European Fab Database
November 1991

Source:
Dataquest

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Semiconductors *Europe*

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Published by Dataquest Incorporated

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Background

The material in this booklet applies to the European portions of Dataquest's Semiconductors *Europe* service Wafer Fab Database. The Wafer Fab Database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this booklet highlight both production and pilot line wafer fabs.

General Definitions

A *fab line* is a processing line in a clean room that is equipped to do all front-end wafer processing. Occasionally there are two separate product-specific fab lines or two different wafer sizes in a clean room. In this situation, a clean room will be documented as two fab lines if the equipment is dedicated to each wafer size or product line. There can be many fab lines at one location.

Front-end wafer processing is defined as all steps involved with semiconductor processing, beginning with initial oxide and ending at wafer probe.

A *production fab* is defined as a wafer fab capable of front-end processing more than 1,250 wafers per week (type = F).

A *pilot fab* is defined as a wafer fab capable of front-end processing 1,250 wafers or less per week (type = P).

Definitions of Table Columns

The *Products Produced* column contains product information for seven product categories. The information in this column can be very detailed, depending on the information's availability. The nomenclature used within the seven product groups of the fab database is as follows, with definitions where warranted:

- Analog
  - LIN—Linear/analog devices
  - A/D D/A—Analog-to-digital, digital-to-analog converters
  - AUTOMOTIVE—Dedicated to automobile applications
  - CODEC—Coder/decoder
  - INTERFACE—Interface IC
  - MESFET (GaAs)—Metal Schottky field-effect transistor
  - MODFET (GaAs)
  - MDIODE (GaAs)—Microwave diode
  - MFET (GaAs)—Microwave field-effect transistor
  - MODEM—Modulator/demodulator
  - MMIC—Monolithic microwave IC
  - OP AMP—Operational amplifier
  - PWR IC—Power IC
  - REG—Voltage regulator
  - SMART PWR—Smart power
  - SWITCHES—Switching device
  - TELECOM—Telecommunications chips
- Memory
  - MEM—Memory
  - RAM—Random-access memory
  - DRAM—Dynamic RAM
  - SRAM 4 TR.—Static RAM uses a 4-transistor cell design
  - SRAM 6 TR.—Static RAM uses a 6-transistor cell design
  - VRAM—Video RAM
  - ROM—Read-only memory
  - PROM—Programmable ROM
  - EPROM—Ultraviolet erasable PROM
  - EEPROM or E2—Electrically erasable PROM
  - FERRAM—Ferroelectric RAM
  - NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
  - FIFO—First-in, first-out memory
  - SPMEM—Other specialty memory (dual port, shift-register, color look-up, etc.)
- Micrologic
  - ASSP—Application-specific standard product
  - BIT—Bit slice (subset of MPU functions)
  - DSP—Digital signal processor
  - MCU—Microcontroller unit

- MPR—Microperipheral
- MPRCOM—MPR digital communications (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computation 32-bit MPU

• Standard logic

- LOG—Standard logic

• ASIC logic

- ASIC—Application-specific IC
- ARRAYS—Gate arrays
- CBIC—Cell-based IC
- CUSTOM—Full-custom IC (single user)
- PLD—Programmable logic device

• Discrete

- DIS—Discrete
- DIODE
- FET—Field-effect transistor
- GTO—Gate turn-off thyristor
- HEMT (GaAs)—High-electron-mobility transistor
- MOSFET—MOS-based field-effect transistor
- PWR TRAN—Power transistor
- RECTIFIER
- RF—Radio frequency
- SCR—Schottky rectifier
- SENSORS
- SST—Small-signal transistor
- THYRISTOR
- TRAN—Transistor
- ZENER DIODE

• Optoelectronic

- OPTO—Optoelectronic
- CCD—Charge-coupled device (imaging)
- COUPLERS—Photocouplers
- IED—Infrared-emitting diode
- IMAGE SENSOR
- LASER (GaP)—Semiconductor laser or laser IC
- LED—Light-emitting diode
- PDIODE—Photo diode
- PTRAN—Photo transistor
- SAW—Surface acoustic wave device
- SIT IMAGE SENSOR—Static induction transistor image sensor

The *Process Technology* column lists four major types of technologies. This column also lists a few uncommon technologies along with information on levels of metal, type of well, and logic structure, when available. Definitions of the nomenclature used in the Process Technology column are as follows:

• MOS (silicon-based)

- CMOS—Complementary metal-oxide semiconductor
- MOS—n-channel metal-oxide semiconductor (NMOS) and p-channel metal-oxide semiconductor (PMOS) (More than 90 percent of the MOS fabs use n-channel MOS.)
- M1—Single-level metal
- M2—Double-level metal
- M3—Triple-level metal
- N-WELL
- P-WELL
- POLY1—Single-level polysilicon
- POLY2—Double-level polysilicon
- POLY3—Triple-level polysilicon

• BiCMOS (silicon-based)

- BICMOS—Bipolar and CMOS combined on a chip
- BIMOS—Bipolar and MOS combined on a chip
- ECL I/O—ECL input/output
- TTL I/O—TTL input/output

• Bipolar (silicon-based)

- BIP—Bipolar
- ECL—Emitter-coupled logic
- TTL—Transistor-transistor logic
- STTL—Schottky TTL

• Gallium arsenide and other compound semiconductor materials

- GaAs—Gallium arsenide
- GaAlAs—Gallium aluminum arsenide
- GaAs on Si—Gallium arsenide on silicon
- GaP—Gallium phosphide

- HgCdTe—Mercuric cadmium telluride
- InAs—Indium arsenide
- InP—Indium phosphide
- InSb—Indium antimony
- LiNbO3—Lithium niobate
- SOS—Silicon on sapphire

The number in the *Minimum Linewidth* column represents the minimum linewidth at the critical mask layers as drawn. This number is stated in microns and is defined in Dataquest's fab survey as being available in production volumes.

The *Wafer Size* column represents the wafer diameter expressed colloquially in inches. However, for wafers greater than 3 inches in diameter, the colloquial expression is inaccurate. When calculating square inches, the following approximations are used:

Wafer-Start Capacity is defined in the fab survey as the equipment-limited wafer-start capacity per four-week period. Start capacity is not limited by current staffing or the number of shifts operating; it is limited only by the installed equipment in the fab and the complexity of the process it runs. Start capacity in square inches is calculated using the approximate diameter and the wafer-start capacity.

The *Clean Room Class* column represents the level of cleanliness in the cleanest part of the clean room. This area represents the true environment to which the wafer is exposed.

The *Origin of Owner* column represents the country where the parent company is headquartered.

The *Merchant or Captive* column categorizes each fab line on the tables as one of these two types. Definitions of the various categories are as follows:

- A *Merchant* fab line is a fab line that produces devices that end up available on the merchant market.
- A *Captive* fab line does not sell any of its devices on the merchant market. All production is consumed by the owner of the fab line.

