out and evaluate the latest foreign advances in technology. By contrast, the Japanese invest considerable time, money, and effort into identifying and acquiring key technologies that will improve their manufacturing capabilities and lead to new and better products. They benefit from a culture and a corporate structure better suited to stimulating technology transfer and assimilating technology internally. Examples of Japanese success in technology transfer include videocassette recording and optical storage, both of which were invented outside of Japan, but have been more aggressively exploited by the Japanese for commercial advantage.

While generally acclaimed for their innovative research, U.S. electronics firms are at a competitive disadvantage in manufacturing processes and product development. Part of this disadvantage is due to the fact that U.S. firms generally devote less attention to R&D in manufacturing processes and part is due to the fact that there has been relatively little emphasis on manufacturing in engineering and master of business administration curricula. Manufacturing is often viewed as a linear process in which design and engineering are separate from production and marketing.

The Japanese and other Far Eastern competitors take an integrated, team-oriented approach that includes staff responsible for each point in the spectrum, from design to manufacturing. As a result, they take far less time to bring their products to market. In addition, Japanese firms are stronger in making incremental improvements in their products and processes that help to reduce manufacturing costs and result in higher product quality and reliability. ^{9/}

3. Unfair International Trade Practices

Foreign Government Practices

Since it has become clear that electronics can be a key to economic growth, foreign governments have instituted a number of practices to

^{9/} See Michael Dertouzos, et al, Made in America: Regaining the Productive Edge, MIT Commission on Industrial Productivity, Cambridge, Massachusetts, 1989.

create and nurture domestic electronics sectors. These practices have covered a broad range as shown below.

Market barriers

- Import licensing/quotas
- Restricted markets
- Investment restrictions
- Preferential procurement
- Exclusionary standards
- Local content requirements
- Export performance requirements

Forced technology transfer/investment

Financial support

- Joint R&D
- Subsidies

Offsets

U.S. electronics firms have increasingly faced many of the above practices in a growing number of foreign markets. Foreign government intervention has resulted in a restructuring of the U.S. electronics sector and a distortion of trade and investment patterns in the sector. For example, forced technology transfer in exchange for access to a country's market has meant that foreign competition has emerged more rapidly, and a company's revenues over the product's life cycle have been reduced. Forced local investment, local content requirements, and export performance requirements have changed trading patterns and moved production out of the United States in order to serve these markets. Some of this trade has flowed back to the United States, negatively affecting the sector's trade balance.

Offsets, which are mandated by foreign governments when purchasing weapons systems, are another method in which foreign competitors are enhanced through acquisition of U.S. technology and new market opportunities at the expense of U.S. firms. Offsets, which include mandatory investment, subcontractor production, technology transfer, coproduction, licensed production, and countertrade, have had a major effect on the U.S. electronics sector because of the strong presence of this sector in military systems. In fact, the electronics sector was second only to aerospace in offset requirements from U.S. firms.

Dumping and Subsidies

U.S. trade law provides for the protection of U.S. manufacturers from unfair foreign trade practices, such as dumping and subsidies. For example, if manufacturers believe that foreign competitors are dumping merchandise in the United States or are being subsidized by foreign governments, they may file for relief with the U.S. Department of Commerce and the U.S. International Trade Commission (ITC).

Through its antidumping law, which levies duties on goods dumped on the U.S. market, the United States discourages the sale of merchandise in the United States at less than fair value if such sales cause or threaten material injury to a U.S. industry. By imposing similar duties, the government checks the unfair competitive advantage foreign manufacturers and exporters receive from subsidies.

In general, merchandise is considered to have been sold at less-than-fair value when the U.S. price of the imported good is less than the home market price (i.e., foreign manufacturer's domestic price), after adjustments for differences in the merchandise, quantities purchased, and circumstances of sale are made. If a home market price is not available, a third-country market is used, or a value is constructed factoring in costs of all inputs in the home market and an 8 percent profit assumption.

Another unfair trade practice that appears to have made a substantial difference in the course of events of the electronics sector is subsidies. Subsidies are direct and indirect grants for the production or exportation of goods. They can take many forms, including direct cash benefits, credits against taxes, and loans with artificially low interest rates. The U.S. countervailing duty law provides relief to U.S. manufacturers facing unfair competition from subsidized imports. Upon investigation, if subsidies are found and a U.S. industry is injured, countervailing duties can be imposed.

Whether material injury results from dumping or subsidies depends upon an analysis of the effects that U.S. imports have on U.S. producers of like products. Injury may take the form of depressed prices; lost sales; a general decline in sales, market share, profits, productivity, or return on investment; or underutilization of production capacity.

In the U.S. market, foreign companies have often used dumping to enter and gain market share. Such practices have been responsible for profound changes in the composition of the U.S. electronics sector. From television sets and portable electric typewriters to the recent case of semiconductors, U.S. firms have been driven out of the market because of dumping by foreign firms. Moreover, the dumping duties imposed upon foreign suppliers have not enabled the U.S. firms to reestablish themselves in the market.

4. Intellectual Property Rights

To maintain a competitive position, the electronics sector relies heavily on intellectual property protection, e.g., patent, trademark, trade secrets, copyright and mask work protection. As companies expand their operations into foreign markets, they often discover that protection in those markets is inadequate. Specifically, some forms of protection available in the United States are not available in other countries. Enforcement of existing laws can be ineffective or nonexistent.

Proposals by some countries to eliminate copyright coverage for software altogether and replace it with a sui generis form of protection also pose a threat to the sector, if adopted. This form of coverage would shorten the period of protection significantly and require mandatory registration and disclosure of source code. It might also adversely affect the protection of microcode embedded in semiconductor chips.

Intellectual property rights violations in the electronics sector have grown significantly during the 1980s, mainly in the semiconductor, computer hardware, and software industries. U.S. semiconductor companies have had to contend with the copying of semiconductor masks and microcode, which has allowed several Far Eastern suppliers to flood the market with counterfeit chips. Texas Instruments was one of the first U.S. semiconductor manufacturers to take aggressive action, filing lawsuits in early 1986 against eight Japanese and one South Korean memory chip producers for patent infringements.

In the computer area, firms such as Apple and IBM have long suffered from cheap clones of their personal computers appearing on the world market while U.S. software companies have been victimized by the illegal copying of software programs by users and software pirates. Revenue losses from software piracy, for example, reached an estimated \$4 billion in 1988 alone. Countries in which counterfeiting and software piracy are particular problems include Brazil, Mexico, Italy, Saudi Arabia, India, the People's Republic of China, Thailand, South Korea, and Taiwan.

These violations substantially injure U.S. electronics firms. They cause sizeable revenue losses, which make it very difficult for a company to recover its R&D costs on current products and fund the necessary R&D required to develop new products. In short, intellectual property rights violations can have a dampening effect on the rate of innovation, which is one of the sector's strongest competitive advantages.

5. Export Regulations

The United States' policy of controlling the export of certain items stems primarily from its concern over supplying strategically significant technologies to countries in the Soviet Bloc. Contention arises when national security controls are applied to dual-use technologies. U.S. electronics firms have expressed concern over the federal government's application of export controls, citing the importance of these dual-use technologies to their companies and to the economic vitality of the United States. In addition to national security controls, U.S. companies have expressed concern over foreign policy controls, unilateral national security controls, export license processing times, the perceived, unequal internal export control systems among COCOM allies, and the

availability of controlled commodities from non-COCOM countries. They claim the uncertainties inherent in the process have convinced some foreign customers that U.S. companies are unpredictable and unreliable suppliers.

6. Growing Dependence on Foreign Suppliers

In the section that examined the competitive status of the U.S. electronics industries, the discussions on the technology base and world market shares showed that U.S. electronics firms are losing their historic technological and commercial leadership to foreign competitors in a broad range of products. Another perspective on this trend is the growing U.S. dependence on foreign suppliers. Many firms in the sector increasingly rely on foreign manufacturers for their components, subsystems, equipment, and, in some cases, entire systems.

For example, in the case of silicon wafers, some U.S. suppliers remain that produce for their internal needs (so-called captive suppliers). No significant U.S. supplier to the commercial market exists since the purchase of Monsanto Electronic Materials Company by Huels of Germany in early 1989. Virtually all manufacturing of this basic ingredient to downstream electronics manufacturing is now under the control of Japanese and European companies.

The U.S. Erosion in PC Subsystems

Chart 8 presents another illustration of this phenomenon. It focuses more narrowly on the dynamic personal computer segment of the computer industry showing the top five suppliers worldwide of major components pieces of a personal computer system. The chart shows the strong position of Far Eastern manufacturers in key components (memory chips or DRAMs, application specific integrated circuits or ASICs) and subsystems (floppy and optical drives, and video displays). However, U.S. firms are still quite strong in several key products--microprocessors (MPUs), software (including operating and data base management systems or DBMS), and local area networks (LANs). Although U.S. firms appear strong in laser printers, the principal subassembly in these printers, the laser engine, comes from Japan. The Japanese, in particular, are steadily becoming the principal suppliers of the upstream products in these systems, while U.S. companies are becoming systems integrators.

As systems integrators, companies buy the lowest cost, highest performance components, subsystems and equipment from wherever they can be obtained in the world market. The companies then integrate the "pieces" into a system of their own design, adding software, and sell the combined system. The systems integrators count on being able to buy the latest component and subsystem technologies, often from the vertically integrated manufacturers who may be their competitors at the systems level. They assume that these technologies will be commercially available at the same time that their suppliers incorporate them into their own systems.

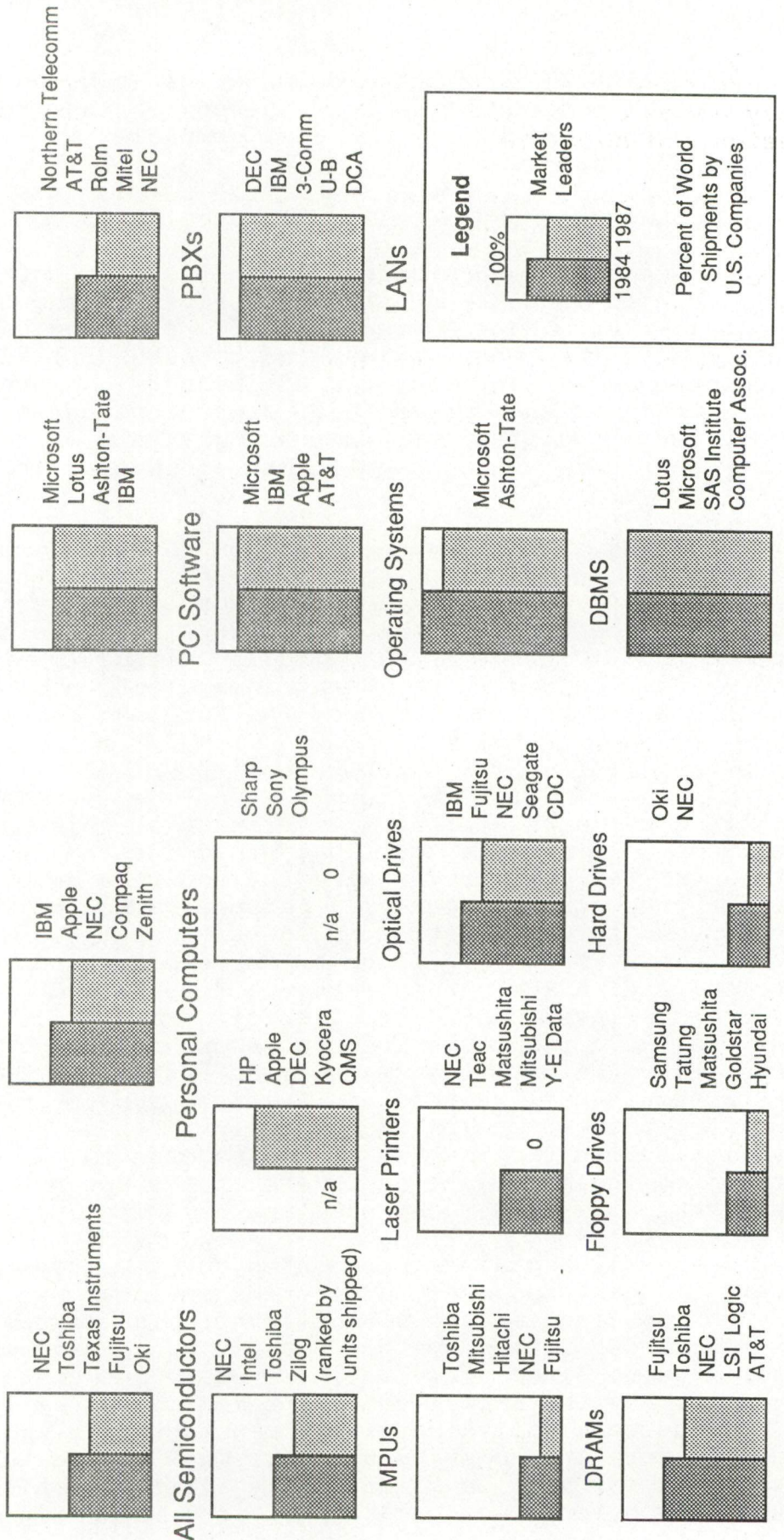
U.S. Share of Computer Shipments (1984 and 1987)

Software

Networks

Personal Computers

Components



Note: Exact percentages can be found in Table 10

A corollary to this strategy is that the systems integrators can stay ahead of their vertically integrated suppliers by better system design and software.

An example of the weakness of this strategy is U.S. suppliers' experience in the laptop portion of the PC market. The Japanese moved from a 24 percent worldwide market share in 1984 to a 41 percent share in 1988. Table 15 shows the Japanese strength in the various component and subsystem products which was an important reason for their success at the systems level. U.S. competitors did not maintain an advantage in systems design nor in software. The Japanese laptop suppliers had competitive designs and incorporated standard U.S. microprocessors and software packages.

The U.S. Strength in Microprocessors and Software

The strong U.S. position in microprocessors and software has been critical in the development of the personal computer segment. There has been a synergism between U.S. suppliers in these technologies, which has helped U.S. personal computer suppliers become leaders at the systems level. Some foreign-made microprocessors are now beginning to make inroads, notably the "transputer" from Inmos, a British firm, and the "V" series from Nippon Electric Company (NEC).

But U.S. suppliers remain leaders in the latest microprocessor designs, both in RISC--reduced instruction set computers, which promise higher processing speeds than their predecessors--and CISC or complex instruction set computers. Not only are the traditional U.S. microprocessor firms bringing out new designs, but others, particularly workstation suppliers, have designed RISC chips for use in their products. Japanese firms, such as NEC, Toshiba, and Fujitsu, have targeted RISC as a technology of choice and have entered into licensing agreements with the U.S. suppliers to obtain the technology (see the workstation case study in Appendix B).

For the Japanese to truly excel in the PC systems market, they must have the lead in operating systems software and the associated microprocessors. In order to achieve this, the Japanese have initiated a joint government-industry effort to design and produce their own operating system and associated microprocessors--TRON-- which they hope will become a world standard in a wide range of electronic equipment, from workstations to telecommunications switching equipment. Importantly, one of the principal goals of the project is to allow the Japanese to become independent of U.S. suppliers and avoid frictions over intellectual property rights and the payment of royalties for use of U.S. software and microprocessors in their equipment.

More broadly, the Japanese have substantial resources devoted to software development. In addition to TRON and efforts within the Japanese computer companies, the joint industry and government R&D project SIGMA (Software Industrialized Generation and Maintenance Aids) is striving to create the necessary software development tools and train programmers and systems analysts to take the lead away from the U.S. software industry.

Table 15 The Worldwide Laptop Computer and Components Market; U.S. & Japanese Share

		<u>1984</u>	<u>1988</u>	<u>Unit Value</u>	<u>Source</u>
Laptop Computers	U.S.	71%	57%	\$2500	DataQuest
	Japan	24	41		
	Other	0	2		
Microprocessors 80C88	U.S.	22	31	\$10	DataQuest
	Japan	78	68		
	Other	0	0		
80C86	U.S.	23	16	\$10	DataQuest
	Japan	77	84		
	Other	0	0		
80286 & 80386	U.S.	-	100	\$25 & \$250	DataQuest
	Japan	-	0		
	Other	-	0		
Rigid Disk Drives (upto 300 MB)	U.S.	67	78	\$500-600	Disk/Trends
	Japan	30	12		
	Other	3	10		
Flexible Disk Drives	U.S.	30	2	\$50	Disk/Trends
	Japan	67	95		
	Other	3	3		
Memory Chips 256K	U.S.	15	24	\$5	DataQuest
	Japan	85	66		
	Other	0	0		
1Megabit	U.S.	1	1	\$25	DataQuest
	Japan	99	99		
	Other	0	0		
Flat Panel Displays Liquid Crystal	U.S.	5	3	\$188	S.R.I.
	Japan	72	82		
	Other	23	15		
Electroluminescence	U.S.	49	53	\$380	S.R.I.
	Japan	27	29		
	Other	24	18		
Gas Plasma	U.S.	57	24	\$340	S.R.I.
	Japan	41	68		
	Other	2	8		

If the Japanese achieve this goal, they will have neutralized one of the few remaining competitive advantages that the United States currently has in electronics.

7. Increased Foreign Investment in the Sector

The issue of increased foreign investment and its role in the U.S. economy has sparked considerable debate over the past few years. Supporters of open foreign investment have cited its economic benefits such as job creation and growth in local tax bases and exports. They stress the fact that the United States has become more dependent on foreign capital to finance the federal deficit and point out that any attempts to discourage this investment might harm the economy. In addition, they note that the U.S. Government has advocated an unrestricted foreign investment climate with its trading partners and encouraged them to maintain markets that are open to U.S. investment.

Others have taken a more cautious approach based on their concern over the adverse economic, national security, and political implications that they see in the rising tide of foreign investment. They believe that the United States should not provide blanket support for all foreign investments, but should actively encourage only those which are clearly beneficial. Among the questions they most often ask about foreign investment are whether or not foreign-owned firms make a substantial contribution to U.S. employment and trade, whether these firms reinvest their profits in the United States or repatriate them, and whether they import as much technology from abroad as their parent companies export through acquisitions, minority investments, and technology licensing/development agreements. They also question whether foreign dominance in a growing number of critical U.S. industries might leave the United States vulnerable in a national emergency and impair the country's ability to develop both trade and foreign policy independently.^{10/} The following section will endeavor to shed light on some of these questions as they pertain to the U.S. electronics sector.

Foreign Investment in U.S. Electronics

Cumulative foreign direct investment in the U.S. electronics sector has tripled since 1980 to over \$12 billion in 1988. This compares to \$31 billion in U.S. direct investment in foreign electronics

^{10/} Linda M. Spencer, American Assets: An Examination of Foreign Investment in the United States, Congressional Economic Leadership Institute, Arlington, VA, July 1988. Also, Anne Marie Richter, Foreign Direct Investment: A Global Shift in Corporate Power, November 1988, and Who Owns America?: Foreign Direct Investment and the Globalization of Capital, November 1987, Nuala Beck & Associates, Inc., Toronto, Canada.

sectors abroad. The focus of this investment has been the radio, television, and communications industry, but high growth rates were evident in most of the other industries during this period (see Table 16) ^{11/}. In the case of the first industry, the high percentage stemmed from the acquisition of former U.S. TV equipment producers by Dutch and Japanese companies. Investment in the computer industry grew strongly.

The data from the Bureau of Economic Analysis (BEA) cover not only the cumulative equity investments from outside the United States in start-ups, acquisitions, joint ventures, and plant establishments and expansions, but also intercompany loans and reinvested earnings. However, BEA data on the leading nations' investments in the U.S. electronics sector are not published and may be incomplete due to disclosure considerations.

Table 17 shows an incomplete but revealing picture of foreign acquisition and business/plant establishment activity in the electronics sector. Foreign outlays were particularly heavy from 1986 through 1988 in the electronic components, radio, TV and communication equipment, and computer industries. Several factors were responsible for this upsurge in spending. First, the sharp depreciation of the U.S. dollar relative to other major currencies lowered the cost of U.S. assets, making many innovative U.S. companies attractive investment targets. The objectives of these investors were reportedly to gain access to the latest advances in U.S. electronics technology and to expand their U.S. market presence. Secondly, cash-poor start-ups that had difficulty obtaining financing from domestic sources sought out foreign investors to remain in business and to underwrite their R&D efforts. Finally, the concern of some foreign firms over U.S. trade actions led them to establish assembly operations in the United States.

The Japanese have been very active investors in the U.S. market over the past few years (see Table 18). In the office and computing equipment industry during 1987, they acquired investment positions in five U.S. computer firms and opened eight new plants. Among the investments were Ardent Computer, a start-up graphics supercomputer company; and MIPS Computer Systems, an acknowledged leader in RISC microprocessor technology. Several of the new plants were built to avoid 100 percent duties placed on certain Japanese personal computer imports as part of the trade sanctions in the semiconductor area. Japanese suppliers of portable typewriters also moved some operations to the United States in part to avoid dumping duties imposed on their imports. A number of Japanese firms announced plans in mid-1989 to establish new production facilities and to expand existing ones over the next few years to manufacture laser

^{11/} BEA data does not break out radio and TV products (part of consumer electronics) from communications equipment. The figures also exclude software in the tables on foreign investment and U.S. affiliates of foreign companies used in this section.

printers and color displays, copiers, communications equipment, and semiconductor devices such as 4MB DRAMS, ASICS, and microprocessors.

Table 16 Foreign Direct Investment Position in the
U.S. Electronics Sector
(\$ Millions)

<u>Industry</u>	<u>1980</u>	<u>Share of Total (%)</u>	<u>1988</u>	<u>Share of Total (%)</u>	<u>Annual Growth 1980-88 (%)</u>
Office and Computing Machines	443	13	2,701	22	25
Radio, TV and Communications Equipment	1,104	33	4,598	38	20
Electronic Components	1,522	46	3,052	25	9
Scientific and Measuring Instruments	89	3	702	6	29
Photographic Equipment	<u>166</u>	<u>5</u>	<u>1,077</u>	<u>9</u>	<u>17</u>
Total Electronics	3,324	100	12,130	100	18
Total Mfg. All Industries	33,011	--	121,434	--	18
	83,046	--	328,850	--	19

Source: Bureau of Economic Analysis, U.S. Department of Commerce.

Table 17 Annual Foreign Investment Outlays for Acquisitions and Establishments in the U.S. Electronics Sector
(\$ Millions)

<u>Industry</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987(R)</u>	<u>1988(P)</u>
Office and Computing Machines	118	42	(D)	19	49	(D)	62	429	986
Radio, TV, and Communications Equipment	(D)	147	(D)	(D)	(D)	(D)	(D)	(D)	1,463
Electronic Components	130	147	92	60	107	275	338	933	2,070
Scientific and Measuring Instruments	20	(D)	45	(D)	32	(D)	635	597	484
Photographic Equipment	(D)	6	0	0	0	0	1	(D)	(D)

(D) - Not provided due to disclosure regulations.

(R) - Revised

(P) - Preliminary

Source: Bureau of Economic Analysis, U.S. Department of Commerce.

Table 18 Investment/Acquisition and New Plant Establishments of Japanese Companies in Selected U.S. Electronic Industries
1980-87

(Number of Transactions)

Industry	Activity	1980	1981	1982	1983	1984	1985	1986	1987	Total
Computers/ Business Equipment	Invest/Acq.	-	1	-	2	1	1	-	5	10
	New Plants	-	-	-	1	-	1	2	8	12
Electronic Components	Invest/Acq.	3	-	-	-	-	3	4	2	12
	New Plants	3	2	2	1	2	4	4	3	21
Communi- cations Equipment	Invest/Acq.	-	-	1	1	1	-	-	2	5
	New Plants	-	1	-	-	3	2	1	2	9

Source: Japan's Expanding U.S. Manufacturing Presence, Japan Economic Institute of America, December 1988.

Data on the affiliates of foreign companies in the United States provide some insights into their role in the U.S. electronics sector. According to statistics compiled by BEA, the number of foreign affiliates participating in the U.S. electronics market has increased from 71 in 1977 to 209 in 1986. Their annual sales jumped five fold to \$20.5 billion by the end of this period, concentrated largely in electronic components, and radio, TV, and communications equipment. Table 19 shows that their total assets in the United States expanded at a 24 percent annual rate through 1985, substantially outpacing the asset growth of the U.S. electronics sector. As a result, their share of the domestic electronics asset base nearly doubled to 20 percent in those eight years. Roughly half of these assets were held in the electronic components industry. The upswing in foreign investment for acquisitions and new plants in the United States during 1986 and 1987 may have raised the foreign affiliate share of asset holdings further.

The value that these manufacturing operations added in the United States cannot be determined since sufficient detail at the industry level is not available for this purpose. However, trade data show that imports represented an important ingredient in the significant U.S. sales growth of these affiliates. Table 20 shows that in 1986 these affiliates imported twice as much as they exported, leaving a trade deficit of \$2 billion. As a result, they were a major contributor to the U.S. electronic sector's overall trade deficit.

Table 19 Share of Total Assets of U.S. Electronics Sector Held by U.S. Affiliates of Foreign Companies

	<u>1977</u>	<u>1980</u>	<u>1985</u>	<u>Annual Growth 1977-85 (%)</u>
U.S. Affiliates of Foreign Companies	2,914	8,791	15,779	+24
U.S. Electronics Sector	24,866	40,336	78,079	+15
Share U.S. Affiliates Hold (%)	11.7	21.8	20.2	

Sources: Bureau of Economic Analysis and the Census Bureau, U.S. Department of Commerce.

Table 20 U.S. Sales and Trade of U.S. Affiliates of Foreign Electronics Companies

	<u>1977</u>	<u>1980</u>	<u>1986</u>
Sales (\$M)	4,136	10,421	20,500
Exports (\$M)	364	1,511	1,968
Imports (\$M)	640	1,384	4,071
Trade Balance (\$M)	-276	+127	-2,103
Imports as Percent of Sales (%)	15.5	13.3	19.9
Exports as Percent of Sales (%)	8.8	14.5	9.6

Source: Bureau of Economic Analysis, U.S. Department of Commerce, unpublished data.

With regard to the affiliates' contributions to employment in the sector, Table 21 shows that they doubled the number of U.S. employees in their operations and their share of electronics sector employment since 1977. The data do not reveal the composition of this employment, e.g., the percentage of manufacturing versus sales or marketing positions. Nor do they indicate whether or not the skill levels and pay scales of the jobs these affiliates have created match those of U.S.-owned firms.

The R&D outlays of U.S. affiliates rose at a 34 percent annual rate from 1977 to around \$1.3 billion in 1986 as shown in Table 22. Despite this rapid growth, the monies that they allocated to R&D represented less than 10 percent of the research spending by industry within the U.S. electronics sector. Most of their outlays were for research on electronic components, and radio, TV, and communications equipment.

Affiliates of European electronics firms have established the strongest foreign R&D presence in the United States. They accounted for the bulk of affiliate research expenditures in 1986. Philips of the Netherlands, Siemens of Germany, and Thomson-CSF of France have research interests that span a broad range of technologies from materials and integrated circuits through computer and telecommunications systems (see Appendix C). In telecommunications, Northern Telecom of Canada has devoted significant resources to R&D efforts at its Bell Northern Research (BNR) laboratories in Ann Arbor, Dallas, Mountain View, and Research Triangle Park, employing more than 1,000 U.S. researchers.

The Japanese have reportedly moved much more slowly in building up a U.S. research capability. They performed some product development and design work through 1986, but their level of research activity was not on the same scale as their European counterparts. However, their U.S. R&D efforts have begun to expand in recent years. For example, in the computer area, NEC has launched laptop personal computer and workstation development projects while Fujitsu and Hitachi have software engineering centers in California to tap U.S. programming talent.

The question of how much technology has been transferred from foreign parents to their U.S. affiliates and vice versa is difficult to answer. Many of the affiliate R&D operations in the major high tech regions of the United States were established in part as "listening posts" to monitor important technological developments within U.S. companies and leading university research laboratories and to transfer this information back to their foreign parents. In addition, some of the affiliate research base has been obtained through minority investments in and acquisitions of U.S. firms possessing advanced technology. BEA data on licensing fees and royalties are too broad to assess with any degree of accuracy the flow of technical know-how across U.S. borders.

Table 21 Share of Total Employment in the U.S. Electronics Sector Held by Affiliates of Foreign Companies

	<u>1977</u>	<u>1980</u>	<u>1986</u>	<u>Annual Growth 1977-86 (%)</u>
U.S. Affiliates of Foreign Companies	73,046	154,395	182,065	+11
Total U.S. Electronics	1,543,100	1,924,300	1,951,800	+ 3
U.S. Affiliate Share of Total Employment (%)	4.7	8.0	9.3	

Sources: Bureau of Economic Analysis and the Census Bureau,
U.S. Department of Commerce.

Table 22 Research and Development Outlays* of U.S. Affiliates of Foreign Electronics Companies
(\$ Millions)

<u>Industry</u>	<u>1977</u>	<u>1980</u>	<u>1986</u>	<u>Annual Growth 1977-86 (%)</u>
Office and Computing Machines	15	99	219	+35
Radio, TVs and Communications Equipment	38	68	445	+31
Electronic Components	31	194	570	+38
Scientific and Measuring Instruments	2	8	17	+27
Photographic Equipment	<u>2</u>	<u>4</u>	<u>12</u>	<u>+22</u>
Total Electronics R&D Outlays	88	373	1,263	+34
R&D as Percent of U.S. Affiliate Sales (%)	2.1	3.6	6.2	
Share U.S. Affiliates Hold of U.S. Electronics Sector R&D (%)	1.9	4.8	8.0	

* Represents all R&D costs incurred including cost of R&D conducted
by others on behalf of U.S. affiliates.

Sources: Bureau of Economic Analysis, U.S. Department of Commerce,
and American Electronics Association.

8. Export Financing

U.S. electronics firms have been put at a disadvantage relative to their foreign competitors due to the limitations of the U.S. export financing program in addressing the sector's global supply structure. The U.S. electronics sector sources parts and components worldwide. Such sourcing patterns can reduce the U.S. content of electronics products exported from the United States to the point that they become ineligible for U.S. export financing. The export financing authorities of other nations, in contrast, are more flexible and do not have such stringent requirements on domestic content. Electronics suppliers from these countries therefore have an advantage when competing with U.S. companies on a worldwide basis.

The U.S. disadvantage is most evident in competitions involving multimillion dollar electronics projects, such as large-scale telecommunications and computer networks. U.S. export financing institutions have traditionally been very effective in financing large, capital-intensive infrastructure projects in developing countries, such as power generating plants. Historically, the equipment for these projects was largely built in the United States and had a high percentage of U.S. content. However, large-scale electronic systems may have levels of U.S. content below the current 85 percent requirement of the U.S. Export-Import Bank (Eximbank). In such situations, U.S. electronics systems suppliers would not be able to compete with Eximbank support. In response, some U.S. electronics firms have applied for export financing assistance from foreign countries in which they have subsidiary operations and have shipped systems from those countries instead of the United States.

III. ACTIONS TAKEN ON BEHALF OF THE ELECTRONICS SECTOR

Introduction

There have been a number of actions taken to address some of the issues affecting the U.S. electronics sector listed in the previous chapter. Federal and state governments alone and in concert with companies in the sector, as well as the companies themselves, have been involved in dealing with these problems.

While there has never been a coordinated set of federal government policies in the United States that have been applied to U.S. industry in general, and the electronics sector in particular, the U.S. Government has a number of policies, laws, and regulations that have affected the course of events in this sector. For many of the electronics industries, the principal historic role of the U.S. Government has been to fund R&D and to serve as a major market for their output. Foreign competition was at a minimum because electronics originated and was developed in the United States. Government involvement was the most extensive in the telecommunications industry, which was regulated as a natural monopoly. In the rest of the sector, the U.S. Government had a laissez faire approach, leaving companies to determine their own destinies. These factors have tended to mitigate against extensive cooperation between companies and with the government to address common problems.

At the state level, a number of governments have been actively courting U.S. electronics firms to locate various facets of their operations in their states to develop their local economies. In some cases, these efforts have been done in a broad, coordinated fashion. For example, the State of Georgia has worked to achieve close cooperation with the state government, local universities, and companies to ensure that an adequate infrastructure and resources are available to foster innovation and new firm creation. An important aspect of the state's strategy has been to attract a broad range of electronics companies, from component suppliers to systems level manufacturers in order to create a self-sufficient, interdependent local industry.

Some of the experience at the state level in the United States is comparable to programs in a number of foreign countries, where governments have been actively involved in a coordinated effort to nurture their electronics industries. Additional detail on other countries' development programs is covered in Appendix H of this study.

The following is a brief review of recent government actions that have been directed toward the issues raised previously in this study.

A. Actions on National Issues

1. The Cost and Availability of Capital

In 1986, the Gramm-Rudman Amendment set spending guidelines for reducing the federal budget deficit, but the results have not had a positive effect yet on lowering capital costs or increasing capital availability. A lower savings rate in the United States, particularly relative to Japan, has often been cited as contributing to higher costs of capital in this country. Although the U.S. Government has instituted tax reforms in recent years, the net effect has not been a significant stimulation of savings in the United States.

2. Exchange Rates

The effect of the weakening of the U.S. dollar since February 1985 on the electronics sector may have had more of a negative influence than a positive one, since imports continued to grow faster than exports. Because the Japanese are sole source suppliers in several categories of consumer electronics, the depreciation of the dollar may not have any stimulative affect on certain categories of U.S. exports. In addition, the weaker dollar has reduced the cost to foreign firms of investing in U.S. electronics technology, U.S. subsidiaries, and equity positions in a wide variety of firms across the spectrum of the sector.

3. R&D Tax Credits

The tax credit for R&D expenditures has been extended for another year, but debate continues over making it permanent. Companies state that they need a permanent tax credit to remove the uncertainty in their long-term R&D efforts. The Department of Commerce was instrumental in creating the original R&D tax credit in 1981. Recently, the Bush administration has proposed to extend and redesign the credit to ensure maximum effect on technological innovation and U.S. competitiveness. Discussions within the administration led to general agreement on three major points:

First, the credit should be made permanent. Protracted temporary status significantly reduces the credit's incentive value, leaving little long-lasting effect on R&D spending.

Second, the credit should be made available to new technology ventures. The current credit is available only to ongoing businesses.

Third, the credit's incremental feature should be redesigned because it drastically limits the effectiveness of the credit as an R&D incentive. Currently, the credit is calculated as 20 percent of a firm's R&D expenditures above the average of its qualified R&D expenditures over the preceding three years. Since only the new increment of R&D counts for credit purposes, there is no incentive for firms with a base period of high R&D expenditures to maintain

expenditures at high levels. Indeed, there is an artificial incentive for firms to make R&D expenditures in cycles. A fixed base credit indexed to nominal GNP would be more effective as an incentive. The critical feature of the base is that a firm's current spending will have no effect on future credits.

The administration is working with Congress, which has introduced two identical bills (HR.1416 and S.570), to correct some of the original deficiencies of the R&D credit and make the R&D tax credit permanent. Both bills provide a fixed historical base period that should considerably broaden the number of eligible users by encouraging more companies to increase or sustain their R&D spending. They also extend eligibility for the credit to start-ups. The bills do not address the issue of expanding coverage to include other important R&D activities in the sector, such as nonexperimental product development and nonlaboratory process technology.

The administration has also responded to industry's concern about the effects of Treasury Regulation 1.861-8 on allocation of U.S. R&D expenses by drafting a compromise proposal to treat 67 percent of U.S. R&D spending as U.S. source income. Congress passed a series of full and partial moratoria to handle this problem, but the last one generally expired on May 1, 1988.

4. Education and the Work Force

Currently, the federal government has a number of programs aimed at improving scientific and engineering education. Agencies such as the National Science Foundation, the Department of Education and the National Institutes of Health support and fund teacher training, curriculum and materials development, and research and graduate fellowships. The Department of Education sponsors the Educational Resources Information Center (ERIC). The Science, Mathematics, and Environmental Clearinghouse, one of ERIC's 16 clearinghouses, is designed to acquire the significant educational literature within the field. The clearinghouse is used by academics and students who wish to improve their teaching methods and enhance their research sources.

Many state governments have made changes to improve their educational systems. They have toughened academic standards, requiring students to take more science and math courses to qualify for graduation. They have also established special magnet schools for science and technology. For example, in 1984, the State of South Carolina enacted the Education Improvement Act (EIA). A one-cent sales tax increase funded 61 new programs and policies, including raising science and math course requirements, higher teacher's salaries, remedial education, and bonus dollars for schools that perform well. South Carolina also established the Governor's School for Science and Mathematics where two science courses are required each semester and a major research project in science, math, or computer science is mandatory.

Universities and colleges are also attempting to increase interest in science and engineering. For example, "Engineering 2000," sponsored by the Catholic University of America, is a program designed to educate high school students on career opportunities in engineering. This is accomplished through a seminar program led by leading engineers from government, industry, universities, and professional societies.

U.S. companies, including those in the electronics sector are making a response to the education issues. Some solutions supported by private industry include funding for experimental teaching programs, support of state-level educational reforms, employee/teacher exchanges, and job training. For example, members of the American Electronics Association (AEA) contributed more than \$23 million to their Electronics Education Foundation for graduate fellowships, faculty development grants, and equipment donations. University research has benefited from funding by U.S. electronics companies, both on an individual company basis, as well as through cooperative efforts such as the Semiconductor Research Corporation.

A recent effort is "Project 2061" designed by the American Association for the Advancement of Science (AAAS), funded by the National Science Foundation, and industry. The program seeks to develop a new approach to teaching, including possibly eliminating regular subjects and ending standardized testing. Teaching may consist largely of guiding students through projects that include not only science and mathematics, but also related aspects of literature, economics, and history. The program falls into three phases. The first, already completed, established the conceptual base by outlining the knowledge of science and nature that students should have upon leaving high school. The second phase, just under way, teams teachers from school districts led by the AAAS group to outline new curricula, texts, and student schedules. In the last phase, these outlines will be adopted by states and local school districts, modified to fit local conditions; and then installed in schools. According to AAAS the goal is to bring together "scientific societies, educational organizations and institutions in a nationwide effort to turn the second phase into education practice."

The President and the nation's governors met for an education summit in September 1989 in Virginia. In a joint statement, they agreed to establish a process for setting national education goals; seek greater flexibility and enhanced accountability in the use of federal resources to meet the goals, through both regulatory and legislative changes; undertake a major state-by-state effort to restructure the education system; and report annually on progress in achieving goals.

The National Governor's Association Task Force on Education was instructed to have the national performance standards completed and announced in early 1990 after consultations with educators, parents groups, and the business community. The performance goals are to guarantee an internationally competitive standard in seven areas:

- o the readiness of all children to start school;
- o the performance of students on international achievement tests, especially in math and science;
- o the reduction of the dropout rate and the improvement of academic performance, especially among at-risk students;
- o the functional literacy of adult Americans;
- o the level of training necessary to guarantee a competitive work force;
- o the supply of qualified teachers and up-to-date technology;
- o the establishment of safe, disciplined and drug-free schools.

5. Antitrust

U.S. antitrust laws have affected developments within the electronics industries, most notably the telecommunications industry. Under pressure from an antitrust suit filed by the Justice Department in 1974, American Telephone and Telegraph (AT&T) agreed in 1982 to a divestiture which split the nationwide Bell System into a new, smaller AT&T corporation and seven regional Bell operating companies (RBOCs). As part of the settlement, AT&T was allowed to enter the computer market, from which it had been banned since a 1956 Consent Decree with the Justice Department. A continuing review of the effect of the settlement has led to a number of proposals to allow the RBOCs to engage in the manufacturing of telecommunications equipment and to provide information services, activities from which they are currently prohibited.

Another major example of the use of antitrust laws by the government relative to the electronics industries was the suit brought against IBM in 1969. The trial ran from 1975 to 1982, when the Justice Department decided to dismiss the suit.

The thrust of the government's past actions with regard to both the telecommunications and computer industries was to increase competition. However, since 1982, the government has taken several steps to liberalize antitrust laws to allow U.S. firms to cooperate more closely in certain situations. Reflecting the awareness that many of their foreign rivals acting in concert have a competitive edge in the world market, the government has relaxed antitrust restrictions covering joint R&D activities and passed legislation that allowed the issuance of export trade certificates of review for the purpose of joint marketing overseas. Most recently, the Secretary of Commerce and the Attorney General have expressed interest in further relaxation of antitrust laws to permit joint production by rival firms under certain conditions.

The actions described above have been undertaken to address problems that broadly affect the industrial base in the United States. While some progress has been made, problems remain. Debate at the national level continues in order to reach a consensus on more effective solutions. To the extent solutions to these problems are found, the electronics sector and all U.S. industries will benefit.

6. Short-Term Corporate View

There has been a number of actions taken recently by companies in the electronics sector that imply a change of attitude to the extent possible in the U.S. economic system toward developing a longer term view of the market. There has been a greater emphasis on quality control, which is not only responsive to customer needs, but also represents a commitment to regaining market share lost on this basis. Some companies have brought back manufacturing operations to the United States, which, while being responsive to the effects of the weaker dollar, also allows companies to link more closely their R&D and manufacturing processes and, in turn, helps to stem the erosion of the U.S. manufacturing base. Another perspective on recent efforts to form R&D and manufacturing consortia is that these actions have been taken with a long-term view of supporting U.S. research and manufacturing capabilities.

B. Actions on Sectoral Issues

1. Lack of Consensus

As part of the effort to fashion this statement on the competitive status of the U.S. electronics sector, the Science and Electronics unit of the Department of Commerce (DOC) went out to industry and academia to elicit their views. It became clear that this outreach effort coincided with a growing awareness on the part of many companies that the U.S. electronics sector was in fact facing a growing erosion in its historic leadership role and that some extraordinary actions on the part of industry, with support from government, were needed. Efforts are already under way in the U.S. electronics sector. The fact that several research consortia have been formed shows that many companies in the sector are beginning to take a more cooperative, long-term approach to competitiveness.

2. Research and Development

One of the basic channels by which the U.S. Government has been involved in the electronics sector has been through funding of R&D, principally for military and national security applications. The funding has been channeled through such agencies as the Department of Defense (DOD), Department of Energy (DOE), National Aeronautic and Space Administration (NASA), National Science Foundation (NSF), and National Institute of Health (NIH). Some, such as DOE and DOC, also perform electronics-related R&D. A summary of the historical involvement of these agencies in R&D is provided in Appendix F.

Although U.S. Government R&D has been directed toward defense and space applications, there are examples of R&D projects which have had commercial spin-offs. From DOD, examples include integrated circuits, value-added networks, computer timesharing, the computer language ADA, artificial intelligence/expert systems, and semiconductor design systems.

From NASA, the space program provided such advances as high-resolution video displays, communications satellite systems, high-speed data transfer techniques, real-time data base systems, portable emergency medical systems, ultrasound imaging systems, and electronic component miniaturization.

Several other government agencies have been important funders of basic research in the electronics area, principally through universities. Important contributions, for example, have been made to the theory of computer science by NSF and DOE funding. NSF has also played a significant role in providing universities with access to high performance computers for a wide range of basic research, including electronics applications, through its Supercomputer Centers Program.

Recent R&D Efforts

Department of Defense

DOD's concern over the effect that the loss of U.S. leadership in electronics technologies will have on its near- and long-term national security objectives has moved the agency into new research efforts. In 1987, DOD's Defense Advanced Research Projects Agency (DARPA), with 14 U.S. semiconductor companies, jointly funded SEMATECH, a R&D consortium devoted to the development of semiconductor manufacturing technologies. The goal of the effort is to regain U.S. leadership in the technologies lost to foreign competitors, particularly the Japanese. Because the R&D covers basic process technologies, the results originally directed toward military uses could serve equally to improve the commercial competitiveness of the U.S. electronics sector (see SEMATECH case study in Appendix D).

In January 1989, DARPA issued a call for proposals for R&D on high resolution displays that also could be considered dual-use technologies. Such displays could be used in military systems, such as "heads up" displays for crews of fighter aircraft, as well as in commercial systems, such as laptop computers, workstations and HDTV (high definition television). The concern over dominance of foreign suppliers, particularly Japanese, in the potentially lucrative market for HDTV led to the formation of study and advisory groups to agree on a plan of action to ensure that U.S. suppliers would not be excluded. The Secretary of Commerce established an Advanced Television (ATV) advisory committee, made up of representatives from those offices involved in science and technology and trade policy in the Commerce Department, and representatives from the private sector.

Department of Energy

The DOE's laboratories, such as Los Alamos, Sandia, and Lawrence Livermore, have had important roles in supporting the U.S. electronics industries. They have historically been a significant user of and contributor to high performance computer technology. Most recently, Sandia, for example, has been involved in developing

software for massively parallel computer systems which has demonstrated a substantial improvement in the solution of a particular kind of complex mathematical problem. The laboratories also continue to perform, state-of-the-art developments in semiconductor manufacturing processes such as synchrotron radiation sources for X-ray lithography.

National Science Foundation

NSF has been an important funder of R&D in academia. Table 23 shows that its role in supporting both applied and basic research in U.S. universities and colleges has grown while the involvement of DOD and DOE has declined over the past few years. NSF now accounts for 40 percent of these federal research obligations.

NSF figures in Table 24 show the emphasis on basic versus applied research in federally-supported academic projects. The funding for these basic research efforts has increased at a much faster pace since 1986.

Department of Commerce

The National Institute of Standards and Technology (NIST) within the Department of Commerce does not normally rely on grants or contracts but rather carries on R&D in-house and provides technical services and consultation to industry and government agencies. NIST's programs in semiconductors, optoelectronics, microwaves and millimeter waves, and electronic instrumentation are directed at

Table 23 Federal Obligations for Research Performed in Universities and Colleges in Electronics-Related Disciplines by Major U.S. Government Agency
(Million of Dollars)

	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>CAGR (86-88)</u>
DOD	240.4	237.0	227.3	- 2.8
NSF	128.4	148.5	183.9	+19.7
DOE	21.0	24.9	16.7	-10.8
NASA	17.0	19.1	20.9	+10.9
Other U.S. Govt. Agencies	<u>5.6</u>	<u>6.1</u>	<u>6.5</u>	<u>+ 7.7</u>
Total	412.4	435.6	455.3	+ 5.1

Source: National Science Foundation.

Table 24 Federal Obligations for Applied and Basic Research Performed at Universities and Colleges in Electronics-Related Disciplines
(Millions of Dollars)

	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>CAGR (86-88)</u>
Applied	131.8	137.4	142.1	+3.8
Basic	<u>280.6</u>	<u>298.2</u>	<u>313.2</u>	<u>+5.6</u>
Total	412.4	435.6	455.3	+5.1

Source: National Science Foundation, 1989.

generic problems deemed important by the U.S. electronics sector. NIST works closely with the Semiconductor Research Corporation and SEMATECH as well as with individual electronics companies and with trade and voluntary standards organizations such as the Electronics Industries Association and the American Society for Testing and Materials.

NIST has Regional Centers for the Transfer of Manufacturing Technology to provide direct support to small and medium firms in automating and modernizing their facilities.

Federal Laboratory Consortium

The Federal Technology Transfer Act of 1986 gave authority to directors of all government-operated federal laboratories to enter into cooperative R&D agreements with the private sector, universities, and state and local governments. The law allows them to negotiate licensing agreements and contracts, giving special consideration to small businesses and those companies willing to manufacture in the United States.

Within the Federal Laboratory Consortium, there are over 600 federal laboratories and centers, which have annual in-house R&D budgets of \$20 billion and employ 17 percent of the nation's science and engineering professionals. The consortium has a clearinghouse for industry and academic access to its technical resources and proven technology and technology assessments through special data bases. The consortium has seven regional coordinators to assist industry and academia.

Argonne/University of Chicago Development Corporation

An example of cooperative efforts to transfer federal laboratory technology into commercial products is the Argonne/University of Chicago Development Corporation (ARCH), a joint venture formed in 1986 between Argonne National Laboratory and the University of

Chicago. As part of ARCH, an industrial affiliates program was established to provide a mechanism for transferring results in advanced computing between the research laboratory and industry.

Implications of the New Trade Act

The Omnibus Trade and Competitiveness Act (The Trade Act) of 1988 contains a number of provisions that could affect R&D projects and funding in the electronics sector. An example of these would be the authority to create advisory bodies on semiconductors, semiconductor manufacturing equipment, and superconductors to assess and recommend strategies to improve the U.S. competitive position in these areas. One of the responsibilities of these advisory groups is to identify key technologies that will impact the national defense or U.S. competitiveness as well as to recommend appropriate action.

Another aspect of the Trade Act that affected R&D was the establishment of an Advanced Technology Program within the Department of Commerce's NIST. Congress gave NIST the authority to provide seed money for joint projects in critical emerging technologies.

Private Sector Efforts

The high cost of trying to stay ahead technologically and the competitive threat represented by joint government and private sector R&D programs in Europe and Japan have stimulated several cooperative R&D efforts in the United States. A list of these efforts include the Semiconductor Research Consortium (SRC), which channels private sector funds to academic research, and the Microelectronics and Computer Technology Corporation (MCC), in which researchers from member companies engage in joint R&D. The results of the R&D are then shared among corporate partners, thus focusing research and reducing risk and costly duplication of effort.

As a result of recommendations made by the National Advisory Committee on Superconductivity, AT&T, IBM, and Lincoln Laboratories at MIT announced their intention in mid-1989 to cooperate in an R&D consortium on superconductivity. DARPA will provide more than \$4 million in funding for MIT's research while both AT&T and IBM are expected to match this amount to support their own efforts.

3. Unfair International Trade Practices

a. Recent U.S. Government Trade Actions

The federal government has been active in addressing unfair trade practices by foreign governments and companies both on a bilateral and multilateral basis (see Table 25). Within the context of the current Uruguay Round of the General Agreement on Tariffs and Trade (GATT), the government has established negotiating priorities in several areas particularly affecting the electronics sector. These include services, investment, and intellectual property rights.

Table 25 U.S. Government Trade Actions in the Electronics Sector

<u>Action</u>	<u>Product</u>	<u>Complaints</u>	<u>Country</u>	<u>Date</u>	
				<u>Initiated</u>	<u>Results</u>
Telecom negotiations	Telecom equip.	Market restricted	Japan	1980	U.S.-Japan agreement on NTT procurement
301	Informatics	Trade/invest restrictions No copyright law for software	Brazil	1984	Case-by-case relief copyright coverage of software
301	Software and other works	No copyright law	Korea	1985	Copyright law, including separate law for software
301/sanctions	Semiconductors/ DRAMs/EPROMs	Market restricted	Japan	1985	Semiconductor trade sanctions imposed Sanctions remain
Antidumping investigation/sanctions	256K DRAMs and future generations	Dumping in U.S. and 3rd markets	Japan	1985	Semiconductor trade arrangement Sanctions imposed Dumping ended Sanctions removed
MAFF talks	Telecom Equip.	Market restricted	Europe/ Korea	1985	Discussions folded into 1988 Trade Act implementation
MOSS talks	Telephone equipment and services	Standards/certific/services barriers	Japan	1985	MOSS agreement; regulatory structure reformed
MOSS talks	Radio equipment and services	Standards/certific/services barriers	Japan	1985	MOSS Agreement; regulatory structure reformed
Free trade agreement	Telecom equipment	High tariffs, discriminatory procurement	Canada	1987	Tariff reductions
305 study	Supercomputers	GOJ market restricted Price discounting	Japan	1987	Procurement agreement
1377 determination	Telecom equip. and services	Noncompliance with Moss Agreement	Japan	1989	Telecom agreement concluded
1374 determination	Telecom equip. and services	Market restricted	EC and Korea	1989	EC and Korea were named priority countries
Super 301	Supercomputers and satellites	Market restricted	Japan	1989	Investigations initiated

On a bilateral basis, the U.S. Government has addressed a number of unfair trade practices affecting this sector under various provisions of U.S. trade laws. In the 1970s, for example, the U.S. Government found that Japanese typewriter manufacturers were dumping portable electric typewriters in the U.S. market and imposed duties to compensate for the injury to U.S. suppliers. However, the action came too late to stop U.S. typewriter producers from leaving the portable segment of the industry.

Telecommunications

The United States and Japan signed a bilateral telecommunications agreement, implemented in 1981, as an adjunct to the Government Procurement Agreement of the General Agreement on Tariffs and Trade. As part of this agreement, Nippon Telephone and Telegraph (NTT) agreed to allow foreign telecommunications equipment suppliers to compete for some categories of its procurement (NTT Agreement). This agreement was renewed in 1984 and 1987.

Beginning in 1985, Market-Oriented Sector-Specific (MOSS) talks on telecommunications were conducted with Japan in two phases. Phase I centered on telephone communications--in particular standards, certification, testing of terminal equipment, and value-added (VAN) services--and was concluded in April 1985 by an agreement. Phase II, which focused on radio telecommunications, was concluded with an agreement in January 1986.

In order to encourage liberalization and gather information on foreign telecommunications markets, the U.S. Government began bilateral telecommunications discussions, Market Access Fact Finding (MAFFs) discussions, with a number of countries. The MAFF discussions have been overtaken by the implementation of the telecommunications section of the new Trade Act.

The new Trade Act included measures to address trade barriers affecting telecommunications products and services. Pursuant to these provisions, the United States Trade Representative (USTR), in January 1989, designated South Korea and the European Community as priority countries that have significant barriers to trade in U.S. telecommunications products and services. USTR has initiated consultations as required by the law. If trade agreements to remove the barriers are not entered by February 1991, retaliation may take place.

On January 1, 1989 the U.S.-Canada Free-Trade Agreement went into force. This followed two years of negotiations. With respect to telecommunications, the issues addressed were high tariffs and discriminatory procurement. Tariff reductions resulted from this effort.

Section 1377 of the 1988 Trade Act requires an annual review of trade agreements involving telecommunications products or services. This review is to determine whether the foreign country is in

compliance with the terms of the agreement or otherwise denies mutually advantageous market opportunities within the context of the terms of the agreement to U.S. telecommunications products and services. In April 1989, USTR determined under this provision that certain practices of Japan with respect to third party radio and cellular phone products and services were not in compliance with Japan's commitments under the MOSS agreements on telecommunications. After extensive negotiations, an agreement was reached in June 1989 in which the Government of Japan agreed to bring these practices into compliance.

Semiconductors

In 1986, the United States suspended two antidumping investigations when Japanese semiconductor producers agreed to stop dumping programmable read only memories (EPROM's) and dynamic random access memory semiconductors of 256K and future generations (DRAM's) in the U.S. and third country markets. Concurrently, the Semiconductor Arrangement, signed by USTR and the Government of Japan, suspended a Section 301 investigation against Japan, which had been filed by the U.S. semiconductor producers in protest of restrictions on the U.S. industry's access to the Japanese semiconductor market. Under the Semiconductor Arrangement, Japan agreed not to dump in the United States or third countries and to provide foreign producers with greater access to its market.

In 1987, after the U.S. Government found that no significant progress had been made under the Semiconductor Arrangement, the President invoked his authority under Section 301 to unilaterally assess penalties against certain imports from Japan, including some personal computers. The sanctions were partially lifted in November 1987 to reflect the cessation of dumping in the U.S. and third-country markets. The U.S. Government retained the remaining sanctions because little progress had been made in terms of increased market share. The United States continues to monitor the prices at which Japanese companies export to the United States, to ensure that these prices are not below the cost of production.

The U.S. Government, in consultation with the appropriate segments of the electronics sector, is proposing to extend price monitoring to application specific integrated circuits (ASICs) from Japanese suppliers. This particular type of semiconductor is becoming a critical component in a wide range of electronics equipment, including microcomputers and automotive controls.

Supercomputers

Under Section 305 of the 1974 Trade Act, a study was initiated on barriers to U.S. supercomputer sales in the Japanese Government market and price discounting practices by Japanese supercomputer firms in the world market. An agreement covering public sector procurement of supercomputers was signed between the U.S. and Japanese Governments in August 1987.

However, in spite of this agreement, subsequent procurements by the Government of Japan went to Japanese supercomputer suppliers, and U.S. firms remained shut out of the market. As a result, in June 1989, USTR initiated "Super 301" investigations of Japanese procurement of supercomputers and satellites in accordance with the 1988 Trade Act.

Software

In August 1989, the Import Administration initiated a countervailing duty investigation to determine whether manufacturers, producers, or exporters in Singapore of certain computer-aided software engineering (CASE) software products receive benefits that constitute bounties or grants within the meaning of the countervailing duty law.

Accomplishments

Most of these trade actions on market access have resulted in agreements that were structured to remove foreign market barriers. In some cases, such as copyright protection for U.S. software firms in Brazil and South Korea, negotiations have been successful and barriers have disappeared. In others, such as semiconductors, the process of opening foreign markets has taken longer.

The U.S. Government has also engaged in bilateral talks with the Governments of Colombia, Indonesia, South Korea, and Mexico to persuade them to keep their computer markets open to U.S. suppliers. The Commerce Department, in particular, has focused its trade promotion efforts on products that appear to have good export potential in certain markets based on market research and has worked closely with the Export-Import Bank to help U.S. companies obtain low-interest financing to offset government support provided to foreign competitors on major telecommunications and computer systems projects overseas.

The Omnibus Trade and Competitiveness Act of 1988

The Omnibus Trade and Competitiveness Act of 1988 included a number of changes to strengthen U.S. trade law to deal with unfair trade practices of foreign governments and companies. Some of these changes had the special circumstances of the electronics sector in mind. For example, the act established dumping procedures under the antidumping law for short life cycle products i.e., products which are likely to become outmoded within four years. This new provision allows a U.S. company to file a petition requesting that a product category be established with respect to short life cycle merchandise any time after the merchandise becomes the subject of two or more affirmative dumping determinations.

The act also identified several electronics industries and product sectors where Congress gave the President greater authority to address unfair trade practices and requested that specific reviews

of such practices be undertaken. For example, monitoring the supercomputer procurement agreement and increasing the access of U.S. supercomputer suppliers to the Japanese Government market.

Advisory Committees

In order to maintain a continuing consultation process with the electronics sector, the Department of Commerce utilizes its program of private sector advisory committees. The committees are comprised of representatives from the private sector who advise the Secretary of Commerce and the U.S. Trade Representative on international trade negotiations. Private sector advice has helped the U.S. Government develop negotiating positions that seek to enhance the competitive status of U.S. industry.

Issues relating to the electronics industry are addressed in the Industry Sector Advisory Committee (ISAC) on Electronics and Instrumentation and the Industry Functional Advisory Committees (IFACs) on Intellectual Property Rights, Standards, and Customs.

The Bush administration has utilized this valuable means of continuing the U.S. Government dialogue with the private sector. Recent agenda items for these advisory groups have included U.S. strategy for the Uruguay Round of the GATT and Europe 1992.

Congress has a critical role to play in maximizing federal participation in the enhancement of the competitiveness of the U.S. electronics sector. The creation of the National Advisory Committee on Semiconductors to devise a national semiconductor strategy is an example of congressional action to promote joint private industry and government initiatives to strengthen the international competitiveness of the U.S. semiconductor and electronics industries.

b. U.S. Company Actions

Trade law actions, principally antidumping petitions, have been filed by companies within the electronics sector (see Table 26). For example, Micron Technology filed an antidumping petition against Japanese suppliers of 64K DRAMs in 1985. The U.S. Government found dumping and levied duties on imports of these products from Japan. Also in 1985, Intel Corporation, Advanced Micro Devices, Inc., and National Semiconductor Corp. filed an antidumping petition against Japanese suppliers of electronically programmable read only memories (EPROMs). This latter suit was suspended under terms of the Semiconductor Trade Arrangement between the U.S. and Japanese Governments.

On March 17, 1988, Verbatim, a leading U.S. floppy disk supplier, filed a petition on behalf of the U.S. industry, charging that certain Japanese suppliers were selling 3.5 inch diskettes below cost in the U.S. market. On February 7, 1989, the Department of Commerce announced a final determination that the Japanese suppliers were dumping these products, ranging from 28 to 51 percent below cost. In March 1989, the International Trade Commission (ITC)

Table 26 U.S. Industry Trade Actions in the Electronics Sector

<u>Action</u>	<u>Product</u>	<u>Complaints</u>	<u>Country</u>	<u>Date Initiated</u>	<u>Results</u>
Antidumping	Televisions	Dumping	Japan	1968	Duties levied
Antidumping	Tuners	Dumping	Japan	1970	Duties levied
Antidumping	Portable electric typewriters	Dumping	Japan	1974	Duties levied
Antidumping	High-powered microwave amplifiers	Dumping	Japan	1981	Duties levied
Antidumping	Televisions	Dumping	S. Korea	1983	Duties levied
Antidumping	Televisions	Dumping	Taiwan	1983	Duties levied
Antidumping	64K DRAMs	Dumping	Japan	1985	Included in semiconductor arrangement
Antidumping	EPROMs	Dumping	Japan	1985	Included in semiconductor arrangement
Antidumping	Cellular radio telephones	Dumping	Japan	1985	Duties levied
Antidumping	Color picture tubes	Dumping	Singapore	1986	Duties levied
Antidumping	Color picture tubes	Dumping	S. Korea	1986	Duties levied
Antidumping	Color picture tubes	Dumping	Canada	1986	Duties levied
Antidumping	Color picture tubes	Dumping	Japan	1986	Duties levied
Antidumping	Floppy disks	Dumping	Japan	1988	Dumping determined
Antidumping	Small business phone systems	Dumping	Japan	1988	Duties levied
Antidumping	Small business phone systems	Dumping	S. Korea	1988	In progress
Antidumping	Small business phone systems	Dumping	Taiwan	1988	Duties levied

determined that the imports materially injured the U.S. industry. The Commerce Department has issued a final order instructing the U.S. Customs Service to collect antidumping duties.

At the end of 1988, AT&T initiated an antidumping investigation of suppliers of small business telephone systems in Taiwan, Japan and South Korea. In October 1989, the Commerce Department concluded its investigation of Taiwan and Japan and made a determination of dumping in both cases, with antidumping margins as high as 178 percent. The investigation of Korea South is continuing.

c. Future Trade Concern--EC 92

The long-term effects on the U.S. electronics sector of the European Community's internal market liberalization by 1992 (EC 92) remain unclear. The EC has begun to issue policy directives for comment that will be implemented to form a single regional market by eliminating trade and investment barriers between its member states. Some observers are concerned that this internal liberalization will result in the creation of external barriers to trade that will exclude U.S. suppliers. Others believe that the liberalization will make it easier and less costly to produce and market foreign products in Europe. In anticipation of the 1992 goal, many U.S. firms are expanding their operations in Europe, including joint ventures with European partners. U.S. Government actions on this issue have included an outreach program to U.S. industry, providing information on EC directives and receiving comments in return to gauge the potential effect on U.S. trade and investment (see Appendix G for listing of EC directives), and appropriate representation to the EC to defend American interests.

4. Intellectual Property Rights

a. U.S. Government Actions

A 301 case initiated in 1985 against Brazil on informatics was terminated in October 1989. Under the 301 action, Brazil adopted a copyright law for the protection of computer software.

In 1985, the U.S. initiated a 301 case against South Korea concerning intellectual property rights (IPR) and reached a settlement in 1986, which included commitments by Korea to amend its patent and copyright laws and to enact a computer program protection act. A Section 305 study of Korea's patent system, initiated in 1988, is ongoing. The U.S. industry alleges that the system discriminates against foreign applicants and owners.

Working closely with the U.S. software industry, the U.S. Government has conducted bilateral negotiations with countries of the Pacific Rim with regard to unauthorized copying and distribution of computer software and illicit cloning of computer systems. Using leverage under the Generalized System of Preferences (GSP) program, the U.S. Government has urged Asian governments to enact laws providing

explicit copyright protection for software, including computer programs, descriptions, and user manuals, and to enforce vigorously the laws that already exist. Successes have been recorded in Singapore, South Korea, Taiwan, Malaysia, and Indonesia. However, the failure of the Royal Thai Government to provide copyright protection for software resulted in reduction of Thailand's GSP benefits. U.S. Government pressure also figured in the Japanese Government's decision to protect software under copyright rather than under a sui generis regime favored by Japan's Ministry of International Trade and Industry.

The 1988 Trade Act amended Section 301 of the Trade Act of 1974 to create a "special" 301 proceeding, which relates solely to IPR. Under the amended law, USTR must identify "priority foreign countries" that deny adequate and effective protection for U.S. IPR. In May 1989, the USTR announced a "special" 301 action, identifying 25 countries as deserving special attention because of the denial of protection of IPR and market access to U.S. firms relying on such protection. Of these countries, 17 were placed on a "Watch List," with eight on a "Priority Watch List." These eight were Brazil, India, Mexico, the People's Republic of China, the South Korea, Saudi Arabia, Taiwan, and Thailand. On November 1, 1989, USTR moved Korea, Saudi Arabia, and Taiwan off the "Priority Watch List" in light of their commitments to improve their intellectual property policies. These countries joined the original 17 countries on the "Watch List."

The U.S. Government has acted on the multilateral level to improve protection in foreign markets for U.S. intellectual property. On March 1, 1989, the United States became a member of the Berne Convention for the Protection of Literary and Artistic Works, the oldest and most respected copyright treaty, with more than 75 members. Works of U.S. origin are now entitled to the same degree of copyright protection in all Berne countries that is provided to works originating in such countries.

Also on the multilateral level, the U.S. Government is seeking an agreement on intellectual property in the Uruguay Round of negotiations under GATT. Such an agreement would provide substantive standards for protection of patents, trademarks, copyrights, trade secrets, and rights in semiconductor chip layout designs (mask works), which all parties to the agreement would be required to incorporate into their domestic laws. The agreement would also contain minimum standards for enforcement of IPR and would provide for dispute settlement among signatories, including the possibility of retaliation for noncompliance. Developing countries have opposed protecting IPR in the GATT, principally because they believe that IPR issues should be addressed not in the GATT but in the World Intellectual Property Organization (WIPO), which administers the major multilateral IPR agreements. However, this impasse has recently been broken and prospects for the substantive negotiations are reasonably good.

The United States has shown leadership in the protection of microchip technology through enactment of the Semiconductor Chip Protection Act of 1984 (SCPA), the world's first law to protect the mask works of semiconductors (layout designs), an entirely new form of intellectual property. SCPA provides rights-owners with 10 years of exclusivity for making and distributing masks. A unique provision of SCPA authorizes the Secretary of Commerce to issue orders providing interim protection in the United States for mask works produced in countries that are making good-faith efforts to institute legal regimes for chip protection. This incentive has resulted in efforts to develop laws providing mask work protection in 19 countries.

b. Company Level Actions

In the software area, IBM filed lawsuits in the early 1980s against Hitachi and Fujitsu for violating copyrights on its mainframe operating systems. The company received support from the U.S. Government in the Hitachi case when an undercover "sting" operation of the Federal Bureau of Investigation caught Hitachi America officials attempting to buy confidential IBM product information. Hitachi agreed to allow IBM to inspect its mainframe operating system enhancements and to make substantial compensatory payments. IBM chose to resolve its legal action against Fujitsu by agreeing to accept independent arbitration of the dispute. As in the Hitachi case, IBM is receiving multimillion dollar annual payments over a specified time period in exchange for access to some of its operating system software technology.

In the semiconductor industry, several suits have been brought by U.S. manufacturers of microprocessors against foreign suppliers over alleged infringements in both copyrights and patents. In February, 1985, Intel filed a suit against Nippon Electric Corporation (NEC) alleging the use of Intel's microcode from the 8088 and 8086 microprocessors in NEC's "V" series of microprocessors. In February, 1989, the U.S. District Court in San Jose, California reaffirmed a 1986 ruling that microcode may be protected by copyright law, but ruled that NEC had not infringed Intel's copyright.

In the beginning of 1989, Motorola filed suit against Hitachi, accusing the Japanese firm of infringing certain patents covering several designs in Motorola's 68000 microprocessor family.

5. Export Regulations

Establishment of the Bureau of Export Administration

In 1987, the new Bureau of Export Administration (BXA) was established within the U.S. Department of Commerce giving U.S. export control policy a higher profile. This marked an elevation of the U.S. Government's export administration responsibilities in managing export controls, strengthening enforcement of export laws,

reducing administrative burdens on exporters, and enhancing the United States' export competitiveness of U.S. exporters.

The Trade Act

The Omnibus Trade and Competitiveness Act of 1988 amended the Export Administration Act of 1979 and extended it until October 1990. The Trade Act liberalized the export control regime of the United States by requiring the elimination of export controls on entire categories of low to mid-level dual-use technologies to certain destinations, by lifting some reexport controls, and by strengthening control list and foreign availability review procedures with a view towards decontrol. It also amended the Export Administration Act by establishing sanctions for future national security violations of regulations issued pursuant to COCOM agreement that are comparable to the Toshiba/Kongsberg sanctions.

Relaxation of the Controls

BXA significantly revised export controls on low-level computers and computerized equipment effective August 1, 1988. The most significant changes affected exports to the People's Republic of China (PRC). The action allowed computers with a processing data rate (PDR) of up to 550 million bits per second to be exported to the PRC with no disk drive and memory limitations. These relaxations to the PRC eliminated the requirement to refer license requests for this commodity to COCOM. By eliminating referral to COCOM, export license processing time for this class of computer has been cut by approximately 50 days. Other changes allowed the bulk export of personal and business computers with PDRs of 136 million bits per second for resale in the PRC.

In a separate action effective August 15, 1989, BXA as a result of a determination of foreign availability removed validated licensing requirements for AT compatible personal computers, for all destinations except S and Z countries (Libya, Cambodia, Cuba, North Korea, and Vietnam), and some sections of the South African Government. The decontrol measure includes personal computers using industry standard architecture at levels up to a PDR of 69 million bits per second (equivalent to an Intel 80286 microprocessor with a clock rate of 16 MHz), up to 4 MB of random access memory, and hard disk capacity of up to 140 MB.

In September 1988, the decontrol of certain telecommunications products was announced. The United States and COCOM raised the level of decontrol for telecommunication transmission equipment from a transmission rate of 8.5 million bits per second to 45 million bits per second. In addition, the level of transmission and associated test equipment that can be exported to the PRC at national discretion has been uniformly raised to 140 million bits per second for all types of communications media including fiber optic installations. The regulations governing transmission equipment have been entirely revised and shortened, thus reducing the administrative and licensing burden on exporters.

There were also a number of changes in 1988 affecting the exports of microelectronics and instrumentation to the PRC. All test equipment for bare printed circuit boards, certain single wafer dry-etchers, steppers, and sample and hold integrated circuits are now Green Line to the PRC and, thus, may be licensed without referral to COCOM.

Unilateral Controls

On February 23, 1989, BXA implemented the Trade Act provision that required the removal of all unilateral national security controls, except for controls on items for which the Secretary determined that foreign availability did not exist, or where the administration was negotiating to eliminate foreign availability.

Bilateral Discussions

The U.S. Government is continuing talks with a number of non-COCOM countries with the purpose of securing cooperation in controlling exports and reexports of controlled goods and technology. Countries that agree to institute controls equivalent to those of COCOM may be eligible for the same licensing benefits granted to COCOM member countries with respect to certain U.S. licensing requirements.

Foreign Availability

During fiscal year 1989, the Office of Foreign Availability (OFA) completed 21 foreign availability studies, including studies on array processors, low capacity hard disk drives, die bonders and, AT-level IBM compatible personal computers. The OFA assessment on AT-level IBM compatible personal computers resulted in the August 1989 decontrol for all destinations except S and Z countries.

The new Trade Act makes a number of changes affecting the foreign availability program. OFA has been given the additional responsibility for conducting assessments of availability of controlled items to noncontrolled countries. Included are decontrol assessments and denied license assessments. Positive determinations of foreign availability following decontrol assessments will lead to the decontrol of the item, unless the President issues a national security override. Positive determinations following a denied license assessment will lead to mandatory approval of the validated license applications in question, unless the President issues a national security override. In the event that the President determines to maintain controls notwithstanding a positive determination of foreign availability, he is required to begin negotiations with the foreign source(s) to eliminate the availability.

A new procedure, called "expedited licensing," was intended to shorten the licensing process time for items that are similar to items available to noncontrolled countries from non-U.S. sources. Determination of eligibility for expedited licensing must be completed within a maximum of 35 working days following receipt of an allegation of such availability.

Rigid deadlines have been applied to foreign availability determinations. Determination of foreign availability must be made within four months following receipt of a claim. Other deadlines apply to determinations of eligibility for the expedited licensing procedure or determinations following Technical Advisory Committee certifications. One additional month is allotted for interagency review. For multilaterally controlled items, an additional four months is allotted for consultation with COCOM. Failure to meet the "claims" deadlines for publishing the determination (positive or negative) of foreign availability results in automatic removal of the requirement for a validated license.

Export License Processing

BXA's automation advances have added significantly to its time response capabilities on both status inquiries and application processing. The establishment of a computerized voice response system, System for Tracking Export License Applications (STELA) provides the status of pending license applications for export, reexport and amendment requests. In addition, STELA allows for instant verbal authorization to ship on licenses approved without conditions. On January 2, 1988, the Office of Export Licensing began to accept and approve Free World license applications and reexport requests electronically using the new Export License Application and Information Network (ELAIN). ELAIN offers speed and convenience in the submission of license applications. Applicants with a licensing history can obtain clearance from BXA to submit licenses electronically, using value added electronic mail networks.

In addition, our effort to provide exporters with quick, accurate and timely information on changes in export licensing policy and procedures has resulted in the installation of a new phone system. This system includes an automated attendant, the Export License Voice Information System (ELVIS). Recorded information is available to callers on a range of topics such as commodity classifications, regulations updates, emergency handling procedures and upcoming seminars. In addition, forms and publications may be ordered without waiting to speak to a consultant. This new system allows exporters to obtain needed information quickly, while permitting our export counseling staff to handle calls requiring more extensive analysis or follow-up.

Overall average processing time has declined from 25 days in 1986, 21 days in 1987, 17 days in 1988, to 16 in 1989. The average processing time in 1989 for applications not requiring referral to other agencies in 1988 was 8 days.

Public Awareness Programs

In addition to our licensing activities, the Bureau of Export Administration maintains an active public outreach program. BXA sponsored Update 1989, the annual update conference of Export Administration Regulations and Licensing Policy, held in Washington

from July 5-7. Last year's conference included working sessions on computers, technical data, automation, and semiconductors, discussions on recent changes in the Export Administration Regulations as a result of the Omnibus Trade and Competitiveness Act of 1988, and organized tours of our licensing and enforcement offices. The number of exporters attending this annual conference has been steadily increasing. Approximately 650 exporters participated in this year's update, making it the most successful conference to date. This year's Update conference is scheduled for June 18-20, 1990.

6. Growing Dependence on Foreign Suppliers

The report in 1988 by the Defense Science Board (DSB) accepted the fact that the U.S. electronics industries have lost leadership in key technologies to foreign competitors. DSB offered several options for action to address this slippage, including funding R&D, and, if necessary, stockpiling key products that could only be obtained from foreign suppliers.

In the private sector, the American Electronics Association (AEA) has been the trade association that has spearheaded discussion and study of the HDTV issue. A recent study from AEA asserts that U.S. industry must be a significant player in the HDTV market or lose out on billions of dollars in revenues and see related industries such as computers negatively affected.

In addition, AEA also worked with the Semiconductor Industry Association (SIA) to create a plan of action for the reentry into DRAM production by U.S. suppliers. The plan would create production consortia of U.S. memory users and makers, which would be able to act as alternative sources to the Japanese of these vital chips. These production consortia would require the amendment of U.S. antitrust laws to allow joint production efforts without fear of legal suits. As mentioned previously, such amendments have recently been proposed by the Secretary of Commerce and the Attorney General.

In June 1989, seven U.S. electronics firms announced the formation of a DRAM production consortium, which was named "U.S. Memories." However, in January 1990, the consortium effort was cancelled after an effort to raise required capital funding failed.

7. Increased Foreign Investment in the Sector

The U.S. Government's position on foreign direct investment has been one of open investment within the United States, which flows from the free trade position of the government. Open investment in all countries is the most efficient in economic terms, since this allows capital to flow to the most appropriate investment opportunities. As in all major industrial countries, this policy is tempered by laws that may limit or prohibit foreign direct investment in order to protect the U.S. national security. Among these is Section 5021 of the Omnibus Trade and Competitiveness Act of 1988, which gives

the President the authority to seek appropriate relief, including divestment, when the President finds, inter alia, that there is credible evidence that a foreign person exercising control of a U.S. person by means of a merger, acquisition, or takeover might take action that threatens to impair the national security. The Committee on Foreign Investment in the United States (CFIUS) is an interagency group that may investigate the effects on national security of mergers, acquisitions, and takeovers which could result in foreign control of U.S. persons. Members of CFIUS are the Secretaries of Treasury (chairman), Commerce, Defense, and State; the Attorney General; the Director of the Office of Management and Budget; the Chairman of the Council of Economic Advisors; and the U.S. Trade Representative.

8. Export Financing

Bilateral foreign AID programs have been an integral part of the conduct of the U.S. foreign policy for many years. Though the underlying objectives have always been the same--to further U.S. political, strategic, economic, and humanitarian goals--successive administrations have adjusted the rationale and priorities in response to changing conditions and public attitudes.

These changes have brought about a shift in program emphasis from capital transfers in the form of large- and medium size capital projects to projects of relatively modest size that: (a) are designed to expand and enhance the role of the private sector; (b) address the problems of poverty in an equitable growth context; and (c) must be justified on development grounds. Against this background, by 1982 large capital project assistance in such areas as industry, energy, and transportation, among others, had declined to 6.5 percent of total U.S. bilateral official development assistance, compared with a figure of 11 percent for 1972 and about 25 percent in the early 1960s.

The following is a summary of the U.S. bilateral foreign assistance programs and their objectives.

The U.S. Agency for International Development (AID) was established by the Foreign Assistance Act of 1961 and given the major responsibility for administering and coordinating the U.S. bilateral assistance program. This responsibility is jointly shared with the Department of Agriculture in the case of food aid and the Department of State in regard to country allocations of economic support funds.

The Export-Import Bank of the United States (Eximbank) was created in 1934 by Executive Order 6581 and was established as an independent U.S. Government agency in the Export-Import Bank Act of 1945. Its major purpose is to facilitate U.S. exports by providing loan, guarantee, and insurance financing support. Unlike the U.S. Agency for International Development, its primary purpose has never been to promote foreign economic development.

In fulfilling its role, the Eximbank offers a wide range of loan, guarantee, and insurance programs designed to complement and encourage private sector financing of U.S. companies' foreign sales. Eximbank does not compete with private sector export credit sources. Rather, its programs are designed to fill gaps left by the private sector, such as the provision of longer maturities in the face of commercial bank preference for short terms; assumption of foreign credit risk that the private sector finds unacceptable on creditworthiness grounds; and neutralization of the export credit subsidies of foreign governments.

Eximbank funds its operations by constantly rolling over its capital and reserves; quarterly borrowing of long-term debt at market rates from the Federal Financing Bank of the United States Treasury; and from revenues earned through payment of interest, fees, and principal on its insurance, guarantees, and direct loans. Except for tied aid credit transactions, no appropriated funds are used to support its activities. Nevertheless, each year Congress sets lending and guarantee limitations.

The Trade and Development Program (TDP) was created in 1980 and established as an independent agency by the Omnibus Trade and Competitiveness Act of 1988. TDP has two objectives: to assist in the economic development of friendly developing and lesser-income countries and to promote the export of U.S. goods and services to those countries.

IV. GOVERNMENT AND PRIVATE SECTOR ROLES IN THE ELECTRONICS SECTOR

Introduction

In Section C of the Chapter I, "The Competitive Status of the U.S. Electronics Sector," the relative position of eight countries and the European Community (EC) was compared, using a set of parameters ranging from production volume and growth to the number of scientists and engineers in the country. Based on these parameters, the U.S. electronics sector remained the largest in the world, but was seriously challenged by other competitors, particularly the Japanese and South Koreans. While the private sector has played an important role in determining success in all of these countries, the government has played significant roles in both Japan and Korea in terms of fostering the growth of their respective electronics sectors. Other countries, such as India and Brazil, have also had significant government involvement in their electronics sectors, but have not progressed as quickly. A question arises as to what were some of the elements of success in the United States, Japan and Korea. In comparison, why have other countries been less competitive?

This section will discuss the role of government and the private sector in the United States, seven other nations, and the EC, highlighting those elements that appear to have been instrumental in the successful development of electronics sectors. Appendix H contains additional information and analysis to support this section's conclusions.

A. Role of Government

The involvement of government in industrial development has ranged from pure laissez faire economic policies to government ownership and management of industrial units. The countries in this study lie along this spectrum in terms of their treatment of the electronics sector, from the relative hands-off policies of the United States to the industrial micro-management policies of Brazil, where some production is government owned.

Table 27 shows some of the elements of government involvement that have contributed to the success of the electronics sectors in the United States and major competitor nations. The U.S. Government's approach has been largely ad hoc and fragmented over the years due to the historic dominance of the U.S. electronics sector in the world market and the prevailing philosophy that governments should not pick winners and intervene in the marketplace. As noted previously, the U.S. Government's support has been limited to indirect stimulation of R&D and procurement, and strong promotion of an intellectual property rights (IPR) regime both domestically and internationally. The government's intervention has been confined to promoting competition through antitrust regulation and preventing the transfer of strategically important technologies to East Bloc countries through export controls.

Table 27 Elements That Have Led To Success in Electronics

<u>U.S.</u>	<u>Foreign</u>
<p><u>Government</u></p> <p>Strengthening IPR overseas through trade negotiations;</p> <p>Indirect stimulation through defense and space R&D, procurement;</p> <p>Strong physical and human infrastructure fostered;</p> <p>Regulatory involvement largely limited to antitrust, export controls;</p> <p>Strong domestic IPR in support of innovation and new firm growth;</p>	<p><u>Government</u></p> <p>Coordination with industry across broad policy spectrum;</p> <p>Adaptive policy-making;</p> <p>Use of economic policies to foster favorable business climate for targeted industries;</p> <p>Continuing support of joint commercial R&D; procurement favors domestic firms;</p> <p>Strong physical and human infrastructure fostered;</p> <p>Broad regulatory involvement, including trade and investment;</p> <p>Larger firms, with interfirm competition fostered;</p>
<p><u>Private Sector</u></p> <p>Pioneers, "first on the block";</p> <p>Vigorous competition in unregulated industries among many firms;</p> <p>Strong entrepreneurial character; transition to stable, larger firms;</p> <p>High rate of new firm creation;</p> <p>High levels of R&D investment;</p> <p>High rate of innovation;</p> <p>Large, sophisticated domestic market;</p> <p>Strong export orientation.</p>	<p><u>Private Sector</u></p> <p>Strong technology transfer and assimilation from foreign sources;</p> <p>Few, large, vertically integrated firms;</p> <p>Long-term strategic view of market;</p> <p>Emphasis on product development/manufacturing technology; quality control;</p> <p>Dumping, IPR infringement sometimes used as tools to enter/win markets;</p> <p>Strong export orientation.</p>

Although the offshore manufacturing operations and the technology transfer agreements of some U.S. firms have contributed to the growth of foreign electronics industries, the progress of these competitors has been aided by effective government targeting policies and support mechanisms. The Governments of Japan and Korea have played a key role in the development of their electronics sectors through close coordination with industry across a broad policy spectrum and through policies that have been flexible and adaptive. They have used economic policies, particularly those pertaining to the tax structure and fiscal incentives, to foster a favorable business climate and have nurtured strong physical and human infrastructures as the foundation for their skilled and efficient labor forces and their technological advancement. Their direct involvement in their electronics sectors initially focused on protecting emerging firms, controlling imports and foreign investment, and helping their firms to acquire foreign technology. Over the years, they have favored larger firms, while allowing inter-firm competition. They have also provided continuing support for commercially-oriented joint R&D.

Many of these elements are missing in the nations that have made less progress. Brazil, for example, while coordinating with industry across a broad policy spectrum, has not been able to develop a favorable business climate, nor a strong physical and human infrastructure. In addition, Brazilian electronics companies have not had a strong export orientation, which has meant that they have not benefited from the rigors of international competition.

B. Role of the Private Sector

In the United States, the private sector has been the prime mover in the commercial success of the electronics sector to date. As shown previously, the private sector has been the major funder and performer of R&D, a wellspring of innovation and new firm creation, and has had a major presence overseas virtually since its commercial beginnings. The sector also benefited from creating many of the early electronics technologies, that were commercialized by these U.S. firms establishing themselves as leaders in the world marketplace.

By the early 1980s, the competitive situation began to change for the U.S. electronics sector. Foreign governments had concluded earlier on that electronics was critical to their future economic growth and intervened to foster the development of indigenous industries. That intervention and the growing strength of foreign firms brought a fundamental change in the world market. U.S. electronics firms found themselves in an international arena where certain markets were closed to them and foreign rivals now were competitive in technology, price, and quality in an increasing number of products.

Foreign companies had reduced the U.S. lead, benefiting from joint R&D, active technology transfer and assimilation from U.S. sources, and a strong emphasis on product development and manufacturing

technology. Based on previous successes in such products as typewriters, television sets, and calculators, Far Eastern suppliers became a visible competitive force in more sophisticated electronics technologies. Japanese computer printer suppliers rapidly gained dominance in the world personal computer market. Korean companies progressed to computer displays, and eventually personal computer systems--the first clones.

Most of these Far Eastern firms are large, vertically integrated companies, which have taken a long-term strategic view of the electronics market. Some of these firms have entered and won markets through such unfair trade practices as dumping and IPR intellectual property rights infringements (see Chapter III--- Actions Taken on Behalf of the Electronics Sector). In some cases, the smaller U.S. electronics suppliers in these markets were no match for foreign conglomerates, with greater financial and technical resources. As a result, they were often forced to leave the market or were acquired by larger domestic or foreign firms.

C. Conclusions

The involvement of foreign governments in their electronics sectors is unlikely to diminish in the future. The sector is too vital to their economic growth and national security.

Clearly, the history of government and private sector roles in the development of electronics in the United States and overseas has been different. There appear to have been few common elements, save for the importance of having a strong physical and human infrastructure and a strong export orientation. However, some of the elements of success in the case of foreign government and private sector involvement may be adaptable to the U.S. environment in order to stop the erosion of the U.S. competitive position. The challenge will be how to preserve those elements that have made the U.S. electronics sector preeminent in the past and to select and modify those elements of foreign success that will help to ensure its survival in the future.

V. FUTURE COMPETITIVE TRENDS

Introduction

Unfair trade practices at the company level will likely spread to new segments of the sector. For example, dumping of computer software and integrated systems is likely to occur as foreign suppliers progress technically and begin to move into these markets.