Table 1
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
ABB-HAFO AB	JARFALLA	SWEDEN	N/A	DIS OPTO	BIP CMOS SOS	1.50	4	5,000	60,850	6,000	1/10	SWITZ/SWEDEN	M
ABB-IXYS	LAMPERTHEIM	GERMANY	N/A	PWR DIS LIN	BIP	5.00	3	16,000	113,120	0	100	SWITZ/SWEDEN	M
AEG AG (DAIMLER BENZ)	ULM	GERMANY	ULM RSCH	3D ICs mm-WAVE OPTO	GaAs MOS	0.00	0	0	0	0	N/A	GERMANY	M
ANALOG DEVICES	LIMERICK	IRELAND	N/A	LIN AD/DA TELECOM	CMOS BICMOS	1.00	4	15,000	182,550	10,000	10	U.S.A.	M
ANALOG DEVICES	LIMERICK	IRELAND	N/A	LIN AD/DA TELECOM	BIP BICMOS	1.20	6	20,000	547,600	0	N/A	U.S.A.	M
ANSALDO TRASPORTI	GENOA	ITALY	[illegible]	PWR DIS	BIP 1M	2.00	4	6,000	73,020	0	10	ITALY	M
ASCOM FAVAG	[illegible]	SWITZERLAND	N/A	ARRAYS CUSTOM	BIP	3.00	4	1,000	12,170	0	100	SWITZERLAND	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
AT&T MICROELECTRONICS	MADRID	SPAIN	N/A	CBIC CUSTOM	CMOS M2	1.25	6	14,000	383,320	25,000	1	U.S.A.	M
ATMEL	N/A	NETHERLANDS	N/A	EPROM EEPROM ARRAYS	CMOS	0.60	6	5,000	243,350	0	N/A	U.S.A.	
AUSTRIA MIKROSYSTEME GMBH	GRAZ	AUSTRIA	N/A	ARRAYS	NMOS CMOS BICMOS	1.00	4	25,000	304,250	10,000	10	AUSTRIA	M
DIGITAL EQUIPMENT	SOUTH QUEENSFERRY	SCOTLAND	N/A	MPU FPU LOG	CMOS	0.70	6	3,000	82,140	20,000	1	U.S.A.	C
ELMOS GMBH	DORTMUND	GERMANY	N/A	LIN CUSTOM	CMOS	1.50	4	4,166	50,700	0	10	GREMANY	M
[illegible]	[illegible]	GERMANY	N/A	N/A	CMOS	1.60	5	0	0	0	N/A	GERMANY	M
ES2 EUROPEAN SILICON STRUCTURES	ROUSSET CEDEX	FRANCE	ROUSSET	CBIC ARRAYS CUSTOM MIL	CMOS M2	0.80	5	1,000	19,020	0	10/1	FRANCE	M

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
				STD 883									
FUJITSU	NEWTON AYCLIFFE	ENGLAND	PHASE 1	4Mb DRAM ASIC	CMOS	1.00	6	25,000	684,500	0	N/A	JAPAN	M
GEC PLESSEY S/C	LINCOLN	ENGLAND	N/A	LIN MPU ARRAYS SRAM CUST	CMOS MOS	1.50	4	13,000	158,210	12,000	10	ENGLAND	M
GEC PLESSEY S/C	PLYMPTON	ENGLAND	N/A	N/A	MOS	3.00	4	15,000	182,550	0	N/A	ENGLAND	M
GEC PLESSEY S/C	ROBOROUGH	ENGLAND	N/A	ASIC DSP TELECOM	CMOS NMOS M3	0.70	6	6,000	164,280	19,906	1	ENGLAND	M
GEC PLESSEY S/C	SWINDON	ENGLAND	N/A	DIODES DIS LIN	BIP	5.00	5	12,000	228,240	29,000	N/A	ENGLAND	M
GEC PLESSEY S/C	SWINDON	ENGLAND	N/A	LIN	BIP	3.00	4	14,000	170,360	0	N/A	ENGLAND	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
EMT	BRUGG	SWITZERLAND	N/A	CONSUMER ICs	MOS	0.00	3	15,000	106,050	15,000	N/A	SWITZERLAND	M
HUGHES MICROELECT.	GLENROTHES	SCOTLAND	N/A	ARRAYS CBIC EPROM CUSTOM	CMOS MOS	3.00	4	6,400	77,888	28,000	100	U.S.A.	M
IBM	BOEBLINGEN	GERMANY	N/A	PWR DIS HYBRID	BIP	0.00	4	20,000	243,400	0	N/A	U.S.A.	C
IBM	CORBEIL-ESSONNES	FRANCE	N/A	ARRAYS LIN CUSTOM	BIP	2.00	5	40,000	760,800	50,000	N/A	U.S.A.	C
IBM	CORBEIL-ESSONNES	FRANCE	N/A	256K DRAM 64K SRAM	CMOS MOS	1.00	5	25,000	475,500	25,000	N/A	U.S.A.	C
IBM	CORBEIL-ESSONNES	FRANCE	N/A	1Mb DRAM	CMOS	0.00	8	7,000	340,690	0	N/A	U.S.A.	C
IBM	HANNOVER	GERMANY	N/A	DIS	BIP	0.00	4	20,000	243,400	0	N/A	U.S.A.	C

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
IBM	SINDELFINGEN	GERMANY	N/A	ARRAYS	BIP	2.00	5	15,000	285,300	20,000	N/A	U.S.A.	C
IBM	SINDELFINGEN	GERMANY	N/A	1Mb DRAM 4Mb DRAM	CMOS	0.80	8	20,000	973,400	45,000	N/A	U.S.A.	C
IBM	SINDELFINGEN	GERMANY	N/A	256K DRAM SRAM DSP MPU	MOS	1.50	6	25,000	475,500	20,000	N/A	U.S.A.	C
IBM	SINDELFINGEN	GERMANY	N/A	CUSTOM	BIP	1.50	5	15,000	285,300	20,000	N/A	U.S.A.	C
IBM	SINDELFINGEN	GERMANY	N/A	4Mb DRAM	CMOS	0.80	8	30,000	1,460,100	45,000	N/A	U.S.A.	C
ICL	N/A	BULGARIA	N/A	16K DRAM, 64K DRAM		0.00	0	0	0	0	N/A	U.K.	M
INST. SCIENCE & TECH.	TRENTO	ITALY	N/A	CCD	CMOS	0.00	4	10,000	121,700	0	N/A	ITALY	R