Overseas, violations of intellectual property rights (IPR) will continue where foreign governments do not institute effective intellectual property laws or do not adequately enforce existing laws. In the U.S. market, IPR violations could increase, if both the U.S. Government and industry do not remain diligent in addressing any perceived violations. Smaller U.S. electronics firms will be most vulnerable, since they do not have sufficient internal resources to support the legal costs associated with IPR litigations.

The main competition in the world's electronics markets should come from the Far East and Europe. Japanese suppliers are becoming more multinational in character, establishing manufacturing facilities to serve local customers in the United States and key European nations. They are also expanding their R&D operations overseas to take advantage of foreign research talent. The Europeans are hoping to emerge as a stronger force in the world market for electronics products through their national and regional R&D projects and the 1992 initiatives. The developing countries generally have targeted the production of low-end equipment (personal computers, peripherals, and customer premises equipment). However, as their technological know-how improves, they should move upstream into more capital-intensive areas (semiconductors) and knowledge-intensive areas (software and services).

Table 28 indicates which of the countries discussed in this chapter will be major players in the various parts of the sector.

A. Computers

Japan is already the United States' main competitor in almost all product segments. The United States is still ahead in some--microcomputers, workstations, and high performance computer systems; Japan leads in others--optical storage, video displays, and

Table 28 Principal U.S. Competitors in the Future

	<u>Ind</u>	<u>Brz</u>	<u>Sng</u>	<u>Twn</u>	<u>Kor</u>	<u>Frn</u>	<u>Jpn</u>	<u>EC</u>
Computers				x	x		x	x
Software	x		x			x	x	x
Systems Integration						x	x	x
Telecommunications						x	x	x
Semiconductors					x		x	x
Elect. Instruments							x	x
Medical Electronics							x	x

laser printers. South Korea and Taiwan are becoming very competitive in microcomputers and peripherals. The EC may play a significant role in several areas, such as parallel processors, but much of this will depend upon the outcome of their R&D efforts, such as ESPRIT.

B. Software

Japan may also emerge as the leading competitor in software, based on the amount of resources it is putting into the TRON and SIGMA projects and into software engineering research. Japan is seeking to exploit the synergism between microprocessors and software through these R&D efforts and through becoming a leading force in the important area of technical and market standards. To obtain the necessary programming talent, Japanese companies are linking up with software firms in the United States and Europe, while the Japanese Government is revamping Japan's educational system, including closer relationships between industry and academic research.

Singapore and India have targeted software for domestic development. Both benefit from low-cost labor and close ties with U.S. and European firms which, in turn, are transferring technology and serving as major customers. India has a large number of trained software developers available for contract programming. Singapore, committed to becoming the leading center for software and computer services in South East Asia, has expended substantial resources on increasing the technical capabilities of its work force. (The Europeans have always had a sound research base and have demonstrated particular skill in developing custom software. In recent years, they have become more interested in overseas markets.)

Systems integration (SI) can be viewed as a software-based activity, in that SI suppliers generally select computer and telecommunications equipment from a variety of vendors, develop software for specific applications, and sell the complete system directly to the users. These systems can be microcomputer-based, e.g., a personal computer system for doctors or dentists, or very large systems, e.g., an air traffic control system. U.S. firms are currently leaders worldwide in the large systems. The smaller systems often have to be customized for geographic and cultural differences, and, thus, U.S. suppliers frequently compete with domestic suppliers in each country.

Both the Japanese and the Europeans should draw on their strengths in custom software development to make them very competitive with U.S. firms in systems integration. The leading Japanese computer suppliers are also major telecommunications suppliers and can bring to bear a broadly based expertise in competing for large-scale information systems projects.

C. Telecommunications

Japan, France, West Germany, Sweden, and Canada are the major U.S. competitors in telecommunications. These nations are seriously

challenging the U.S. lead in networking equipment. Japan, in particular, has become a primary rival in terminal equipment while Taiwan and South Korea are now the dominant suppliers in certain low-end telecommunications products like telephone handsets. Japanese and European firms have also mounted a significant challenge in the newer fiber optics, satellite, and cellular radiotelephone technologies.

D. Semiconductors

Japan, the current world leader in DRAM memory chip production, is vying with the United States for the technological lead in all segments of the semiconductor industry, especially in the latest generation of memory devices and application-specific integrated circuits (ASICs). Japan is also making a strong effort to catch up in microprocessors. Other challengers are on the horizon. Most of the major Asian and European players in the electronics equipment market realize the importance of domestic semiconductor production to their long-term strategies of competing more effectively at the systems level and are actively promoting this sector. For example, Korea has made significant strides in DRAM production, while the EC is using its internal rules-of-origin directives to improve its capabilities in semiconductor production. Notable EC R&D efforts in this area are the Joint European Submicron Silicon Initiative (JESSI) and the MEGA Project.

E. Electronic Instruments

In process controls, the Japanese have replaced the Europeans as the major competitor of the United States. The principal Japanese supplier, Yokogawa, rose from obscurity during the 1980s to become one of the world's three major manufacturers in this area. The other two are U.S. companies. A Japanese firm, Advantest, has also become a major challenger in electrical test and measuring instruments, having benefited significantly from the government-sponsored VLSI research project during the 1970s. In laboratory instruments, which is populated by smaller firms, the market is divided among American, Swiss, West German, British, and Japanese companies. Because the electronic instruments sector is characterized by specialized markets and customized products that are less applicable to low cost or mass production, the newly industrialized countries have made little headway in capturing market share.

F. Medical Electronics

West Germany has historically been the leading U.S. competitor in the medical electronics field and should remain so in the near future. Siemens, the largest German manufacturer, has moved aggressively into the U.S. market by establishing manufacturing plants and purchasing U.S. medical device firms. Siemens is active in pacemakers, lithotripters, hearing aids, and all modes of diagnostic imaging.

Japan has just begun challenging the United States in this industry, but will probably be the leading contender over the long run. Unlike West Germany, Japan has a number of small competitive firms that traditionally have been OEM (original equipment manufacturers) suppliers of components and devices to U.S. and European firms. However, these firms are now marketing their products under their own brand names. Japan has been strong in X-ray apparatus, and ultrasound and CT scanners; it also is becoming very active in low-cost magnetic resonance imaging.

VI. OPTIONS FOR ADDRESSING THE ISSUES FACING THE U.S. ELECTRONICS SECTOR

The previous pages of this study established the importance of the electronics sector, explored the issues facing the sector, and reviewed actions already taken to address these issues by the government and the private sector. Based on this previous material, this chapter will highlight some areas for additional actions that could be helpful. In addition, Chapter IV, "Government and Private Sector Roles in the Electronics Sector," highlighted some elements of success in fostering the growth and health of electronics sectors both in the United States and overseas. These elements have been considered in drafting this chapter.

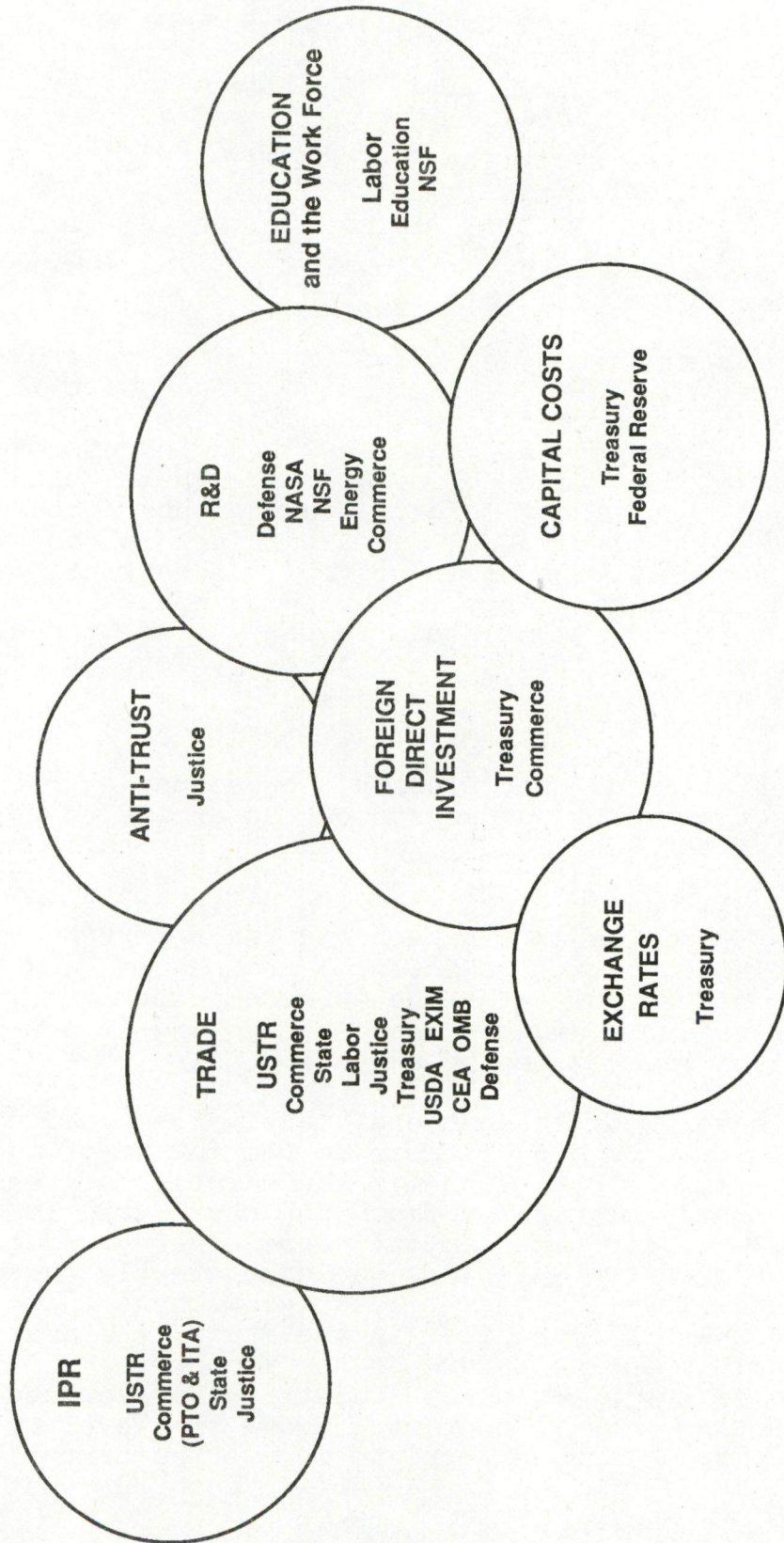
Chart 9 represents the major issues and the government agencies primarily responsible for each issue. The chart illustrates the breadth of the issues facing the sector and the diversity within the government of responsible agencies. The issues cover both domestic and international trade policy arenas. These formerly distinct arenas are increasingly intertwined and thus a coordination of policies across traditional dividing lines is necessary. For example, the growing erosion of the international market presence of U.S. electronics suppliers is having an effect on the Defense Department's procurement needs in the United States. Collaborative R&D and production arrangements taken by foreign suppliers have important antitrust implications in the U.S. market, which has become only one segment of a broader global marketplace.

A fundamental issue that clearly emerged during the drafting of this study was the lack of consensus on the extent to which the sector's competitiveness has eroded, the reasons for this erosion, and what actions should be taken to address the erosion. Sufficient consensus has developed to form the basis for such diverse cooperative efforts as Sematech and the report by the Federal Coordinating Committee on Science, Engineering and Technology (FCCSET) on strategies for the supercomputer area. However, the electronics sector and the issues affecting it are much broader and deserving of more extensive attention.

Although several of the national level problems facing the electronics sector are critical to the future of many other industries in the U.S. economy, the solution of these problems could be particularly critical to both the short- and long-term viability of the U.S. electronics sector. Some observers feel that many of the sector's current problems could be greatly eased by focusing on the national level issues at least as much as those on the sectoral level. For example, earlier in the study, the analysis illustrated the capital intensive nature of the industries in the electronics sector. All the electronics industries have capital expenditures per production worker at or well above the level of all manufacturing. Thus, efforts to remove the competitive disadvantage that U.S. manufacturing firms face in both the cost and

Chart 9

Competitiveness Issues and U.S. Government Agencies Responsible



availability of capital relative to their foreign competitors would be of major significance to the electronics sector.

Representatives of the U.S. semiconductor industry have stated that higher capital costs in the United States have been a fundamental reason for the erosion of their leadership relative to their Japanese competitors. The acute nature of this problem is heightened for the sector as a whole, since the Japanese have specifically targeted most of the industries in the sector for market leadership, and they are emerging as the strongest foreign competitors that the United States faces in electronics.

In order for the U.S. electronics sector to match the Japanese in capital investment, the capital cost issue must be resolved. The solution would address the relatively lower savings rate in the United States versus Japan, as well as the federal budget deficit, and tax policies that encourage investment. In the United States, debate at the national level continues on the question of the higher costs of capital and underlying causes. A solution to the deficit problem will require a national consensus. The electronics sector has added its voice to those asking for such a solution.

This section is divided into two sets of proposals that would continue federal involvement with the private sector on matters relating to the competitiveness of the electronics industry: 1) those that the Department of Commerce could consider on its own and 2) those that the Department could explore with other federal agencies and the private sector.

The proposals are designed to insure that the Executive Branch remain attentive to opportunities to promote U.S. competitiveness. However, they are made with the recognition that the private sector has the primary responsibility for leadership in this area.

A. Department of Commerce Initiatives

Those proposals within the mission of the Department of Commerce have been segmented into those that can be considered in the near term (category I) and those requiring a longer term for consideration (category II).

Category I

Research and Development

- o Establish a Foreign Technology Assessment Specialist in Tokyo to provide U.S. electronics companies with early warning and strategic assessments about foreign R&D breakthroughs likely to affect the market.
- o Meet with chief executive officers in the exporting industries to stimulate the increased use of supercomputers in the design, simulation, and testing functions to match increased use by Japanese competitors.

Export Development

- o Build on current efforts--the MITI-Commerce Industrial Cooperation Initiative, aimed at giving Commerce Department analysts a better understanding of MITI and its relationship with Japanese industry and providing a channel to promote industrial cooperation and two-way technology transfer with Japan, and the Export Promotion Initiative--to ensure that U.S. business is better equipped to pursue opportunities in the Japanese and third-country markets.

Education and the Work Force

- o Continue outreach programs designed to encourage women and minorities to study science and mathematics and highlight the linkages to high technology business.
- o Consider the possibility of establishing cooperative education programs with colleges and universities to encourage long-term study of Japanese and international trade beginning in the student's initial year.

Category II

Research and Development

- o Consider ways to establish Commerce Department/industry committees to develop a strategic plan to increase the flow of technology to the United States from Japan and Europe.
- o Consider ways to expand the efforts of the Office of Japan Technical Literature.
- o Consider ways to expand the efforts of recruiting scientists to regularly visit Japanese Government research labs, reporting back to U.S. Government and industry.
- o Explore ways to expand efforts to improve the commercialization of research breakthroughs resulting from federal R&D.

Unfair International Trade Practices

- o Review dumping, subsidies, and intellectual property rights policies based on strategic view of technical and market trends in electronics, to anticipate foreign threats (e.g., software dumping).

Increased Foreign Investment in the Sector

- o Assess ways to improve the provision of a more detailed industry breakdown of foreign investment in the U.S. electronics sector.

B. Proposals for Consideration by Other Organizations

In discussions with other U.S. Government agencies and the private sector during the course of the study, the following suggestions were made for consideration by other organizations.

Education and the Work Force

- o Examine the status of federal data collection of statistics on science and engineering educational programs.
- o Explore the possibility of creating a clearinghouse to coordinate science and engineering educational programs which are supported by private, federal, state and local agencies.
- o Continue to encourage states to develop action plans to address critical problems in science and electronics education using committees of university/college officials and representatives of local school districts and teacher associations.
- o Continue to encourage local school districts to establish standards for the number of science and mathematics courses required for high school graduation. Stress teaching the practical applications of these subjects where possible and more reasoning/problem-solving activities.
- o Encourage local school districts to consider establishing "provisional teacher" programs that would ease restrictive teacher certification requirements and attract recent college graduates and people from industry with strong science and mathematics background into schools on a full- or part-time basis.
- o Explore the possibility of increased support for graduate fellowships and trainee programs in science and engineering.
- o Explore expanded support for teacher training and informal education in science and mathematics.
- o Work with corporate university donors and leading business and engineering schools to encourage greater emphasis in master of business administration and engineering programs on manufacturing.
- o Based on the findings of the Workforce 2000 study, develop policies to increase the availability of skilled workers.
- o Consider the means by which firms in the electronics sector could expand in-plant job training to develop multiskilled rather than single skilled workers through apprenticeship programs, job rotations, off-the-job training using company centers or correspondence courses, and worker involvement in quality circles.
- o Consider ways to encourage state and local governments to offer incentives to firms that emphasize the development of multiskilled labor forces and continuous job training.

- o Encourage partnerships among unions, companies, and state and local governments to develop vocational training programs within high schools and community colleges that are directly relevant to the needs of local employers.

Short-Term Corporate View

- o Encourage firms within the sector and the financial community to establish new measures of productive performance such as indicators of quality, productivity, product-development time, and time-to-market, rather than merely indicators of short-term financial performance.

Research and Development

- o Encourage increased emphasis on manufacturing R&D and continuous improvements in manufacturing process technology through seminars with trade associations on latest domestic and foreign advances.
- o Encourage universities to establish or expand "incubator" programs for those firms that require R&D facilities and support as well as management expertise.

R&D Tax Credits

- o Consider making R&D tax credits permanent.
- o Consider broadening R&D tax credits to cover new technology ventures.
- o Consider the effect of broadening R&D tax credits to cover nonexperimental product development and nonlaboratory process technology R&D.
- o Consider establishing a fixed-historical base period for calculation of R&D tax credits.
- o Examine the possibility of recommending a change in Treasury regulation 1.861-8 on allocation of U.S. R&D expenses by treating 67 percent of U.S. R&D spending as a "set-aside" and not characterizing it as foreign.

Appendix A

Semiconductor Case Study: Memory Market *

INTRODUCTION

Due to the semiconductor industry's close linkages to other high technology industries, a strong U.S. semiconductor industry is regarded as an important national asset. The memory market, in particular, has a bearing on the competitive health of the U.S. semiconductor industry. Memory devices are the key components for computers, consumer electronics, telecommunications, industrial electronics, and defense electronics. They account for almost one-half of semiconductor consumption in the United States. Memories also serve as a semiconductor "technology driver," pushing a broader range of semiconductor device technology to the limits and perfecting manufacturing processes.

STATE OF U.S. MEMORY PRODUCTION

Since 1983, U.S. market share in the metal-oxide semiconductors (MOS) memory area has fallen from almost 50 percent to less than 30 percent. Japan has assumed a commanding lead and now holds about a 65 percent world market share (see Charts 10 and 11). Within the MOS memory market, dynamic random access memories (DRAMs) are the dominant memory device. The major customer industries and their respective shares of the DRAM market are featured in Chart 12.

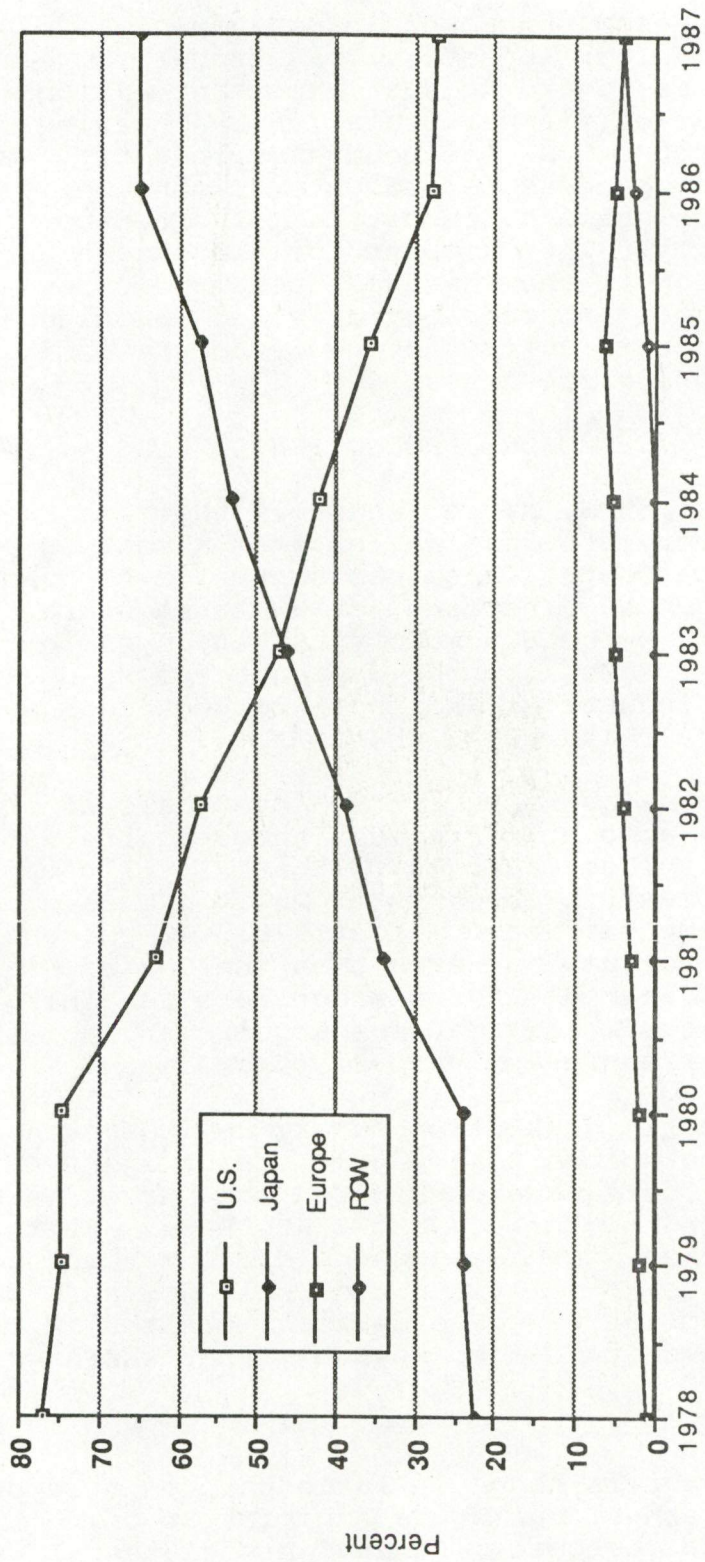
By 1982 the Japanese captured over half of the DRAM market and currently account for almost three-quarters of world DRAM production (see Chart 13). Chart 14 illustrates that Japanese DRAM shipment revenue has grown at a much greater rate than U.S. shipment revenue since 1978: 42 percent compounded annually versus 7.6 percent in the United States. With only three U.S.-owned DRAM manufacturers remaining, U.S. users of leading-edge memory devices acquire an increasing share of the product offshore--principally from Japan.

For the early generation memory devices such as the 4K and 16K DRAMs, the United States held the dominant market share. However, the Japanese cornered the market in such later generations as the 64K and 256K DRAMs. At the time of their introduction, the Japanese held 100 percent of the market shares; they have maintained their dominant position throughout the production of these devices. In the 1M DRAM market, the Japanese maintain a worldwide market share of 98 percent.

* This paper is based in large part on a report prepared for the International Trade Administration, U.S. Department of Commerce, by Quick, Finan & Associates of Washington, D.C. in October 1988.

Chart 10

MOS Memory World Market Share



Source: Dataquest

Chart 11
Worldwide MOS Memory Market Share of Sales

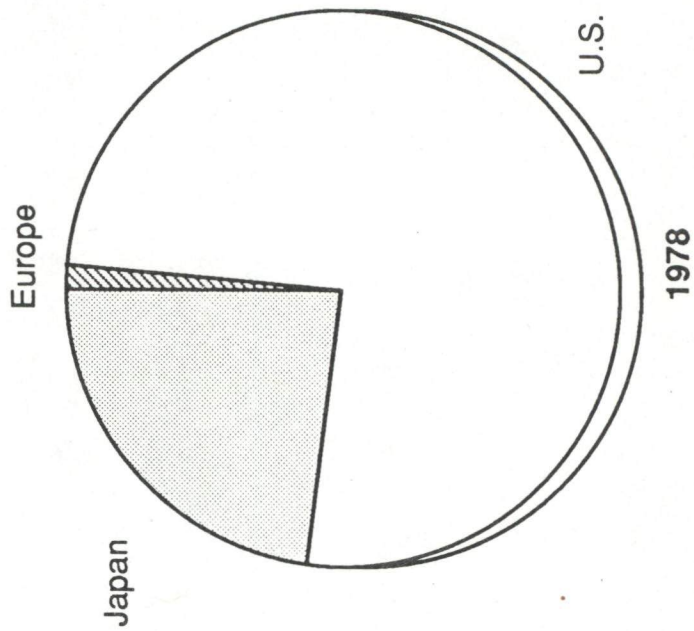
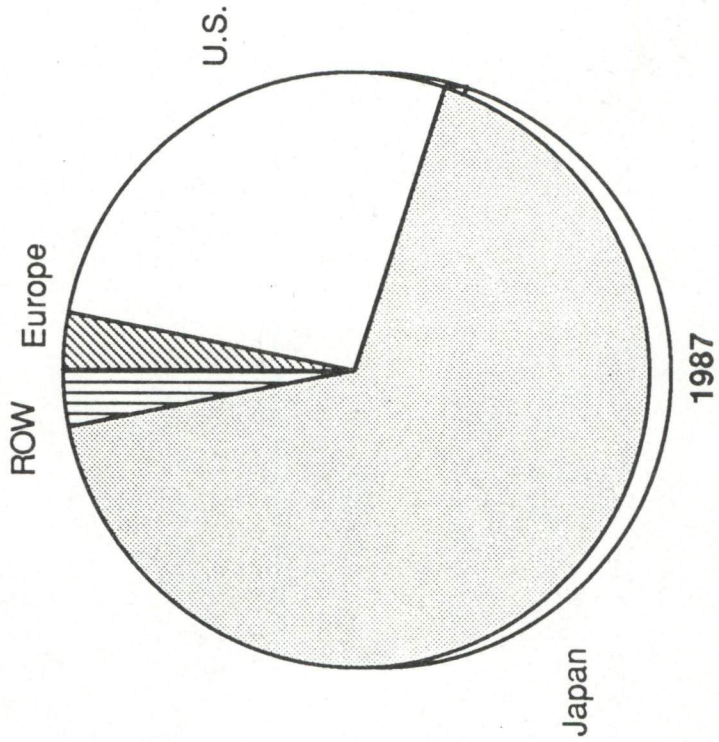
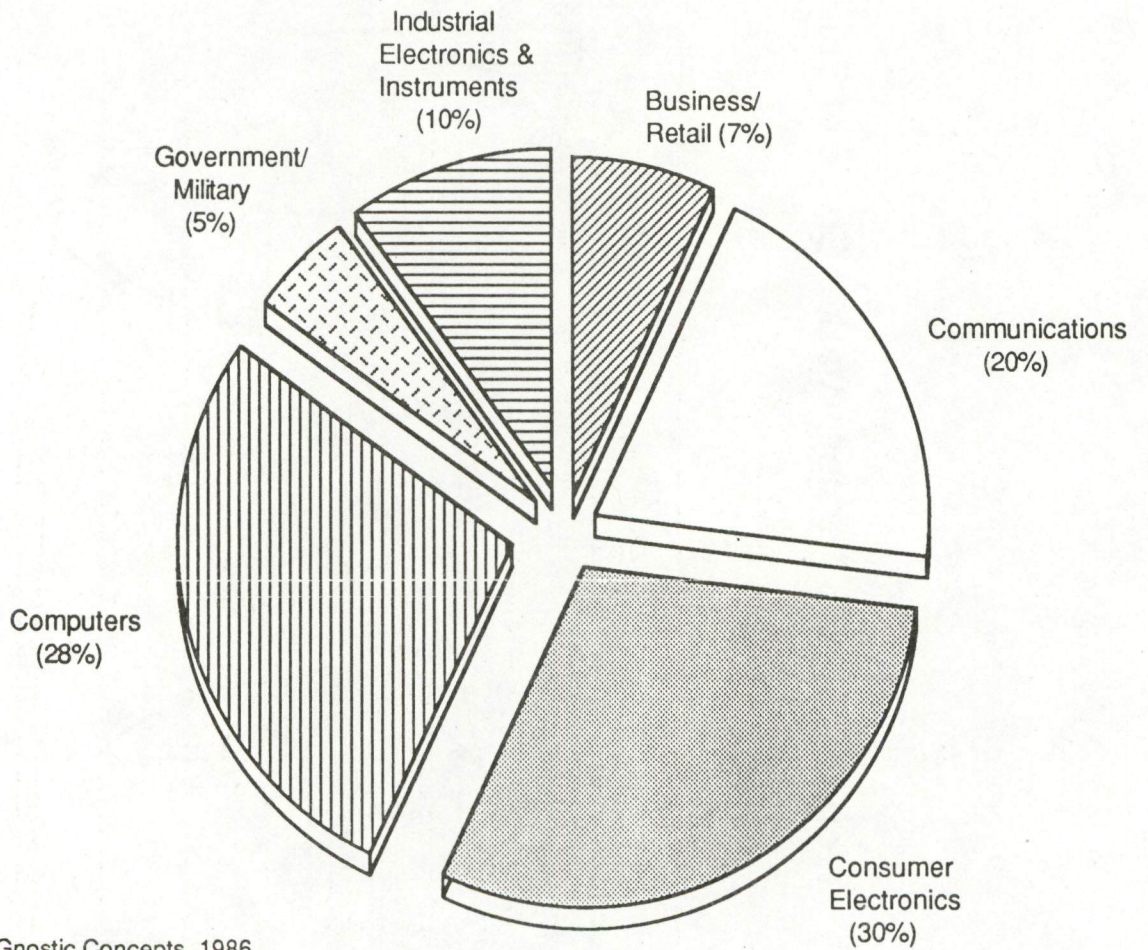


Chart 12

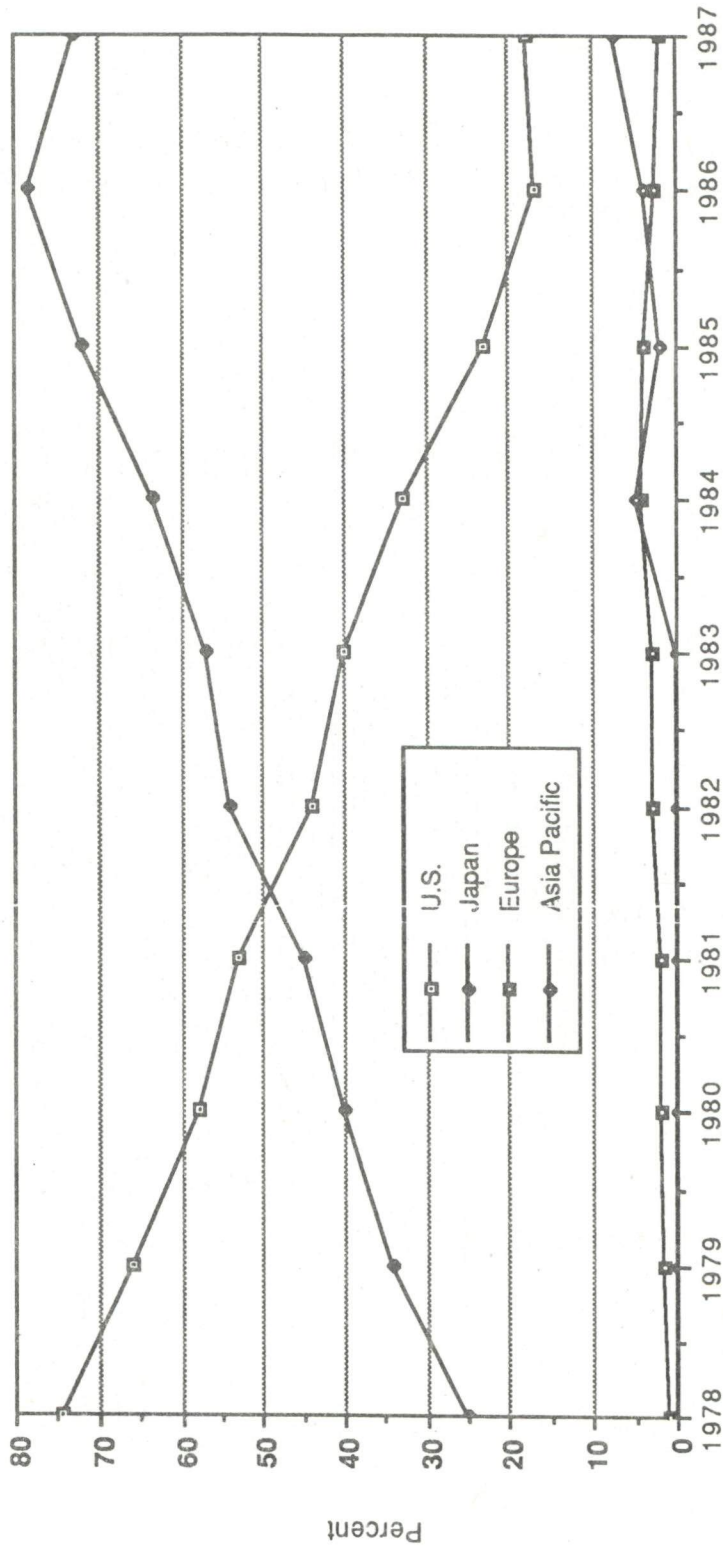
1987 Worldwide DRAM Demand By End-Use Product Type



Source: Gnostic Concepts, 1986

Chart 13

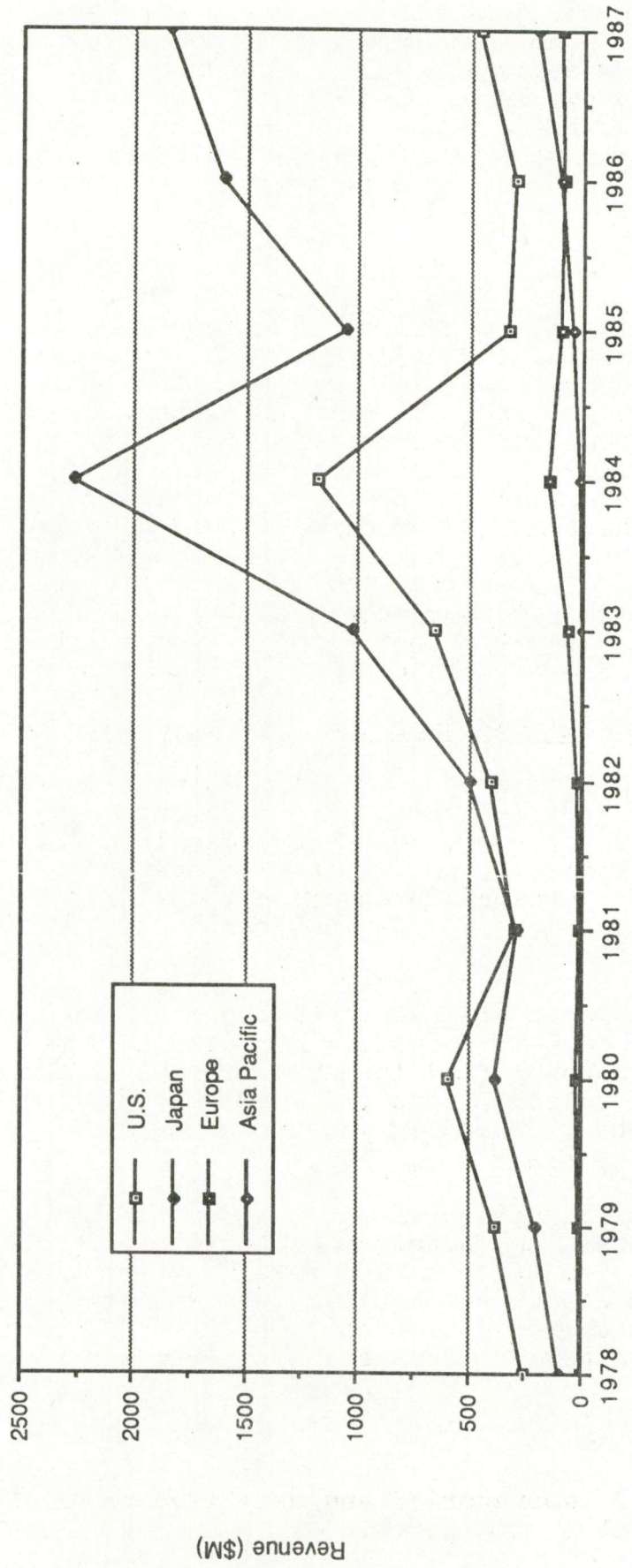
DRAM Market Share



Source: Dataquest

Chart 14

DRAM Revenue by Region of Production



Source: Dataquest

The Japanese and U.S. firms are now vying for the technological lead in newer generation devices. The successor to the 1M, the 4M DRAM, is not yet in volume production, so a market leader is not yet established. At least three Japanese firms and one U.S. company, Texas Instruments, are in the early sampling stages for these DRAMs. In December 1988 Texas Instruments and a major Japanese DRAM producer, Hitachi Ltd., entered an agreement to develop a future-generation memory product, 16M DRAMs.

JAPANESE COMPETITIVENESS

Several factors contribute to Japan's ascendancy in the global memory market, and by implication, the decline of the U.S. memory production. These factors include the Japanese semiconductor industry structure, the role of the Japanese Government, and macroeconomic considerations. In addition, the growth of the Japanese market, which is the world's largest market for all types of semiconductors, helped erode U.S. market share. U.S. producers would have welcomed this growth, had they been able to supply the Japanese market with their products. In contrast to their U.S. counterparts, Japanese memory producers thrived on a stable source of unit demand. The U.S. firms were not, and still are not able, to penetrate the Japanese market to any significant extent.

Japanese Semiconductor Industry Structure

Japan's semiconductor industry is more integrated than the U.S. semiconductor industry. Its horizontal and vertical integration can provide advantages in gaining market share and a technological lead. With more captive production in Japan (a degree of vertical integration), a Japanese in-house producer is more likely to supply devices than a U.S. merchant producer.

The vertically integrated Japanese firms that dominate Japanese memory circuit (and semiconductor) consumption also dominate memory (and semiconductor) production, and some develop semiconductor materials and equipment in-house. These close, vertical relationships prove important in developing and implementing manufacturing techniques needed to sustain competitiveness.

A degree of horizontal integration has helped the Japanese gain and maintain the significant market share in their home market. For example, "keiretsu" ^{1/} member companies favor the products of other members of the Keiretsu, thereby reducing the opportunity for U.S. producers to supply memory circuits and semiconductors to Japanese end-use markets.

The Role of the Japanese Government

Programs sponsored by the Japanese Government have featured joint R&D laboratories and extensive collaboration among industrial participants. Japan's Ministry of International

Trade and Industry (MITI) was an active sponsor in the VLSI (very large scale integration) project, which was begun in the mid-1970s. According to a federal interagency staff working group, "The major factor in Japan's success in VLSI development was that it put its R&D efforts on the footing of a national project, in which government and industry worked together, at a much earlier date than the United States or European countries did." 2/

Due to the commercialization of process and device technology developed in the MITI VLSI project, Japan eventually captured about 70 percent of the world market for the 64K DRAM device. This was a major setback for the U.S. memory producers who previously dominated the world DRAM market.

Implications of these Factors

With adequate funding available due to the strong and visible presence of the government and the keiretsu along with a profitable domestic market, Japan reinvested in the production of all semiconductor devices. Japanese producers' aggressive capital and R&D investment policy enabled them to accelerate new product introductions; in fact, the Japanese were the first to market the 64K and 256K DRAMs. Early market entry is critical to memory device producers, since relative cost advantages accrue to the firm reaching a given production volume first. U.S. firms, faced with waning demand and Japanese pricing pressure, were forced to curtail investment.

Intense capital spending has also enabled the Japanese to expand capacity substantially, even during market downturns. Japan's capacity levels in manufacturing have enabled it to sell memory devices (and other commodity devices) at prices so low that the United States cannot easily compete. With excess capacity, Japan gained substantial worldwide market share through low-cost production.

MACROECONOMIC FACTORS

In addition to factors specific to the semiconductor industry, macroeconomic factors have contributed to the shift in memory competitive advantage from the United States to Japan. Factors that influence the competitive advantage to varying degrees are the exchange rate, the national savings rate, the cost of capital, human capital, and cultural differences.

In the early 1980s, when the dollar was high relative to the yen, the Japanese were able to increase their sales at home and abroad. Since the fall of the dollar in 1986, Japanese producers elected to offset exchange rate changes through price reductions rather than lose market share.

With a savings rate higher than most other countries, including the United States, Japan has a pool of savings, which allows for high rates of capital investment in DRAM production. The

availability of capital and high rates of investment in the semiconductor industry enable higher yields and greater equipment-use rates, thus lowering unit costs.

The savings pool also relates to the cost of capital, a factor that is much debated in the discussions of DRAM competitiveness. The availability of capital affects the cost of capital because the Japanese Government has significant discretion in the control of investment funds. As a recent report written for the U.S. Department of Commerce notes, "Most analysts conclude the relative cost of capital is lower for Japanese firms, including semiconductor firms, than for U.S. firms. But there is far from a consensus on the size and importance of the gap. The relevance of this difference in the cost of capital is its translation into a competitive advantage for capital intensive sectors, such as semiconductors, through capacity expansion and the selection of relatively more capital intensive manufacturing methods." 3/

Human capital also plays a role in competitiveness. As Japan began its challenge of the U.S. position in DRAMs, Japan benefited from a low-cost, high-quality labor force. Due to Japan's promotion of education, Japan's semiconductor industry has a highly skilled work force, critical to developing Japanese advantage in the manufacturing process. Japanese management's widely asserted long-term view emphasizing market share rather than profitability may also contribute to Japan's competitive position in the DRAM industry.

ECONOMIC FACTORS RELATING TO MEMORY PRODUCTION

Besides the above-noted factors, economic factors also impact the structure and participation of the memory market. These are discussed below.

Learning Economies and Scale Economies

Early market entry is critical to the success of memory device producers, as cost advantages accrue to the first firm reaching a given production volume. As production experience (measured by cumulative unit volume) rises, unit costs decline rapidly in the early part of the product life cycle. This exemplifies the learning curve in DRAM production. Scale economies are gained by firms operating at full capacity, since costs of production can be spread across more units. These factors hold significant implications for U.S. companies. When faced with waning demand and Japanese pricing pressure, U.S. firms had to cut their investment. Eventually, their learning and scale economies diminished.

Entry Barriers/Other Factors

The complexity of the memory manufacturing process is a significant entry barrier, since it is based upon state-of-the-art design and production technology. Potential

market entrants must also weigh substantial capital investment outlays with the prospect of losses, such as those incurred over the life cycles of the particular products, such as 64K and 256K DRAMS.

Supply/demand imbalances and external benefits, both associated with production of memory devices, also impact the participation and structure of the market. The external benefits include the fact that memory devices serve as technology drivers, forcing production of leading-edge, cost-competitive products, and employing technologies used to produce other products. In addition, the mutual dependence between memory producers and users has consequences for memory producers. Offshore memory producers are typically part of highly diversified firms, producing computer equipment and consumer electronics. If offshore suppliers withhold leading-edge memory devices from the United States, or sell them in limited quantities or at inflated prices, they can hurt the competitiveness of downstream U.S. industries. Loss of market share in the memory market may also hurt U.S. equipment and material suppliers, engineering expertise, and institutions conducting basic and applied research in semiconductor process/product technology.

Overcapacity, Declining Prices, and U.S. Government Investigations -- 1985 to Present

The year 1985 was marked by severe overcapacity and associated price declines. To keep equipment and production lines running, Japanese manufacturers sustained high production levels, and witnessed a smaller decline in factory shipments (about 9 percent in value) than did U.S. firms (a 30 percent decline). Memory prices, led by the price of DRAMS, plummeted, with both 64K and 256K DRAMS reaching lows of under \$1.00. On the basis of reports that Japan was selling its memory devices in the United States at less than fair value, the U.S. Government in 1985 instituted antidumping cases on the Japanese imports.

The difficult market conditions, including dumping by Japanese firms, altered the U.S. semiconductor industry. Two major U.S. semiconductor firms, Advanced Micro Devices and National Semiconductor, aborted plans to sample and manufacture two types of DRAM devices in volume. The pricing situation also encouraged another U.S. company, Intel Corporation, to focus on a stable niche in the memory marketplace, rather than on a mainstream device. Pricing considerations led Mostek, formerly the second largest U.S. DRAM producer, to withdraw from the market. Texas Instruments and Micron Technology were the only 2 of the 12 U.S. merchant DRAM manufacturers to survive the Japanese dumping strategy. Only Motorola has reentered the market since 1985--through an agreement with Toshiba. 4/

In 1985 antidumping cases were filed on the following memory devices from Japan: 64K DRAMS, 256K and above DRAMS, and erasable programmable read-only memories (EPROMs). Eventually,

antidumping duties were assessed on imports of Japanese 64K DRAMs. As part of the 1986 U.S.-Japan Semiconductor Trade Arrangement, the United States suspended the antidumping investigation of EPROMs and 256K and above DRAMs.

The arrangement also addressed the problem of lack of foreign access to the Japanese semiconductor market. Besides suspending the two antidumping cases, the arrangement suspended the U.S. Government's Section 301 investigation, a key objective of which was to open the Japanese market to foreign semiconductors.

The arrangement and the antidumping monitoring system, which arose from the arrangement, stemmed the Japanese dumping of EPROMs and DRAMs in the U.S. market. However, Japanese dumping of memory devices in third country markets ended only after the President imposed sanctions against certain Japanese imports. Due to foreign suppliers' continued lack of access to the Japanese semiconductor market, tariffs on \$165 million worth of Japanese imports remain in effect.

FORCES ACTING ON INDUSTRY STRUCTURE

The DRAM market will generally remain the domain of the high-volume, commodity chip manufacturer. For such large-scale operations, the following factors will shape the operating environment:

- o To obtain an adequate return on capital, some of the current producers will exit the market, because investment costs are growing faster than projected revenues.
- o Some firms will have to pay royalties to utilize the key technologies. Firms not controlling the technologies must have other advantages to offset the cost of paying royalties. This may limit future entry.
- o Economies of scale will play an increasingly greater role. Some firms are contemplating larger scale production facilities, as measured by the number of wafers started per month. With new facilities, investment costs would increase as firms purchase new equipment capable of producing not only larger wafer sizes, but also smaller line geometries.

These conditions indicate that the number of companies producing DRAMs may decline in the future.

However, Japanese and U.S. DRAM producers must also keep a watchful eye on the South Koreans and Taiwanese who are striving to gain market position in the memory market. With additional players, excess capacity may well emerge in the 1990s. Due to the Koreans' experience as contract producers for some American firms, many are now independent merchant producers. Currently, the Koreans are limited by: 1) the lack of manufacturing disciplines related to the cutting-edge

technologies and 2) the fact that key DRAM technologies are under patent by Japanese and American firms. The Taiwanese are now building one large memory facility and have another under contract.

IMPLICATIONS FOR U.S. COMPETITIVENESS

Increasing U.S. DRAM Production

The prospect of losing its DRAM production capability has forced the U.S. electronics industry, both semiconductor users and producers, to consider its strategy for remaining competitive. In January 1989 the Joint Steering Committee of the American Electronics Association and the Semiconductor Industry Association endorsed an initiative to develop a proposal to spur new DRAM production in the United States. This initiative was followed six months later by an announcement that a \$1 billion DRAM manufacturing consortium, U.S. Memories, would be formed. However, in January 1990, the consortium was closed due to insufficient capital funding.

Loss of Memory Production Capability

As mentioned earlier, DRAMs drive a broader range of technology. Foreign firms utilizing DRAM technology as a driver may increasingly threaten the U.S. position in other memory markets, as well as other product lines. For example, nonmemory products such as application specific integrated circuits (ASICs) and microprocessors development may be slowed if more firms withdraw from memory markets.

Losing memory production capability may also have national security implications. To meet military needs, the United States must increasingly rely on foreign producers of leading-edge memory devices. This poses the risks of: 1) supply disruptions, not only of memory devices but also the technology used in their manufacture and 2) the loss of semiconductor process and product technology.

Marguerite Markey
Office of Microelectronics and
Instrumentation

Footnotes

- 1/ Keiretsu refers to the large Japanese groups of firms tied together by interlocking directorates, by some cross-ownership of each other's stocks, and by regular meetings of chief executive officers. The keiretsus are particularly beneficial during a downturn, as they reduce a company's risk.
- 2/ Quick, Finan & Associates, Semiconductor Case Study: Memory Market, a report prepared for Science and Electronics, International Trade Administration, U.S. Department of Commerce, October 1988, p.54.
- 3/ Ibid., p. 63.
- 4/ Ibid., p. 79.

Appendix B

Workstation Case Study

Introduction and Overview

The workstation area of the computer industry exhibits many characteristics of the electronics sector as a whole. A new multibillion dollar market has grown from a need recognized by a handful of dynamic computer entrepreneurs. These risk-takers, with their talent for systems design, used existing technologies to create and commercialize innovative products. This activity has stimulated growth in the computer industry. It has also given scientists and engineers throughout electronics new tools to increase their productivity and develop their own new products and markets.

The sector's rapid growth has attracted larger, more established computer manufacturers, intensifying an already high level of competition based on price and technology. Among the recent entrants are Japanese computer firms, which are leveraging their strengths in electronics manufacturing and financial resources.

Nine years after the first workstation hit the market in 1981, some of the companies that started the sector are still its leaders. They have grown to be multi-million enterprises, serving a global market whose potential remains virtually untapped. High levels of R&D and a rapid rate of product innovation have kept them ahead of their larger, more diversified competitors. But are these advantages enough to sustain their growth over the long term? The innovation edge that they currently have may be eroded by larger U.S. and Japanese firms that have resources to develop or acquire the latest technology. These smaller firms and the U.S. workstation sector as a whole face a growing dependence for critical components from the same Japanese suppliers that they compete with in the workstation marketplace. Several other crucial questions need to be answered in the future. Will they also be forced to give up their system design and software secrets for these key components and, as a result, their only remaining competitive advantage?

Definition

Workstations are single-user, high performance computer systems, with advanced graphics capabilities, whose principal use has been in computationally intensive scientific and engineering applications. A basic 32-bit desktop system includes at least 4 million bytes of semiconductor memory, a large, high resolution, monochrome or color monitor, and has sophisticated software to handle more than one task at a time and communication with other computers (networking), at a price of about \$5,000. At the high end, a new class of 64-bit workstations, called graphics supercomputers, was introduced in early 1988, with a price tag of around \$100,000.

Price and performance distinctions between workstations and other types of computer systems are blurring at both the low and high ends of the market (see Chart 15). Entry level systems have experienced a 60-fold reduction in price since 1981, placing them in the cost range of personal computers. At the same time, high-end personal computers from Apple, Compaq and IBM have begun to match the performance of these entry-level workstations. At the high end of the workstation wedge, superworkstations have shown a 70-fold increase in performance over the past six years, placing them in the realm of superminicomputers (see Chart 16).

These dramatic improvements in the price and performance of workstations are expected to continue over the next five years. By 1993, entry-level workstations will have the power of some of today's mainframes, for under \$2,000. At the high end, graphics supercomputers could have five times the performance of the most powerful mainframes available today.

Markets

Workstation pioneers exploited a growing need for low-cost high performance computing in science and engineering during the early 1980s. At that time, personal computers lacked many of the capabilities--such as high processing speed, large memory, and a high resolution display--necessary for these tasks. Minicomputers had these capabilities, but they were too bulky and expensive to dedicate to a single user. The first workstation products bridged this gap.

Workstation suppliers initially targeted two markets where they felt their systems could be used as tools to speed up design, analysis and testing in hardware and software development, while dramatically lowering costs. At the high end, Apollo initially addressed CAD/CAM/CAE (computer aided design/computer aided manufacturing/computer aided engineering) applications, undercutting established minicomputer suppliers. Early uses included printed circuit board and integrated circuit design. At the low end, Sun Microsystems focused on CASE (computer aided software engineering), where cost was the major concern of users.

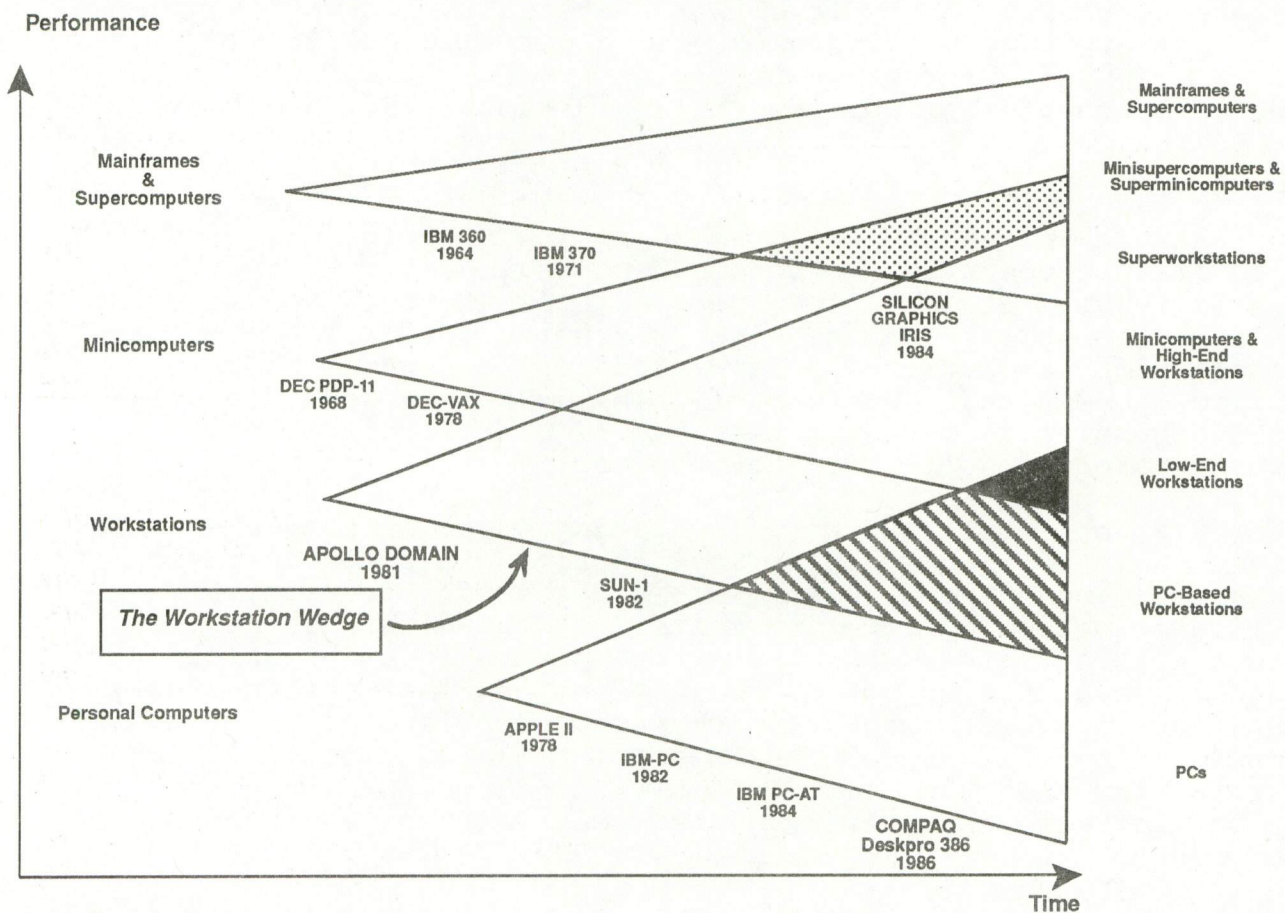
While these two applications still remain their principal revenue sources, traditional workstation suppliers have branched out into commercial markets, such as electronic publishing, financial services, and office automation markets. At the high end, the graphics supercomputer and superworkstation suppliers are emphasizing sophisticated applications in computational chemistry, animation, computational fluid dynamics and image processing.

The potential market for workstations is virtually untapped. Current penetration of the technical market is only about 3 percent of the estimated 8 million scientists, engineers, programmers, and systems analysts worldwide, and demand for

Chart 15

EVOLUTION OF COMPUTER ARCHITECTURES

Recent Fragmentation by the Workstation Wedge



Source: Apollo Computer

Chart 16

SELECTED U.S. WORKSTATION PRODUCTS: PRICE AND PERFORMANCE

<u>MARKET SEGMENT</u>	<u>ENTRY PRICE</u>	<u>PERFORMANCE RANGE*</u>	<u>COMPANY</u>	<u>MODEL</u>	<u>DATE OF INTRODUCTION</u>
Entry-level	\$5 K **	1 - 2 MIPS	Apollo	DN 3000	2/86
			Apple	MacIntosh II	3/87
			DEC	Vax Station 2000	2/87
			HP	HP 9000 Model 319C	12/87
			IBM	PS/2 Model 80	4/87
			Sun	3/50M	7/87
Mid-range	2-D \$18K to \$20 K 3-D \$30K to 40K	3 - 5 MIPS	Apollo	DN 580	6/86
				DN 4000	8/87
			DEC	Vax Station 3500	9/87
			HP	HP 9000 Model 350	11/86
			IBM	RT/PC 6151	2/87
			Sun	386i/150	4/88
	3/260	9/86			
High-performance	\$50K to \$75K	7 - 14 MIPS	Apollo	DN 590 T	6/87
			DEC	Vax Station 8000	2/88
			HP	HP 9000 Model 825 SRX	6/87
				HP 9000 Model 835 SRX	3/88
			Silicon Graphics	Iris 4D/50	4/88
				Iris 4D/60T	3/87
			Sun	4/110	7/87
	4/260	7/87			
Very high-performance	\$73 to \$100K	10 - 120 MIPS	Apollo	Series 10000 Personal Supercomputer	3/88
		16 - 140 MFLOPS	Ardent	Titan	3/88
	Stellar	GS 1000	3/88		

* Vendor's performance claims

(MIPS = Millions of instructions per second,

MFLOPS = Millions of floating point operations per second)

** Diskless

Sources: Sandy Friedman, "A New Dawn for Workstations," Mini-Micro Systems, May 1988; Morgan Stanley and Montgomery Securities research reports, Datapro Research, and company product literature.

these systems has been mushrooming. In 1987 U.S. suppliers shipped over 113,000 workstations, valued at \$2.5 billion, matching in one year alone the total number of units previously shipped.

Although the United States remains the largest single workstation market in the world, both Europe and Japan have emerged recently as significant sources of revenues for U.S. suppliers. Apollo, Digital Equipment Corporation (DEC), Hewlett Packard (HP), and Sun Microsystems together held a 90 percent share of the \$765 million European market in 1987. Several of these companies have established manufacturing plants there to serve their European customers more effectively and have forged alliances over the past few years with leading European electronics firms such as Ericsson of Sweden and Siemens of Germany to increase their market penetration. In Japan, they faced some competition from Japanese suppliers who have their own well-developed distribution channels, but still managed to gain a 67 percent share of a market worth roughly \$500 million last year, based on their technological superiority. Their long-term prospects in these markets appear less bright. They can expect growing competition in Western Europe and a struggle for control of the Japanese market once their Japanese rivals reach technical parity.

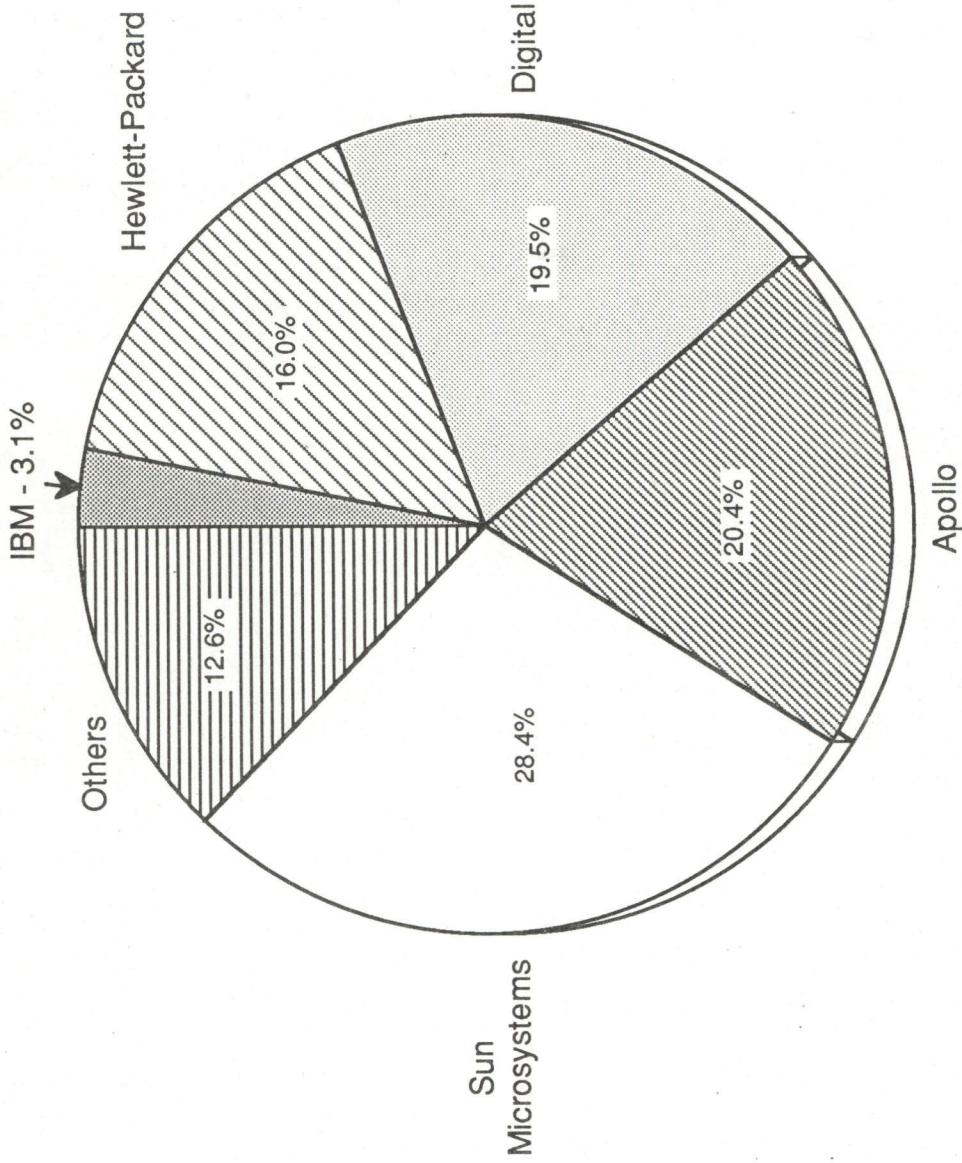
Industry Structure

The U.S. industry is relatively concentrated, with four manufacturers accounting for 80 percent of the revenues and nearly 85 percent of the units shipped worldwide in 1987 (see Chart 17). These four companies offer a broad range of workstations. Apollo and Sun are dedicated workstation suppliers while Digital Equipment and Hewlett Packard produce other types of computers. The remaining major competitors are niche players at present. Silicon Graphics has a strong position in the market for superworkstations, with the first 3-D graphics systems. IBM has begun to challenge suppliers of lower performance workstations with its high-end personal computers. Japanese suppliers may emerge as the U.S. industry's only significant foreign competition. Both NEC and Sony have entered the U.S. market and shipped systems out of U.S. production facilities during 1988. Fujitsu, Toshiba, and Hitachi are other likely entrants.

Entrepreneurial Origins

The U.S. workstation sector embodies the strong entrepreneurial character that has characterized the rest of the electronics industry. Several of the sector's key executives, after gaining management and technical experience at established computer firms, left to form workstation companies. Others in academia were engaged in research on related technologies that they decided to commercialize. For example, Bill Poduska, a MIT graduate and Honeywell alumnus, began his entrepreneurial endeavors by co-founding Prime Computer, then workstation

Technical Workstation Vendor Market Share



1987 Shipments - 113,000 Units

Source: Dataquest

pioneer Apollo, and most recently graphics supercomputer supplier Stellar Computer. Sun Microsystems founders came from Berkeley, Stanford, and Xerox's renowned Palo Alto Research Center (PARC).

Introduced in February 1982, the Sun-1 was an outgrowth of a Stanford doctoral project, aimed at building a high performance, single-user computer with strong networking capabilities, based on standardized components, software, and communications technologies. This open architecture approach contrasted sharply with the proprietary emphasis of the first workstations. Sun's first operating system was a version of AT&T's UNIX, enhanced by co-founder Bill Joy at Berkeley. The "windowing" software and Ethernet networking technologies were developed at Xerox PARC.

Silicon Graphics has an equally interesting history. After working closely at Stanford with Dr. Ivan Sutherland, considered the father of 3-D graphics, chairman and co-founder James Clark created a proprietary graphics processing chip (called the "Geometry Engine") and introduced the first workstation based on that technology in 1983. He recruited a management team consisting largely of executives from Hewlett Packard and Xerox's Office Products Division to run his fledgling company.

Key Components

A workstation's performance characteristics are partly a result of an unique combination of various components and subassemblies. At the heart of most workstations is a 32-bit microprocessor. The earliest workstation models from Apollo, Sun, and other major suppliers used standard chips from Motorola and Intel to provide scientists and engineers with minicomputer power on their desks. While this trend has continued, some manufacturers over the past few years have introduced systems with increased processing capability that incorporate microprocessors of their own design. Examples include DEC's VAX 8250, Hewlett Packard's Precision Architecture, and Sun SPARC chips.

SRAMS and DRAMS (static and dynamic random access memories) are critical to satisfying the substantial internal memory required to handle multitasking and sophisticated applications programs. These chips currently represent up to 25 percent of the total cost of a workstation.

The exceptional graphics performance of these systems over personal computers is due to high-speed, bit-mapped color displays with extremely high screen resolutions in the megapixel range. At the high end, superworkstations and graphics supercomputers perform real-time, 3-D modeling and simulation through the use of video RAMS and dedicated graphics procesors based on custom chips.

Systems software and networking are other important elements in workstation performance. Suppliers offer extensive software programs, including operating systems that manage the interaction between semiconductor and disk-based storage and support the processing and viewing of more than one task at a time; sophisticated graphics and applications software development tools; and networking software that links users over high speed networks.

Supplier Dependencies

The degree to which workstation suppliers provide their own system elements varies widely. Workstation suppliers such as Sun Microsystems and Apollo, rely heavily on outside sources for components and subassemblies, which they combine in final assembly and testing operations. They feel it is more cost effective to source from specialized, outside producers than to have in-house manufacturing. They argue that they can more profitably direct the investment to R&D that maintains their innovative edge.

By contrast, DEC, HP, and IBM are larger, more vertically integrated suppliers and are less dependent on outside suppliers. To varying degrees, they often produce internally the microprocessors and semiconductor memory, printed circuit boards, power supplies, and certain peripheral units.

Microprocessors and operating systems software are key areas that the United States still has technological leadership over the Japanese (see Chart 18). U.S. workstation firms usually produce microprocessors of their own design or buy these chips from U.S. suppliers. However, several are currently sourcing their internally designed RISC (reduced instruction set chips) microprocessors from Japanese companies that are manufacturing these chips under license. They recognize that the Japanese are important players due to their prowess in semiconductor manufacturing technology.

Operating systems, whether proprietary or UNIX derivatives, are developed in-house along with other kinds of system software. This software is not only a competitive advantage for U.S. workstation suppliers over their Japanese competitors, but it is also regarded as a primary contributor to the value that they add to a workstation system.

Much of the highly competitive workstation market is solutions oriented, i.e., users expect suppliers to offer "one stop shopping"--complete systems (equipment and software)--tailored to their needs. To meet this demand, many suppliers depend on third-party software houses to develop applications software for their systems, e.g., CAD/CAM, CASE. U.S. companies depend upon third-party suppliers to develop applications software worldwide, but source the bulk of their software from U.S. companies.

CHART 18

U.S. Versus Japanese Competitive Advantages

<u>Competitive Advantage</u>	U.S.	Japan
1. Hardware Design:		
Overall system	X	
Critical Components		
- Microprocessors	X	
- Graphics processors	X	
- Buses	X	
- Random access memories		X
- High resolution displays		X
2. Software Development:		
Systems software		
- Operating systems	X	
- Communications	X	
- Graphics	X	
- Applications development	X	
- tools		
3. Manufacturing Process Technology:		
Overall system	X	X
Critical components		
- Semiconductors		X
- Displays		X
4. Distribution Channels:		
Direct to end user	X	
OEMS	X	
VAR/Dealers	X	
Distributors	X	

In other component and subassembly areas, the dependence of the U.S. industry has been growing. U.S. manufacturers obtain a high percentage of their DRAMS and all of the color monitors used in their workstations from Japanese suppliers. Monochrome displays come from subsidiaries of Philips of the Netherlands in Canada and Italy. Several executives in these companies claim they would like to have U.S. sourcing but are concerned about the poor quality of American-made color monitors and the lack of interest among U.S. semiconductor houses in producing DRAMS to their specifications. Their dependence on the Japanese for high performance disk storage is lessened by the availability of such products from U.S. suppliers, many of whom produce offshore in Singapore and Mexico.

Standard Versus Proprietary Technology

Early workstation models from Apollo, Daisy Systems, and Valid Logic were designed as closed system architectures using proprietary operating systems, graphics, and networking technologies. This situation began to change in late 1982 when Sun Microsystems entered the market, promoting the concept of an open system architecture that would allow workstations to connect to a wide range of equipment and to run applications software written for other systems. Today the battle among workstation suppliers over standards has created some confusion in the marketplace and raised questions about the advantages and inherent dangers in promoting standards over proprietary technologies. Microprocessor and operating systems have become the principal focus of this standards activity thus far.

In the microprocessor arena, standard complex instruction set chips (CISC) from U.S. semiconductor houses remain the microprocessors used in most of the U.S. and Japanese workstations (see Chart 19). RISC microprocessors have been designed by Apollo, HP, IBM, MIPS, and SUN over the past few years, but are currently used in superworkstations and graphics supercomputers. However, there are signs that the RISC architecture may replace CISC in the near future. Some U.S. suppliers have expressed considerable interest lately in promoting their proprietary RISC designs as industry standards and incorporating this technology eventually throughout their product line.

Some of this RISC technology has been licensed to several U.S. and Japanese semiconductor houses to create second sources for these chips, to stimulate competition among suppliers to produce the fastest microprocessor, and to obtain the lowest cost chips. Through these arrangements they aim to lower production costs at the systems level. Other workstation suppliers are concerned that these arrangements constitute the transfer of critical technology to competitors, particularly to Japanese firms that lag behind the United States in microprocessor technology but are working feverishly to close the gap.

CHART 19

Major Workstation Microprocessor Architectures

<u>Company</u>	<u>Microprocessor</u>	<u>Architecture</u>	<u>Workstation Vendors</u>	<u>Selected Workstation Products</u>
DEC	Micro VAX 78032 CVAX 78134 VAX 8250	CISC CISC CISC	DEC	VAX Station 2000 VAX Station 3000 VAX Station 8000
Intel	80386	CISC	IBM NEC Sun	PS/2 Model 80 ND5311 Sun 3861 Model 150
Motorola	68020	CISC	Apollo Apple Fujitsu FACOM HP NEC Silicon Graphics Sony	DN 3000, 4000, 580, 590 MacIntosh II SIGMA Station HP 9000 Model 300 Series EWS 4800 Models 10, and 50 IRIS 3000 Series NEWS 711 and 841
Apollo	PRISM	RISC	Apollo	Series 10000 Personal Supercomputer
Hewlett Packard	Precision Architecture	RISC	HP	HP 9000 Models 825 and 835 SRX
IBM	ROMP	RISC	IBM	RT/PC 6151
MIPS	R 2000	RISC	Ardent Silicon Graphics	Titan Series IRIS 4D Series
Sun	SPARC	RISC	Sun	Sun 4 Series

Sources: Datapro Research and company product literature.

Although Apollo and DEC proprietary operating systems have large customer bases, AT&T's UNIX has rapidly gained strong support in the workstation market in recent years, with virtually every supplier offering its own version. However, rather than a defacto standard emerging, which would allow software compatibility across the workstation spectrum, the result is a proliferation of incompatible versions of UNIX. An effort to create a standard version of UNIX had led to the emergence of two separate camps in the U.S. workstation sector. One is an alliance between Sun and AT&T to develop a UNIX version around Sun's RISC microprocessor (SPARC) architecture. The other is a UNIX development consortium called the Open Systems Foundation which was informed in mid-1988 under the leadership of Apollo, DEC, HP, and IBM.

The lack of a UNIX standard may offer the Japanese an opportunity to become players in the competition to establish a standard operating system for workstations. Recognizing their weakness in software, the leading Japanese computer manufacturers have been emphasizing software R&D. For example, since 1985, the Software Industrialized Generator and Maintenance Aids (SIGMA) project, jointly funded by the Government Japanese and industry, has focused on developing a Japanese version of UNIX. This version will include software development tools, data base and networks. The project has already produced a workstation.

Since 1984, a second Japanese effort, TRON (The Real-Time Operating System Nucleus), has developed a family of operating systems and related 32-bit and 64-bit microprocessors. The operating systems will have versions dedicated to uses in industry, business, and communications. Japanese companies have begun producing the first TRON 32-bit microprocessors, which can also run UNIX. One of the first products anticipated from the TRON effort is a 32-bit workstation. As a consequence of these two R&D programs, the Japanese could enter the U.S. workstation market with yet another version of UNIX or the TRON system, incorporating their own microprocessors.

Marketing and Distribution

As in other sectors of the electronics industry, workstation suppliers use a variety of distribution channels to market their products: direct sales forces, OEMs (original equipment manufacturers), VARs (value added resellers), and industrial and retail distributors.

Workstation firms originally emphasized direct sales forces and OEMs to focus on serving the technical user. But competitive pressures and technological developments have caused them to enter commercial markets and begin to build up VAR channels. Such alliances have played an important role in the industry's recent moves into new end-use sectors such as aerospace, financial services, home building and telecommunications. They have also greatly expanded their presence in Western Europe

and Asia through marketing and manufacturing agreements with major foreign partners (see Chart 20).

Access to these other distribution channels is a critical competitive factor for these suppliers if they are to continue to grow by reaching smaller accounts and penetrating new commercial markets. This is particularly true in any competition with leading personal computer manufacturers that already have highly developed commercial VAR and retail distributor channels.

In early 1988, the Japanese launched a concerted effort to penetrate the U.S. workstation market and targeted the CAD/CAM/CAE, software development, and electronic publishing sectors. They are concentrating on the price sensitive commodity end of the market where they can use their strength as high volume, low cost producers. They will eventually migrate into the higher performance sectors as they acquire some of the technologies that they need through licensing, joint development agreements, and minority investments in U.S. component and system suppliers.

In addition to suffering from a lack of applications software, the Japanese have few established distribution channels for their products. Their software offerings total no more than a few hundred applications packages compared to more than 1,000 each for Apollo and Sun and roughly 6,000 for DEC's VAX stations. They must convince advantages of their workstations outweigh the lack of applications software.

The Japanese are working hard to overcome these obstacles and have the financial resources to buy into this market. Several companies are actively recruiting independent software houses in the United States to develop a wide range of applications software for technical users. Another Japanese supplier has established in-house development projects using U.S. and European programming. In addressing their distribution weaknesses, the Japanese have decided not to begin with direct marketing in the United States. For example, NEC plans to go through the 1,000 U.S. VARs that carry its personal computer lines since a high percentage of them currently sell into technical markets. As a new entrant to the computer systems business, Sony must start from scratch to build a U.S. distribution and customer support network. In May 1988, Symbolics, a U.S. artificial intelligence computer supplier, signed a \$60 million, three-year contract with Sony to become a distributor of Sony's NEWS workstations.

Outlook for the U.S. Workstation Sector

Recognizing the challenges facing them in the 1990s, U.S. workstation manufacturers are convinced that the key to continued competitiveness is to maintain their technological edge. R&D budgets average 12 percent of total revenues annually to support this lead. As a result, U.S. workstation

CHART 20

Major Strategic Alliances of U.S. Workstation Suppliers

<u>Type of Alliance</u>	<u>Number of Partnerships</u>	<u>Selected Examples Partnerships</u>	<u>Comments</u>	
Technology Licensing Agreements	1 - India	Apollo/HCL, Ltd	Kit assembly for Indian market	
	2 - PRC	Apollo/Shanghai computer market	Kit assembly for Chinese market	
	4 - Japan	Apollo/Fujian computer factory Apollo/Toshiba; Ardent/Kubota;	" "	
	10 - U.S.	Stellar/Mitsui; Sun/Fujitsu Sun/BIT/Cypress/LSI Logic; Sun/Microsoft	RISC microprocessor and workstation manufacture RISC microprocessor manufacture System software development	
Technology Development Agreements	1 - Japan	SAE, Inc./Matsushita	64-bit microprocessor and workstation	
	7 - U.S.	DEC/Evans & Sutherland Sun/AT&T/Microsoft	Graphics systems Systems software	
Marketing Agreements	1 - Italy	Sun/Olivetti USA	Legal and medical markets	
	1 - Sweden	Sun/Ericsson	CAD/CAM/CAE	
	1 - West Germany	Apollo/Siemens	CAD/CAM/CAE; CASE	
	1 - Netherlands	Apollo/Philips	CAD/CAE	
	2 - France	Sun/Matra	CAD/CAM/CAE	
	2 - United Kingdom	Sun/ICL	CIM and public administration	
	6 - Japan	Apollo/Mitsubishi Electric; Ardent/Kubota, Stellar/Asahi Chemical;	CAD/CAM/CAE; CASE Computational chemistry; molecular modeling; fluid dynamics	
	22 - U.S.	Sun/Toshiba Apollo/Mentor Graphics DEC/McDonnell Douglas Sun/Daisy Systems	CAD/CAM/CAE; CASE CAE CAD/CAM CAE	
	Minority Investments	2 - Japan	SAE/Matsushita Ardent/Kubota	\$10 million investment 25% investment from Kubota
		3 - U.S.	Silicon Graphics/Control Data Sun/AT&T	20% investment from CDC Up to 20% investment planned

manufacturers they have accelerated the rate at which they develop and introduce new products to the market, reducing this period to only six months for lower performance workstations and around two years for high end models.

More generally, Chart 18 compares competitive advantages of U.S. and Japanese workstation suppliers, from hardware design through distribution channels. U.S. firms currently are quite strong in most areas, lacking only access to or manufacturing prowess in certain critical components. Their Japanese rivals have a design advantage only in DRAM's and high resolution displays. Japanese workstations now on the market are considered to be two generations behind U.S. offerings technologically. The rapid pace of U.S. product introductions and shortened product life cycles make it difficult for the Japanese to reduce the U.S. lead.

But the Japanese dominance in the DRAM market poses a problem for U.S. firms since this component plays such a prominent role in workstation performance. If the current shortages of these chips are not alleviated, U.S. workstation suppliers will be severely constrained. Such effects are already evident. Sun Microsystems states that it has lost \$100 million in sales during 198 because of DRAM supply shortfalls. Some U.S. suppliers have stated that they are concerned that they may be forced to transfer proprietary design technology to Japanese suppliers in return for adequate supplies of DRAMs in the future.

While the Japanese have a clear lead in their ability to produce semiconductors and displays, they may not have as strong competitive advantage in manufacturing process technology at the system level. Several U.S. suppliers believe their assembly, testing, and quality control operations match any in Japan. In one U.S. supplier's domestic plant, for example, the assembly of high-end workstations consumes only 90 minutes and half that for low-end models. Testing is so thorough that the company boasts of yields exceeding 98 percent for initial output coming off its assembly lines.

The U.S. industry has a strong hold on distribution channels in the United States, which poses a significant but not overwhelming barrier to the Japanese. In addition, U.S. strength in software is currently unchallenged. But if the Japanese can develop a substantial number of VARs, offering them attractive price discounts, good performance, and high-quality products, they will begin to solve this problem. VARs and third-party software houses will help them overcome their applications software deficiency and become powerful players in the booming workstation market of the 1990s.

Tim Miles
Office of Computers and
Business Equipment

Appendix C

Major R&D Facilities of Foreign Electronics
Companies in the United States

<u>Company</u>	<u>Location of Facility</u>	<u>R&D Activities in Electronics</u>
Cambridge Instruments (U.K.)	Chicago, IL	Semiconductor manufacturing equipment; instruments
Ericsson (Sweden)	Richardson, TX	Central office switching equipment
Nixdorf (Germany)	Santa Clara, CA; Burlington, MA	Computers
	Richmond, VA	Software engineering
Northern Telecom (Canada)	BNR Ann Arbor, MI; Dallas, TX; Mountain View, CA; and Research Triangle Park, NC	Telecommunications network products; PBX systems, integrated data and voice products.
Philips (Netherlands)	Briarcliff Manor, NY	Integrated circuits; computers (AI, multiprocessor architectures, software engineering); HDTV; electronic materials.
SGS Thomson (Italy/France)	Mostek (sub.), Montgomeryville, PA; Carrollton, TX	Integrated circuits
Siemens (Germany)	Research and Technology Labs, Princeton, NJ	High-speed electronic and photonic devices and special IC's for advanced computers and communications equipment; CAD; artificial intelligence (expert systems, machine perception and speech recognition).

<u>Company</u>	<u>Location of Facility</u>	<u>R&D Activities in Electronics</u>
Siemens (Germany) (continued)	Siemens Components, Iselin, NJ	Power MOS-FET wafers; optical sensors; IC's for industrial use (MPUs, micro- controllers), tele- communications and consumer electronics; and memories.
	Siemens Communications Systems, Boca Raton, FL	Central office switching equipment
	Databit (sub.), Hauppauge, NY	Packet switched data network equipment and software. High- speed fiber optic links.
	Crystal Technology (sub.), Palo Alto, CA	Optics
	Siecor (sub.), Hickory, NC	Fiber optics
	Microwave Semiconductor Corp. (sub.), Somerset, NJ	High speed, sub-micron Gallium Arsenide and silicon components
	Hell Graphics Systems, Inc. (sub.), Port Washington, NY	Graphics
Thomson-CSF (France)	Knoxville, TN	Custom integrated circuits for TV's
	David Sarnoff Research Center, Princeton, NJ*	Displays; HDTV; CAD/CAM; integrated circuits; TV receivers; manufacturing technology
	Indianapolis, IN	TV receivers; integrated circuit design; CAD/CAM; VCR and Camcorder; electronic materials

*Owned by Stanford Research Institute and on contract to Thomson.

<u>Company</u>	<u>Location of Facility</u>	<u>R&D Activities in Electronics</u>
Thomson-CSF (France) (continued)	Lancaster, PA	TV components
	Los Angeles, CA	Software
Canon (Japan)	Lake Success, NY	Desktop publishing and workstations (1988)
Epson (Japan)	Epson Technology Center, Silicon Valley, CA	Personal computers (1988)
Fujitsu (Japan)	Fujitsu Microelectronics, Boston, MA; Dallas, TX; Santa Clara, CA	Custom gate array design
	Fujitsu Business Communications Systems Anaheim, CA	Voice and data communications
	Fujitsu America, Longmont, CO	Disk storage devices (1989)
	Fujitsu Systems, San Diego, CA	Software engineering
Hitachi (Japan)	Hitachi Microsystems, San Jose, CA	Software engineering; design and engineering support
	Detroit, MI	Electronic components for automotive use (1989)
	San Francisco, CA;	Semiconductors (1989)
	Boston, MA	Software and workstation development (1989)
Matsushita (Japan)	Microelectronic Technology Corp., Palo Alto, CA;	Integrated circuits
	Santa Barbara, CA	Speech acoustics
	Burlington, NJ	Video broadcasting
	Woodwide, IL	POS terminals; computers (1987)

<u>Company</u>	<u>Location of Facility</u>	<u>R&D Activities in Electronics</u>
Mitsubishi (Japan)	Horizon Research, Boston, MA	Computers
NTT (Japan)	Photonic Integration Research	Optical integrated circuits (1987)
NEC (Japan)	NEC Information Systems, Boxboro, MA	Workstations
	NEC Home Electronics, San Jose, CA	Laptop personal computers
	NEC Home Electronics, Natick, MA	Semiconductors (ASICS) (1987)
	NEC Research Institute, Princeton, NJ	AI (1989)
Ricoh (Japan)	American Software, San Jose, CA	Software
	Advanced Technology, West Caldwell, NJ	Office automation (1987)
	San Jose, CA	Semiconductors (1989)
Sharp (Japan)	Vancouver, WA	Semiconductors (1988)
Sony (Japan)	Sony Technology Engineering Operations, San Jose, CA	HDTV
	Sony America, San Diego, CA	TV components
	Sony Telecommunications Technology Center, Paramus, NJ	Telecommunications
TDK (Japan)	Components Engineering, Torrance, CA	Microwave-related components

Sources: Dataquest, Inc., The Structure of the Japanese Electronics Industry, Technomic Dodwell Consultants, Tokyo, Japan, December 1988; and company annual reports.

Tim Miles
Office of Computers and
Business Equipment

Appendix D

SEMATECH

In 1987, a group of chief executive officers (CEOs) from leading U.S. semiconductor production companies agreed that the rapid erosion of the U.S. semiconductor industry's market was a threat to the survivability of that industry and to the long-term competitiveness of the U.S. electronics sector. That group of CEOs, led by Charles Sporck of National Semiconductor, also agreed that while unfair trading practices by leading foreign producers had been a major cause for this market erosion, high costs and duplication of research and development efforts coupled with the U.S. industry's lack of focus on improved semiconductor processing technologies, had also been major contributors to the U.S. industry's decline. In order to reverse that decline, the group decided to establish a center that would concentrate on improving semiconductor manufacturing processing and where companies could pool their R&D resources. The center's existence would be made possible through joint funding from companies participating in this effort and from governments (federal, state, and local).

SEMATECH (Semiconductor Manufacturing Technology) is a publicly sponsored consortium of 14 U.S. semiconductor producers aimed at achieving global leadership in semiconductor manufacturing technology by 1993. The consortium will develop advanced manufacturing technology and transfer this technology to member firms. It is barred by its charter from producing semiconductors for sale. This consortium also has an adjunct organization, SEMI/SEMATECH, which represents the U.S. semiconductor manufacturing equipment and materials industries and is a member of the SEMATECH board of directors.