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines (Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
INTL. RECTIFIER	TURIN	ITALY	BORGARO	RECTIFIER THYRISTOR	N/A	0.00	4	15,000	182,550	13,000	100	U.S.A.	M
INTL. RECTIFIER	TURIN	ITALY	VENARIA	RECTIFIER THYRISTOR	N/A	0.00	4	10,000	121,700	0	N/A	U.S.A.	M
ISKRA	TRBOVLJE	YUGOSLAVIA	N/A	DIS	BIP	0.00	3	5,000	35,350	0	N/A	YUGOSLAVIA	M
ISOCOM	HARTLEPOOL	ENGLAND	N/A	OPTO	GaAs	0.00	0	0	0	0	N/A	ENGLAND	M
ITALTEL	ROME	ITALY	N/A	N/A	GaAs	0.00	0	0	0	0	N/A	ITALY	M
ITT	FREIBURG	GERMANY	N/A	PWR TRAN DIS	BIP MOS	5.00	4	42,000	511,140	0	1000	U.S.A.	M
ITT	FREIBURG	GERMANY	N/A	DSP NVMEM CUSTOM	CMOS MOS	1.20	5	21,500	408,930	0	10	U.S.A.	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
ITT	FREIBURG	GERMANY	N/A	DIS CUSTOM	BIP	5.00	4	16,500	200,805	0	10	U.S.A.	M
LUCAS	SUTTON COLDFIELD	ENGLAND	N/A	PWR DIS	GaAs	0.00	0	0	0	54,000	N/A	ENGLAND	M
MATRA MHS	[illegible]	FRANCE	N/A	256K SRAM MCU ASIC LIN	CMOS BiCMOS M2	0.70	5	10,000	190,200	21,500	10	FRANCE/U.S.	M
MATRA MHS/CYPRESS	N/A	FRANCE	N/A	N/A	N/A	0.00	0	0	0	0	N/A	FRANCE/U.S.	M
MICORELECT.-MARIN	MARIN	SWITZERLAND	N/A	CUSTOM	N/A	0.00	4	10,000	121,700	0	N/A	SWITZERLAND	M
MICROELECT.-MARIN	MARIN	SWITZERLAND	N/A	ARRAYS LIN CUSTOM	CMOS	3.00	4	10,000	121,700	0	10	SWITZERLAND	M
MICRONAS, INC.	[illegible]	FINLAND	N/A	LIN CBIC CUSTOM	CMOS M2	2.00	4	4,000	48,680	12,912	100	FINLAND	C

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
MIETEC ALCATEL	OUDENAARDE	BELGIUM	FAB 1	CUSTOM CBIC ANA	MOS CMOS BICMOS	1.00	4	15,000	182,550	21,520	10	BELGIUM	M
MOTOROLA	EAST KILBRIDE	SCOTLAND	MOS-1	MCU MEM LOG	CMOS MOS MI	3.00	4	20,000	243,400	25,600	100	U.S.A.	M
MOTOROLA	EAST KILBRIDE	SCOTLAND	MOS-4	MCU MEM LOG	CMOS MOS	2.00	6	45,000	855,900	35,000	N/A	U.S.A.	M
MOTOROLA	EAST KILBRIDE	SCOTLAND	MOS-9	SRAM 1Mb DRAM 68040 MPU	CMOS TOSHIBA	1.00	6	25,000	684,500	34,000	10	U.S.A.	M
MOTOROLA	TOULOUSE	FRANCE	BIP PWR	PWR TRAN	BIP	10.00	5	12,000	228,240	6,700	100	U.S.A.	M
MOTOROLA	TOULOUSE	FRANCE	BP-4	TELECOM OP AMP REG AUTO	BIP	2.00	4	25,000	304,250	22,000	100	U.S.A.	M
MOTOROLA	TOULOUSE	FRANCE	N/A	DIS	BIP	0.00	4	14,000	170,380	5,800	N/A	U.S.A.	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Merchant or Captive
NATIONAL S/C	GREENOCK	SCOTLAND	BIP 4	LOG	BIP	5.00	4	40,000	486,800	10,000	100	U.S.A.	M
NATIONAL S/C	GREENOCK	SCOTLAND	LOGIC	LOG	N/A	0.00	5	15,000	285,300	15,000	N/A	U.S.A.	M
NATIONAL S/C	GREENOCK	SCOTLAND	UK 6"	LOG CUSTOM ARRAYS	BIP	1.50	6	7,000	191,660	10,000	10	U.S.A.	M
NEC	LIVINGSTON, WEST LOTHIAN	SCOTLAND	PHASE 1	1Mb DRAM 4Mb DRAM	CMOS M2 M3	0.70	5	9,000	171,180	19,500	1	JAPAN	M
NEC	LIVINGSTON, WEST LOTHIAN	SCOTLAND	PHASE 2	4Mb DRAM 256K SRAM MPU	CMOS	0.00	6	9,000	246,420	19,500	N/A	JAPAN	M
NEWMARKET MICROSYS.	NEWMARKET	ENGLAND	N/A	LIN DIS	BIP	0.00	4	10,000	121,700	0	N/A	ENGLAND	M
NUOVA MISTRAL S.P.A.	SERMONETA	ITALY	N/A	ZENER DIODE DIODES	N/A	3.00	3	15,000	106,050	10,760	1000	ITALY	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines (Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
PHILIPS	CAEN	FRANCE	N/A	CONSUMER ICS	BIPOLAR M2 M3	1.50	5	18,000	342,360	0	100	NETHERLANDS	
PHILIPS	HAMBURG	GERMANY	CONSUMER	CON	BIP M2	1.20	5	18,000	342,360	16,140	100	NETHERLANDS	M
PHILIPS	HAMBURG	GERMANY	DISCRETE	DIS	BIP M1	2.00	4	22,000	267,740	0	1K/10	NETHERLANDS	M
PHILIPS	HAMBURG	GERMANY	N/A	8-BIT MCU 16-BIT MCU EEPROM ASIC	CMOS MOS M1 M2	1.00	5	12,500	237,750	32,280	10K/1	NETHERLANDS	M
PHILIPS	HAZELGROVE, STOCKPORT CHESHIRE	ENGLAND	BIPOLAR	TRAN DIODE RECTIFIER	BIP	10.00	4	45,000	547,650	19,368	100	NETHERLANDS	
PHILIPS	HAZELGROVE, STOCKPORT CHESHIRE	ENGLAND	POWERMOS	DIODE SMART PWR	MOS 1M	3.00	4	10,000	121,700	11,836	10	NETHERLANDS	M
PHILIPS	NIJMEGEN	NETHERLANDS	N/A	N/A	MOS 1M	3.00	4	26,000	316,420	23,456	100	NETHERLANDS	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Merchant or Captive
PHILIPS	NIJMEGEN	NETHERLANDS	N/A	SRAM CON	CMOS NMOS M2	0.80	6	8,400	229,992	0	1	NETHERLANDS	M
PHILIPS	NIJMEGEN	NETHERLANDS	N/A	DIS	MOS BICMOS BIP	1.50	5	20,000	380,400	39,338	100	NETHERLANDS	M
PHILIPS	NIJMEGEN	NETHERLANDS	N/A	PWR DIS DIODES	N/A	0.70	4	0	0	12,912	10000	NETHERLANDS	M
PHILIPS	STADSKANAAL	NETHERLANDS	N/A	RECTIFIER	BIP M3	0.00	5	70,000	494,900	0	N/A	NETHERLANDS	M
PHILIPS RTC	CAEN	FRANCE	N/A	SRAM		5.00	5	12,000	228,240	12,589	10	FRANCE	M
PHILIPS/FASELEC	ZURICH	SWITZERLAND	N/A	N/A	CMOS 1M	2.00	4	12,000	146,040	21,520	100	NETHERLANDS	M
PIHER	GRANOLLERS	SPAIN	N/A	DIS LIN	BIP	0.00	3	10,000	70,700	13,000	N/A	SPAIN	M

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Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Merchant or Captive
RACAL	READING	ENGLAND	N/A	N/A	MOS	0.00	3	10,000	70,700	0	N/A	ENGLAND	M
RIFA AB	KALMAR	SWEDEN	N/A	PWR DIS	BIP	0.00	4	25,000	304,250	92,000	N/A	SWEDEN	M
RIFA AB	KISTA	SWEDEN	N/A	N/A	BIP MOS	0.00	4	10,000	121,700	0	N/A	SWEDEN	M
ROBERT BOSCH	REUTLINGEN	GERMANY	[illegible]	LIN DIS CUSTOM	BIP BICMOS	3.00	4	20,000	243,400	0	100	GERMANY	C
SEAGATE MICROELECT.	LIVINGSTON	SCOTLAND	N/A	LIN	BIP [illegible]	3.00	4	5,000	60,850	16,140	100	U.S.A.	C
SEMEFAB	GLENROTHES	SCOTLAND	N/A	LIN DIS OPTO	BIP CMOS MOS	4.00	4	2,000	24,340	0	10	SCOTLAND	M
SEMITRON	CRICKLADE	ENGLAND	N/A	DIS	BIP	0.00	4	10,000	121,700	0	N/A	GERMANY	M

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
SEMITRON	NURNBERG	GERMANY	N/A	DIS	BIP	0.00	4	10,000	121,700	0	N/A	GERMANY	M
SGS-THOMSON	35041 RENNES	FRANCE	N/A	LIN	BIP M2	5.00	6	16,000	304,320	0	10	ITALY	M
SGS-THOMSON	AGRATE	ITALY	[illegible]	LIN ARRAYS LOGIC	BIP BICMOS	4.00	5	16,000	304,320	22,000	10	ITALY	M
SGS-THOMSON	AGRATE (MILAN)	ITALY	[illegible]	64K 256K 1Mb EPROM PLD LIN ARRAYS	CMOS	0.70	6	28,000	766,640	22,000	10/1	ITALY	M
SGS-THOMSON	CATANIA	ITALY	N/A	DIS	N/A	3.00	[illegible]	34,000	646,680	0	100	ITALY	M
SGS-THOMSON	CATANIA	ITALY	N/A	LOG LIN CUSTOM	CMOS	[illegible]	4	21,000	255,570	0	100	ITALY	M
SGS-THOMSON	COSTALETTO		N/A	MPU	CMOS	0.00	5	0	0	0	N/A	ITALY	

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
SGS-THOMSON	GRENOBLE	FRANCE	N/A	LIN PWR IC CUSTOM	BIP CMOS	1.50	4	20,000	243,400	14,000	100	ITALY	M
SGS-THOMSON	ROUSSET	FRANCE	MODULE 4	MPU LIN	CMOS MOS	2.00	4	22,000	267,740	0	10	ITALY	M
SGS-THOMSON	ROUSSET	FRANCE	MODULE 5	NVMEM MPU	CMOS MOS	1.50	5	16,000	304,320	0	1	ITALY	M
SGS-THOMSON	TOURS	FRANCE	MESA	DIS	N/A	5.00	3	70,000	494,900	0	100	ITALY	M
SGS-THOMSON	TOURS	FRANCE	[illegible]	DIS	N/A	5.00	4	20,000	243,400	0	100	ITALY	M
SIEMENS	MUNICH	GERMANY	BALANSTRAS	ASIC CUSTOM LIN	BIP	2.00	5	15,000	285,300	0	N/A	GERMANY	M
SIEMENS	MUNICH	GERMANY	BALANSTRAS	ASIC CUSTOM	CMOS MOS	1.50	5	15,000	285,300	0	N/A	GERMANY	M

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
SIEMENS	REGENSBURG	GERMANY	MEGA 1	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	20,800	569,504	0	N/A	GERMANY	M
SIEMENS	REGENSBURG	GERMANY	MEGA 2	4Mb DRAM	CMOS	0.80	6	16,000	436,080	0	N/A	GERMANY	M
SIEMENS	REGENSBURG	GERMANY	N/A	[illegible]	N/A	0.00	4	10,000	121,700	0	N/A	GERMANY	M
SIEMENS	VILLACH	AUSTRIA	FAB 1	64K DRAM LOG	MOS	2.00	4	40,000	486,800	0	N/A	GERMANY	M
SIEMENS	VILLACH	AUSTRIA	FAB 2	256K DRAM	MOS	1.20	5	40,000	760,800	0	N/A	GERMANY	M
TAG	ZURICH	SWITZERLAND	N/A	DIS	N/A	0.00	4	10,000	121,700	0	N/A	SWITZERLAND	M
TELEFUNKEN	ECHING	GERMANY	N/A	LOG MPU MCU ARRAYS	CMOS	3.00	4	24,000	292,080	3,000	100	GERMANY	M

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
				CUST									
TELEFUNKEN ELECT.	HEILBRONN	GERMANY	N/A	CUSTOM LIN DIS MCU	BIP MOS CMOS	1.00	4	20,000	243,400	0	1	GERMANY	M
TELEFUNKEN ELECT.	HEILBRONN	GERMANY	N/A	OPTO HIGH FREQUENCY	BIP	1.00	3	5,000	35,350	0	N/A	GERMANY	M
TELEFUNKEN ELECT.	HEILBRONN	GERMANY	N/A	OPTO	GaAs	1.00	2	3,000	9,420	0	N/A	GERMANY	M
TEXES	NICE	FRANCE	N/A	DIS	N/A	0.00	4	10,000	121,700	25,000	N/A	FRANCE	M
TI	AVEZZANO	ITALY	PHASE 1	4Mb DRAM ASSP CBIC	CMOS	0.80	6	23,740	650,001	46,000	1	U.S.A.	M
TI	BEDFORD	ENGLAND	PWR FAB	PWR DIS	BIP	0.00	4	14,379	174,992	9,000	100	U.S.A.	M
TI	FREISING	GERMANY	N/A	LIN ASSP	BIP CMOS BICMOS	0.80	5	9,463	179,986	10,000	100	U.S.A.	M