SEMATECH's strategic objectives are fourfold: developing and disseminating advanced manufacturing technology; strengthening the supplier base; strengthening the technology base; and supporting national security.

The consortium's long-term strategic plan focuses on high-yield, factory-scale production of 64Mb DRAMs and comparably complex integrated circuits in their own facility by 1993. The timeframe for this device has been estimated to be 12 months ahead of foreign competitors and three years in advance of U.S. producers (without SEMATECH).

An integral facet of this plan will be to strengthen the supplier base. As an initial step, it will provide a framework and incentives for cooperation between U.S. semiconductor producers and their suppliers in the equipment and materials industry. This will be conducted through the auspices of SEMI/SEMATECH.

To strengthen the technology base, SEMATECH will work through the Semiconductor Research Corporation (SRC), a joint

government-industry-academia effort based in Research Triangle Park, NC, to finance dedicated research at U.S. universities and federal laboratories. This effort is expected to help generate new technical knowledge and contribute to the nation's electronics, science, and engineering expertise.

By achieving accelerated production of advanced devices, strengthening the supplier base, and increasing the nation's expertise in high technology, the consortium's goal of a stronger commercial electronics sector should be realized. Since semiconductor producers in the United States supply both the merchant market and the defense establishment, a stronger commercial sector will undoubtedly benefit the defense sector as well as bolstering our national military preparedness.

The SEMATECH consortium is a joint industry-government funded effort. The annual budget for this five-year activity is estimated at \$200 million, with the Department of Defense contributing \$100 million for the first two years and industry, state, and local governments contributing the remaining amounts. Future U.S. Government contributions will be considered during legislative sessions, although it is tacitly understood that government will continue to participate over the life of the project. The Defense Advanced Research Projects Agency (DARPA) has been charged with oversight responsibilities, but the consortium retains independence in the selection and management of the projects.

SEMATECH's ability to attain all its objectives remains to be seen although it already has made significant progress towards meeting many of the goals outlined in its strategic plans. Construction of a state-of-the-art fabrication facility was completed in less than half the time normally needed to build such facilities and with credible cost savings. This construction technology will be transferred to SEMATECH members.

Several concerns still exist, however. These concerns include:

- (1) The potential of premature technology transfer to foreigners through normal international business alliances in the semiconductor and equipment industries;
- (2) Ownership of intellectual property developed in SEMATECH;
- (3) The erosion of critical segments of the semiconductor infrastructure (e.g., the materials industry);
- (4) Future U.S. government involvement; and

- (5) The extent to which SEMATECH's effort will help the U.S. industry regain its competitive leadership in semiconductor production as well as in the semiconductor manufacturing equipment and materials industries.

Peggy Haggerty
Office of Microelectronics
and Instrumentation

Appendix E

Digital Central Office Switches

Product Description and Overview

The central office switch is the core of any telecommunications network and constitutes a critical portion of the telecommunications equipment market. Telecommunications service providers purchase central office switches to perform the signaling, switching, and control functions essential to operation. The central office switch completes connections and routes information, in the form of voice, data, printed text, or images, from one caller to another.

Digital switching systems are expected to be the dominant switching technology through the 1990s. Digital switches offer service providers the greatest variety of features at the lowest operational cost. By continuing to upgrade their digital switches through new system software developments, service providers will be able to furnish users with additional value-added services at attractive prices. Advancements in digital switching technology are leading toward the evolution of an integrated services digital network (ISDN), which would allow users to transmit voice, data, and video over the telecommunications network.

Where the sole function of the central office switch was formerly to complete connections for verbal communications between callers, today's digital central office switches are expected to perform a much wider range of applications. In addition to voice connections, today's switches are expected to route data, printed text, and images. Besides telephone sets, they now connect computers, facsimile, telex, and videotext units to the telecommunications network, as well as security alarm systems and automatic meter reading equipment. Digital networks allow worldwide electronic funds transfer, access to remote data bases, and customer-controlled network management. As a result, the telecommunications network has become a vital link in the operations of a broad spectrum of manufacturing and service industries in the United States and throughout the world. Telecommunications networks are also a vital element in any nation's national defense, and most major central office switch manufacturing companies develop products for sale to defense agencies.

As the world's telecommunications networks evolve toward ISDN, greater standardization of network architecture and equipment design is emerging to ensure compatibility with other networks. Digital central office switches tend to feature multiprocessor, distributed functionality with modular hardware and software. This design provides for more efficient growth and change. As technology spawns improved features, or the customer base is expanded, new components can be plugged in to existing systems to provide upgraded service.

While digital central office switches constitute a key, but only a small fraction of the U.S. economy, they represent a significant portion of the telecommunications market. The U.S. telecommunications equipment market was estimated at over \$30 billion, of which digital central office switches constituted \$2.83 billion in 1987.

The Companies and the Marketplace

Central office switch manufacturing is an integral part of not just the telecommunications sector, but the electronics industry as a whole. Most of the world's major digital switch manufacturers are engaged in manufacturing a wide range of telecommunications hardware as well as a number of related electronics products, including computer equipment and microelectronic components. The activities of these companies, both in terms of in-house operations and through alliances with other companies, illustrate the convergence of the telecommunications and computer industries and the integration of the electronics industry as a whole.

The major digital central office (CO) switch manufacturers are located in North America, Europe, and Japan. Although many countries initially attempted to develop digital CO switches, few succeeded. In the short history of digital central office switches, there has already been a significant shakeout in the industry, and this process is expected to continue. Industry analysts generally agree that there is already a surplus of world production capacity. Approximately 20 companies currently produce digital switches, but that number should shrink to about 12 over the next few years. Smaller companies will merge, be absorbed by larger manufacturers, or cease production.

The combination of high development costs and a relatively inelastic market effectively limits the number of equipment manufacturers able to compete profitably in the digital central office switch arena. Many national networks are too small to justify the investment required to develop a native product or technology. Since existing manufacturers are well advanced in product development and well entrenched in particular geographic markets, new manufacturers find it extremely difficult to break into the world market.

Nevertheless, certain newly industrialized and developing countries--such as Brazil, India, and South Korea--are working to develop an indigenous manufacturing capability. Government policies in these nations strongly support these efforts. The Korean Government has financed the development of a digital office switch and has transferred this technology to four domestic manufacturing concerns. While its production is not yet significant when measured as a percentage of the world market, Korea is already pursuing export sales and has reportedly won a contract from the Philippines for delivery of its digital switching system.

The Table 1 lists the world's larger digital office switch manufacturers. Note that there have been numerous alliances, mergers, and joint ventures in recent years.

Table 1

Manufacturers of Digital Central Office Switches - 1988

North America

AT&T (U.S.)
 Northern Telecom (Canada & U.S.)
 GTE (U.S. & Canada)
 Stromberg-Carlson (U.S. based, owned by GPT, U.K.)

Europe

Alcatel (France) Note: Includes ITT
 APT (Netherlands) Note: Phillips & AT&T joint venture.
 CGCT (France) Note: Ericsson (Sweden) holds 20% interest.
 Italtel (Italy)
 Telettra (Italy)
 GPT (U.K.) Note: Formerly GEC-Plessey
 Siemens (Germany)
 LM Ericsson (Sweden)
 Nokia (Finland)

Japan

NEC
 Fujitsu
 Hitachi
 OKI

Table 2 lists world market shares of major switch manufacturing companies in 1987, recognizing alliances and joint ventures between various manufacturers:

Table 2

WORLD MARKET SHARE OF DIGITAL CO SWITCH MANUFACTURERS - 1987
 (based on lines shipped)

AT&T	19%
Northern Telecom	17
Alcatel-ITT	16
LM Ericsson	11
NEC	8
Siemens*	6
GPT	6
GTE	3
All others	14

* Siemens' total includes sales by former international plants of GTE.

AT&T, in addition to its wide-ranging telecommunications equipment line, is also a major manufacturer of semiconductors (electronic components) and software, both for in-house use and for sale outside the company. Since its divestiture in 1984 and the lifting of certain restrictions on its operations outside the field of telecommunications, AT&T has made a major commitment to becoming a world class competitor in the field of information movement and management, including computer applications.

Siemens of Germany is a significant manufacturer of both telecommunications and computer equipment. Also, the company produces a wide range of other electronic and electrical capital goods, including electronic components, medical engineering equipment, and power generating equipment.

Ericsson of Sweden is also an important manufacturer of electronic components and power supplies in addition to being a producer of a wide range of telecommunications products. However, Ericsson sold its data systems and office equipment divisions in 1988, abandoning its effort to establish itself in the computer field in favor of strengthening its position in the telecommunications sector. Ericsson still recognizes the importance of linking computer and telecommunications technology, but the company has decided to meet these objectives through cooperative agreements rather than internally. As an example, Ericsson has signed an agreement with IBM to cooperate in finding ways to interface IBM systems with Ericsson switches.

Telephone companies demand that digital central office switches be adaptable to offer the value-added services that their customers demand. Custom-tailored services provide telephone companies with increased opportunities for generating service revenues as well as helping to reduce costs, which in turn reduce bypass incentives. As digital switches make these services more widely available, business and residential user expectations will increase, and user demands for information-based services will expand.

Competitiveness in the digital central office switch industry centers on the production of a switching system that meets the demands of the world market in price as well as performance. The complex nature of digital central office switch manufacturing usually requires that certain production processes, especially software development, take place in the market in which the switch is to be installed. Purchases require large capital investments and are expected to have a long life span. Therefore, purchasers of central office switches buy not just the switching system, but the supplies as well. Purchasers expect suppliers to be responsive to their needs. Customer support can often be the determining factor in a carrier's decision to purchase switching equipment. Digital switches are expected to last for 20 years. When analyzing bids, procurement officers perform in-depth analyses of the

long-term viability of suppliers. Carriers expect customer support services to extend over the life of the equipment. This is a critical factor with digital systems because future software development is the key to improved performance and the development of enhanced features.

Switch purchasers are also concerned about reliability, maintenance, and repairs. They prefer regional service centers with adequate qualified technicians to provide immediate support and assistance. Delays weaken service to the system user, reducing revenues and eroding the customer base.

Traditional Industry Structure

Historically, most industrialized countries were able to support an indigenous central office switch manufacturer. Usually, the central office switch manufacturer was closely linked to a monopolistic telecommunications service provider (i.e., the telephone company). There were, and still are, significant differences in this relationship in North America versus Europe and Japan, which are explained below. However, in most cases, a close working relationship between the service provider and equipment manufacturer meant that the service provider was assured that the equipment manufacturer would be responsive to the service provider's needs and the equipment manufacturer was guaranteed a market for its product. The service provider was not concerned if equipment from competitive suppliers was offered at a lower price, because the service provider was reasonably able to pass its equipment costs on to ratepayers.

In North America, where telecommunications service providers are usually private companies, the large equipment manufacturers tended to be vertically integrated with a service provider. For example, AT&T owned Western Electric, Bell Canada owned Northern Telecom, and GTE owned the GTE operating companies. In such relationships, there was a strong economic incentive for the service provider to purchase central office switches from the related manufacturer rather than from another manufacturer with which there was no corporate affiliation. Prior to divestiture, AT&T established de facto standards for telecommunications equipment in the United States based upon its own needs and interests. Other U.S. manufacturers produced switches with the AT&T system standards in mind in order to assure equipment compatibility with the dominant Bell System.

In Europe and Japan, telecommunications service providers were traditionally government monopolies, commonly called PTTs (Post, Telephone and Telegraph administrations), which, as a matter of public policy, purchased their equipment from a limited number (one to four) of favored domestic manufacturers. Government procurement through the PTT was utilized as a tool to promote the development of the domestic telecommunications industry and, by association, the domestic electronics industry. In Japan, Nippon Telephone and Telegraph

encouraged competition among Japanese suppliers, but rarely purchased switches from foreign suppliers. In Germany, the PTT favored Siemens and other German manufacturers over foreign equipment suppliers. Standards in these countries were usually developed by the PTTs in cooperation with domestic equipment manufacturers. While national standards nominally conformed to international standards, individual nations usually varied their standards sufficiently to deny market access to foreign manufacturers.

Certain market forces in addition to the economics of vertical integration supported the favoring of domestic switch manufacturers by telephone service providers. Location in-country enables the switch manufacturer to be more readily available to deal with product difficulties and make repairs. Domestic manufacturers are usually familiar with their national market and are better able to accommodate the needs of the buyer. They also understand fully national standards and can design their equipment from scratch to meet those standards. When a switch manufacturer sells its product abroad, it must usually modify equipment designed for its home market to meet foreign standards. This often results in a more costly and less capable switch compared to those designed from the outset to meet the standards of the market in which it is being installed.

Political reasons also favored this traditional market structure. Telephone networks were recognized as critical to national defense, industrial growth, and innovation, and most governments very carefully fostered the development of a domestic telecommunications industry. Those countries that were too small to develop their own technology often licensed technology from foreign companies for domestic manufacture. Governments protected domestic manufacturers from imports that might erode the domestic manufacturers' market share and threaten the domestic industry. A wide variety of formal and informal barriers to market entry, such as high tariffs, national standards, buy national policies, and cultural preferences, evolved to ensure the dominant position of the domestic equipment manufacturer. Governments generally accepted the proposal that the telecommunications industry should be exempt from most free trade agreements. An excellent example of this is the refusal of European governments to subject their PTTs to the strictures of the GATT Government Procurement Code.

This lack of competition often resulted in the service provider paying more for central office switches than if procured competitively. These higher costs were ultimately passed on to ratepayers. Government regulatory agencies usually recognized and accepted the fact that ratepayers were effectively subsidizing their domestic telecommunications industries, but considered it preferable to the alternative of not having a domestic industry. In cases where home markets were too small to justify a domestic telecommunications industry, ratepayers

had to subsidize even greater inefficiencies in product development and manufacturing costs.

Forces for Change

There are several problems inherent in the traditional, noncompetitive market structure. Since manufacturers are effectively guaranteed a market for their products, few incentives exist for product innovation or improvements in productivity. While AT&T, through its subsidiary Bell Laboratories, was (and is) a major force for innovation in the telecommunications and electronics industries, critics argued that new products were introduced into the AT&T system more slowly than they would have been in a competitive environment. Sheltered markets limit the equipment choice available to telecommunications service providers, resulting in higher consumer prices and deprivation of new products and services. In some European countries, users, led by the business community, are now demanding access to services available elsewhere at competitive rates.

The development, manufacture, and installation of digital central office switches is an enormously expensive undertaking. Researching and developing a digital central office switching system costs between \$0.5 billion and \$1.5 billion. Additional costs involve updating the hardware and, especially, the software of digital switching systems. Software, by various estimates, currently accounts for between 30 and 50 percent of the cost of digital switches and could rise between 75 and 80 percent by the 1990s. By comparison, software amounted to only 20 percent of the cost of older electronic switches. Most manufacturers work continuously to improve their product and periodically update software packages to improve operating efficiencies and provide new features.

But the rising development costs of digital switching systems require that manufacturers attain higher sales volumes to recoup higher R&D expenses. Under the traditional market structure, only advanced industrial economies with large, comprehensive and well-developed networks have the resources necessary to foster central office switch manufacturing capabilities. Higher R&D costs reinforce efforts to maintain protected home markets and increase competition for third-country markets while new technologies create conflicting pressures.

The advent of new technology, typified by the digital central office switch, and the availability of new services have tended to promote competition and liberalize restrictive telecommunications environments. The traditional relationship between monopoly service provider and favored domestic supplier is increasingly subject to competitive pressure. In most, if not all instances, user demands for a wider variety of services at less cost have been most effective in bringing about change.

The U.S. Model

The most important development contributing to worldwide telecommunications liberalization occurred in the United States, which accounts for 30-40 percent of the Free World's market for telecommunications equipment and services. The divestiture of AT&T in settlement of an antitrust suit brought against the company by the Justice Department resulted in the creation of seven Regional Bell Operating Companies (RBOCs). Each of these newly created, independent telephone companies was responsible for operating a telecommunications network which was comparable in size to the network of any of a number of European countries. Under the terms of the divestiture agreement, the RBOCs were prohibited from manufacturing telecommunications equipment and were legally required to develop competitive procurement procedures. They were specifically prohibited from favoring their former parent, AT&T, as a source of supply.

The AT&T divestiture and the attendant U.S. telecommunications industry restructuring, coupled with deregulation that had begun in 1968, effectively resulted in the unilateral opening of the U.S. telecommunications equipment market to international competition. Faced as they were with the terms of the AT&T Consent Decree and the Modified Final Judgement, the RBOCs were forced to look for new sources of supply for equipment. The RBOCs have encouraged competition in the central office switch market because it increases their leverage in negotiating with equipment suppliers to obtain better equipment at lower prices. Foreign manufacturers of digital central office switching equipment, recognizing the opportunities and economies of scale inherent in the U.S. market, have wasted no time in courting the RBOCs.

Northern Telecom, a Canadian equipment manufacturer, had a head start on other foreign manufacturers because its equipment was originally designed and built to North American standards and its digital switching apparatus had been approved by the former Bell System in January 1980. Northern Telecom had also made a firm corporate commitment to digital switching technology and aggressively marketed this technology to prospective customers in the United States. As a result, Northern Telecom surpassed even AT&T in U.S. sales of digital switching equipment in the period immediately following divestiture. At one stage, Northern Telecom reportedly held a 70 percent share of the U.S. digital central office switch market, based on number of lines shipped.

Other foreign switch manufacturers, notably Ericsson of Sweden, Siemens of Germany, Alcatel of France, and Nippon Electric Corporation (NEC) and Fujitsu of Japan, recognizing the importance of gaining a foothold in the major markets represented by the RBOCs, are working to develop the hardware and software sought by the RBOCs and have achieved some success in making sales to these companies.

Tables 3-5 illustrate the shifting market shares, based on lines shipped, of central office switch manufacturers competing in the U.S. market and the increasing inroads being made by foreign manufacturers:

Table 3 1979 U.S. Central Office Switch Market Share
(Digital & Analog)

<u>Company</u>	<u>Share</u>
AT&T	82%
GTE	8
Stromberg-Carlson	3
Northern Telecom	3
ITT	2
TRW/Vidar	1
NEC	<1

Table 4 1984 U.S. Central Switch Office Market Share
(Digital & Analog)

<u>Company</u>	<u>Share</u>
AT&T	47%
Northern Telecom	28
GTE	22
Stromberg-Carlson	2
ITT	1
NEC	<1

Table 5 1987 U.S. Central Office Switch Market Share
(Digital)

<u>Company</u>	<u>Share</u>
AT&T	47%
Northern Telecom	39
GTE	7
Stromberg-Carlson	2
Alcatel	2
NEC	1
Ericsson	<1
Siemens	<1

Note: Sums may not equal 100 due to rounding errors.

Europe and Japan

The divestiture of AT&T in the United States increased pressure on other developed countries to liberalize their telecommunications environments. U.S. equipment manufacturers, faced with the loss of market share in the United States to foreign manufacturers, complained that they were being denied

access to foreign markets. U.S. Government officials, in response to these complaints and recognizing a turnabout in the U.S. telecommunications equipment balance of trade from a surplus to a steadily increasing deficit, began seeking to eliminate foreign barriers to trade in telecommunications equipment. In the Congress, Senator Danforth was the principal sponsor of telecommunications trade legislation while the administration engaged in telecommunications MOSS (market-oriented sector specific) talks with Japan and MAFF (market access fact finding) discussions with a number of countries in Europe and Korea. At the same time, the convergence of telecommunications and computer technologies and an expanding array of information-based industries resulted in more strident demands from users (primarily business users) in foreign countries for access to new equipment and services at reasonable rates.

The result of these pressures has been a gradual movement toward the easing of monopolies and a shift towards increased competition in the provision of telecommunications equipment and services in a number of countries throughout the world. Nevertheless, most European countries still maintain significant barriers to prevent penetration by foreign manufacturers of central office switches.

While user demands and the rise of alternative service providers present the European PTTs with greater economic incentives to purchase equipment competitively, nationalistic policies still constitute a major hurdle to a more open and competitive market. European countries have recognized the technological importance of developing digital central office switches and their governments have placed great emphasis on maintaining the strength of their respective telecommunications equipment industries, often at heavy cost. A European Economic Commission-Information Technology Task Force conducted a study of the expenses incurred in developing digital switching systems and determined that while Japan had spent about \$1.6 billion to develop this technology and the United States had spent about \$2.5 billion, EC member states had spent more than \$7 billion competing against each other in developing this technology. The report concluded that the lack of cooperation between member states had resulted in a wasteful duplication of scarce technical expertise and financial resources while contributing to delays in development of common standards and a compatible telecommunications infrastructure. Other studies have shown that the European PTTs pay 60 to 100 percent more for comparable equipment than telephone companies in the United States do. Ultimately, it is the ratepayer who must bear these costs in the form of higher use rates.

While European governments have long provided financial support to finance telecommunications research and development, they have only belatedly recognized the importance of cooperation in developing digital central office switch technology. The

creation of the Information Technologies and Telecommunications Task Force within the EC Commission in 1983 has led to the creation of two programs to promote cooperation in this area: The European Strategic Program for Research in Information Technology (ESPRIT) was founded in 1984, followed by Research-development in Advanced Communications-technologies for Europe (RACE) in 1985.

The benefits expected from this collaboration are a reduction of research costs, an improvement in overall performance, a contribution to the definition of European or international standards, and a reduction of component costs through standardization. European manufacturers believe these types of initiatives are necessary to maintain their positions in the new competitive market environment. Through such agreements they can expect to expand their potential markets and share the load of the extremely high development costs of the new generation digital voice/data and ISDN products.

The EC Commission is working to harmonize standards and network technologies within the EC with the objective of eliminating barriers to trade in equipment and services between member countries. Ultimately, the EC hopes to achieve a unified internal market by 1992. However, such an objective implies that less efficient manufacturers will surrender market share to competitors from other nations, and it remains to be seen whether nationalistic pride will intervene at some point to prevent this from occurring.

While a unified EC market would offer improved economies of scale to U.S. manufacturers hoping to sell in Europe, it could also present a serious obstacle to entry by manufacturers located outside the EC. AT&T has entered into a joint venture with the Dutch manufacturer, Phillips, in an effort to crack the European market, but this alliance has achieved very little in sales outside of the Netherlands.

The Government of Japan has long recognized the benefits of cooperation and planning. The Ministry of International Trade and Industry (MITI) was established after World War II with the authority to plan fundamental policies for production, distribution, consumption, and foreign trading of commodities. In recent years, MITI has relied on "administrative guidance" in implementing policy, a process that consists of a government ministry giving suggestions or advice to private business or public organizations over which the ministry has regulatory jurisdiction.

Japan's telecommunications equipment market is dominated by Nippon Telegraph and Telephone (NTT), a government entity prior to its privatization in 1985, which utilized several aspects of Japanese Government procurement practices to restrict imports into Japan. NTT manufactures none of its own equipment, but instead relies on outside equipment manufacturers. NTT traditionally followed a "Buy Japan" procurement policy,

developing close relationships with four major Japanese firms which became known as the "family" - NEC, Fujitsu, Oki, and Hitachi. NTT's research and development programs have involved joint R&D of the products purchased by NTT with the members of the manufacturing "family." Thus, R&D and procurement were a closed loop, denying access to foreign manufacturers.

Japan's accession to the Government Procurement Code and the inclusion of NTT under code procedures improved access of foreign manufacturers to NTT procurement. However, actual equipment sales by foreign manufacturers to Japan remain at low levels.

Third-Country Markets

In order to be price competitive, a switch manufacturer must be able to distribute the high research and development costs of digital switch technology over a large sales volume. Producers in small countries where the telecommunications network does not afford this scale minimum must look to foreign markets. Historically, this meant developing or underdeveloped countries, since most industrialized countries had a domestic switch manufacturing industry, generally were protected by a variety of trade barriers. A protected home market gave the equipment manufacturer a secure base from which to launch export sales, often with negligible profit margins or even at a loss.

As a result, strong competition has developed among major firms to establish themselves in third-world markets. Most switch manufacturers receive some form of government support for their export efforts. In most instances, U.S. companies are at a disadvantage in this regard compared to producers in other countries.

Many foreign governments provide attractive financing packages to support the sales of their domestic manufacturers to third-country markets. For example, the Governments of France and Japan reportedly offer equipment financing at interest rates as low as 3.5 percent, over a 30 year term with a 10 year grace period. A typical U.S. Eximbank financing package offers interest rates at 8-9 percent over a 10-year term with a 6-month grace period.

Switch manufacturers will often sell equipment below cost in order to establish a presence in a foreign market. Once committed to a particular switching system, the service provider finds it difficult and expensive to change suppliers. In some cases, the switch manufacturer can finance sales below cost in foreign markets by selling equipment at inflated prices in its protected home markets. As an example, competitors claim that the German manufacturer, Siemens, is selling its digital switches in China at prices as low as \$100 per line. China has placed great emphasis on expanding and modernizing its severely underdeveloped telecommunications network and

represents a huge potential market for central office switches. Many equipment manufacturers are competing furiously to establish themselves in the Chinese market. In the United States, which is a more competitive market, Siemens reportedly sells its switching equipment at about \$200 per line, which experts estimate is a fair market price. In Germany, where Siemens enjoys a protected market, Siemens reportedly sells its switches at prices equivalent to about \$400 per line.

Northern Telecom of Canada also enjoys a protected home market which competitors claim it uses to advantage in achieving export sales. Under the terms of its preferred supplier relationship with Bell Canada, the operating company with which it is corporately related, Northern is obliged to sell equipment to Bell Canada at prices that are as low or lower than the prices it charges to any other companies in Canada. However, Canadian regulatory agencies have specifically exempted export sales from this comparison, thus allowing Northern Telecom to sell its products in foreign markets at prices lower than it charges in its home markets. Competitors allege that Northern Telecom is thus subsidizing export sales by charging higher prices for its equipment in Canada.

Switch manufacturers whose domestic markets have never been large enough to support an indigenous manufacturer have more experience in pursuing export sales. Ericsson of Sweden is an example of a company that has historically depended on its foreign marketing efforts to sustain it because sales in its home market could not sustain its operations. The Swedish Government recognized this situation and supported Ericsson in its overseas efforts, thus helping Ericsson to achieve a significant international presence in the telecommunications equipment industry.

In the United States, AT&T was banned from selling equipment in export markets from 1924, at which time its foreign operations were sold to form the basis of ITT, until its divestiture in 1984. AT&T is therefore a relative newcomer to the exporting game and has been forced to play catch-up with more entrenched and experienced international competitors.

Cooperation and Competition

Telecommunications has become a global industry, and national telecommunications networks are no longer guaranteed the luxury of existing as insular entities. Fueled by the increasing growth of multinational firms and their attendant desires for improved voice and data communications technology, there has been a general trend, noted earlier, toward an integration of telecommunications and computer technologies. In many instances, firms are relying on acquisitions, mergers or cooperative agreements rather than internal development to achieve this integration.

In the case of digital central office switches, recent alliances include joint ventures between AT&T (U.S.) and Philips (Netherlands) Siemens (Germany) and GTE (U.S.) Alcatel (France) and ITT (U.S.) CGCT (France) and Ericsson (Sweden) and GTE (U.S.) and AT&T (U.S.).

The reasons for these partnerships vary depending on the individual countries involved and the markets in which the companies operate. Firms may cooperate in standards development, product research and development, licensing of technology, or manufacturing. In many cases, it is impossible for a foreign manufacturer to enter a particular market except through a joint venture with a domestic firm. In other instances, joint ventures allow partners their only access to new technologies. Cooperation generally allows partners to combine market shares and reduce production costs by better exploiting economies of scale. In the case of GTE and ITT, the companies wanted to withdraw from the international telecommunications business because of the high R&D costs of remaining competitive in the world market.

The AT&T-GTE agreement is interesting in several respects. It is somewhat unusual in that it is between two U.S. vertically integrated companies that have traditionally insisted on developing their own switching systems for internal use. GTE is by far the smaller of the two companies and had already sold its international equipment business to Siemens of Germany. Because of its fairly limited market share in the United States, it was questionable whether the company could afford to continue to compete in the digital central office switch business, and several foreign manufacturers were positioning themselves to supply CO switching equipment to the GTE operating companies. The joint venture arrangement with AT&T could allow GTE to maintain a share of the U.S. market while helping AT&T to regain some of the market share that it lost as a result of divestiture. The agreement would also appear to stiffen competition against foreign manufacturers in the U.S. market.

While cooperation between switch manufacturers offers the financial benefits of shared R&D costs and standardization, competition is the driving force of technological development. Even as cooperation between manufacturers has concentrated capacity in fewer companies, competition between these companies for market share has increased. The advent of digital technology has spawned a variety of value-added services, and more companies have moved into this field to challenge the traditional monopoly service provider. Faced with this new competition in providing the additional services that users demand, traditional service providers come under pressure to meet customer needs while maintaining competitive rates. Competitive equipment procurement is one means by which the service provider can lower costs and keep charges down.

At the same time, digital technology gives service providers more flexibility in operating different switching systems in the same network. This also increases the potential for competition in equipment procurement, opening any single network to multiple switch sources. In the United States, the RBOCs have for several years utilized both AT&T and Northern Telecom digital central office equipment within their networks. In recent years, they have encouraged additional suppliers, such as Siemens and Ericsson, to adapt their switches to the U.S. market and thus provide additional competition to AT&T and Northern Telecom. The RBOCs report that this has reduced further the per-line procurement cost of central office switches.

Summary and Conclusions

The manufacture of digital central office switches is an expensive and complex industry that relies heavily on other segments of the electronics industry such as software, high-capacity semiconductors, and microprocessors. Other industries, such as manufacturing, banking, and travel, have become increasingly dependent on the services provided by the telecommunications industry to operate economically and competitively.

The increased cost of developing digital central office switching equipment has intensified the battle for market share among the world's equipment manufacturers. The structure of the industry has changed dramatically as a result of acquisitions and joint venturing between some manufacturers and the disappearance of others from the market. While industry restructuring has resulted in a reduction in the number of companies producing digital central office equipment, it has increased the competition between the remaining companies.

Joint ventures and movements by manufacturers into new markets has in some instances resulted in a blurring of national identification of producers. Northern Telecom has been so successful in the U.S. market that it is often assumed to be a U.S. company. It has established a significant manufacturing presence in the United States and its U.S. sales exceed its sales in its home market of Canada.

Central office switch manufacturers are heavily dependent on government policy both in their home markets and abroad. Government policies can help to preserve domestic market share for domestic manufacturers or promote international competition in the domestic market. Government policies can also assist domestic manufacturers in gaining access to foreign markets.

Deregulation and the divestiture of AT&T opened the U.S. market to international competition while freeing AT&T to compete abroad. However, while market access barriers in the United States were eliminated, there was no corresponding opening in foreign countries. Additionally, the terms of the Modified

Final Judgement--requiring the RBOCs to develop competitive procurement policies that did not favor AT&T--effectively stripped AT&T of a significant share of the U.S. market.

Northern Telecom has been the principal beneficiary of this policy, increasing its share of the U.S. central office switch market from less than 3 percent in 1979 to over 30 percent in 1986. The other principal U.S. central office switch manufacturers, GTE and Stromberg-Carlson, did not capitalize appreciably on the AT&T divestiture, either domestically or in international markets. In fact, Stromberg-Carlson was acquired by the U.K. firm Plessey, while GTE sold 80 percent of its international telephone-transmission business to Siemens of Germany (now expected to purchase the remaining 20 percent in the near future).

The other major foreign switch manufacturers continue to jockey for position in the U.S. market. Ericsson, Siemens, Alcatel, NEC, and Fujitsu have all established "beachheads" and are expected to steadily increase their share of the U.S. market, while still enjoying protection from foreign competition at home.

In the race for third-country sales, AT&T has routinely lost to these same foreign manufacturers, whose governments offer attractive concessionary financing packages, which AT&T and the U.S. Government have been unable or unwilling to match.

The U.S. Government has recognized the inequities in market access between the United States and most of the rest of the world and has actively negotiated to open foreign markets to competition. U.S. Government pressure has achieved some success, but principally in the area of customer premises equipment, not with such network equipment as central office switches. Also, while many of these agreements have looked good on paper, few concrete results (i.e., increased U.S. exports) have materialized.

Increased competition in the central office switch market in the United States has presented users with a greater variety of services and lower costs. But deregulation of the U.S. market without reciprocal access abroad will have detrimental long-term effects on U.S. manufacturers of central office switches.

John Henry
Office of Telecommunications

Appendix F

History of U.S. Government Involvement in Research and Development

The level of U.S. Government support for R&D has varied over the last four decades. Prior to World War II, the U.S. Government funded 15-20 percent of the national R&D effort. During the war, it supported an increasing portion of the nation's R&D for military applications, with the majority going to industrial and university laboratories. After the war, the U.S. Government funded about half of the nation's R&D, which increased to almost two-thirds of total R&D by 1960. From the late 1960s onward, federal support of R&D dropped off until the mid-1970s when its support began to steadily increase once again.

U.S. Government Support of Electronics R&D

The beginnings of the U.S. electronics sector can be traced to the research and development of various analytical machines for military and intelligence uses during the Second World War. Between 1949 and 1959, the U.S. Government supported almost 60 percent of computer R&D, with companies funding 20-25 percent. The Department of Defense (DOD) was the key U.S. Government agency in this effort during this period. Industry leaders such as National Cash Register (NCR), Remington Rand, and IBM were the principal performers of the R&D.*

Academic institutions were also important R&D performers. For example, the University of Pennsylvania's Moore School of Engineering built the first large-scale electronic digital computer under Army contract, which ultimately led to the Univac 1, the first computer for the commercial market. The Massachusetts Institute of Technology worked with IBM, Bell Telephone Laboratories, and Burroughs to produce the Air Force's SAGE air defense system and also made important advances in computer graphics, timesharing, and digital communications.

Successful developments in high performance computers during the 1950s influenced computer design well into the 1960s. Solid state computers, built in the mid-1950s, benefited from government-funded R&D on advanced electronic components.

* U.S. Government R&D effort is characterized by intramural and extramural performers. Intramural performers are the agencies of the federal government whose work is carried out directly by agency personnel. The extramural performers include all organizations outside the federal sector that perform with federal funds under contract or grant. The main extramural performers include industrial firms, universities and colleges, other nonprofit institutions, federally funded research and development centers, state and local governments, foreign performers, and private individuals. Most federally funded R&D is performed by extramural performers.

National Aeronautics and Space Administration

Research for the space program of the National Aeronautics and Space Administration (NASA) influenced the development of the electronics industry during the 1960s. Much of the space program's research was applicable to the development of software and programming. Since most of NASA's hardware efforts focused on redundant fault-tolerant computers, later computer systems incorporated these concepts and techniques in the design of non-stop transaction processing and processors used in systems that needed to be highly reliable. The STAR (self-test and repair) computer established the leading edge for fault tolerant techniques in the 1960s. By the end of the 1960s, the space program had peaked and most NASA-funded research in computers came to a halt.

National Institutes of Health (NIH)

By 1965, the U.S. Government-funded share of industrial R&D declined to approximately a third of total spending and continued to fall for the rest of the decade. Support of artificial intelligence by the National Institute of Health (NIH) during this period led to the construction of the DENDRAL system, the first successful application of artificial intelligence and probably the first system to enter the commercial market. Major spin-offs resulting from DENDRAL included the SUMEX experimental computer, the MYCIN, CASNET, PUFF, and INTERNIST expert systems.

Department of Energy

The Department of Energy (DOE) has been an important funder of electronics R&D. For example, the agency's requirement for connecting incompatible computer systems from various manufacturers led to the development of the first local area network (LAN).

As a result of DOE funding, Control Data Corporation produced a supercomputer that dominated supercomputing throughout the 1960s. By 1976, private industry commercialized supercomputer technology with the development of the CRAY-1 by Cray Research. In addition, DOE laboratories aided Cray in developing its timesharing operating system and some of the applications software for the CRAY-1.

Department of Commerce

The National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), within the U.S. Department of Commerce has been involved in the U.S. electronics sector since the 1920s, when it developed new measurement methods and instruments to support radio technology. Over the past few decades, the NIST programs have evolved rapidly to keep pace with advances in electronics. Work on integrated circuit line width measurement, wire bonding

integrity, and semiconductor materials characterization at NIST helped the U.S. semiconductor industry to move into the large-scale integration era, significantly increasing productivity and quality control within that industry.

Defense Advanced Research Projects Agency

In 1958, the Department of Defense created the Defense Advanced Research Projects Agency (DARPA) to foster and manage advanced research programs for military applications. An early focus on space science and technology broadened to encompass strategic and tactical weapons development, nuclear test verification techniques, basic sciences research, and information processing technology.

Due to DARPA funding in the early 1960s, advances were made in timesharing systems and computer graphics, and the field of artificial intelligence came into existence. By the mid-to-late 1960s, DARPA funding supported the development of a complex, secure operating system, called MULTICS. Other DARPA projects like SOLOMON advanced computer architecture by linking multiple processors together to execute simultaneously small parts of a single large program. SOLOMON led to the development of the ILLIAC IV, the first parallel-processing supercomputer.

From the timesharing research conducted, computer aided design (CAD) and computer network technology advanced. CAD techniques such as STRUDL, CIRCAL, MACSYMA, and SCHEME were descendants of the MULTICS program. Computer network advances appeared in the early 1970s. Although military support of R&D declined dramatically throughout the 1970s, important advances in electronics were achieved. Advances in parallel processing pioneered the use of high-performance emitter coupled logic (ECL) chips, constructed circuitry design for CAD techniques, and developed technology for printed circuit board (PCB) fabrication.

DOD's R&D funding in the late 1970s and 1980s was directed toward the development of very high-speed integrated circuits--the so-called VHSIC program. This effort began at the Office of the Secretary of Defense (OSD) but was transferred to DARPA in 1988. Another DOD research effort, the Monolithic Microwave Integrated Circuit (MIMIC) program, was devoted to gallium-arsenide (GaAs)-based chips in place of silicon. After the initial R&D phase produced prototypes, DOD instituted a program to speed the introduction of these circuits into weapons systems.

Through the Strategic Computing Initiative, DOD has funded R&D in innovative parallel architecture for symbolic computing applications, artificial intelligence, and advanced microelectronics. Its Strategic Defense Initiative emphasizes research in parallel architecture and optical computers.

Maria de la Guardia
Office of Computers and Business Equipment

Appendix G

Directives for EC 92

The EC 1992 program has raised concern within the U.S. electronics sector about issues as divergent as the rules of origin of semiconductors to the safety and health requirements for visual display terminals to EC medical and telecommunications equipment standards.

1. Rules of Origin of Integrated Circuits

Since 1968, the EC rule of origin has become increasingly product specific. The EC claims that stricter interpretations have been needed to keep pace with technological developments and evolving trade patterns. Recently, as a result of certain countries' circumvention of antidumping provisions related to electronic products, the requirements for confirming EC origin have been tightened for integrated circuits (IC's).

Such new requirements necessitate complete fabrication to be carried out in the EC, where as previously assembly and testing were sufficient to confer EC origin. By making market access to the EC conditional on local production, such measures encourage direct investment to be substituted for imports, thereby challenging established trade patterns. Since the announcement of the new directive, Japan is the leading investor in EC fabrication facilities, changing the competitive situation of a market traditionally dominated by the United States.

The indirect affect of the reinterpretation of the EC rule of origin is of more immediate significance to the U.S. electronics sector. Being that the United States implements a similar rule of origin for IC's, the main issue of contention is not over the EC rule of origin by definition, but in the context of regulating dumping, there is vaguely defined interplay among product-specific rules of origin in "downstream" application. Some U.S. semiconductor suppliers claim that the use of the anti-circumvention provision in the IC ruling, combined with use of the rule of origin for TV receivers as a guide to determining the origin for printed circuit boards, has resulted in the replacement of U.S. components in photocopiers by European suppliers.

Some Japanese firms have interpreted the rule of origin under the dumping provisions to stipulate the increase of EC content, at the expense of U.S. content. Thus, even though U.S. semiconductor suppliers were not under allegations for dumping, their components were "designed-out," because of the lack of transparency in the application of the EC rule of origin.

Judee Mussehl
Office of Microelectronics
and Instrumentation

2. Health and Safety Requirements for Visual Display Units

An EC directive on the health and safety requirements for visual display units (VDU) has been proposed by the European Community Commission. It is part of a health and safety action program with primary support from European socialists and labor to achieve a more uniform "social work environment" for workers among the European countries.

Although the EC prepared the original draft directive in March 1988, which included minimum equipment and physical environment standards, vision programs, training, and time limits on work, it has yet to be adopted by the European Parliament. In December 1988, the European Parliament voted through a series of substantial amendments to the original directive that came as a surprise to the EC Commission and to industry as well. The amendments would add stronger codetermination rights, training, specific radiation standards, significant time limits (four hours) on VDU work, mandatory alternate work for pregnant women, and many controversial minimum equipment standards.

Given the progress being made on international VDU standards, U.S. industry, European employers, member states United Kingdom and Ireland, and standards groups have voiced varying degrees of concern and even opposition to the VDU directive. The major point of contention is over the need for such a directive, given the lack of evidence from both European and international scientific organizations that VDUs and VDU work constitute a priority health and safety risk for workers.

The directive would result in new, perhaps unreasonable, requirements for VDU workstation equipment beyond those generally recognized in the United States or being considered for international standards. The additional investments that would be required in implementing VDU requirements would divert funds that might otherwise have been spent on R&D for VDU and related equipment. The VDU directive might well discourage or slow down overall acceptance of computer technology in the work place based not only on cost but also on unproven fears for the safety of working with this equipment--a result which would have repercussions in the United States as well.

Maria de la Guardia
Office of Computers and
Business Equipment

3. Principal EC Measures for Telecommunications Sector

The Green Paper

In June 1987, EC Commission published the "EC Green Paper on the Development of the Common Market for Telecommunications Services and Equipment." The Green Paper establishes as the

"overriding aim" of the EC Commission the development of market conditions that provide "users with a greater variety of telecommunications services, of better quality and at lower cost." It then lists a series of proposals designed to increase competition in the EC market for telecommunications services and equipment. For example, it states that the regulatory and operational functions of "Telecommunications Administrations" (common carriers) must be separated, and it recommends that all telecommunications services except for voice telephony be opened to competition.

The U.S. Government presented the EC Commission with its official response to the EC Green Paper in the form of a 15-page paper delivered to the EC Commission in December 1987. The United States welcomed the overriding aim of the Green Paper, which is similar to the policy objectives underlying its own liberalization. However, the United States also noted that the U.S. experience with liberalization leads it to conclude that the objectives enumerated in the Green Paper can best be achieved in a market that emphasizes competition from all sources, both intra- and extra-European. The EC Commission responded that "the European approach is...being decided with due respect to the internal European context, and Community markets for telecommunications equipment will be progressively opened to international competition." However, the EC cautioned that "the pace and conditions of this change should, in our view, take account of the international context, including the Uruguay Round and genuine improvements in the conditions of access to markets of export interest to the Community."