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
TI	FREISING	GERMANY	N/A	CBIC LIN ASSP	CMOS BICMOS	0.80	5	10,515	199,995	17,000	10	U.S.A.	M
VAISALA	VANTAA	FINLAND	N/A	LIN	CMOS	5.00	3	200	1,414	0	100	FINLAND	M
VEB GLEICHRICHTERWERK	STAHNSDORF	GERMANY	N/A	PWR DIS	N/A	0.00	0	0	0	0	N/A	GERMANY	C
VEB HALBLEITERWERK	FRANKFURT (ODER)	GERMANY	N/A	LIN	BIP	0.00	0	0	0	0	N/A	GERMANY	C
VEB KOMBINAT MIKROELEKTRONIK	ERFURT	GERMANY	N/A	N/A	CMOS MOS	0.00	0	0	0	0	N/A	GERMANY	C
VEB [illegible]	NEUHAUS AM RENNWEG	GERMANY	N/A	[illegible]	N/A	0.00	0	0	0	0	N/A	GERMANY	C
VEB WERK FUER FERNSEHELEKTRONIK	BERLIN-OBERSCHOENE WEIDE	GERMANY	N/A	SENSOR CCD	N/A	0.00	0	0	0	0	N/A	GERMANY	C

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines (Including Fabs Going into Production During 1992)

Company	City	Country	Fab Name	Products Produced	Process Technology	Min. Line-width	Waf. Size	Max. W/Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (square feet)	Clean Room Class	Origin of Owner	Mercant or Captive
WESTCODE S/C	CHIPPENHAM	ENGLAND	N/A	DIS	N/A	0.00	4	10,000	121,700	0	N/A	ENGLAND	C
ZETEX	OLDHAM	ENGLAND	N/A	[illegible]	BIP MOS	1.50	5	10,000	190,200	26,000	N/A	ENGLAND	M

NA = Not Available
Source: Dataquest (November 1991)

Table 2
European Future Pilot and Production Fab Lines
(Planned Facilities Going into Production by Year)

Company	City	Country	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
Production Begins: 1992												
HITACHI	LANDSHUT	GERMANY	N/A	4Mb DRAM 256K 1Mb SRAM	N/A	F	01/01/92	0.80	8	16,000	778,720	0
MITSUBISHI	ALSDORF	GERMANY	N/A	4Mb DRAM MPU 1Mb DRAM	CMOS	FAT	03/01/92	0.80	6	22,000	602,360	25,000
TI	AVEZZANO	ITALY	PHASE 2	16Mb DRAM	CMOS	F	02/01/92	0.60	8	20,000	973,400	30,000
Production Begins: 1993												
FUJITSU	NEWTON AYCLIFFE	ENGLAND	PHASE 2	4Mb DRAM ASIC	CMOS	F	/ /	0.80	6	45,000	1,232,100	0
INTEL	LEIXLIP, KILDARE	IRELAND	FAB 10	386 486 586 MPU LOG	CMOS	F	06/01/93	0.80	8	18,000	876,060	30,000
MIETEC ALCATEL	OUDENAARDE	BELGIUM	FAB 2	ASIC	CMOS M2 POLY2	FAT	07/01/93	0.50	6	5,000	136,900	12,917
Production Begins: 1994												
FUJITSU	NEWTON AYCLIFFE	ENGLAND	PHASE 3	16Mb DRAM	CMOS	F	/ /	0.60	8	30,000	1,460,100	0

Dataquest (October 1991)

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Introduction to the Service

EUROPEAN SEMICONDUCTOR INDUSTRY SERVICE

Dataquest's European Semiconductor Industry Service (ESIS) is a comprehensive information service covering the European semiconductor industry. It is a product-oriented, executive-level perspective intended to assist with strategic decisions of key executives and product managers of semiconductor manufacturing companies, suppliers to the semiconductor industry, semiconductor users, and other businesses or institutions interested in the semiconductor industry. The service consists of the following:

- Data-base reference notebooks containing sections that are continually revised and updated as developments occur or additional information becomes available
- Research newsletters and bulletins on current industry issues and events
- An inquiry service providing access to Dataquest's European Components Group Client Inquiry Center and access to the European Components Group Research Staff
- The IC Europe monthly report, providing timely information on European high-technology industries and 1992
- An annual conference in Europe, with industry experts discussing developments of current interest and importance
- Access to Dataquest's semiconductor on-line information service and The DQ Monday Report, providing pricing and lead-time updates
- Access to Dataquest's European semiconductor library resources

SERVICE STRUCTURE

The service analyzes and reports on the products, markets, and major companies in the semiconductor industry in Europe as a whole and in individual countries. The service does the following:

- Provides semiconductor consumption forecasts in the following ways:
  - By product technology
  - By product function
  - By application market—includes data processing, communications, industrial, military, consumer, and transportation

- Analyzes European semiconductor markets for the following regions:
  - Benelux—includes Belgium, Luxembourg, and the Netherlands
  - France
  - Italy
  - Scandinavia—includes Denmark, Finland, Norway, and Sweden
  - United Kingdom and Ireland
  - West Germany
  - Rest of Europe—includes Austria, Portugal, Spain, and Switzerland
- Identifies services and suppliers to the European semiconductor industry
- Analyzes the forces affecting the European semiconductor market, such as:
  - Supply and demand
  - Technological developments
  - Economic issues
  - Government policies
  - Distribution

SERVICE ORGANIZATION

Volume I

Volume I contains separate sections for each of the European geographical regions covered by the service, and each regional section covers the following topics:

- Overview—discussion of the economic environment
- Semiconductor Device Markets—analysis of the local markets by technology and function

- Application Markets—analysis of local application markets for semiconductors in data processing, communications, industrial, consumer, military, and transportation sectors
- Plant Locations—manufacturing locations by company within the region
- Design Center Locations—semiconductor design center locations by company for the region

Volume II

Volume II, which discusses Europe as a whole, is divided into the following topics:

- European Overview—covers analysis of trends in capital and research and development expenditures, venture capital, and government and private investment; discusses the European economic environment and channels of distribution
- Semiconductor Device Markets—analyzes the European market for integrated circuits, discrete devices, and optoelectronics, by technology and function
- Semiconductor Application Markets—analyzes the European application markets for semiconductors in data processing, communications, industrial, consumer, military, and transportation sectors
- Major Users—analyzes the major semiconductor users in Europe
- Services and Suppliers to the Semiconductor Industry—identifies the key services and suppliers to the European semiconductor industry: assembly services, capital equipment suppliers, design services, materials suppliers, testing services, and wafer fabrication services
- Memory—analyzes the European memory semiconductor markets
- Microcomponents—analyzes the European microcontroller, microprocessor, and microperipheral markets

Volume III

Volume III, which contains the company-related data, is divided into the following topics:

- European Plant Locations—lists the plant locations for all major semiconductor manufacturers

- European Design Center Locations--lists the design center locations for worldwide semiconductor companies in Europe
- European Semiconductor Production—analyzes wafer fabrication in Europe
- Company Profiles—profiles selected companies active in Europe

Also included in Volume III are Dataquest's Market Share Estimates, which consist of the following:

- Worldwide market shares of European companies
- European market shares of:
  - European companies
  - U.S. companies
  - Japanese companies
  - Rest of World companies

Other Components

The ASIC binder contains quantitative and qualitative analyses of the European gate array, cell-based IC, programmable logic, and full-custom businesses.