Principal Telecommunications Measures Adopted by the EC

a. Community Resolution on Common Market for Telecommunications Services and Equipment by 1992: The EC Council of Telecommunications Ministers approved this resolution on June 30, 1988, outlining the 11 major goals of EC telecommunications policy. In addition, this resolution constitutes the EC Council's approval of the action program announced on February 9, 1988, to implement the EC Commission's Green Paper of 1987.

b. Pan European Digital Cellular Network: The EC Council of Ministers recommended in 1987 the coordinated introduction of public pan-European digital cellular communications by 1991. In addition, a directive reserves specific radio frequency bands for this pan-European system. Eighteen European countries have already signed a memorandum of understanding (MOU) to implement this system, for which 11 countries have already started procuring equipment.

c. Directive on the Initial Stage of the Mutual Recognition of Type Approval for Telecommunications Terminal Equipment: Approved in 1986, this directive establishes agreement to seek common standards (NETs) for terminal equipment (customer premises equipment) and to recognize other European countries'

laboratory tests concerning whether a certain type of equipment conforms with those standards. The directive implements an MOU between the EC and the Council of European Post and Telecommunications Organizations (CEPT), which includes European Free Trade Association (EFTA) countries. The newly established European Telecommunications Standards Institute, which represents 21 EC and EFTA member countries, has already approved NETs for the interface between data terminals and public data networks, and it is currently drafting an NET for integrated services digital network (ISDN) terminal equipment.

d. Recommendation on the Coordinated Introduction of ISDN: The EC Council recommended in 1986 that EC telecommunications administrations coordinate with each other concerning how they will introduce ISDN, especially on the subject of standards and the interface between the user and the network. Although ISDN is already starting to be introduced into commercial service in such countries as France and Germany, there is no indication that any significant coordination has been accomplished yet. Nevertheless, 18 members of the CEPT signed a MOU in March 1989, which was effective immediately, concerning common standards for public ISDN services by 1992.

e. Directive on Standardization in Information Technology and Telecommunications: Effective February 1988, this directive is intended to establish standards for information technology systems and functional specifications for information and data services provided over public telecommunications networks. The objective is to promote the preparation and use of standards to ensure the exchange of information and data as well as systems inter-operability, and thereby to create an EC-wide market for products and services.

f. Directive on Competition in the Markets for Telecommunications Terminal Equipment: By 8/88, EC member states were required to propose measures to abolish special or exclusive rights for the importation, marketing, connection, bringing into service, or maintenance of terminal equipment. This directive is intended to allow private suppliers to compete with telecommunications administrations by 1990 in offering equipment for direct or indirect connection to the network. It requires that the development of specifications and rules for type approval be the responsibility of an organization independent of the network operator or any other terminal equipment supplier. France, Germany, Italy, and Belgium are contesting the EC Commission's authority to implement this directive under Article 90 of the Treaty of Rome (which provides for competition) without submitting it to the EC Council of Ministers for approval, but they are required to implement the directive until their cases are decided by the European Court of Justice.

g. Radio Interference: Adopted in May 1989, this directive is intended to prevent harmful electromagnetic emissions, such as those which interfere with the operation of radio and

television equipment, by a wide range of products. It establishes a provisional mutual recognition procedure for member state standards and plans for eventual establishment of a harmonized standards development process in the EC.

Principal Telecommunications Proposals Pending

a. 18th Value-Added Tax Directive: This directive would abolish the exemption of telecommunications administrations from EC value-added taxes.

b. Opening of Public Procurement in the Telecommunications Sector: Proposed in October 1988, this draft directive would introduce procurement procedures to open up purchases of supplies, software services, and public works by public network operators, whether publicly or privately owned. The directive would cover entities that are granted special and exclusive rights by member states to operate public telecommunications networks or offer one or more telecommunications services to the public. The directive would replace the 1984 Procurement Recommendation with a requirement that such common carriers open to competition at least 70 percent of the value of such procurement during 1990 and 1991 and all such procurement thereafter. Covered entities will be permitted to exclude offers containing less than 50 percent EC content and must grant a 3 percent price preference to equivalent offers containing at least 50 percent EC content. The benefits of the directive can be extended to non-EC countries via international agreements.

c. Open Network Provision: On June 23, 1989, the EC Commission proposed a "framework directive" on open network provision (ONP) for the progressive establishment of harmonized conditions for open access to and open use of the public telecommunications network infrastructure and public telecommunications services. ONP is a prerequisite for creating an open EC-wide market for telecommunications services, particularly value-added services, by 1992. This framework directive establishes procedures for the EC Commission to submit specific directives on subjects such as ISDN and the use of leasedlines to the Council of Ministers for the progressive definition and implementation of ONP conditions.

Other Telecommunications Proposals Planned:

a. Draft EC Directive on Competition in the Markets for Telecommunications Services: In July 1989, the EC Commission circulated this draft proposal to eliminate all special or exclusive rights to supply telecommunications services other than real-time, switched voice telephony, and telex, as well as provision of the underlying network infrastructure. The directive is also intended to ensure that any operator is entitled to supply such services. Member states that make the supply of such services subject to a licensing procedure to

ensure compliance with essential requirements would be required to ensure that licensing criteria are objective, nondiscriminatory, and transparent. Member states would be allowed to require until the end of 1992 that operators must not supply to the public the simple resale of leased line capacity. The EC Commission plans to issue this draft under Article 90 of the Treaty of Rome. The proposal is being delayed by a procedural dispute over the legal basis of the directive (Article 90) as well as by a substantive dispute over whether public data communications services should be included or excluded from its provisions. Certain telecommunications administrations seek to reserve such data services as monopoly offerings in order to protect their managed data network services from competition, at least during their first few years of operation. This directive will enter into effect on April 1, 1990, unless the Council reaches a common position on the ONP directive by that time, in which case the two directives will be implemented simultaneously, as the EC Commission prefers.

b. Proposal for a Council Directive on the Approximation of the Laws of Member States concerning Telecommunications Terminal Equipment, Including the Mutual Recognition of Their

Conformity: On June 16, 1989, the EC Commission circulated a preliminary draft of this proposal to require EC member states to introduce measures for the mutual recognition of type approvals throughout the EC by January, 1990. This directive would replace the 1986 directive on the mutual recognition of testing required for type approval, which was the first step towards full mutual recognition of type approval. However, the implementation date may be postponed for about a year because the directive is not expected to be approved before April 1990. The directive proposes that manufacturers be allowed to choose between two procedures to establish conformity of a terminal with relevant EC technical regulations: EC type examination or EC declaration of conformity. Both procedures would be performed by a "notified body," but the latter procedure would allow a manufacturer to declare conformity, based on its own quality system for design, manufacture, final inspection, and testing if the quality system were approved by the notified body. The notified body would be chosen by EC member states and could not be a supplier or installer of terminal equipment.

Effect of EC Measures on U.S. Competitiveness

Directives to integrate the EC market by 1992 focus primarily on the internal EC market and rarely specify how they will apply to third-country suppliers, because the EC does not want third countries to benefit from EC 92 unless they offer similar access to their markets. This reciprocity requirement is explicit in the proposed telecommunications procurement directive, which requires third countries to agree to offer comparable access to telecommunications procurement in order

for their suppliers to obtain the same preference as products with over 50 percent EC content.

In addition, the EC Commission has taken a similar position in refusing to recognize U.S.-generated test data on conformity to EC standards for terminal equipment, on the grounds that this is a matter for trade negotiations. Nevertheless, EC measures on both standards and procurement could improve U.S. suppliers' access to the EC market because it should be easier to satisfy one set of requirements for the EC than to satisfy each of the 12 member states' requirements. The establishment of the European Telecommunications Standards Institute (ETSI) in April 1988 increased the transparency of the standards development process by allowing manufacturers and users to join network operators as participants.

However, U.S. firms can participate in ETSI only as observers unless they have an EC subsidiary. EC interconnectivity requirements could impede access for U.S. suppliers, unless exceptions are allowed for genuinely innovative or cost-effective systems. The proposed EC directives on services may increase the access of U.S. providers of telecommunications services, especially value-added services, if adequate competitive safeguards are provided. However, the prohibition on resale of leased lines until 1993 handicaps the efforts of private providers of data communications services to compete with telecommunications administrations in offering the same services.

In conclusion, the EC Commission has made progress in its efforts to promote competition in terminal equipment by 1990 and to gradually open the market for telecommunications services, except voice telephony and telex. However, the benefits of such liberalization will be offset to some extent by such factors as the following:

- o The EC has not agreed to define terminal equipment as everything that is attached to transmission equipment, whether analog or digital;
- o It has not provided for adequate transparency and openness at every stage of the standards development process, including the exchange of draft documents;
- o It has not recognized testing and certification in third countries to EC standards;
- o The current draft services directives would allow EC member states to impose burdensome obligations on competitive service providers, such as mandatory standards to assure interconnectivity.

The proposed directive on telecommunications procurement is a good step towards establishment of an open, nondiscriminatory

procurement market, consistent with the provisions of the GATT Government Procurement Code. This should facilitate extension of the code to cover European telecommunications administrations. Such an agreement could obtain the same preferential treatment for U.S. suppliers as for EC suppliers. However, any subjects not covered by a multilateral agreement, such as government subsidies and discriminatory specifications, may need to be addressed in a bilateral agreement. In every area of the EC program for telecommunications, there still remains some latitude for member states to offset the momentum towards liberalization by footdragging in the implementation phase. For example, there continue to be 14 exclusive supply arrangements of telecommunications administrations for certain kinds of terminal equipment. Close monitoring of implementation is necessary to assure that U.S. suppliers' market access concerns are not neglected.

Myles Denny-Brown
Office of Telecommunications

4. Medical Equipment

At present, the main barrier for creating a single market for medical equipment is the lack of harmonized standards. The U.S. industry is represented primarily by the National Electrical Manufacturers Association (NEMA) and the Health Industry Manufacturers Association (HIMA). These associations have been actively involved in EC harmonization issues since standards have been among the most significant non-tariff barriers for the access of the U.S. medical equipment industry in the European market.

The U.S. industry is aware that a liberalized EC medical equipment environment may benefit both the U.S. firms already situated in the Common Market as well as firms exporting to the Common Market. However, the trade associations fear that EC harmonization may be implemented in such a way as to favor European companies. To prevent the latter scenario from occurring, the U.S. associations prefer to see the establishment of open and consistent communication links with the EC Commission prior to implementation of directives.

Other areas of concern include the use of CEN and CENELEC (two European standards organizations) standards as opposed to ISO and IEC (two international standards organizations) standards, flexibility of EC harmonized regulations to allow for current and future negotiations with the rest of the world, and maintenance of a transparent system in the process of developing directives.

Michael Fuchs
Office of Microelectronics and
Instrumentation

5. Information Technology

The Directive on Standardization in Information Technology & Telecommunications which went into effect in February 1988 should have a positive impact on U.S. industrial competitiveness as long as it is not used to force manufacturers to abandon proprietary standards, such as those for value-added networks.

The goal is to establish EC standards for information technology systems and functional specifications for information and data services provided over public telecommunications networks. The objective is to promote the preparation and application of standards in the EC that are deemed necessary to ensure the exchange of information and data as well as systems inter-operability. The end result would be a larger market for products and services.

The directive covers both private information technology systems and services offered over the public telecommunications network (value-added network or VAN services). The application of these standards in public procurement is a fundamental component of this directive in order to prevent the potential anti-competitive effects of national and proprietary specifications on both public procurement and on the entire market.

This directive should allow U.S. companies to increase exports to the EC. New-to-market companies will benefit most from the directive. As long as the directive does not become a tool of an individual member state's industrial policy, the directive will facilitate market access for most U.S. firms.

Ivan Shefrin
Office of Telecommunications

Appendix H

Comparison of Electronics Policies in Selected Countries

The electronics industries in eight countries (Brazil, India, Singapore, South Korea, Taiwan, France, Japan, and the United States) and one regional group (the European Community) are examined here. Although these countries differ considerably in size, level of industrial development, and socio/political structures, each has an established electronics industry that, while differing in scope, has experienced relatively rapid growth. Each government has also undertaken various kinds of targeted intervention to promote or support its electronics sector.

While these countries share similar goals and assessments regarding the strategic importance of having a domestic electronics industry, development experiences have differed. A mixture of conscious policies and unique economic, technical, and social circumstances in each country has resulted in distinct developmental strategies and, consequently, different levels of success. Even when similar policies have been adopted, outcomes have differed due to these factors. Policies and ambitions also have been bound by the realities of global technologies and markets. The relentless march of technology has provided both opportunities and constraints on countries trying to establish or maintain a share of the global electronics market.

Sections I, II and III of this appendix compare the electronics industries in these countries in terms of the level of government involvement, the kinds of developmental policies pursued, and the degree of industrial development achieved.

I. Levels of Government Involvement

On an absolute scale, the level of government involvement in any industry can range from pure laissez faire economic policies to government control and ownership of all industrial units. The countries in this study lie somewhere on the continuum between these two extremes in terms of governmental intervention in the electronics sector. Government roles range from the relative hands-off policies of the United States to the industrial micro-management policies of Brazil, which include some government ownership of production. For comparison purposes, five points along the involvement continuum were identified:

Abstinence (A): Within broad macroeconomic structural and regulatory constraints, the government follows a basically noninterventionist industrial strategy. If policies are adopted to assist industry, they are not sector specific.

Guidance (G): The government provides general guidance to industry and may adopt supportive measures, such as preferential procurement procedures or funding and other incentives for general research, education, or development of the domestic infrastructure.

Oversight (O): In addition to guidance, the government monitors specific behavior and results in the industry and provides detailed recommendations, incentives, supports, and controls to induce firms in the industry to take preferred actions.

Management (M): In addition to the above, the government may issue specific directions to individual firms regarding detailed management decisions. Trade and foreign investment may also be strictly regulated.

Control (C): The government owns a significant portion of the industry or effectively controls all management decisions.

Table 1 classifies each country in terms of the level of government involvement in the electronics industry. Most regimes use guidance or oversight or a combination of the two. Only France, Brazil, and India use management or control, and they appear to be gradually moving away from this pattern.

Table 1 Level of Government Involvement

<u>India</u>	<u>Braz</u>	<u>Sing</u>	<u>Taiwan</u>	<u>S.Korea</u>	<u>France</u>	<u>Japan</u>	<u>E.C.</u>	<u>U.S.</u>
M/C	M	O	O	O	O/M	O/G	G	A/G

National Government Roles

INDIA. The Indian Government, since independence in 1947, has played a predominant and controlling role in the development of that country's electronics sector. This is consistent with an industrial policy that has been formulated within the context of a strong socialist philosophy and very inward looking economic policies. Beginning with the Industrial Policy Resolution of 1948, the government was granted the authority to control or regulate industries that were identified as critical to the national interest. Nationalization, it was thought, would increase the country's bargaining power with foreign suppliers, provide control over the local market, and generate government revenue. One of these early industries was telecommunications, and today, a substantial segment of India's electronics sector is government owned. The public sector's involvement is manifested in an elaborate web of laws, programs, and Five-Year Plans that gives it control over key facets of the industry, such as production, pricing, distribution, imports, and foreign investment. But because of the global nature of the electronics industry, it appears that this sector has been treated more liberally than other industries.

India was an early entrant in the electronics policy field. In 1963, the government established an Electronics Committee to review the industry and advise it on how to achieve self-sufficiency. In 1964, India was also among the first countries to build a national computer, the ISIJU, which was fabricated jointly by the Indian Statistical Institute and the Jadavpur University. However, it was not until 1970, during its Fourth Five-Year Plan, that a separate Department of Electronics reporting directly to the Prime Minister was established, along with a high-level Electronics Commission to formulate policies and guide industry development. The commission established policies to promote greater control and ownership of technology and production by indigenous firms. Ironically, this thrust eventually caused IBM, one of the foreign companies that led India into the computer age, to abandon its market presence there.

The other traditional aspect of India's industrial policy, which is characteristic of other large developing countries, is an inward looking economic strategy that emphasizes import substitution over export promotion policies. Such policies result in a larger government role and more intervention in industrial affairs. India's approach has paralleled that of Brazil in its pursuit of independence from the influence of multinational suppliers and in its use of strict market reserve policies to protect indigenous companies. Although there was a significant reorientation of economic policy in the early eighties leading to a reduction in electronics regulations, there is an indication that this trend is being reversed at least in terms of protecting locally made computers.

The government has placed special emphasis on developing an international caliber software industry with the adoption of a new software policy in 1986. To promote software exports, it is establishing export technology parks to act as centers for software development that use satellite links to foreign customers. This approach has proved successful in obtaining business from abroad, particularly from the United States.

BRAZIL. The Brazilian government has played a key role in the development of its electronics industry since the early 1970s, when it created a government agency (CAPRE) to oversee development and established a national company (Cobra) to produce a domestically designed computer. (Cobra began as a joint venture with Feranti, a British firm.) Although the government has provided tax and credit preferences and funding subsidies, its main role has been to regulate trade, foreign investment, government procurement and technology transfer in order to promote and protect its nascent firms from foreign competition. These market reserve policies have been successful to the extent that a number of national firms have been created, some through licensing and joint venture arrangements, along with a sizeable technical work force. However, since 1987 many of these firms have incurred

substantial losses, and the government has had to intervene to rescue them. Brazil has not been successful in creating an internationally competitive industry. Besides computers and telecommunications equipment, Brazil is actively promoting the semiconductor and software sectors.

SINGAPORE. Singapore has embarked on a policy to promote its electronics industry that is based on maintaining an open market for foreign investment, while building a technically superior work force. It has attempted to move away from the low-skill assembly operations that have characterized its economy. (The industry is dominated by U.S. and Japanese firms. Less than 5 percent of the electronics firms manufacturing in Singapore are domestically owned.) The government is seeking to improve value added by moving into more knowledge intensive areas like software. The National Computer Board (NCB) was charged with promoting software exports and making Singapore an international software center by the end of the 1980s. As part of this effort, the NCB has established training institutes that have been cosponsored by foreign computer firms seeking additional software capabilities in Asia, such as IBM.

A National Information Technology Plan was launched in late 1986 to promote electronics exports. At the same time, the NCB set up an Information Technology Institute to work on software engineering, communications technology and knowledge systems, and in 1987 established a Software Development Assistance Scheme to stimulate innovative product development by local firms. The NCB has also encouraged local software firms to form strategic alliances with foreign firms.

The Government of Singapore has also played an activist role in accelerating the growth of local semiconductor technology. Although Singapore has been a base for assembly for two decades, with \$1.68 billion in exports in 1987, Chartered Semiconductors, a joint venture between state-owned Singapore Technology Corporation and two U.S. manufacturers, is the first effort at locally owned fabrication. It will concentrate on ASICs (application specific chips) that will not compete with DRAMs that dominate Japan's and South Korea's production.

TAIWAN. Taiwan's 1980 Economic Plan emphasized the promotion of high technology industries, with large-scale integrated (LSI) semiconductors, computer technology, and laser technology receiving particular emphasis. Domestic industry is to be aided by export and local content requirements for foreign direct investment. A Ten Point Plan for high technology development was adopted in 1983, with the Industrial Development Bureau providing the funding for new technological know-how. Taiwan's Institute of Information Industry promotes software development and has been very involved in training programmers and software engineers. The Electronics Research Institute (ERSO) has focused on VLSI (very large scale

integration) technology, computer technology and automation. Through ERSO, the government has targeted a number of areas of applications software for local development.

Taiwan has recently adopted a Communications Industry Plan to last from 1987 to 1991. Its main goals include developing memory boards and switching software. The government of Taiwan has also intervened in the semiconductor industry to develop a market that is based on custom designed chips, since there are few large volume producers as in South Korea. Although the government had funded ERSO to make semiconductors in the late 1970s, it was not until it set up the Taiwan Semiconductor Manufacturing Co. (TSMC) with Philips as an entity to produce chips for Taiwan's 40 chip design houses and foreign manufacturers that the industry began to grow.

SOUTH KOREA. South Korea has been committed to building firms that can compete in international markets, a goal that is reflected in the support offered to its electronics industry. Although the country is best known for the rapid growth of its consumer electronics industry, it was not until 1981 that the government modified its Electronics Industry Promotion Law to begin focusing on industrial electronics.

The Korean Government has played a major role in nurturing its domestic electronics companies. It has protected the local market through import licensing, high tariffs, and strong buy-national policies, especially for the telecommunications sector. Imports of computers, software, semiconductors and communications equipment have had to be approved and usually were only certified if a domestic source was not available. While most import licensing restrictions were eliminated in the early 1980s and some tariffs have been reduced, buy-national policies remain important. To facilitate the acquisition of foreign technology, capital and know-how, the Korean Government has offered investment incentives, including exemption from Korean income, property, and corporate taxes for up to five years to multinational firms.

The government has also been given strong support through the use of direct public funding. The Ministry of Trade and Industry (MTI) has provided funds to electronics firms to develop semiconductors and computers, while the Korean Institute of Electronics Technology (KIET) has conducted research and played an active role in building the early production lines for large-scale integrated circuits. In 1983, the Ministry of Science and Technology adopted a four-year R&D program for semiconductors and computers budgeted at \$44 million. The Korea Development Bank (KDB) and other sources have provided investment loans to firms. A KDB-sponsored Technology Development Fund assembled \$214 million for long-term loans to firms commercializing technology products or purchasing equipment for research labs.

South Korea has had a Software Development Center since 1967. The Center provides consulting and design assistance to public and private entities. In 1984, IBM established a software engineering center in Korea that was modelled after the Institute of Systems Science it helped establish in Singapore. Its aim is to graduate 900 professionals a year. While not much progress has been made in making Korea a major center for software, the government expects the large local base of computers to stimulate software development.

FRANCE. French industrial policy in the postwar period has been characterized by nationalization and industrial restructuring, state intervention at all levels, "planification" (administrative guidelines for production, investment, etc.), the promotion of "national champions," the regulation of foreign investment, industry subsidies, and preferential government procurement. This approach was followed with the computer industry beginning in 1967 with the first Plan Calcul, which was designed to direct development of an independent electronics industry and to form a national computer manufacturer. Current policies for the electronics industry are shifting away from placing an emphasis on the development of national champions and other targeting efforts.

The French Government has also initiated and funded large research efforts. The Filiere Electronique, or Electronics Sector Program, started in 1982, included computer hardware and software design projects. A five-year electronics plan was launched in 1983, where the government invested \$26 billion to improve the electronics industry's competitiveness, to create 200,000 new jobs, and create an electronics trade surplus. While the four largest electronics firms were to receive most of the funds in the program, it was focused on export promotion and increasing cooperation with other nations in Europe. Much of the R&D effort has targeted the development of VLSI technology and large-scale computers.

French policies appear to have had their greatest success where French firms are the strongest competitors, in the telecommunications and software sectors. This is less so in computers where in the mid-1960s France tried to create a national champion and failed after a number of efforts, which involved extensive subsidies (more than \$1 billion from 1964 to 1979). During this time, the government also invested substantial amounts in new firms (\$1.1 billion to create Unidata, which failed as a trans-European computer venture in 1975) and to promote mergers (\$957 million from 1977 to 1980 for the creation of CII-Honeywell Bull). When French computer firms were nationalized in 1981, the government adopted a new plan to accelerate the development of Fifth Generation computing, advanced programming, and artificial intelligence. It also created a new agency, the ADI, or Computing Development Agency, to spearhead computer-related research.

France has a strong software industry, one of the largest in the world, and has recently adopted several policies to foster the development of new languages (GRECO), advanced software engineering (EMERAUDE and CONCERTO), and speech synthesis (GRECO PAROLE). France's early policies for the computer industry in the late 1960s had included an effort to create market entry barriers for U.S. software firms, but these have not been incorporated in recent programs.

JAPAN. The Japanese electronics industry was established in the late 1950s, and it was actively promoted by the government because of the sector's perceived commercial and strategic importance. In the 1960s and early 1970s, the government mainly played a regulatory role to ensure the growth and development of indigenous manufacturers. By the mid-seventies, the role began to switch to one of financier (for major research programs) and industry defender (in trade complaint and intellectual property cases). From 1972 to 1991, the Japanese Government will have provided nearly 400 billion yen through its Ministry of International Trade and Industry (MITI) for a number of highly visible computer and semiconductor research programs. Government and industry also reportedly spent \$45 million in a recent year on public relations to improve its image in the United States. These public outlays and programs are the visible elements of an extensive pro-business, pro-high technology policy environment.

The Japanese Government has played a key role in each segment of the electronics industry by providing early research funds, nurturing private research, creating vehicles for direct government support during critical periods, and creating mechanisms to support state-of-the-art development and to maintain technological advantage once companies have become competitive. Major legislation was passed in 1957, 1971, and 1978 to establish support mechanisms for Japanese electronics firms and to create an organizational structure to guide and coordinate the industry's activities, which brought together government agencies, industry councils, trade associations, and joint research groups. The government's role in supporting research activities was especially important. In the early seventies, as Japanese computer companies faced an enormous competitive threat from IBM, substantial government support probably saved the industry from succumbing to this pressure.

EUROPEAN COMMUNITY. The objective of the EC has been to promote cooperation and integrated efforts among the national electronics industries, research centers, and governments in Europe. The primary means has been by initiating and funding cooperative research projects, including RACE (telecommunications), BRITE-EURAM (industrial technology, CAD/CAM, advanced materials), ESPRIT (microelectronics), and EUREKA (high tech areas, including information technologies and robotics). The first three programs are funded through the EC Community, but EUREKA is European-wide with funding provided by

national corporate, university, and government participants. The EC has budgeted over 4 billion ECUs over the next five years for the three programs it is sponsoring. In addition to these undertakings, there are a number of research programs sponsored by individual governments. Through these efforts, the EC has established a means of promoting large projects that have several important features: (1) These activities link together key national firms with some of Europe's leading universities and research centers in joint research efforts. This is the first time such extensive cross-border research has been undertaken, (2) They place a community-wide emphasis on pre-competitive research, while previous national programs had emphasized basic research or used national procurement and incentives to create strong national firms in certain segments of the industry, as in France's case.

UNITED STATES. The industrial policy of the United States has been largely ad hoc and fragmented over the years primarily because of two factors: the sector's continuing (although declining) dominance of the industry worldwide and the dominant free market philosophy that governments cannot pick winners as well as the private sector. Although the United States used targeted policies (government research funding and procurement) to promote the emergence of the computer industry in the 1950s, it has not expanded this role, and until recently, its involvement had declined, except in certain state-of-the-art technologies important for military or strategic applications. (For example, during the 1950s, the Department of Defense procured about 70 percent of the output of the computer industry, but by the mid-1960s, this had fallen to 10 percent.) In the 1960s, much of the research for commercially viable products had been taken over by the private sector. Consequently, little direct assistance has been offered to industry. Overall, U.S. policies have been much less targeted, coordinated, and integrated than those employed by its major competitors.

In the early 1980s, U.S. Government interests and involvement in the sector has increased substantially due primarily to the military and economic implications of the loss of dominance in many electronic product areas. This has resulted in a variety of efforts, mainly in funding research, but also in the trade and intellectual property protection areas. Through the liberalization of antitrust law, the government has encouraged a number of cooperative research ventures.

II. Strategies of Industrial Development

While every country follows its own unique path toward development, similar policies and strategies are often adopted. In terms of national strategies or a group of related policies with common objectives regarding the electronics industry, countries can be placed into one of three broad categories: intrinsic (I), extrinsic (E), or technological (T) (see Table 2). The first two apply to newly industrializing

countries where the objective is to create and nourish a fledgling industry. The third model applies to more mature industries, characterized by the United States, the European Community, and Japan, where the emphasis is less on protective trade and investment regulations than on efforts to create technological advantage.

In practice, these abstract models are not mutually exclusive. Countries, although leaning in one direction, demonstrate elements of each model as they respond to internal and external pressures. Moreover, policies in some countries have changed dramatically over time in response to shifts in competitive positions and changes in global technologies and markets. As Japan's electronics industry matured, policy moved from direct protection of local firms to promoting global technological competitiveness. India has shifted its policy focus toward a more open policy regarding foreign investment and technology. Also, because of its importance, the electronics industry has been exempted at times from general economic and trade policies that are applicable to other industrial sectors. Brazil is rated as moderately trade oriented in many product areas, but is extremely restrictive in its electronics sector.

Intrinsic Strategies (I)

The intrinsic model represents the more traditional inward looking, import substitution policies followed by Brazil, India and at times France. The objective is to protect an infant industry, in this case the electronics sector, from foreign competition while encouraging local firms to produce complete systems with minimal foreign input. These policies, although historically effective for certain traditional industries, have proven to be less successful for the electronics sector that relies heavily on the international flow of technology and global markets. This approach requires a major role for government and a high degree of industrial planning. The intrinsic strategy has the following characteristics:

(1) Imports that compete with actual or planned local production are heavily regulated or banned. This is accomplished through an assortment of restrictive trade instruments, including prohibitive tariffs, import licenses, technical standards, and other non-tariff barriers. While the focus is on creating locally owned plants, protection can also be extended to foreign manufacturers who meet government criteria.

(2) Foreign investment is either prohibited or discouraged. Both new and existing investment is subjected to numerous restrictions regarding equity ownership, income remittance, technology transfer, trade and local content. Existing foreign investment for the expansion and modernization of plants and production is strictly regulated.

(3) There is less emphasis on using stimulants like subsidies and fiscal incentives. When available, they are usually applied only to national companies, unless strict conditions are met by foreign producers. National treatment is generally not accorded to foreign suppliers.

(4) A backward integration strategy is followed in which domestic firms are encouraged to design and produce complete systems as the quickest way to import substitution. Critical components, subassemblies, and software are acquired through imports, although there is pressure to buy locally when these products are available. It is assumed that the human and capital infrastructure thus created will facilitate movement back along the input chain.

(5) The focus is on developing technology locally and, thereby, reducing foreign influence and control. If foreign technology is needed, then the intent is to acquire its ownership rather than engage in cooperative endeavors with foreign companies. The attempt is to create a comparative advantage based on national technology.

(6) Policies favor production for the domestic market over exports. It is assumed that the internal market will provide adequate opportunities for economies of scale. Protection of local producers discourages exports by increasing the price of imported inputs and raising the relative costs of domestic inputs.

(7) Sector targeting practices are extreme. The selected sector is exempted from cross-sectoral or macroeconomic considerations, such as user needs, inflation, or general industrial competitiveness.

Extrinsic Strategies (E)

This outward looking, export-oriented strategy is epitomized by the Asian NICs (South Korea, Taiwan, and Singapore) and Japan prior to the 1980s. This approach also requires heavy government input, but policies are designed more to exploit foreign technology and to promote production in areas where comparative advantage can be created.

(1) The domestic industry is protected from foreign competition through the usual tools of import restrictions and foreign investment regulations. But internal competition is promoted in order to maintain internationally competitive firms.

(2) Policies are designed to facilitate exporting by not discriminating between production for domestic and foreign markets or between domestic and foreign products, such as in local content regulations. The usual result of nondiscriminatory trade policies is increased trade. Market promotion policies are used to encourage yet control domestic competition in order to promote exports.

(3) There is a forward integration strategy, which is based on existing production capabilities. This model follows more closely the logic of comparative advantage. Taiwan and Korea built their systems capabilities upon a strong industrial base competitive in the production of consumer electronics and parts. The movement down the input chain is facilitated by a sound production base. This model assumes that governments can successfully pick winners in the international marketplace.

(4) There is less emphasis on local design and control over technology and more encouragement of foreign investment. Foreign manufacturers play a greater role in this model, particularly in terms of technology transfer.

(5) Macroeconomic policies are stressed to restructure industry away from declining sectors toward higher value-added areas. Policy is more aligned with cross-sectoral considerations, and user requirements are considered.

Technological Strategies (T)

The technology model is used to describe the policy initiatives of Japan, the European Community, and generally of the United States. The emphasis in these more mature industries is less on protective trade and investment restrictions than on efforts to create technological advantage. Unlike the developing nations, which are merely trying to remain at the periphery of global competition, the advanced countries are engaged in strategic efforts to sustain their industries and to compete at the leading edge of technology. Elements of this model are listed below.

(1) National projects target priority R&D areas and create cooperative research organizations that are supported by government, industry and academia. The kinds and levels of support vary from project to project. This requires adopting exceptions to antitrust regulations that balance anti-competitive concerns with the need to pool resources.

(2) The nationally supported projects tend to focus on areas where results, if any, are long term, payoffs are more speculative, and research is more basic and pre-competitive. Research that is closer to the product development and commercialization stage is generally left to private companies and laboratories.

(3) The shared research activities of these national projects minimize costs and reduce risks of this kind of R&D for industry. They also act as technology transfer vehicles for pre-competitive research. Companies share the results, then develop the technology further in corporate labs to produce commercial products. If the research fails to achieve beneficial results, then the blame is shared.

(4) Government and private efforts are directed toward ensuring that adequate and affordable sources of capital are available to all innovative and commercially productive companies. Mechanisms must meet the needs of small start-ups as well as large multinationals.

(5) The government focus is less on protecting domestic markets than on protecting the technological secrets and know-how of national companies. When foreign technology is acquired, it is usually advanced, not mature technology.

(6) Sources of technological discovery and innovation are coveted. Policies are directed toward fostering advanced technological training in the universities and retaining technological talent at home.

Table 2 Current Strategy of Industrial Development

<u>India</u>	<u>Braz</u>	<u>Sing</u>	<u>Taiwan</u>	<u>S.Korea</u>	<u>France</u>	<u>Japan</u>	<u>EC</u>	<u>U.S.</u>
I	I	E	E	E	T	T	T	T

National Policies

Brazil and India. These countries have long and somewhat similar traditions of industrial development policy. Many of these policy biases have been carried into the electronics sector. Brazil's economy, of nearly continental size, has long been inward looking with relatively small dependence on international trade. India has also had a very inward looking economic policy with strong socialist leanings and state run enterprises. Industrial and trade policy has tended to focus on promoting domestic production through strong import substitution, rather than by encouraging exports of domestic products, leaving exporters of many goods at a severe disadvantage.

Faced with strong foreign competition and increasing imports, these countries have erected trade barriers to shelter local firms, which were then encouraged to design and assemble complete systems with minimal foreign input. As the infrastructure of trained labor, industrial know-how and capital goods expanded, it was felt that the industry could integrate backwards into components and move into ever higher levels of technology. It was hoped that local technological development could prosper under these conditions and that needed technologies could be appropriated from abroad in return for access to the local market. Both nations have employed most of the restrictive and preferential policies available to promote their industries, including import and investment barriers, production and capital remittance controls, export subsidies, incentives for national firms, and resistance to adequate intellectual property protection.

One notable difference has been a decided shift recently in official policy in India, while Brazil's Government, although appearing sympathetic to liberalization, has as yet not affected meaningful change. Under India's 1985 Seventh Five-Year Plan, restrictions on most imports of electronics, including computers, were lifted, and policies changed to a more open market orientation, including incentives for multinational firms that establish subsidiaries in India. This resulted in accelerated growth for the industry. However, three years after lifting the import restrictions, the Export/Import Policy for 1988-91 again called for restrictions on all computers, except high-end minicomputers and mainframes. The official justification was that the government had to protect the capability of its firms to produce at the low end of the equipment spectrum.

Taiwan and South Korea. Taiwan and South Korea are often compared regarding economic development. Both countries have relatively similar economic circumstances and strategies, although with different nuances. Both governments have played an active role in shaping economic development using export growth as the major impetus for success. The focus on electronics, though important in consumer areas in the 1970s, became targeted in the early 1980s on informatics, as the principal high skill and technology intensive industry to spearhead economic growth into the future. In order to achieve these goals, these governments have used a combination of traditional, indirect approaches to industrial policymaking and a variety of direct initiatives targeted on specific sectors. All components of the industry are viewed as an integrated complex of industrial and service sectors that are mutually supportive of expansion and growth. Sector-specific targeting plans are designed as part of the overall economic planning process and emphasize the integrated nature of the industry. Policies are integrated to exploit cross-sector linkages and market/production relationships. For example, Korea's planned state-wide telecommunications network will require substantial amounts of custom software development. Similarly, these integrated networks will create substantial demand for computing power at remote locations and will enforce the standardization of communication protocols and other system features.

The development strategy of Taiwan and Korea has been built upon the following elements: promoting economic growth through the acquisition of foreign technology; tightly controlling imports to protect domestic producers, while providing preferential access to cheap imported inputs; creating internationally competitive firms that are independent of government support; promoting exports; and identifying market niches that offer opportunities for creative comparative advantage. Overall, this strategy has been highly successful. A key aspect has been the establishment of technological relationships with foreign multinationals. Various policies have been used to enhance the cooperation between foreign and

domestic firms resulting in important subcontracting, licensing, joint venture, and other relationships that have facilitated technology transfer and growth for their domestic companies. This success has made them major competitors at the low end of the electronics equipment spectrum and has established them as models for other developing countries.

There are two notable differences, however, between Taiwan and South Korea. First, because of its smaller domestic market, Taiwan has had a much stronger export orientation with less market protection and emphasis on domestic demand than Korea. Therefore, Taiwan has generally pursued a more market-oriented, incentive approach to economic policy. Secondly, the industrial structure in Korea is dominated by large, highly diversified conglomerates that compare with Japanese firms in resources and strategic outlook. Taiwanese firms, by contrast, are smaller, more specialized concerns that do not have the same financial clout and ability to cross-subsidize production. As a result of this industrial structure, Korea is emerging as a world force in semiconductor manufacturing, particularly of DRAMs.

Singapore. Because of the need to maintain international competitiveness, government policy formulation and implementation typically have not interfered with the market, but have been very responsive to market forces. A fundamental component of Singapore's strategy, which it pursues tenaciously, has been to attract foreign investment and technology in favored areas. The government's guidance of its electronics industry has generally been very successful, but mistakes have been made. Most importantly, the sharp increase in domestic wages to encourage the shift to capital intensive industries. However, the government has been quick to recognize mistakes and to adjust.

France. In France, policy concern initially focused on the creation of a competitive national champion in computers. But when this effort stalled, attention shifted to promotion of the larger electronic sector. The interplay of a political desire for a European leadership role in technology, a complex and relatively anti-growth policy environment, and the dynamics of EC integration must be considered in order to explain this French policy shift.

Japan. As the Japanese electronics industry developed from infancy to world class status, Japan's development strategy evolved from extrinsic to technological, and the country is now engaged in an intense technological race with the United States. During the sixties and seventies, the Japanese had two objectives: to create viable manufacturers and to ensure their survival by protecting the domestic market. By the eighties, these policies were so successful that Japan had surpassed Europe as the principal U.S. competitor, had become the world's preeminent exporter, and was establishing subsidiaries and

challenging U.S. companies in their own market. The Japanese Government is now directing its efforts toward establishing global technological superiority through more attention to basic research.

Before 1970, Japanese firms lagged well behind the United States in technology and depended heavily on licensing and joint ventures with foreign suppliers to acquire the critical manufacturing and product know-how. After it became apparent that technology transfer from abroad would be insufficient to reduce the lag with foreign suppliers, the government began massive funding of national research projects. By 1980, as Japanese firms became more self-sufficient, the government's proportion of funding had diminished as the private sector assumed a greater role in research efforts, especially in the applied and product development areas.

The government also used a standard array of policies to reserve its markets and protect its companies during the formative stages of its industry. These policies included trade/investment restrictions (high tariffs, import quotas, and foreign exchange allocations), preferential government procurement, and indirect financial support for local companies (tax and credit subsidies). To assure its firms of a continuing source of demand, the Ministry of International Trade and Industry (MITI) established the Japan Electronics Computer Corporation (JECC) that purchased Japanese computers and leased them to users at subsidized rates. By taking the financial burden of leasing off the shoulders of Japanese firms, MITI released additional funds for R&D and capital expansion. The kinds of financial support instruments used included general tax benefits for all industries (R&D credits, accelerated depreciation allowances, and deductions for export expenses), industry-specific measures (special tax breaks for computer purchases and repurchase arrangements), and industry loans at preferential interest rates.

Policy formulation was flexible, and as objectives were achieved, policies were formally abolished or modified. Import quotas and limits on foreign participation in the Japanese market were removed in the seventies, while computer tariffs were lowered in the mid-1970s and eliminated in 1986. The JECC continues to operate, but has declined in importance as Japanese producers handle their own leasing arrangements. However, Japanese companies still benefit from a strong preference for local products that exists within government and the private sector, even though the "Buy Japan" policy was formally rescinded in 1978.

Competition has been carefully nurtured within the industry to foster self-reliance and to maintain government influence. During the early years, the government avoided the national champion strategies of some European countries, i.e., supporting only one firm, and let competitive forces determine which firms would emerge as leaders. The government has also

shaped the way in which new technologies are developed, often stretching its leverage over new technology development by creating rivalries between groups of companies that competed to be first to commercialize new technologies. These rivalries were sometimes paralleled by rivalries between government agencies and their laboratories.

Summary of National Policies

Table 3 lists the principal policy instruments in each country that affect the electronics industry. These may be targeted policies aimed only at the electronics industry or general policies that apply to all industries. The policies are divided into those that are externally directed at foreign suppliers and those that are internally directed at indigenous firms. External policies can be either restrictive or incentive oriented, but most tend to regulate or prohibit foreign activity for a variety of national goals. While internal policies generally provide positive support to local firms. In theory, preferential treatment provided to national firms can also be offered to foreign subsidiaries; however, this is generally not the case.

III. Stages of Industrial Development

Definition of Industrial Activity

The level of sophistication among national electronics industries ranges from "screwdriver" assembly plants in low-wage developing countries to state-of-the-art operations of multinational companies in the developed world. Regardless of its level, industrial activity can be defined in terms of three functions that are necessary to any productive enterprise: research and design, manufacturing, and marketing. In the case of simple contract assembly, very little research or marketing is carried out by the company, whereas large conglomerates are heavily involved in all three activities and in trying to coordinate them efficiently in the marketplace. Although these are distinct tasks, they are closely linked. For example, ideally engineering, production and marketing staffs should coordinate closely in new product development and design.

Research and Design

Stages in research and design include basic research, applied research, and product/process development. Basic research is defined as the investigation of fundamental aspects of phenomena without assurances that the knowledge gained will lead to practical or commercial applications. The objective of applied research is to gain the necessary knowledge to develop the means to meet specific needs, while development translates this knowledge into the production of goods and services. As companies or industries move back along the spectrum from product development to basic research, the opportunity for innovation increases, but greater risks and costs are incurred

TABLE 3 Key Government Policy Instruments

	<u>Ind</u>	<u>Bra</u>	<u>Sng</u>	<u>Tw</u>	<u>Kor</u>	<u>Frn</u>	<u>Jpn</u>	<u>EC</u>	<u>US</u>
<u>EXTERNAL POLICIES</u>									
TRADE									
Tariffs	x				x				
Non-tariff barriers									
Import licenses	x	x			x				
Others									x
FOREIGN INVESTMENT									
Incentives									x
Restrictions	x	x							
TECHNOLOGY TRANSFER									
Regulations	x	x							
Lack of IPR protection	x	x							
<u>INTERNAL POLICIES</u>									
Financial support	x	x		x	x	x			
R&D funding						x	x	x	x
Export subsidies	x			x	x				
Government procurement						x	x		
Market stimulation						x			
Physical infrastructure development			x	x	x				
Education					x		x		
Pro business climate							x		x

along with longer payback periods. Research carried out by firms in developing countries tends to be at the product/process engineering end of the spectrum. These firms are also heavily dependent upon foreign technology. While developed countries place significant resources into basic research and are generally net exporters of technology.

Manufacturing

The manufacturing spectrum includes two separate dimensions: process and product. High tech products can be produced with relatively low tech methods, while low tech products can be produced with highly automated processes. At one end of the process spectrum are manual operations that require low skilled workers and employ simple management techniques and input sourcing methods. At the high end are automated processes, highly skilled workers, complex management problems, and global sourcing strategies. Similarly, the product spectrum ranges from low tech products, which are often dependent on foreign-sourced inputs to high tech products, mostly based on domestic inputs. Ideally, the more developed an industry is the more capable it is of producing all of the necessary physical and human inputs domestically to manufacture a final product, including materials, components, subassemblies, and units. As a company moves along the manufacturing spectrum, its value added increases, but operational complexities and capital costs also rise significantly.

Marketing

Marketing activities include product distribution, pricing, promotion, maintenance, and support. The marketing spectrum ranges from the simple marketing activities of a small plant that sells to middlemen or original equipment manufacturers to the sophisticated techniques of a large integrated company with an extensive global customer base and broad array of marketing channels.

Level of Industrial Development

Table 4 classifies the selected countries as imitators (I), assimilators (A), or innovators (N) according to their overall level of industrial development. These concepts are not exact, but are intended only to typify the indigenous industry and current capabilities of particular countries in a subject area that is difficult to quantify. It is also difficult to definitively classify countries in terms of a single concept. Even the most advanced countries contain examples of rudimentary manufacturing plants, while relatively poor countries can point to advanced plants built by multinational companies. Similarly, high tech companies in advanced countries may choose more basic manufacturing methods or marketing channels for a particular product depending on the commercial situation. Finally, country capabilities vary

across the various sectors in the electronics industry. For example, India has a much stronger global position in software than in hardware.

Table 4 Stage of Industrial Development

<u>India</u>	<u>Braz</u>	<u>Sing</u>	<u>Taiwan</u>	<u>S.Korea</u>	<u>France</u>	<u>Japan</u>	<u>E.C.</u>	<u>U.S.</u>
I	I	A	A	A	N	N	N	N

Imitators (I) rely heavily upon foreign technology, know-how, and capital. Little R&D is done locally except at the production engineering level. Production is the simple assembly of foreign components and subassemblies using equipment purchased from abroad. Production units are usually loosely organized using inefficient, manual, low skill processes. Marketing efforts are virtually nonexistent and undertaken by foreign firms which have contracted for local assembly.

Assimilators (A) have begun to develop local technical talent and know-how. Technology is enhanced and often diffused through the mobility of local technical and entrepreneurial personnel, which leads to the establishment of new firms. Production units become more competitive and efficient and the finished product industry creates a market for and stimulates growth of a local parts industry. Marketing efforts become broader to include marketing to original equipment manufacturers (OEMs).

Innovators (N) rely mostly on domestic technology and engineering talent. An important percentage of industry revenue is spent on R&D, including basic research. Foreign technology is sought where necessary to fill voids through licensing and joint venture agreements. Production units stress productivity and economies of scale to meet competition in local and foreign markets. Most inputs are available locally. Industrial engineering and production management techniques are introduced to rationalize production processes. The industry is engaged in global marketing efforts, including directly to users or customers.

R. Clay Woods
Office of Computers and
Business Equipment

APPENDIX I

Country Profiles*

Japan

Computer Hardware

I. Historical Development

The Japanese computer industry was established in the late 1950s and carefully nurtured by the Japanese Government, based on an awareness of its commercial and strategic importance. Since Japan lagged well behind the United States in computer development, the Japanese depended heavily at first on licenses from and joint ventures with several leading U.S. suppliers to acquire the critical manufacturing and product technologies needed to compete in this area. Over the next 10 years, the industry gained self-sufficiency in component and computer equipment production, and when it had a secure hold on its domestic market, it began to export. However, the Japanese faced an enormous competitive threat from U.S. suppliers in the world computer market and would have probably succumbed to this pressure had it not been for substantial government support and protection.

By the 1980s, the industry emerged as the principal competitor of the United States in a wide range of computer products based on its strength in high-volume, low-cost manufacturing and growing prowess in component technology. It has also recently become more multinational in character in response to fears of protectionism in key overseas markets and the appreciation of the yen relative to the U.S. dollar. Japanese suppliers have now increased their market presence beyond the major OEM (original equipment manufacturer) agreements they concluded with U.S. and European companies in the 1970s by opening their own foreign manufacturing plants and R&D facilities.

II. Stage of Development

In terms of their technological development, the Japanese have evolved well beyond the imitator stage and are universally renowned for their ability to assimilate the best research developed in other countries, to improve significantly on existing technologies, and to incorporate their research results into marketable products faster than their foreign competitors. Their R&D efforts in the past, particularly the VLSI (very large scale integration) project, have helped them to become a dominant force in certain key components such as

* Some of the country profiles contained in this appendix were based on studies prepared for the U.S. Department of Commerce by the Hudson Institute.

as dynamic random access memory (DRAM), high-speed logic, and opto-electronics. They are currently working hard to catch up with the United States in microprocessors and application specific integrated circuits (ASICs). The scope of and monies committed to Japanese research on superconductivity have given U.S. observers great cause for concern. Breakthroughs in this area would not only help the Japanese to surpass the United States in computer technology but would also affect the competitiveness of U.S. firms in several other industries.

At the systems level, the Japanese are reportedly nearly on par with U.S. firms in hardware design. Their large-scale mainframes and supercomputers match the best that the United States has to offer in single processor performance and have established an impressive reputation for high quality and reliability. They still lag slightly behind in the development of parallel, multiprocessor systems. However, Fujitsu and Nippon Electric Company (NEC) have announced the availability of their first multiprocessor supercomputers which will compete with U.S. models on the market. Japanese suppliers have also gained a strong position in laptop computers and peripheral equipment and are now attempting to make inroads into the technical workstation market through licensing agreements, joint ventures, and investments in promising U.S. start-ups. The innovativeness of the Japanese has often been overlooked in assessments of their progress in computer hardware development. They have cleverly adapted their products to take advantage of their strength in engineering and manufacturing and have incorporated many of their key innovations in audio, video, and optical recording into disk storage devices and monitors.

III. Industry Structure

The Japanese computer industry is highly concentrated with less than 2 percent of the more than 1,500 manufacturers controlling roughly 70 percent of production and almost half of total employment (see Table 1). Fujitsu, Hitachi, and NEC have always been the dominant suppliers within this elite group and the principal participants in and the beneficiaries of Japan's national computer R&D programs. They are multibillion dollar conglomerates whose interests in electronics include not only computer systems, but also advanced components, telecommunications equipment, and consumer electronics products. Other highly diversified manufacturers such as Canon, Matsushita, Mitsubishi, Oki, Seiko, Sony, and Toshiba are in a second-tier of leading suppliers. These companies have become world class competitors in certain market sectors such as laptop computers and low-end disk storage devices and printers. The remaining firms in the industry are either subcontractors or subsidiaries and affiliates of the large Japanese computer producers.

Japanese computer production reached an estimated \$27 billion in 1987, second only to the U.S. industry in output. Peripheral shipments accounted for nearly half of this value. Mainframes figured prominently in systems shipments, representing 42 percent of production, followed by small systems (24 percent) and personal computers (21 percent).

Table 1 Structure of Japanese Computer Industry

Size of Firm (Employees)	No. of Firms	%	No. of Employees	%	Percent of Production (value)
1-49	1,237	77.4	21,002	17.1	4.1
50-99	185	11.6	12,002	10.6	3.2
100-299	117	7.3	18,828	15.4	7.4
300-999	36	2.3	19,478	15.9	15.4
1000 or more	24	1.5	50,281	41.0	69.9
Total	1,599	100.0	122,526	100.0	100.0

Source: Census of Manufacturers 1986, MITI.

The Japanese industry has been strongly export oriented, sending nearly a third of its output overseas during the 1980s. More than 50 percent of these exports have gone to the United States. As a result of the rapid build-up in Japanese exports entering the U.S. market and relatively lower Japanese imports from U.S. suppliers in recent years, Japan's computer trade surplus with the United States soared to around \$5 billion in 1987. IBM Japan has traditionally been an important factor in Japanese computer exports. However, its share relative to the exports of other leading Japanese suppliers has fallen sharply since 1980 (see Table 2).

Japan is the second largest computer market in the world with demand exceeding \$18 billion in 1987. Many of the U.S. computer multinationals have participated in the Japanese mainframe market since the 1960s either through wholly owned subsidiaries (IBM and National Cash Register) or joint ventures with Japanese partners (Burroughs, Control Data, Honeywell Information Systems, and Sperry Univac). U.S. companies now sell a broad range of computer systems to Japanese users. Principal U.S. competitors along with the mainframers include Cray Research (supercomputers); Alliant and Convex (minisupercomputers); Data General, Digital Equipment Corporation, Hewlett-Packard, and Prime (minicomputers); Apollo and Sun (workstations); and Apple (personal computers). U.S. suppliers generally have had difficulty in penetrating the Japanese market. Despite their majority shares of key foreign markets elsewhere in the world, they hold only 22 percent

of Japan's installed base of computers. They have had some initial success to date in minisupercomputers and workstations because their Japanese rivals have not yet mounted a competitive challenge in these market sectors. Apple and other U.S. personal computer companies originally dominated the market for these systems in Japan but lost control very quickly in the early 1980s when the Japanese introduced their own models.

Table 2 Exports of Leading Computer Firms in Japan
(In Billions of Yen)

<u>Firm</u>	<u>FY</u> <u>1980</u>	<u>Share</u> <u>of</u> <u>Total</u> <u>(%)</u>	<u>FY</u> <u>1987</u>	<u>Share</u> <u>of</u> <u>Total</u> <u>(%)</u>	<u>Annual Growth</u> <u>FY 80-87</u> <u>(%)</u>
IBM Japan	69	49	317	34	+24
Fujitsu	37	26	209	23	+28
NEC	15	11	180	19	+43
Hitachi	16	11	141	15	+37
Toshiba	4	3	85	9	+54
Total	141	100	932	100	+31

Sources: Japan Economic Journal and International Data Corporation.

IV. Government Objectives

The Japanese Government has actively promoted the Japanese computer industry since the mid-1950s. It passed laws in 1957, 1971, and 1978 to establish support mechanisms for Japanese electronics firms and created an infrastructure to guide and coordinate the industry's activities that brought together the Machinery and Information Industries Bureau of the Ministry of International Trade and Industry (MITI), industry councils, trade associations such as the Japan Electronic Industry Development Association (JEIDA), and joint research associations. However, government policy in Japan has been very flexible and has changed over time to reflect both the needs and the competitive position of the industry. In contrast to the policies of European governments, the Japanese Government did not establish any "national champions" but let competitive forces determine which companies would emerge as leaders. Targeting of strategic market sectors and technologies has been a fundamental element of the Japanese strategy in computers.

The Japanese Government's role in supporting research and development was particularly important to the industry. The government fostered some limited computer R&D in the 1960s

but, when it saw that technology transfer from foreign companies alone would not be enough to catch up with the United States and Europe, it began massive funding of national research projects in the early 1970s. Japanese industry would probably have had difficulty surviving U.S. competition in the world market without this support since Japanese firms did not have enough resources to underwrite these large-scale efforts on their own. By the end of this decade, the Japanese Government's involvement in computer R&D diminished when growth in sales allowed industry to assume more of the research burden. The national projects remained a significant source of technology but focused on more speculative, long-term R&D aimed at helping the industry gain technological leadership.

V. Government Policies, Laws, and Regulations

Research and Development

The principal participants in Japanese computer R&D have been certain government agencies and their major laboratories, universities and colleges, joint research associations, and corporate research laboratories. Their relative contributions to the performance of this R&D appear in Table 3. Within the Japanese Government, MITI has played a crucial role in the development of computer technology not only in providing research subsidies, but also in identifying priority areas for R&D, establishing policies and programs, and building a consensus among Japanese computer firms to work together to achieve significant R&D objectives in national projects. Its Electrotechnical Laboratory (ETL) has generally taken the lead in most of these national efforts. The Ministry of Posts and Telecommunications (MPT) has also had an indirect influence through the work of the four Electrical Communications Laboratories (ECL) of Nippon Telephone and Telegraph (NTT).^{*} NTT has engaged in a wide range of computer-related research projects internally and jointly with Fujitsu, Hitachi, NEC, and Oki, its family of suppliers. Its labs have made substantial contributions to the development of semiconductors, large-scale computers oriented toward timesharing applications, and high performance disk storage devices in Japan. From the late 1970s onwards, NTT has surpassed MITI in spending on computer-related research.

Japanese universities and colleges have been the weak link in the research infrastructure, traditionally performing only 4 to 5 percent of computer-related R&D. Inadequate funding from the Ministry of Education in the past and insufficient numbers of electrical and electronic engineering graduate students have limited the amount of basic and applied research conducted in

* NTT became a private corporation in 1985, but the Japanese Government still has about 60 percent ownership.

academia. Corporate collaborations with universities have also been minimal until recently, further exacerbating the situation. By contrast, U.S. universities have been a wellspring of basic research in engineering and computer science, and have greatly benefited from their close ties to government and industry over several decades.

Table 3 Computer-Related R&D
(Percent of Funding)

<u>Year</u>	<u>Industry</u>	<u>NTT</u>	<u>Central Government</u>	<u>Research Associations</u>	<u>Universities/ Colleges</u>
1970	72	28	-	-	N.A.
1971	65	33	1	-	N.A.
1972	33	32	4	31	N.A.
1973	34	21	3	41	N.A.
1974	22	19	3	51	5
1975	31	20	3	40	5
1976	38	18	2	37	4
1977	48	22	2	23	5
1978	46	21	3	25	5
1979	55	19	4	15	7
1980	65	20	2	8	5
1981	61	17	1	16	4
1982	63	16	2	14	4
1983	68	14	2	10	4
1984	73	15	1	7	3

N.A.: Not available

Source: Kenneth Flamm, Targeting the Computer, Brookings Institution, Washington, DC, 1987.

Joint research associations involving government research institutions and the leading Japanese computer manufacturers were established during the 1960s to participate in national research projects and soon became another major force in technology development. By combining matching funds and resources, they have provided the industry with an effective vehicle to engage in critical long-term, competitive R&D and to share results that are then transferred to corporate laboratories for development into commercial products. Their significance is underscored by the fact that the companies in these associations could not have afforded the expense of the research undertaken jointly in the national projects on their own and would not have assumed the great risk entailed. For example, Fujitsu's after-tax profits of 35 billion yen from 1976 to 1979 would not have sustained the seminal VLSI project, which cost around 72 billion yen. Once a unique feature of Japan's R&D infrastructure, the joint research association now has its counterparts in Europe's Alvey, ESPRIT and EUREKA projects as well as MCC and Sematech in the United States.

Corporations have shouldered more than half of the burden of funding Japan's computer R&D at least since 1970 (see Table 4). Their laboratories have also grown in importance in the 1980s, overtaking joint research associations and even NTT in the amount of R&D work performed. Most of this corporate activity is in applied research and development. However, Japan's progress in computer R&D has been hampered to some extent by not having the large number of small innovative firms that have been spawned by venture capital funding in the United States.

Table 4 Japanese Computer-Related R&D Spending
1970 - 1984
(In Millions of Dollars)

<u>Year</u>	<u>Total Spending</u>	<u>Industry Share (%)</u>	<u>GOJ Share (%)</u>
1970	83	64	36
1971	118	60	40
1972	168	50	50
1973	301	51	49
1974	314	46	54
1975	348	51	49
1976	398	56	44
1977	438	58	42
1978	626	59	41
1979	725	61	39
1980	726	66	34
1981	978	72	28
1982	1,014	72	28
1983	1,230	75	25
1984	1,645	77	23

Source: Kenneth Flamm, Targeting the Computer, Brookings Institution, Washington, DC, 1987.

Government support of Japanese computer R&D evolved through several distinct phases. From the early 1950s to 1961, development efforts that resulted in Japan's first commercial computer systems took place mainly within MITI's Electro-technical Laboratory, NTT, and the University of Tokyo. The technology incorporated in these systems lagged well behind U.S. models. Japanese computer firms played only a subordinate role in these efforts, and government subsidies provided to industry throughout this period amounted to less than \$1 million.

A MITI-organized research committee in 1955 urged direct funding for computer R&D and rapid transfer of foreign technology through patent licensing and technical assistance to accelerate the growth of the fledgling Japanese computer

industry. These recommendations were formalized in the Electronics Promotion Law of 1957, which established R&D support packages and permitted exemptions for the industry from the Anti-Monopoly Law, allowing MITI to form cartels to control production, R&D activities, and raw materials purchases. The Japanese Government later made foreign participation in the Japanese market contingent on transfer of technology to Japanese partners. The technical relationships and joint ventures forged during the 1960s were: Hitachi with RCA (1961); NEC with Honeywell Information Systems (1962); Toshiba with General Electric (1962); Oki with Sperry Univac (1963); and Mitsubishi with TRW, Xerox Data Systems, and Westinghouse (1969). IBM also provided access to its computer patents under license in 1960 to obtain guarantees for foreign exchange remittances and the right to manufacture computers in Japan. However, this arrangement reportedly did not help Japanese firms in active technology transfer as much as their joint relationships with U.S. suppliers.

The first phase culminated in the FONTAC project, a three-year effort began in 1962 to develop a computer competitive with the IBM 7090. It represented the first government-directed joint computer R&D program and created one of Japan's first private industrial research associations, involving Fujitsu as the team leader along with NEC and Oki. Total funding reached about \$1.5 million, with the government providing 50 percent of that amount. Both Fujitsu and NEC introduced medium-scale mainframes in 1964 that were based on technology from the FONTAC project.

A second phase of government support began in the mid-1960s with the government taking a more active role in the Japanese computer industry as a nurturer of industrial research. This was largely in response to the competitive threat posed by IBM's introduction in 1964 of its System 360, a computer family based on hybrid integrated circuits. The Japanese Government recognized at this time that Japanese computer firms would not be able to catch up with their U.S. rivals if they continued to depend on licensed technology. A five-year, Super High Performance Computer System (SHPEC) program was launched in 1966, which brought together the ETL and Japan's five leading computer manufacturers. Fujitsu, Hitachi, and NEC were given the responsibility to build a large-scale mainframe, including operating system and applications software, while Toshiba and Oki were asked to develop peripherals. Receiving \$40 million in R&D funds, this first national computer research project succeeded in developing high performance logic circuitry for use in large-scale computers and Japan's first semiconductor memories. The same logic and memory technology was also used in a complementary industry effort led by NTT to design a computer system for timesharing and data base management (the Dendenkoshi Information Processing System Project). The software development effort within the SHPEC program failed to achieve its goals.

By the end of the 1960s, the Japanese Government had three basic types of institutional mechanisms in place to support computer R&D programs: MITI's conditional loans (Hojokin) and consigned payments (Itakuhi), NTT-provided funds, and research contracts awarded to participants in ETL-managed national R&D projects. The conditional loans were rarely repaid since the R&D associations seldom made a profit.

Two major crises within the Japanese computer industry during the early 1970s brought about a fundamental change in government R&D strategy and funding. One was the departure of General Electric, RCA, and eventually Xerox from the mainframe computer market following the introduction of IBM's System 370, which severed the critical technical linkages they had with a number of Japanese computer firms. The other was the Japanese Government's commitment under pressure from the U.S. Government to open up the Japanese computer market to foreign trade at a time when Japanese manufacturers were confronting a new technological challenge from IBM. MITI's response was to try to rationalize the industry by forming three research and production groups (Fujitsu/Hitachi, NEC/Toshiba, and Mitsubishi/Oki) and by substantially increasing its R&D funding. In addition, the government's R&D policy placed greater emphasis on support for large joint research projects performed by industry associations whose ultimate goal would be to develop commercial products. This led to internal corporate R&D activity declining in importance through 1976 and the transfer of significant resources out of private R&D labs into these projects. Japanese spending on computer-related R&D reached \$398 million in 1976, nearly three times the 1971 level when the Japanese Government began its massive infusions of funding.

The Japanese Government's R&D programs in this phase were directed toward catching up with the United States in computer technology. Although focused largely on theoretical and basic research, the 10-year Pattern Information Processing System (PIPS) project conducted research into artificial intelligence modeled after U.S. efforts that would set the stage for the Fifth Generation Computer and other more advanced R&D projects in the next decade. The shorter term "3.5 Generation" program had mixed results. While all six participants succeeded in developing mainframe products, Mitsubishi, Oki, and Toshiba decided later to drop out of large-scale computer manufacture and to concentrate their efforts on smaller computer systems and peripherals. Fujitsu and Hitachi introduced their own IBM-compatible machines, with Fujitsu benefiting from technical assistance from Amdahl Corporation of the United States. NEC chose to take an independent, non-IBM compatible route by producing a line of mainframes based on the operating system technology that it had acquired from General Electric via Honeywell. The company went on to become a provider of technology and mainframe hardware to Honeywell Information Systems (now part of Honeywell Bull), the source of much of its early computer know-how.

The period beginning in the late 1970s marked another watershed for Japanese computer R&D. A rapid increase in commercial sales allowed the industry to assume more of the burden for computer R&D in terms of funding and performance. By 1984, Fujitsu, Hitachi, and NEC each were spending over \$500 million on their R&D programs. Although MITI's funding of joint research associations remained relatively constant, the government's role in supporting industry research declined sharply. Efforts in the national research projects focused on helping Japanese firms to become state of the art and to maintain their technological advantage. The advanced semiconductor technology gained in the VLSI project was largely responsible for Japanese advances in mainframes and eventually supercomputers in the 1980s. Both the Software Automation and the Fourth Generation computer projects were five year programs that attempted to deal with Japan's weaknesses in software development. They were the forerunners of TRON and SIGMA, which would focus Japanese R&D activities on software engineering and on operating system environments and microprocessors that could lessen Japan's dependence on U.S. standards, particularly those set by IBM.

The Japanese Government also embarked on 10-year R&D programs in the early 1980s that set the goal of surpassing the United States in computer technology. The Fifth Generation Computer effort, based on research into symbolic computing and artificial intelligence, set out to create a radically new computer system capable of imitating the functions of the human brain. Concern about the advantage the research might provide the Japanese in the future sparked the formation of similar efforts in Europe such as the ESPRIT project and the Strategic Computing Program in the United States. Other Japanese projects concentrated at the component level on the development of more sophisticated, high-speed logic and memory circuits based on gallium arsenide, Josephson Junctions, and High Electron Mobility Transistors (HEMT), as well as on the technologies required to automate integrated circuit design and production further. At the system level, the Japanese are working on high-speed, parallel multiprocessor computer architectures. These efforts include the Supercomputer and New Function Elements programs.

Market Protection/Procurement

When viewed from an historical perspective, Japanese Government policies initially protected the Japanese market for domestic suppliers. The Japanese Government effectively limited foreign competition by instituting high tariffs, import quotas, and restrictions on foreign investment and foreign exchange allocated to purchases to computer imports. It also virtually assured the industry of continuing source of demand for Japanese products through the creation of the Japan Electronic Computer Corporation (JECC) by MITI in 1961 and the enactment two years later of a "Buy Japan" decree covering government computer procurement.

The JECC, supported by the Japan Development Bank (JDB) and the leading Japanese manufacturers, is an organization that purchases Japanese computers and leases them to users on very favorable terms. It received \$2 billion in loans from 1961 to 1979, a third of which came from the JDB at below market rates. On the demand side, the JECC became such a major purchaser of computers that it absorbed at least half of the industry's shipments during the 1960s. Its access to cheap capital also provided a subsidy to users who were offered monthly rental fees approximately 40 percent lower than IBM's and, as a result, found it more attractive to buy Japanese systems. The JECC was a godsend to the industry for another reason. By taking the financial burden of leasing off the shoulders of Japanese suppliers, it freed up more money for them to pour into R&D and capital expansion.

The major objective of helping the Japanese computer industry gain strength through capturing the bulk of domestic sales was largely accomplished by the late 1960s. Japanese tariffs on computers were lowered in the mid-1970s and eventually eliminated on U.S. computer imports in 1986. Import quotas and limits on foreign participation in the Japanese market were removed by 1975. The JECC continued to operate but declined in importance during the late 1970s when Japanese producers turned to their own internal leasing operations. However, although the "Buy Japan" policy was formally rescinded in 1978, the Japanese computer industry still benefits from the strong preference for Japanese systems that exists within Japanese Government agencies.

Tax and Loan Policies

Indirect financial support has been another policy tool used by the Japanese Government to foster the growth of the Japanese computer industry. The Japanese Government has provided some tax benefits to Japanese industry in general and others specifically directed toward computer manufacturers and users. Among the general tax benefits enacted to encourage industrial research are an R&D tax credit and accelerated depreciation for R&D capital. Those designed to stimulate exports include special deductions for expenses related to foreign trade and investment.

Industry-specific measures were passed from the late 1960s onwards with two principal objectives in mind. One was to expand the use of computers in Japan through special depreciation deductions for on-line and large-scale computers as well as reductions in local fixed asset taxes on mainframes. These tax breaks effectively lowered the cost of these systems to users, thus stimulating demand. The other objective was to boost return on investment for computer hardware manufacturers and software developers by providing an extensive system of income tax deductions. Perhaps the most important of these is the repurchase reserve allowance. This tax provision allows Japanese computer suppliers to set aside a

fixed percentage of sales as a reserve against the repurchase of obsolete computers from leasing companies and to deduct it from income.

The Japanese Government has also given the industry loans at preferential interest rates. One of the major sources for loans has been the Japan Development Bank, mainly through its support of the JECC. Other significant funding has come through loan guarantee programs involving Japan's three quasi-public industrial development banks and the Small Business Finance Corporation.

VI. Private Sector Initiatives

Japanese computer firms have usually competed fiercely against one another, but have joined together in various private sector groups to pursue certain research, production, and marketing objectives when they felt they had a mutual interest. The JECC and the Japan Electronics Industry Development Association (JEIDA) have been the longest lasting marketing and support organizations. Other efforts have had a much shorter duration. MITI organized an industry cartel to produce punched card, paper tape, line printer, and magnetic drum peripheral equipment that lasted only a few years during the late 1960s. Another experiment in cartels occurred in 1971 when MITI attempted to rationalize the industry by forming three research and production groups. The Fujitsu-Hitachi partnership was the most successful of these ventures. Both produced and marketed different models of the "M Series" of IBM-compatible computers until they decided to go their separate ways in mainframes in 1975. They also participated in a collaborative effort called Nippon Peripherals to develop and market IBM-compatible peripherals and terminals. This venture dissolved in 1976.

Joint research associations have generally been successful endeavors for the Japanese computer industry. They have engaged in only a few research programs that reportedly failed to achieve some of their major objectives. All involved software development. The earliest was the Super High Performance Computer System (SHPEC) program in the 1960s which targeted the development of a mainframe computer operating system and applications software that could compete with IBM's System 360. A second effort was the 3.5 Computer Project (1972 to 1976), which did not produce an advanced operating system. A third was the Software Automation Project (1976 to 1981), which developed only a few computer-generated, applications software packages for commercial use.

VII. Effects of Government Policies

The Japanese Government's efforts to protect its infant computer industry during the 1960s and to turn it into a world class competitor in recent years have been largely successful. In fact, the Japanese experience has served as a model for a number of developing nations such as Brazil that view participation in the world computer market as critical to their national security and economic interests.

Government policies initially limiting the foreign presence in the Japanese market and stimulating demand were instrumental in helping the industry gain competitive strength. Without this involvement, Japanese manufacturers would have fallen victim to their U.S. rivals who were marketing products with vastly superior technology. The advantage provided by a sheltered market and the persistence of a "Buy Japan" mentality later on allowed Japanese firms to capture a dominant share of the installed base of computers in Japan as early as 1966 and, despite official liberalization 10 years later, to tighten their grip on this market.

Similarly, Japanese Government support of industrial R&D laid the foundation for the industry's advances in componentry, process and production technology, and systems development. The national research projects in the 1970s, guided by MITI, played a very significant role in Japan's efforts to catch up with the United States. They reduced the costs and risks of research that Japanese firms could not afford to do internally at that time and provided a particularly effective vehicle for sharing and transferring technology.

While Japanese companies eventually committed greater resources to internal corporate R&D and made important contributions to applied research and product development on their own, they probably would not have become a competitive force in large-scale computers and peripherals as quickly as they have without Japanese Government assistance.

Other policy instruments were helpful in building the industry's research and manufacturing infrastructure and promoting exports. These include various tax breaks and preferential access to cheap capital.

The Japanese computer industry has an impressive array of quantifiable achievements to its credit:

- o Its computer production has grown at almost twice the annual rate of the U.S. industry's output over the past 10 years to \$27 billion in 1987 (26 percent versus 14 percent).
- o Japanese computer exports have risen 36 percent annually on the average during the same period, again outperforming the U.S. industry's growth. Japanese firms compete vigorously against U.S. suppliers in every key foreign market.
- o Japan has become the leading foreign supplier in the U.S. market, accounting now for 42 percent of U.S. computer imports and 16 percent of domestic consumption. The Japanese share of the U.S. market would undoubtedly be much higher if the shipments of Japanese manufacturing facilities in the United States were included.

- o The build-up in Japanese-origin imports, together with offshore U.S. manufacturing, has dramatically altered the U.S. computer trade picture. A mounting deficit with Japan has been a principal contributor to a serious erosion in the traditionally strong U.S. computer trade surplus since 1982.
- o Fujitsu, NEC, and Hitachi are now among the top 10 computer manufacturers in the world and are surpassed in total revenues only by IBM, Digital Electronics Corporation and Unisys.

Although government support substantially influenced the development of the Japanese computer industry, other factors have had some bearing on the success that the Japanese have enjoyed in the world market. Japan has a culture that promotes cooperation between government, industry and labor to achieve national goals once a consensus is reached. This nation also has a well-educated populace that has provided industry with the skilled human resources it needs and assisted in the creation of a strong technical base. For example, the performance of Japanese high school students on international tests of mathematics and science skills has consistently outpaced those of other major industrialized countries for over a decade.

Japanese corporations have certain characteristics of their own that have made them formidable competitors. Their managers generally take a long-term view in developing corporate strategy. As a result, they place great emphasis on gaining market share at the expense of short-term profits and price aggressively (even dump) to attain this goal. They have paid close attention to process and production technology. This has allowed the Japanese to become low-cost, high-volume producers. They also understand the importance of linking R&D and manufacturing to ensure efficient technology transfer within the corporation and to build quality and reliability into their products.

VIII. Future Developments and Trends

Government policy in Japan is currently directed toward helping the Japanese computer industry gain technological superiority during the 1990s and ultimately dominate the world market. However, the Japanese Government's role in charting a course for the industry has become more complicated, and the problems Japan faces today are somewhat different than they were a decade ago. In fostering research, the government continues to set goals for the national projects and contributes funds for them, but it has found cooperation from Japanese companies harder to obtain. It must contend not only with corporations placing a higher priority on their own internal R&D efforts, but also with the fact that both government and industry must compete for a limited number of qualified researchers in Japan

who can work on such exotic technologies as artificial intelligence and superconductivity. In response to this need, the Japanese Government has begun to reform its educational system. It is pouring more funds into basic research within academia, expanding collaborative efforts between universities and industry, and revising science and engineering curricula to improve Japan's capacity to innovate.

The government's involvement in promoting the development of the industry has lessened to some extent now that Japanese computer firms have a secure hold on their own domestic market and have the resources to challenge their major U.S. rivals for market share overseas. By contrast, its trade and foreign policy activities on their behalf have increased enormously over the 1980s. The Japanese Government has had to deal with mounting criticism from foreign governments, particularly the U.S. Government, that the Japanese market is closed to outside suppliers and that Japanese firms routinely engage in unfair trade practices.

The Japanese Government is also concerned about the effect on Japan's trade with Western Europe of the European Community's decision to remove internal trade and economic barriers and to create a single regional market by 1992. Like the U.S. Government, it is closely monitoring the implementation of this decision to see if it will eventually restrict the access of Japanese firms to this critical market.

Tim Miles,
Office of Computers and
Business Equipment

Computer Software

I. Historical Development

The Japanese computer software industry significantly lags behind its counterparts in the United States and Europe. Traditionally, the hardware market in Japan has been dominated by sales of large systems (mainframes). Most users would either buy their software bundled with hardware from the systems suppliers or develop their own custom software in-house. With the increased proliferation of smaller computers (primarily personal computers (PC) and office machines) and the presence in Japan of a number of world-leading software packages (mainly developed in the United States), this pattern is slowly changing. Users are buying more software developed by independent software vendors, both domestic and foreign. Foreign software suppliers currently have an advantage, since few domestic software houses have been able to develop competitive products.

II. Stage of Development

The Japanese domestic software industry is currently an assimilator of foreign technology. The Japanese (government, industry, and academia) have recognized that measures must be taken if the Japanese software industry is to catch up with the West. Consequently, programs aimed at hastening industry development have been undertaken under the auspices of all three. These programs are either based on what appears to be the direction in which the West is heading (using UNIX as the basis for the SIGMA project) or are aimed at developing new systems (TRON) to compete directly with proven products.

III. Industry Structure

Computer software sales in the Japanese market should exceed \$10 billion in 1988. Most custom software continues to be done in-house and that which is not is developed by Japanese firms. Packaged software, which holds a smaller share of the market than custom software but is growing faster, is dominated by foreign products, mostly from the United States. Most major U.S. PC software vendors have established a strong presence in Japan (Ashton-Tate, Lotus, and Microsoft). Many U.S. mainframe and minicomputer software packages are also available in Japan, although more of them work directly through systems suppliers. The market is quite competitive and fair to foreign products if they have been adapted to fit the demands of the Japanese market (including Japanese language capability).

IV. Government Objectives

Many believe that the Government of Japan is trying to overcome what they see as the Japanese's vulnerability in software and microprocessors. Therefore, the Japanese have launched several projects aimed at improving their competitiveness in these areas, and thereby decreasing their dependence on the West, especially the United States.

V. Government Policies, Laws, and Regulations

The Japanese Government has a number of policies aimed at promoting the Japanese software industry. For example, domestic firms may receive tax breaks for software development. There are a number of government-backed projects, including SIGMA (aimed at increasing software developers' productivity) and the Fifth Generation Project (aimed at parallel processing and artificial intelligence technology). Current Japanese law generally provides protection similar to that provided in the United States, but concern has been expressed that MITI would like to switch from copyright protection to a sui generis form of protection for software. This would greatly limit the term of protection and might include provisions for reverse engineering and compulsory licensing of software products. Such changes would clearly

benefit domestic software developers. MITI proposed this approach in 1983, but was rebuffed.

VI. Private Sector Initiatives

Although the relationships between the public and private sector in Japan are often so intertwined that it is difficult to determine where one ends and the other begins, the private sector unquestionably plays a significant role in software development projects. For example, the TRON project includes significant cooperation between the private sector and the academic community. The idea behind TRON originated at the University of Tokyo and the TRON Association, comprised of interested companies, oversees much of the development work. However, it is still not clear that such projects have no ties at all to the government. In addition, there are other projects--primarily aimed at making the Japanese software market more in line with the rest of the world--supported by various industry segments and in which the government does not seem to be involved (e.g., AX- a bilingual AT).

VII. Effects of Government Policies

Until there has been further analysis of the effects of government policies with regard to the development of computer software, it is difficult to assess the failure or success of these policies.

VIII. Future Developments and Trends

There is nothing in the immediate foreseeable future that will improve the competitiveness of the Japanese software industry. However, given the history of government-industry cooperation in Japan, the competitiveness of the domestic software industry may advance. For example, although the technological advantages of new products such as TRON remain unclear, Japanese Government support could give them the critical mass necessary for market acceptance worldwide.

Heidi Hijikata
Office of Computers and
Business Equipment

Telecommunications

This section represents an overview of the Japanese telecommunications sector, which will be explored in more detail in the competitiveness study which is due to be published by the Department of Commerce for Congress.

I. Historical Development

Japan's telecommunications industry has undergone dramatic change during the postwar period. The Nippon Telephone and Telegraph Public Corporation (NTT) was created in 1952. After

rebuilding the telecommunications infrastructure destroyed during the war, NTT engaged in joint R&D programs to develop new network technologies. (Note: This R&D funding came from NTT's huge cash flows.) Using its enormous procurement leverage, NTT perpetuated and strengthened relationships with a "preferred family of suppliers," that were developed by the Ministry of Communications during the 1920's. In 1980, a Policy Bureau was created in the Ministry of Posts and Telecommunications (MPT) to promote the Japanese telecommunications industry. In January 1981, NTT procurement became subject to the U.S.-Japan Agreement, on NTT Procurement. Until that time, NTT procured products exclusively from domestic manufacturers. In April 1985, NTT was privatized and was exposed to competition for the first time. For suppliers, this process created new sales opportunities.

II. Stage of Development

For many years, the Japanese telecommunications industry was regarded as an imitator. Since the early 1980s, however, there has been an increased emphasis on becoming a world class competitor. As a result, the industry can now be considered a commercializer and an innovator.

III. Industry Structure

The Japanese telecommunications industry is highly concentrated. In 1983, there were 435 manufacturers of telecommunications equipment with over 83,000 employees. Although the majority of firms had less than 100 employees each, the 19 largest companies (with over 1,000 employees each) produced nearly 70 percent of all telecommunications production in Japan. Moreover, the industry is dominated by four firms--NEC, Fujitsu, Oki and Hitachi (the "NTT family"). Although telecommunications accounts for only a portion (between 16 and 36 percent) of these firms' total production of all types of equipment, together they account for 60 percent of total telecommunications production in Japan. When their medium-sized affiliates are included, they account for about 75 percent of Japan's telecommunications production.

Japan has the second largest telecommunications market in the world (third if the Soviet Union is included), estimated at \$8.3 billion in 1987. U.S. firms have had considerable difficulty penetrating the Japanese telecommunications market, despite some liberalization. Most successful firms (e.g., Motorola and AT&T) have committed several years of work to entering the market. In addition, many have utilized Japanese distributors to avoid cultural barriers.

IV. Government Objectives

The Japanese Government, through both MPT and the MITI, has made promotion of the telecommunications industry a high

priority. MPT is intimately involved in industry planning and also in R&D funding. Sensing telecommunications as an important export sector, MITI began to push for a larger role in the industry and has made various incentives available. In addition, the NTT family was already export oriented.

V. Government Policies, Laws, and Regulations

Research and Development: Direct Japanese Government funding for R&D projects in the telecommunications sector totals billions of dollars per year. In addition, the Japanese Government used dividends from NTT stock to establish the Basic Technology Research Promotion Center.

Financial/Fiscal Incentives: Japanese incentives for the telecommunications industry include investment tax credits, tax exemptions, and preferential access to low-cost capital.

VI. Private Sector Initiatives

In the early 1980s, many Japanese corporations, unhappy about the cost of service and delays in introducing new technologies and services, began to push for a more aggressive telecommunications policy. Financial service companies, in particular, were concerned about their ability to compete with foreign counterparts following liberalization in 1984. As a result, they exerted pressure to upgrade telecommunications services in Japan. As a result, there has been tremendous improvement in the local infrastructure as well as a higher level of technical capability over the last five years.

Japanese programs to encourage an information society and regional development in remote areas, coupled with the transition to a service economy, have resulted in initiatives such as the Technopolis Program and Integrated Network Services (INS).

VII. Effects of Government Policies

The telecommunications sector has the highest returns on assets of any major Japanese industry. Moreover, Japanese firms have been able to develop and commercialize new technologies with minimal risk.

Since the early 1980s, Japanese production of telecommunications equipment has more than doubled, and Japanese exports of telecommunications products have increased by 60 percent.

VIII. Future Developments and Trends

The U.S.-Japan Agreement on NTT Procurement is scheduled to expire at the end of 1992. In addition, bilateral telecommunications agreements will be reviewed annually under Section 1377 of the Omnibus Trade and Competitiveness Act of 1988.

MPT has established a study group to make recommendations for Japanese telecommunications policy for the 1990s. Also, a subcommittee on administrative reform in the Prime Minister's office is currently examining NTT's role, with the objective of increasing competition further.

Linda Gossack
Office of Telecommunications

BRAZIL

Because Brazil is the eighth largest economy in the West, the importance it places on developing its own informatics industry is not surprising. (In Brazil, the term "informatics" covers all electronic, digitized equipment.) However, what makes Brazil's experience unique and sets it apart from other countries with similar goals are the strategies and policies it has used to accomplish this goal. These policies were established within the context of a convergence of favorable conditions, the application of traditional economic policies, and the hard facts of technological reality.

I. Historical Development

The roots of this development effort lay in the 1960s, when Brazil's "economic miracle" produced the necessary capital for industrial and technological development, and its government provided a certain amount of political stability. But the real impetus came in the early 1970s from several sources. First, there was the military's perceived need for an independent Brazilian computer capability, which led to the production of Brazil's first nationally designed and manufactured computer. Secondly, a coalition of military and civilian technocrats, some of which were educated in the United States, began pushing anti-dependency theories because of their perception that the "minicomputer revolution" would result in increased demand for computers, which would make domestic computer production viable. Finally, the balance-of-payments problem created by the first oil crisis in 1974 made the general imposition of import controls necessary, especially on computers, which were becoming a significant import item. It was not difficult for the Brazilian Government to implement import substitution policies in this emerging sector, because such policies had been the traditional approach to economic development in Brazil.

Like other foreign governments, the Brazilian Government instituted an activist development model for its computer industry. In 1972, a government group (CAPRE) was formed and given significant authority to improve the efficiency of computer procurement and use. CAPRE's charter and power expanded quickly so that four years later, it was charged with formulating a strategy to establish a national computer industry. In 1974, a "national champion" (Cobra) was established as a joint venture between the government, a British computer manufacturer, and a small local firm. This resulted in the first Brazilian-assembled minicomputer. In 1979, SEI (Special Secretariat for Informatics) was created to replace CAPRE and was given additional administrative and regulatory authority over the industry. Reflecting its military/strategic roots, SEI was originally attached to the National Security Council. The evolutionary development of the informatics regime culminated in the passage of the 1984 National Informatics Law. This law created another government body (CONIN), a cabinet-level council established to oversee

the informatics policies, and codified most of the restrictions that the government had decreed over the previous decade. In 1987 Brazil passed a software law that extended the restrictions to the software industry, while also providing explicit copyright coverage for software.

II. Industry Structure

Brazil has a bifurcated computer industry. Mainframes and superminicomputers are either imported, manufactured in country by foreign companies, or assembled domestically under foreign license. Microcomputers, the fastest growing segment of the industry, may be manufactured in Brazil only by domestic companies. Some minicomputers and peripherals are also designed and made by national companies. While there are 50 to 60 active Brazilian firms in the industry, fewer than 15 major foreign computer manufacturers are in Brazil, most of which are long-established U.S. firms. Most of the largest local firms are tied to financial or industrial conglomerates. Because of a recession in the computer industry, however, the Brazilian industry is consolidating as a result of mergers and reorganizations.

III. Policy Structure

The Brazilian Government regulates the production, operation, marketing, and importation of informatics goods and services guided by the Law of Similar--a long-standing policy that reserves the market for local products. The controls, administered by SEI and to a lesser extent other government bodies, are applied to importers, foreign investors, and domestic companies alike and are administered in the name of protecting and expanding the national industry. SEI's principal control mechanism is its authority to approve or deny import licenses, investment plans, and marketing requests. This is basically a negative strategy. Fiscal incentives, R&D support, and other positive development inducements for local firms, although provided for in the law, are not aggressively pursued partly because the Brazilian Government lacks the requisite funds to implement these policies. Furthermore, because of strong resistance to foreign involvement in the industry, there are no foreign investment incentives. For example, in the computer sector, all microcomputers and most minicomputers are reserved for national manufacture, and foreign companies are banned from import or local production. On the other hand, larger computers not made in Brazil can be imported. Software is also subject to the law of similars, although the amount of lost U.S. sales due to restrictions is much less than that for hardware.