IC Europe is a monthly report on European high-technology industry. It covers a monthly update to the status of the industry, industry highlights, research update, semiconductor pricing and analysis, a thought for the month, and a monthly update on events leading up to 1992.

The Newsletters 1988-89 binder contains industry newsletters and bulletins devoted to current topics of specific European interest.

In addition, Volumes I, II, and III contain yearly exchange rate tables. The quarterly exchange rate newsletter may be found in the newsletter volume.

SERVICE FEATURES AND PROCEDURES

Service Sections

The document preparation date is shown at the bottom of each page. Sections are updated on a regular basis, and filing instructions are sent with the new updates.

Introduction to the Service

Newsletters

Newsletters are published regularly throughout the year and should be filed in the latest newsletter volume. The newsletters provide executive summaries of key industry events and serve to underscore significant changes in the reference material presented in the data-base notebooks. In addition, newsletters of an analytical nature are published periodically on a variety of topics not regularly covered in the service.

Inquiry Privilege

There are two forms of inquiry available to the client: access to Dataquest's European Semiconductor Inquiry Center and access to the ESIS semiconductor staff. The registered binderholder has the privilege of direct access to the Inquiry Center, where the staff provides assistance in finding and interpreting material in the data notebooks or other Dataquest-published material. In addition, binderholders have access to the European Semiconductor Industry Service research staff; this privilege allows the client to seek additional commentary on or clarification of the published material, although it is not intended to provide individualized custom research. Using this feature of the service, clients may interact with industry experts on a one-to-one basis to discuss attitudes and opinions about topics covered in the service.

Annual Conference

Each year Dataquest's European Semiconductor Industry Service hosts a two-day conference. In this forum, leading experts and decision makers throughout the industry share their views on the future and on critical external issues affecting the growth of the European semiconductor business. The conference allows executive-to-executive communication about important topics through formal presentations, workshops, and informal discussion periods.

Dataquest's Library Services

Dataquest's library services offer comprehensive secondary research materials covering the full spectrum of high-technology companies, markets, and industries tracked by Dataquest.

Semiconductor On-Line Information

All our clients receive ESIS On-line and the DQ Monday Report as part of the service. The ESIS On-line service holds the ESIS data base, enabling clients receive immediate updates to the data base. The DQ Monday Report gives updates of prices and lead times for 25 selected semiconductor devices. Prices are reported for the United States, Europe, Japan, Taiwan, Hong Kong, and Korea for 1K, 10K, and contract quantities.

PRODUCT TECHNOLOGY DEFINITIONS

Dataquest divides the total semiconductor market into integrated circuits, discrete devices, and optoelectronic devices. These categories are further segmented as shown on the following pages.

Integrated Circuits (ICs)

ICs include bipolar devices, MOS devices, and analog devices, broken down as follows:

- Bipolar—bipolar memory, bipolar logic
  - Bipolar Memory—ECL RAM, ROM, PROM, flip-flops, latches, register files, shift registers
  - Bipolar Logic—bipolar ASIC, bipolar standard logic, bipolar other logic
    - Bipolar ASIC—includes gate arrays, PLDs (programmable logic devices), CBICs (cell-based ICs) and full-custom
    - Bipolar standard logic—includes TTL, ECL, and other family logic, as well as TTL-compatible SSI, MSI, LSI; CML, ECL, I2L, ISL, STL with TTL levels; standard, AS, FAST, LS, ALS lines; ECL-compatible SSI, MSI, LSI; RTL and DTL
    - Bipolar other logic—includes ASSPs (application-specific standard products), bipolar bit-slice (e.g., 2900, 29300 families), ALU, control unit, multiplier, floating point, digital filters; also includes bipolar support chips and chip sets for MPUs
- MOS—MOS memory, MOS microcomponents, MOS logic
  - MOS Memory—DRAM, SRAM, ROM/other
    - DRAM—Dynamic RAM
    - SRAM—Static RAM
    - ROM/other—includes ROM, PROM, EPROM, EEPROM, flip-flops, latches, register files, shift registers
  - MOS Microcomponents—MOS microprocessor, MOS microcontroller, MOS microperipheral, DSP

  - Microprocessor (MPU)—includes all microprocessors such as Intel X86 family, Motorola 68XXX family, RISC

  - Microcontroller (MCU)—includes single-chip controllers such as Intel 8051 and Motorola 68HC05

  - Microperipheral (MPR)—includes MPU support chips used in system support (e.g., timer, interrupt control, DMA, MMU), peripheral controllers (e.g., disk, graphics display, CRT, keyboard), communications controllers (e.g., UART); also includes MOS chip sets for MPU support, LAN coprocessors, accelerator coprocessors (e.g., floating-point unit, graphics coprocessor, image processor)

  - Digital signal processor (DSP)—includes single-chip DSPs, MOS bit-slice, ALC, mulipliers, accumulators, and digital filters

- MOS Logic—MOS ASIC, MOS standard logic, MOS other logic

  - MOS ASIC—includes gate arrays, PLDs (programmable logic devices), CBICs (cell-based ICs), and full-custom

  - MOS standard logic—includes MOS family logic such as HC, HCT, and FACT lines

  - MOS other logic—includes application-specific standard products (ASSPs) (e.g., motor control ICs); also MOS ALC, MAC, digital filters, and other building blocks

- Analog (linear)—monolithic, general-purpose, specialty-purpose, analog ASIC, hybrid

  - Monolithic—includes bipolar and MOS monolithic linear ICs with more than 50 percent analog circuits by area on the die

  - General-purpose—includes input/ouput and power applications

  - Specialty-purpose—includes telecommunications and consumer applications

  - Analog ASIC—includes linear arrays, linear CBIC, and linear full-custom

  - Hybrid—includes hybrid packages sold by semiconductor vendors, used mostly in linear applications

Discrete Devices

Discrete devices include transistor, diode, thyristor, and other discrete devices, as follows:

- Transistor—includes small signal and power transistors, and field effect transistors (FET)
- Diode—includes small signal and power diodes, Zener diodes, and rectifiers
- Thyristors—includes all unidirectional and bidirectional thyristors
- Other discrete—includes tunnel and varactor diodes, microwave diodes, and other polycrystalline devices

Optoelectronic Devices

Optoelectronic devices include light-emitting diodes (LEDs), infrared lamps, LED displays, laser devices, optoelectronic couplers, and sensors (photo diodes, selenium rectifiers, solar cells). They exclude LCD displays and incandescent and fluorescent lamps and displays.

APPLICATION MARKET DEFINITIONS

Dataquest segments and defines the semiconductor application markets as follows:

- Data Processing—This includes all equipment whose main function is flexible information processing. Included in this segment are all personal computers, regardless of price, distribution, or use in the office, education, or home environment.
- Communications—Within the communications market, Dataquest classifies telecommunications as a subsegment that consists of customer premises and public telecommunications equipment. The other communications categories include radio, studio, and broadcast equipment.
- Industrial—The industrial segment includes all manufacturing-related equipment, including scientific, medical, and dedicated systems.
- Consumer—This is equipment that is designed primarily for home or personal use, the primary function of which is not flexible information processing. Audio and video equipment and appliances are typical examples of equipment that is classified in the consumer application market.

- Military—Military electronic equipment is primarily defense-oriented electronic equipment and is classified by major budget area. It does not include all electronic equipment procured by the government because such a breakout would double-count equipment that logically belongs in other market segments.

- Transportation—This segment consists mainly of automotive and light truck electronics. This designation leaves room to analyze other markets, such as off-highway equipment, that are potentially large users of semiconductors.

Further definitions of these segments are included in the European Semiconductor Applications Market (ESAM) binder.

ABOUT DATAQUEST

Dataquest's research covers an entire generation of high-technology industries, with a primary focus on the following six broad areas:

- Semiconductors
- Information systems
- Peripherals
- Office equipment
- Industrial automation
- Telecommunications

Within these primary areas, Dataquest tracks and serves more than 25 separate industries.

Dataquest provides a comprehensive line of products and services designed to meet the varying research and analysis needs of corporate decision makers. The products include the following:

- Industry services similar in nature to the European Semiconductor Industry Service

- Executive and Financial Programs—A series of business opportunity and technology advisory programs specifically designed for senior executives involved in high technology

- Focus Reports—Highly detailed landmark publications on specific issues of topical interest

- Newsletters—General overviews and analyses of specific industries or markets
- Product Specification Guides
- Who's Who Industry Guides
- Consultancy

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What Is On-Line?

On-line is an electronic database containing information from all of Dataquest's worldwide and regional services. Depending on which service a client subscribes to, access may be gained to one or more of the service information bases. Along with the individual service databases there are certain information areas available to all clients, irrespective of which service they subscribe to. Figure 1 illustrates the main menu. Options 1 to 10 are service specific, for example, clients to ESIS are able to access option 3; options 11 to 19 are available to all clients.

Figure 1

Dataquest's Semiconductor On-Line Service Main Menu

```
NASM CLIENTS - Type:  GO NAS  for newsletter menu

AVAILABLE TO ALL CLIENTS - COMPANY BACKGROUNDERS UPDATED 12/90  TYPE: GO COF1

AVAILABLE TO SISPMT CLIENTS - US SEMICONDUCTOR BOOK-TO-BILL REPORT AND ANALYSIS
JANAURY 1991 NEWSLETTER   TYPE: GO SIS288

Press <CR> for more !

DATAQUEST                    DQ-4

 1 ASETS        * INFORMATION AVAILABLE TO ALL CLIENTS
 2 ESAM         11 * Inquiry Service
 3 ESIS         12 * Worldwide Market Share - Update 5/90
 4 JSAM         13 * Worldwide Forecast-History-Shipments-Update 10/90
 5 JSIS         14 * General Newsletters
 6 SAM          15 * Company Information
 7 SEMS         16 * DQ Monday Report
 8 SIS          17 * Keyword Search
 9 SUIS         18 * Stock Market
10 MILAERO      19 * New Updates

Enter choice or <CR> for more !
```

Note: Options 11 to 19 are available to all clients
Source: Dataquest (March 1991)

Online also provides:

- Information on company balance sheets (Option 15)
- Dataquest's latest worldwide market share estimates (Option 12)
- Dataquest's latest worldwide semiconductor forecast (Option 13)
- A selection of important newsletters (Option 14)
- The latest Wall Street stock market prices (Option 18)

Option 11 provides clients with their own electronic mail box. Using this clients are able to send inquiries to Dataquest's Client Inquiry Centers (CIC) in San Jose in the United States and to Denham in England.

The DQ Monday report (option 16) provides pricing information on 26 key semiconductor components from 6 world regions on a twice-monthly basis. An analysis of the recent price changes is also published. In addition, a Dataquest analysis of recent news items is published on a weekly basis. These news items are drawn from Dataquest's worldwide research offices in Japan, Taiwan, Korea, Hong Kong Europe and the United States.

Option 17 provides a keyword search facility. If a client wishes to find out what is on line about certain subjects—for example ASICs or Philips—keyword search provides a reference listing of all the information available. Quick references then enable the inquirer to locate the reference directly.

HOW TO ACCESS THE ON-LINE SERVICE

To access the Dataquest semiconductor on-line service you will require a personal computer, a modem, and a communications software package. Dataquest's on-line database is located in the United States and is supported by Compuserve; it can be accessed directly from major cities around the world. Accessing via a local node rather than phoning directly to the United States will save you telephone charges. Access can also be obtained through your local PTT, for example the Packet SwitchStream (PSS) offered by British Telecom in the United Kingdom.

As the method of access will vary from country to country, you will need to contact either James Heal at Dataquest, Denham, England or Denise Zertuche, Dataquest in San Jose, USA. They will provide you with your local node number (or see Appendix A) and can advise on any login procedures. In addition, Dataquest will issue you with a personal identifier number and password to access the on-line database. This will also provide you with your own electronic mailbox. In your own interest, we urge you to keep your password secret.

Once your password and identifier number have been issued you will need to take certain steps to access the database. Set your software to 7 databits, 1 startbit, 1 stopbit, even parity, no echo, TTY (ASCII) emulation for best effect. The procedure for logging into the semiconductor on-line service using the above setup is as follows:

1. Dial the appropriate telephone number via modem (see Appendix A)
2. Enter several carriage returns <CR> until a pound sign or # prompt appears in the top left-hand corner of your screen.
3. Type in the letter C and then <CR>.
   The system will respond with PORT (number) CENTER:
4. Type in CPS and then <CR>.
   The system will respond by overstriking this several times, and there may be a short delay until it responds with HOST NAME:
5. Type in CPS and then <CR>.
   The system will respond with ID NUMBER:

6. Type in your ID number, for example, 44023,500, and then <CR>.
   The system will respond with PASSWORD:

7. Type in your password and then <CR>.

The system will respond with the Dataquest Welcome Menu, which will offer you various database options. For further assistance in moving around the database type HELP or H, and a list of commands to aid your movement around the database will appear. You are now logged in.