IV. Policy Critique

The success of Brazil's policies to develop an independent indigenous industry must be evaluated in terms of political and military objectives, as well as economic goals. The economic

costs of these policies far outweigh economic gains, and predictions of long-term commercial benefits are extremely risky at best in this fast-changing industry. Although prominent industry sectors within Brazil increasingly voice their opposition to these policies and to the way they are implemented, their dissent, which is mainly on economic grounds, has been overridden by the nationalistic political arguments of the policies' supporters. These supporters point to the progress that has been made toward developing the industry in a relatively short period of time that would not have happened, they believe, without market reserve. They argue that economic disadvantages, therefore, must be overlooked.

Critics of the policies generally focus on the economic impact of the inefficient allocation of resources as it affects the total economy, other industrial sectors, and the computer industry, itself. It has been estimated that the policies cost Brazil around \$500 million a year.

The primary concern is that the nonavailability or delayed availability of needed technology reduces the productivity and competitiveness of other industrial and commercial sectors in Brazil. Lack of availability can be measured in both quantitative and qualitative terms. Brazil's consumption rate of computers, 1.3 percent of the U.S. rate, is low relative to the size of its gross national product, which is roughly 4.6 percent of that of the United States. Brazil's local microcomputer producers also lag technologically behind U.S. suppliers by two to four years and face other complaints of poor quality and user support. One intangible byproduct is the frustration caused by administrative barriers that discourage even the authorized purchase of foreign equipment.

Domestic prices are a second concern. The prices of microcomputers manufactured by Brazilian firms are two to four times more expensive than comparable models sold in the United States. High prices impede exports, increase inflationary pressure, deflate the market, and encourage smuggling.

Finally, critics charge that current policies are essentially counterproductive. These policies retard the industry's development by artificially shielding domestic firms from international competition and by denying them the benefits of technological collaboration with foreign firms. Brazil is mortgaging its future by keeping out foreign investment and technology. It is trapped by restrictive policies and technological realities, and its internal market is not large (roughly 3 percent of the U.S. market). Therefore, without export enhanced markets, Brazilian firms cannot achieve the necessary economies of scale for efficient production at the low end of the product spectrum where these firms have a competitive chance. These firms also cannot compete at the high end without the aid of foreign technology and significant amounts of R&D funding.

V. Future Developments and Trends

Creating a domestic electronics industry is a powerful attraction for countries with strong nationalistic aspirations. Achieving success, however, is another matter. Although Brazil has made tangible strides in production at the low end, its products are neither competitive nor innovative, and may lose their dominance over a seemingly secure and stable domestic market. The industry is also in financial trouble, with after tax losses in 1987 equaling over 12 percent of net worth. Problems include capital shortages, predatory pricing, unrestrained smuggling, insufficient economies of scale, few exports, and the lack of a semiconductor industry. There are discussions within the industry and government to increase company scale and capital concentration through mergers and consolidations. This, however, may not be enough to make the industry self-sufficient.

The government has recently moved to ease the implementation of its informatics policies. It is unclear, however, whether these acts constitute a trend that will eventually lead to systemic changes in the laws or are merely another evolutionary adjustment in the informatics regime. It is certain that the internal debate in Brazil over the efficacy of the policies will continue subjecting the government to increasing political pressure from competing constituencies. Outside pressure will also continue to be applied on behalf of foreign suppliers. But if Brazil is to make significant changes in its informatics regime, it will probably be in response to macro economic conditions. This is something that cannot be ignored for long and that may force the country to choose between long-run economic growth and the short-term viability of its informatics firms.

R. Clay Woods
Office of Computers and
Business Equipment

INDIA

Introduction

There has been much attention paid to the liberalization of the Indian electronics market. Extremely onerous controls have been lifted; many laws on repatriation of profits have been liberalized; and in some sectors manufacturing has been opened to both private and public sector firms with no limit.

However, relative to the United States or one of the newly industrialized economies, the chance that the Indian electronics industry will become an international competitor in the near future is virtually nil.

I. Historical Development and Industry Structure

India's Department of Electronics (DOE) was established in 1970 and reports directly to the Prime Minister. Despite the efforts of the DOE and its various committees, the market reserve policies, and government-provided R&D support, the indigenous industry was unable to keep up with worldwide technological developments. The Indian Government began to change its approach when the Seventh Five-Year Plan specified lifting import restrictions on most electronics equipment. India's electronic equipment production in fiscal year (FY) 1987 was \$3.7 billion, 21.7 percent growth over FY 1986.

However, three years after lifting the import restrictions, the Export/Import Policy for 1988-1991 reinstated restrictions on all computers except high-end minis and high-end mainframes. The official government reason for this action was that India had developed the capability to produce the low-end of the computer spectrum, and these local manufacturers must be protected from foreign competition.

The first digital computer was imported and installed in India in 1956. The first indigenous computer was manufactured jointly by the Indian Statistical Institute and the Jadavpur University in 1964. The real thrust in India's computer era was provided by investment by two foreign computer vendors: IBM and ICL from the United Kingdom. After entering the country with manufacturing and design facilities, IBM chose to leave in 1979 when the Indian Government demanded that IBM transfer ownership to it. At the same time ICL cooperated with the Indian Government and transferred 60 percent of its equity.

Today the computer industry in India is made up of 50-60 medium-to-small firms (\$30 million or less) that either assemble imported knocked-down kits, or are involved in joint-ventures with foreign computer companies and adapt their firm's technology to the Indian market. Many of the computer companies are still trying to find a market niche of their own, in the wake of production decontrols and the resulting market competition. Among imported computer systems, U.S. products

dominate the market. Most Indian endusers are familiar with, and thus prefer, U.S. computers.

The Indian policy for electronic components was introduced in 1981, highlighting the need for economically viable capacity, internationally competitive prices, and freer import of technology. Component production grew 9.4 percent to \$477 million from FY 1986 to FY 1987. The only manufacturer of semiconductors in India is Semiconductor Complex Ltd., which was set up by the Indian Government in 1983, with technical assistance and semiconductor designs from American Microsystems Inc. of Santa Clara, CA. Semiconductor Complex Ltd. primarily produces semiconductors for consumer electronic items and is functioning at about 50 percent of its capacity.

DOE has had a program for promoting computer software development since 1972. However, the software sector was not able to fully develop until both a new software policy was instituted in December 1986 and the computer policy of 1984 was adopted, which allowed hardware to be imported. The software policy has four primary goals: to achieve a greater market share in the international software market; to develop both the domestic and export markets simultaneously; to simplify procedures for starting new software firms; and to promote domestic computerization. Under this new policy, India forecasts 60, 80, and 100 percent export growth over prior years for 1987, 1988, and 1989, respectively.

The Software Development Agency within DOE is the principal organization responsible for implementing the software policy, monitoring software export performance and promoting the growth of the software industry for domestic and overseas markets.

The Indian telecommunications sector is mostly owned and controlled by the Indian Government, with multiple firms (the largest had \$357 million in revenue in 1986) licensed to manufacture telecommunications equipment. The government only recently prioritized the development of an efficient communications network by allocating funds to that sector in the Seventh Five Year Plan.

The domestic production of telecommunications equipment in India grew to an estimated \$795 million in 1987, up 16 percent from 1986. The Indian Government closely controls imports of telecommunications equipment, and imports for purposes of stock and sale are not permitted.

II. Government Objectives

The growth of the electronics sector in India has been based on heavy government support and a hard-line commitment to self-reliance and an anti-isolationist industry. These themes have been constantly repeated in the industrial laws enacted since 1948, which are outlined at the end of this Appendix.

At one time or another India has used almost all of the measures known today to restrict competition within the electronics sector: limits on foreign investment, production controls, incentives to promote local suppliers, restrictions on imports, and promotion of exports through subsidies and import entitlement schemes.

The lack of adequate intellectual property protection in India has also been a continuing concern. The government amended the Copyright Act of 1984 to include computer software in response to both Indian and foreign company concerns. However, many potential investors do not think that, the current protection adequately secures their companies interests. India considered accession to the Paris Convention for the Protection of Industrial Property in 1986, but there has been no movement in that direction since.

The government research and development policy is also based on the belief that indigenous development of technology is one of the important aspects of self-reliance. Hence, India now has a substantial infrastructure of research institutions. Among these are the Central Engineering and Electronics Research Institute and the Telecommunication Research Center. Emphasis is placed on the practical use of technological developments made in these laboratories.

III. Effects of Government Policies

Overall, the electronics industry has suffered from a combination of inadequate funding and the lack of an incentive to expand. However, the effects of the government's electronic policies have varied between sectors.

Thus far, the government policies aimed at creating an indigenous computer industry have been unsuccessful. What they have created are assembly operations and importers who find creative ways to circumvent the present import ban on computers.

The telecommunications industry is still heavily controlled by the Indian Government, and the limited imports and foreign investment requirements make it very difficult for domestic firms to advance technologically. However, with the recent funds allocated to this sector, the foreign interest in the market will increase and likely be followed by the importation of advanced communications equipment.

The components industry has not had much of an opportunity to develop. With little manufacturing of computers and production and investment controls in many end-product manufacturing sectors, there is little incentive to invest or quickly upgrade to a higher level of technology. This has created companies that find little reason to make capital investments and improvements in their products.

From all indications, the new government policy promoting software development both through joint ventures and indigenous Indian ventures is quite successful. The value of software developed in India and exported is forecasted to continue to increase over the next five years.

IV. Future Developments and Trends

The tremendous potential of the Indian market, because of its size and the enormous number of skilled workers, is highly touted by the government. This attractive investment picture is offset by requirements for investment approvals, licensing considerations, inadequate intellectual property protection, export quotas, and import restrictions.

The Indian Government may be forced by the increasing number of skilled Indian workers to liberalize its policy on imports in order to allow them access to the latest technology. The Indians have developed a large pool of trained electronics technicians, engineers, and computer operators, many educated overseas in environments with the latest technology. Many Indians consider the country's "brain drain" a serious problem and believe the government should do something to stop it.

Government Policies

The Industrial Policy Resolution of 1948 - granted the government authority to control public and private industries.

Industrial Development and Regulation Act of 1951 - granted the government the authority to enforce production controls on all industry.

Essential Commodities Act of 1955 - brought both pricing and distribution under the government's control.

At this point there was a serious confrontation between business and government, and little investment was made in India's industrial base.

Industrial Policy Resolution of 1956 - granted the government control over any industry, with greater emphasis on small-scale ventures.

The mid-1950's saw a shortage of foreign exchange, and the government passed the following laws to gain control over capital flows.

Second Five Year Plan (1955-60) - introduced licensing of some goods to control foreign exchange requirements.

Also export subsidies were introduced in fiscal measures, import entitlement schemes, large taxes on some traditional exports, and foreign trade zones.

Monopolies and Restrictive Trade Practices Act (MRTP) 1971 - granted the government the power to nationalize private enterprise.

Foreign Exchange Regulations Act (FERA) 1974 - prevents repatriation of profits to foreign investors by limiting foreign equity to 40 percent.

Open General License 1978 - An effort to relax some harsh import duties.

Phased Manufacturing Program (PMP) - requires that importing firms purchase their inputs from local sources for five years following incorporation.

Heidi Hoffman
Office of Computers and
Business Equipment

SINGAPORE

I. Historical Development

Singapore's electronics industry began in the late 1960s and early 1970s, mainly through U.S. investment in the assembly of TV kits, transistors and simple integrated circuits, and consumer electronics products. The second phase (1975-85) witnessed a focus on consumer electronics, passive components (such as capacitors, connectors, and resistors), printed circuit boards, and the rapid build-up of industrial electronics.

II. Stage of Development

The industry has now developed from labor-intensive assembly to product engineering and automated assembly, integrated circuit design, wafer fabrication, and product development. The electronics industry today produces locally developed audio products and has a highly automated assembly, testing, and support infrastructure for the production of semiconductors and communications equipment. Current capabilities in the industry include the use of surface mount technology, and the production of high density disk drives, high resolution graphic controllers, Chinese-language word processors, and electronic components, such as dynamic random access memory chips and multilayer printed circuit boards.

III. Industry Structure

Electronics, Singapore's premier industry, accounted for 35 percent of total manufacturing output in 1987. There were 217 companies, dominated by American and Japanese multinationals, employing 31 percent of the total work force in the manufacturing sector, or 84,000 workers. Output was \$7.5 billion, while domestic exports were \$7.4 billion, which contributed 40 percent of Singapore's total domestic exports of \$18.6 billion in 1987. It is estimated that the electronics industry accounted for some 40 percent of total investment in Singapore in 1987. Although the Japanese have overtaken the United States as the top investor in Singapore for the past two years, the United States has remained the largest investor in electronics. U.S. companies present in Singapore include Apple, AT&T, Unisys, Hewlett-Packard, Seagate Technology, and Tandon. Many of these companies have expanded beyond manufacturing and now also use Singapore for marketing, sourcing, servicing and support, and for product design and development.

Information technology covers computer hardware, software, and telecommunications services. It is well established in Singapore, with total sales of \$650 million in 1986. The promotion of Singapore's National Information Technology Plan led to rapid growth in the usage of computers.

IV. Government Objectives

In 1986, the government announced its National Information Technology Plan to develop a strong export-oriented information technology industry and to use information technology to improve productivity and competitiveness in all parts of the economy. Many of the new projects under the plan will be joint efforts by the National Computer Board (NCB), and the Economic Development Board.

V. Government Policies, Laws, and Regulations

Through various incentives and training schemes, companies are encouraged to restructure, rationalize, automate, train, and improve their productivity. In addition, companies are encouraged to go beyond manufacturing into other activities such as marketing, sourcing, servicing and support, and product design and development. The government provides incentives to foreign companies setting up overseas headquarters in Singapore, encouraging the use of Singapore as a distribution and procurement center.

As a means of financing new ventures, the government offers pioneer status to firms, which entitles the firms to a tax holiday of up to 10 years. In 1987, Singapore promulgated a copyright law that includes the protection of software. An improved patent system is currently being investigated. The government also funds R&D programs. Between 1981 and 1983, three computer training institutions were opened: the Institute of Systems Science, the Japan-Singapore Institute of Software Technology, and the Center for Computer Studies. NCB established an Information Technology Institute in 1986 to work on software engineering, communications technology, and knowledge systems. The government also established the Product Development Assistance Scheme and the Software Development Assistance Scheme.

VI. Private Sector Initiatives

To create the skilled professionals needed for its software industry, Singapore has established several institutes with the aid of multinational firms in the computer industry. In 1981, the Institute of Systems Science (ISS) was set up as a joint effort between the National University of Singapore and IBM. The government also established the Japan-Singapore Institute of Software Technology. It has also played a role in accelerating the growth of the local semiconductor technology. Chartered Semiconductors is a joint venture between state-owned Singapore Technology Corporation and two U.S. manufacturers.

The Government of Singapore encourages the direct transfer of technology by foreign firms for use by local companies. For example, Hewlett-Packard created a training unit for computer-aided design, manufacturing, and engineering (CAD/CAM/CAE). Local firms, in turn, are encouraged to form

business relationships with multinational companies to penetrate foreign markets. There is some evidence that local information technology firms are joining together into consortia to compete in the world market.

VII. Effects of Government Policies

The information technology industry has yet to achieve the main goals set in the government's plan despite its impressive 15 percent annual growth rate since 1980. Most of the information technology industry's sales (78 percent in 1986) have been to the domestic market. The biggest local customers have been research/education institutions and larger private sector firms. Information technology exports have risen only slowly from 18 percent of total sales in 1983 to 22 percent in 1986. Some constraints affecting the industry are a relatively small technical base; an educational system that does not emphasize intellectual creativity; small, undercapitalized and nonexport-oriented local companies; and the relative lack of venture capital.

The production of industrial electronics and components fits well with Singapore's high tech strategy. However, much of the work in these industries, e.g., the assembly of disk drives, is often labor intensive and low skilled. Although Singapore is the world's largest producer of Winchester disk drives, the Economic Development Board dissuaded at least one manufacturer from expanding its disk drive assembly operation because of the tight labor market.

Singapore's efforts in the telecommunications industry have made it the telecommunications center of South East Asia. It is the western terminus of the Commonwealth Cable System, which extends to Singapore from the United Kingdom via Canada and Australia. Within Singapore the telephone density was slated to be 40 sets per 100 inhabitants by early 1986.

VIII. Future Developments and Trends

Given the importance of high tech manufacturing, the government of Singapore is likely to continue to promote actively electronics investment. Assuming no slowdown in the world economy, prospects are good for continued growth in the future. Growth, however, will be at a slower pace due to local labor constraints and a decline in the rate of productivity growth.

Vivian Spathopoulos
Office of Computers and
Business Equipment

SOUTH KOREA

I. Historical Development

South Korea's electronics industry began in the early 1960s with the assembly of vacuum tube radios from imported parts. The industry, dominated by domestic capital up to the middle of the 1960s, began to attract foreign investment from companies such as Fairchild, Motorola, and Signetics in the mid-1960s. In the early 1970s, Korea largely manufactured parts and components such as transistors, diodes, integrated circuits, radio receivers, and black and white television parts. By the end of the 1970s, Korean-made products included electronic calculators, electronic watches, and videocassette recorders. Computer and peripheral equipment production and exports began to grow rapidly in the 1980s.

II. Stage of Development

Korea's electronics industry has moved beyond the simple assimilation of technology. It is now challenging other major competitor nations, in a variety of consumer products, semiconductors, microcomputers, and display terminals.

III. Industry Structure

The electronics industry in South Korea grew from about 1.5 percent of the country's GNP in 1971 to about 8.8 percent in 1985. Over 50 percent of its production is exported. The electronics share of total exports was about 8.3 percent in 1985, making it, after shipbuilding and textiles, the third largest export industry. The Korean electronics industry produced 0.2 percent of total world electronics output in the early 1970s, a share that increased to 2.8 percent by 1984. Parts and components have the largest share of the industry's production followed by consumer products and industrial equipment. Domestic firms make up the bulk of the industry, led by companies such as Daewoo, Hyundai, Samsung, and Goldstar. Foreign firms and joint ventures are heavily concentrated in the production of parts and components, producing a small share of consumer products and industrial equipment.

IV. Government Objectives

In 1969, the Korean Government promulgated its first eight-year electronics development plan and adopted a national electronics industry promotion plan. This was the first time the Korean Government identified electronics as a strategic industry. In addition, five-year economic development plans were developed to integrate and define the overall direction of industrial policy. The policy has shifted away from labor intensive industries towards promotion of higher value-added, technology intensive industries.

In April 1981, the Korean Government revised its electronics industry promotion law. In addition, the Electronics Industry Technology Upgrading Plan and the Electronics Industry Promotion Fund were established.

V. Government Policies, Laws, and Regulations

Support for R&D for both product and process technology is an important government policy. The Ministry of Trade and Industry has made funds available to Korean electronics firms to develop semiconductors and computers. The Korean Institute of Electronics Technology pursued research in electronics and also played an active role by building the early production lines for large scale integrated circuits.

The government also provides investment funds to electronics firms via established loan mechanisms, such as the Korea Development Bank. It also acts as a substantial purchaser of goods, particularly for the telecommunications industry. To attract foreign companies, the Korean Government gives companies incentives, including exemption from Korean income, property, and corporate taxes, usually for a five-year period. To promote local industry, South Korea protects its local market through import licensing, strong buy-national policies, and high tariffs. Policies include restricting the imports of certain computers, software, semiconductors, and communications equipment when domestic sources are available. While most import licensing restrictions were eliminated in the early 1980s and some tariffs have been reduced, buy-national policies remain.

Korea also has a Software Development Center, which was established in 1967. The center provides consulting and design assistance to public and private entities.

VI. Private Sector Initiatives

A number of Korean companies, including Hyundai, Daewoo, Goldstar, and Samsung, have banded together in a memory chip consortium. Dataquest-Korea reports that the group has already developed a manufacturable 4Mb DRAM. In addition, \$263 million has been allocated to develop a 16 Mb DRAM by March 1991, and a 64 Mb DRAM in 1993. Sixty percent of the funding is company sourced with the remainder financed by the Korean Government.

The Korean Government has provided funds to encourage the formation of private research institutes. Before 1982, private sector investment in R&D averaged less than 1 percent of their turnover. This number jumped to 3 percent before mid-decade. In 1979, there were only 43 private corporate research institutes. By the end of 1983, there were 139, and by late 1987, there were over 400. These private research institutes have been stimulated by a variety of tax incentives, special privileges, and government funds.

VII. Effects of Government Policies

South Korea's efforts to promote its electronics industry have been highly successful. Korea is one of the most successful nations developing microcomputers. Some of the major players in the Korean computer industry now are competitive in the United States. Daewoo produces Leading Edge XT and AT compatibles, while Hyundai is marketing an XT compatible in the United States at prices well below many of its competitors. Korea's growth in this area has been supported by long-term plans for the electronics industry, including a four-year R&D program, and funds for firms available from the Technology Development Fund.

VIII. Future Developments and Trends

The government has played an extensive role in guiding Korea's industrial development. Heavy intervention in economic activity has given way to policies of a more general character, although the government remains highly involved in major decisions.

Korea has set as a goal to achieve industrial country status by the year 2000. Current plans aim to have South Korea rank 15th in terms of gross national product (GNP), 10th in terms of trade volume, and a comparable ranking in industrial technology. Policy planners have identified five major areas for concentration. Two are critical for the future of the electronics industry. One area is microelectronics, information and telecommunications technologies, for an early realization of the information society. The second is industrial key technologies such as design, systems engineering, and automation, for increasing value-added and productivity of industrial production.

In the investment policy area, plans call for R&D investment to expand from about 2 percent of GNP in 1986, to 3 percent of GNP in 1991, and 5 percent of GNP in 2001. This investment would be allocated roughly 40 percent from government and 60 percent from the private sector, of which some 20 percent of the total would be for basic research.

Vivian Spathopoulos
Office of Computers and
Business Equipment

TAIWAN

I. Historical Development

The electronics industry in Taiwan began to take shape in the 1960s with the assembly of transistor radios for local and export markets. In the mid-1970s, electronics became a strategic industry in Taiwan. The 1970s were marked by the local production of terminals and monitors. In the 1980s, the government specifically sought to develop the informatics industry. The big breakthrough in Taiwan's development of informatics came in 1980 when the production of minicomputers and computer terminals began. Consumer electronics and parts and components are the largest electronics sectors, but informatics hardware is the fastest growing. Electronics passed textiles in 1983 as the leading export industry and the largest industrial sector in terms of output, employment, and investment.

II. Stage of Development

Taiwan is strong in the manufacturing of personal computers, monitors, terminals, and modems. In the early stages of Taiwan's development, the majority of products were copies of U.S. designs. In recent years, Taiwan's manufacturing and design capabilities have risen, although Taiwan's local producers continue to focus on the low end of the market. Taiwan's software industry is in its infancy, with imported software dominating the industry. Software produced locally is of medium-to-low quality, although prices are lower than imported software and design may fit local needs better. Taiwan's telecommunications industry is a telephone manufacturing industry, with telephone sets and cordless phones as the two principal items produced. Electronic switching systems and modems are on the low end of the spectrum.

III. Industry Structure

In 1986, the output of Taiwan's electronic industry was valued at \$8.45 billion, about 10.6 percent of Taiwan's total production value. This production was distributed among consumer products (27 percent), commercial and industrial products (35 percent), and electronic parts and components (38 percent). The major consumer products were color television sets and audio equipment. The major commercial and industrial products were equipment related to computers and telecommunications. The main electronic parts and components included integrated circuits, cathode-ray tubes (CRTs), motors, and printed circuit boards. The 10-year electronics industry development plan (1980-89) projects that by 1989, the product structure will be 25 percent for consumer products, 38 percent for commercial and industrial products, and 37 percent for electronic components and parts, with a total production value exceeding \$12 billion. Way-Lin, Tatung, and Mitac are among Taiwan's most successful computer equipment manufacturers. In

1986, it was estimated that U.S. subsidiaries and joint ventures accounted for 27 percent of the total sales of Taiwan's electronics industry. These firms include Texas Instruments, Motorola, Honeywell, Zenith, Hewlett-Packard, and AT&T.

IV. Government Objectives

The government set up a series of production and marketing targets over a 10-year period. Under the current 10-year plan (1980-89) for the electronics industry, the government set out to increase domestic value added, upgrade product development capability, reduce dependency on foreign marketing and distribution organizations, expand the share of domestically owned firms in the industry, move towards the production of higher technology products, and increase the localization for key components and materials. The government specifically targeted scientific instruments, videocassette recorders, telecommunications equipment, and computers. In addition, the government revised its 10-year Telecommunications Plan in 1985, adopted a Ten Point Plan for high technology development in 1983 and a Communication Industry Plan in 1987. Although the government continues to play a major leadership and intervention role, the long-term goal is to promote a private informatics industry. Even when large capital infusions were provided to selected key product areas, the private sector retained management and control.

V. Government Policies, Laws, and Regulations

Market Protection: Import licenses, tariffs, access to foreign exchange, screening of foreign investment, and preferential government procurement are the main instruments used to protect local industries.

Tax Policy: Targeted industries such as the electronics industry are given tax incentives, including tax holidays, reduced income tax rates, and exemption or deferment of import duties.

Financial Market Policy: Taiwan's financial system is tightly controlled by authorities. Since private industry depends on debt financing for 70 to 80 percent of its capital, the government has considerable leverage.

Research and Development: In 1986, 1.02 percent of the value of the electronics industry production was spent on R&D. The government contributed 40 percent and the private sector 60 percent of that total. The government's goal is to increase research and development spending to 3 percent in 1989. It has set up several government-sponsored research institutions, including the Electronics Research and Service Organization. In addition, it has set up several development funds. In 1980, the Hsinchu Industrial Park was founded with the full financial backing of the government. This park was designed to integrate the research efforts of public and private institutes, academic

institutions, and high technology firms. Firms investing in the park receive tax benefits, concessionary financing, and subsidized land costs.

Copyright Protection: Taiwan has enacted a copyright law protecting software, making software development potentially more profitable. However, software piracy remains a problem.

VI. Private Sector Initiatives

The government has worked with private industry and academia through projects such as the Hsinchu Industrial Park. It has also founded a variety of research institutes that work with private firms to develop new products, identify and acquire new technology, and conduct research and development for ultimate transfer to private enterprise. The premier laboratory is the Industrial Technology Research Institute (ITRI) founded in 1973.

VII. Effects of Government Policies

Taiwan surpassed the export goals it set for the computer and peripherals area. Projections made in 1985 for 1990 were exceeded in 1987 by about 20 percent. Exports of computers and related equipment in 1986 increased by 67 percent from 1985 to \$2 billion. Exports are slated to grow by 20 percent by 1991 because of the growing number of medium- and small-scale microcomputer producers. Despite its strategic status, the domestic software market remains highly fragmented among 150 firms with limited capitalization and employment. Although preferences have been given to the domestic telecommunications equipment producers and some telecommunications products are designated as strategic, most of Taiwan's production remains at the low and medium technology end of the spectrum.

VIII. Future Developments and Trends

Particular efforts will be made to accelerate the development of microcomputers, peripherals, and components. Taiwan has demonstrated its ability to compete in the world market for microcomputers. It is moving into the production of higher level microcomputers based on the 80386 chip. The direction of Taiwan's policy development has not been entirely successful. The fragmentation of the software industry and the lack of success in stimulating private sector R&D investment continue to retard future development.

Vivian Spathopoulos
Office of Computers and
Business Equipment

FRANCE

I. Historical Development

In 1967, the Government of France launched the First Plan Calcul to create a viable and independent electronics industry. The French computer sector attempted to overtake IBM's strongest product lines: the medium and large computer markets. By late 1968, the French computer maker, CII, announced the IRIS 50 medium-scale mainframe. Plan Composant was launched in an effort to create a French integrated circuits manufacturing capability and peripherals received \$15 million in R&D support. In telecommunications, France developed expertise in electronic switching technology. The French Government emphasized creation of "national champion" firms.

Under Giscard d'Estaing (1975-81), a greater emphasis was placed on foreign technology acquisition through partnerships with foreign firms, such as CII's merger with Honeywell Bull in 1976. In 1979, the French Government announced its plan to expand the use of computers in education, industry, and small businesses. During this period, a new range of large-scale mainframes was introduced.

President Francois Mitterand (1981-present) began a program of nationalization and a restructuring of the electronics industry occurred. For example, the Filiere Electronique program plans and coordinates development of computers, telecommunications, components, and software. In 1982, the French Government initiated an eight-point program to accelerate the development of electronics and computers in such areas as very large scale integration (VLSI) and computer-aided design (CAD) tools, software engineering, computer-aided design and computer-aided manufacturing (CAD/CAM), computer-aided instruction, automatic translation, display hardware, basic components, and subsystems for microcomputers and minicomputers and supercomputers. The software industry gained government support as part of this program.

After decades of steady growth in a very controlled environment, deregulation and international standardization of telecommunications are taking place. In semiconductors, the recent focus has been on VLSI circuitry.

II. Stage of Development

In spite of the French Government's long-term investment in the electronic sector, few notable developments have resulted. In the computer and semiconductor subsectors, France is an assimilator. Growth in computer market share is largely a result of government procurement policies rather than computer innovations. Outdated plants and equipment constrain the semiconductor sector's ability to assimilate the latest technology.

Of all the electronic subsectors, telecommunications and software have achieved the greatest successes. France has the world's most digitalized network. Minitel, the French videotex system, exemplifies a successfully created and commercialized telecommunications service. As one of the largest producers of software in the world, French software suppliers control three-fourths of the domestic market with high quality products. Recent focus has been on the creation of new languages, advanced software engineering, and speech synthesis.

III. Industry Structure

Computers and Peripherals: The French computer market is the fourth largest in the world. IBM France remains the market leader by value, though the French nationalized company, Groupe Bull, now the largest French manufacturer, is catching up rapidly. In 1987, imports accounted for 44 percent of domestic consumption with U.S. manufacturers accounting for 50 percent of imports. Because many U.S. firms supply a portion of the French computer market through manufacturing operations located in France, the declining U.S. import share understates the U.S. presence. Selective government procurement policies protect domestic producers like Groupe Bull and Alcatel from U.S. competition.

Telecommunications: In 1987, imports of telecommunications equipment accounted for 11.7 percent of total demand. U.S. manufacturers supplied 32.5 percent of imports, while West Germany, Japan, and Italy supplied 16.7, 6.0, and 3.5 percent respectively. France Telecom, France's national telecom authority, has developed the most advanced and sophisticated telecommunications systems in Europe. Recent liberalization encourages competition in value-added services such as data base information and electronic mail. Because of privatization, government control over some major firms like CGE (Compagnie Generale d'Electricite), Thomson, and Alcatel has been eliminated. Selective procurement procedures of core network equipment restrict foreign manufacturers from competing for most equipment contracts. While the market for network equipment remains relatively closed, terminal equipment can now be supplied competitively if the foreign products meet strict testing and certification requirements.

Software: In 1987, software imports accounted for 15.8 percent of domestic demand, which totaled \$7,061 million. Domestic suppliers control 74 percent of the market. U.S. suppliers provided almost 20 percent of software sales. Other supplier nations were West Germany with 3.8 percent of the market followed by the Netherlands, the United Kingdom, and Italy.

Semiconductors: In 1987 imports of electronic components accounted for 90 percent of domestic demand, which totaled \$3,794 million. The French semiconductor market relies heavily on foreign manufacturers, most of which are American such

as Motorola, ITT-Intermetall, Texas Instruments, Harris Semiconductor, Honeywell, and Westinghouse. Many foreign manufacturers of electronic products manufacture componentry for in-house consumption. Major French producers include Alcatel-CIT, Fribourg Condensateurs Intermetall, RTC-Compelec, and Thomson-CSF.

IV. Government Objectives

Since World War II, the Government of France has remained committed to making France an independent, world leader in electronics. It has followed a system of indicative planning with substantial government involvement. The major electronic sectors targeted have been telecommunications and computers. In recent years, components have received special attention through the Plan Composant programs. Ironically, software has received the least attention yet has succeeded in capturing 74 percent of the French market. The French electronic sector is guided through five year, nonbinding plans prepared by the government after consulting with representatives of industry, unions, and other government bodies.

V. Government Policies

The French Government has expanded its role in industrial planning through the nationalized companies of the electronic sector. The current government hopes to use the large nationalized companies as engines to encourage growth and modernization and to gain control over the national market.

Restrictions on Imports: Most restrictions on imports take the form of non-tariff barriers (NTBs). The most popular NTBs employed are strict testing and certification requirements.

Requirements on Foreign Investments: Because foreign investments in some high tech sectors require prior government approval, the government is equipped to channel investment flows to the electronic sectors. Joint ventures most often require foreign minority ownership. Investment requirements are used to protect domestic industries and to obtain foreign technology.

Government R&D Subsidies: Large government expenditures for R&D and guidance over nationalized banks' resources assist the electronics industry. Investment incentives such as capital grants and R&D funding are provided for domestic and foreign investors. In the past, most R&D support was provided to the computer and telecommunications sector. Today, component makers, foreign and domestic, receive government R&D support.

Procurement Policy: Because of preferential treatment given to domestic producers and the nonavailability of bid information, foreign manufacturers have great difficulties bidding on French Government contracts as in the case with the "Computers for All" program. Much of the state-of-the-art technology in the

telecommunications sector and the ability to produce on a mass scale have been the result of government procurement policies.

Tax Policy: French tax policy is designed to promote investments in targeted industries. Some tax benefits include accelerated depreciation allowances for certain expenses, special tax regimes for mergers, tax exemptions for new companies, consolidation privileges, and tax credits equal to 25 percent of the increase in a company's R&D expenditures.

Intellectual Property Rights: The new Copyright Act of 1986 provides copyright benefits to computer software for 25 years and poses no barriers to trade.

Government Sector Initiatives: European efforts to make the European electronics industry internationally competitive include the EUREKA and ESPRIT programs. France participates in both programs. Several government-owned R&D institutes participate in programs for telecommunications. CNET, the PTT research center, emphasizes basic research and applied research and development. INRIA, the computer sector's information systems research agency, brings industrial firms, universities, and CNRS teams together to work on pilot projects. CNET and CNRS are the electronic sector's public research centers.

Post and Telecommunications Law: All equipment must be type-approved by the PTT Secretary of State prior to connection. French equipment is given top priority followed by EC equipment. Foreign equipment is considered when no similar equipment is available or when the foreign manufacturer agrees to manufacture the equipment in France. Other barriers like length of time for approvals also exist.

Restricted Sector: PTT procurement of many telecommunications products, such as network equipment, is restricted. France Telecom uses a closed bidding process and only accepts bids from French manufacturers unless the equipment is not available in France or if it is clearly of inferior quality.

VI. Private Sector Initiatives

Private sector initiatives in France are predominately between domestic and foreign companies in the form of joint ventures. The French firm joins with the foreign firm for access to foreign technology, while the foreign firm joins for market access and to benefit from government subsidies, tax benefits, etc. A lack of coordination exists between the government R&D centers and industry. Industry complains of difficulties in identifying R&D centers working in their field.

VII. Effects of Government Policies

While France's electronic policies appear to have helped its industry survive, the Government's ambitious goals of achieving independence and international competitiveness for the industry

have not been attained. For example, the goal of self-sufficiency in semiconductors by 1983 was not reached due to insufficient funding and outdated plant and equipment.

The French electronics sector has often tried to match developments in the United States rather than develop unique technology niches. An example of this was the unsuccessful attempt to overtake IBM's lead in the medium and large computer market. In the case of Minitel, in contrast, the telecommunications sector succeeded, through creative marketing, to exploit the untapped videotex market.

Selective public procurement and closed bidding serve to protect the domestic electronic industry from foreign competition while inhibiting the industry's international competitiveness.

Frequent restructuring of the industry inhibits long-term planning. Company mergers and breakups stifle product development and company commitment.

Most often the large nationalized or state-favored companies receive the majority of the venture capital from the government, making it difficult for the smaller companies to obtain the needed capital for development and growth. Because software requires little capital, government funding has been minimal. In spite of foreign competition, the French software industry controls 75 percent of the domestic market.

Overall growth of the sector is inhibited because of the lack of coordination between government research institutes and private industry. Instead of urging commercialization and creative marketing, basic research has been emphasized.

VIII. The Future

As Europe implements the integration of its markets under EC 92, the French electronics sector will face increased challenges within a larger, more competitive arena. French electronic companies are already acting to adjust to this imminent change by joining with other European electronics suppliers in joint ventures, mergers and other collaborative efforts.

Maria de la Guardia
Office of Computers and
Business Equipment

EUROPEAN COMMUNITY

I. Historical Development

Only in recent years has the European Community (EC) established a series of initiatives to promote the development of telecommunications equipment and systems (RACE), industrial technology (BRITTE), electronics (ESPRIT), and information technologies (EUREKA). The first three of these are funded through the Community. But the EUREKA program exists outside the Community framework, with funding developed by national corporate, university, and government participants.

These four programs have achieved a means of promoting large projects with several important features. They link together the key national firms in Europe that are working along similar lines in joint research efforts or joint ventures, with some of Europe's leading universities and research centers. In addition, the opportunity for smaller firms to participate in these initiatives exists allowing them to gain valuable knowledge and expertise. This is the first time such extensive cross-border research has been undertaken. EC programs place a community-wide emphasis on precompetitive research. Previous national programs emphasized basic research while governments used national procurement and incentives to create strong national firms in specific parts of the sector. These European collaborative efforts have a 10-year life span during which time certain results must be attained in the first 4 to 5 years or otherwise they lose EC funding.

II. EC Programs

The ESPRIT project is a 10-year effort to create a strong information technology and telecommunications sector in the EC. ESPRIT began in February 1984 by funding a series of precompetitive efforts in microelectronics, software technology, advanced information processing, office systems, and computer integrated manufacturing. The first five-year phase of ESPRIT cost ECU 1.5 billion (\$1.3 billion), with ECU 650 million coming directly from the EC, and the remainder from companies and other national contributions to research support. In ESPRIT's second phase, which began in 1989, greater efforts will be made to stimulate market-oriented investment and production, especially in high-density integrated circuits (ICs), high-speed ICs, and multifunctional ICs. Most evaluations of ESPRIT's work are positive.

The RACE program for telecommunications was begun in 1986 to promote the introduction of integrated broadband communications (IBC) in Europe, using integrated services digital network (ISDN) standards and other technologies. The focus is on pre-competitive research on the technologies needed to establish integrated broadband networks in Europe in the 1990s, especially broadband switching equipment, broadband coding, microelectronics and opto-electronics, and communications

software. The program emphasizes development of optical signal processing, switching, and transmission, which are needed for the transmission of large volumes of information at high speed, particularly to aid the transition to high definition television (HDTV). Total investment in the RACE program will be about ECU 1 billion, with 70 percent going to R&D. The first 46 contracts, funded in 1988 for three years, will receive ECU 186 million in support.

The BRITE program encourages the creation of a broad advanced technology base on which traditional Community industrial firms can draw so as to remain competitive on the international market over the next decade. BRITE was established by the EC Commission in close cooperation with industry. Of the nine key sectors identified as needing research support, laser technology and computer-aided design and computer-aided manufacturing were included. It was launched in March 1985, and its first four-year research program (1985-88) includes pre-competitive efforts that will receive ECU 125 million in support. BRITE's purpose is to improve industrial productivity, product reliability, and overall product quality in addition to encouraging more originality in design.

EUREKA was originally proposed by the French as a response to the U.S. Strategic Defense Initiative (SDI). EUREKA is to promote the joint development of commercial products in high technology industries throughout Europe, thus improving the competitiveness of these industries. EUREKA has become a vehicle for European R&D in computers, telecommunications, microelectronics, robotics, materials, and biotechnologies. It differs from the other programs in the Community since it is not directly funded through the EC. EUREKA programs originate with companies and are not part of any strategic program, as are projects in BRITE or RACE. Funding varies greatly from project to project, with some national government and private funding becoming common. Microelectronics has received a great deal of attention since the first of EUREKA's projects in 1985.

The EC Commission has recently agreed to major funding of the JESSI (Joint European Submicron Silicon) program in the microelectronics/semiconductor field. Funding for the initial group of 72 projects was set at ECU 3.2 billion over a 10-year period.

III. Successes and Failures

As part of the ESPRIT program, 201 projects are under way in the areas of microelectronics, information processing systems, and information technology applications. The first phase of ESPRIT rapidly yielded significant results: one example from the field of microelectronics is the design of a bipolar gate array circuit of 10,000 gates with an access time of 200 picoseconds, for which a production line has just been set up. In advanced information processing, several ESPRIT projects have led to developments in Prolog, a logical programming

language. Under a project headed by the creator of the language, a more efficient version of Prolog (Prolog III) has been developed. Prolog III was used to produce an expert system for detecting engine defects. In the field of software engineering, advances have been made on the Portable Common Tool Environment system designed to standardize interfaces between components of software environments. A consortium of the major semiconductor manufacturers LEP (France), Plessey (UK), Siemens (West Germany), and Thomson-CSF (France) has produced a fully operational gallium arsenide chip using new technologies to rival the performance of the traditional silicon chip. The EC succeeded in developing a new international standard on Office Document Architecture (ISO 8613) within ESPRIT projects which was adopted by the International Standards Organization (ISO).

The BRITE program has mainly increased the mobility, cooperation, and vocational training of research workers within the EC and increased communication between scientists. The second phase of the program should produce more results in the areas of new materials and new production methods.

The main goal of the RACE program as stated by its creators is to prepare for the "introduction of Integrated Broadband Communication (IBC), taking into account the evolving ISDN and national introduction strategies, progressing to Community-wide services by 1995." However, because work on the RACE program only began in January 1988, it is not possible to evaluate the program. Nonetheless, one result of the RACE program should be early standardization in EC telecommunications.

Because a substantial amount of risk is borne by each European firm, the EUREKA program has attracted selective participation. The French have proposed the creation of a venture capital fund with state-backed guarantees. At present, EC member state officials, with the support of the EC Commission, are actively examining how to encourage the flow of capital from the banking system and venture capital companies. Due to overlap between EUREKA projects and EC programs, the EC Commission has organized joint workshops with partners from the Community and EUREKA projects, including BRITE and ESPRIT. Aside from involvement in specific EUREKA projects on a case-by-case basis, the EC Commission is playing a key role in developing mechanisms to encourage a flow of private sector finance to high technology projects, including risk insurance. Projects with EC Commission assistance include COSINE (Cooperation on Open Systems Network in Europe), EAST (EUREKA Advanced Software Technology), JESSI, and HDTV.

IV. R&D Budget

Community R&D spending only represents about 2 percent of national R&D expenditures in the 12 member states.

V. Future Developments and Trends

Aside from the new fiscal policies being adopted by the EC that will affect all industries doing business in the EC, directives targeting the electronics sectors have been proposed or adopted. In essence, by 1992 these directives become Community law. Some of these directives include: 1) the minimum safety and health requirements for work with visual display units; 2) standardization in the field of information technology and telecommunications; 3) pan-European mobile telephones; 4) dissemination of information procedures on standards and technical rules; 5) mutual recognition of type approval for the telecommunications terminal equipment; 6) competition in the supply of telecommunications terminal equipment; 7) Green Paper on copyright and the challenge of technology; 8) competition in the markets for telecommunications services; 9) opening up of public procurement in the telecommunications sector; and 10) a proposal for a directive to protect computer programs.

Maria de la Guardia
Office of Computers and
Business Equipment