European support of Dataquest's semiconductor on-line service is provided by:

- James Heal, Research Analyst, Dataquest Europe Limited
  Tel: +44 895 835 050

In the United States by:

- Denise Zertuche, On-Line Administrator, Dataquest Incorporated, San Jose
  Tel: (408) 437 8000

APPENDIX A

NODE TELEPHONE NUMBERS USED FOR THE ON-LINE SYSTEM
(as at February 1991)

Austria

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Austria:

City	Baud Rate	Number
Vienna	Async access 0-2400 (V.22 bis)	222-7127211

Belgium

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Belgium:

City	Baud Rate	Number
Brussels	Async access 300 (V.21)	02-648-0710
	Async access 1200/2400 (V.22 bis)	02-647-9847
	Async access 1200/75 (V.23)	02-646-3301

Denmark

Access numbers and baud rates supported by Computer Sciences Corp. are in the following city within Denmark:

City	Baud Rate	Number
Copenhagen	Async access 300/1200/2400 (V.21/V.22/V.22 bis)	38-331499

Finland

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Finland:

City	Baud Rate	Number
Helsinki	Async access 0-2400 (V.22 bis/MNP)	92919

(Note: Domestic (National) network users must dial 92919. Users from outside Finland must dial +358.2919, no area code needed.)

France

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within France:

City	Baud Rate	Number
Paris	Async access 300-2400 (V.21, V.22, V.22 bis MNP)	1-43 44 12 12

Germany

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Germany:

City	Baud Rate	Number
Frankfurt	Async access 300 (V.21)	069-6666062
	Async access 1200/2400 (V.22)	069-6666881
	Async access 1200/2400 (V.22 MNP)	069-6666886
	Async access 1200/75 (V.23)	069-6664007

Italy

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Italy:

City	Baud Rate	Number
Milan	Async access 300/2400 (V.22 bis)	2-545-6351
	Async access 300/2400 (V.22 bis)	2-546-8840
	Async access 300/2400 (V.22 bis)	2-545-5716
	Async access 300/2400 (V.22 bis)	2-546-9145
	Async access 300/2400 (V.22 bis)	2-546-8225
	Async access 300/2400 (V.22 bis)	2-545-9857
	Async access 300/2400 (V.22 bis)	2-546-8649
	Async access 300/2400 (V.22 bis)	2-546-2657
	Async access 300/2400 (V.22 bis)	2-598-991
	Async access 300/2400 (V.22 bis)	2-540-0428
	Async access 300/2400 (V.22 bis)	2-540-0425
	Async access 300/2400 (V.22 bis)	2-545-0620
	Async access 300/2400 (V.22 bis)	2-546-8994

Netherlands

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within the Netherlands:

City	Baud Rate	Number
Amstelveen	Async access 300 (V.21)	020-417855
	Async access 1200/2400 (V.22 bis)	020-476171
	Async access 1200/75 (V.23)	020-456955

Norway

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Norway:

City	Baud Rate	Number
Oslo	Async access 300 (V.21)	47-2421217
	Async access 1200/2400 (V.22 bis)	47-2423590

Portugal

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Portugal:

City	Baud Rate	Number
Lisbon	Async access 300/2400 (V.21, V.22)	1-609192

Spain

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Spain:

City	Baud Rate	Number
Madrid	Async access 300/2400 (V.21, V.22 bis)	1-3581951

Sweden

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Sweden:

City	Baud Rate	Number
Stockholm	Async access 300 (V.21)	08-834095
	Async access 1200 (V.22)	08-834090
	Async access 1200/2400 (V.22 bis)	08-7646595

Switzerland

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within Switzerland:

City	Baud Rate	Number
Bern	Async access 300 (V.21)	031-260-931
	Async access 1200/2400 (V.22 bis)	031-260-787
	Async access 1200/2400 (V.22 bis)	031-260-691
Geneva	Async access 300 (V.21)	22-7985756
	Async access 1200/2400 (V.22 bis)	22-7986364

United Kingdom

Access numbers and baud rates supported by Infonet Services Corp. are in the following city within the United Kingdom:

City	Baud Rate	Number
London	Async 0-2400 bit/s (level 5 MNP) (V.21, V.22, V.23, V.22 bis)	71-439-7537

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[1]Titles in capital letters signify tabs.
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[3]In transition

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[1]Titles in capital letters signify tabs.

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[1]Titles in capital letters signify tabs.
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1 European Overview

1.0 Capital Investment

CAPITAL SPENDING BY MERCHANT EUROPEAN COMPANIES

Dataquest surveys the major European merchant semiconductor manufacturers on an annual basis to track their capital spending plans. Table 1 gives a summary of the history of worldwide capital spending in US dollars by European-owned companies for 1989 and 1990. Table 2 expresses European companies' capital expenditure as a percentage of their worldwide sales. It includes a capital spending forecast for 1991. Table 3 shows capital spending by European-owned merchant companies in European Currency Units (ECUs).

Table 1

Estimated European Companies Woldwide Capital Expenditure (Millions of US Dollars)

Company	1989 ($M)	1990 ($M)	AGR 1990/1989
ABB-HAFO	5	5	0.8%
ABB-IXYS	7	7	-0.6%
Austria Mikro Systeme	10	11	12.1%
Ericsson Components	7	8	20.0%
European Silicon Structures	3	6	100.0%
Eurosil	4	5	17.0%
Fagor Electrónica	2	3	50.0%
GEC Plessey Semiconductors*	26	34	30.8%
Matra-MHS	12	13	8.3%
MEDL	8	0	-100.0%
Mietec	8	22	176.0%
Philips	292	290	-0.8%
Semikron International	8	11	35.0%
SGS-Thomson Microelectronics	240	278	15.8%
Siemens	193	175	-9.3%
STC Components	2	3	32.0%
TAG Semiconductors	2	3	50.0%
Telefunken	39	46	18.5%
TMS	20	14	-30.0%
Total	888	934	
Percent Change		5.2%	

* 1989 expenditure is for Plessey Semiconductors only.
AGR = Annual growth rate
Source: Dataquest (March 1991)

Table 2

Estimated European Companies Woldwide Capital Expenditure As a Percentage of Worldwide Semiconductor Revenue

Company	1989	1990	1991
ABB-HAFO	14%	12%	14%
ABB-IXYS	14%	12%	14%
Austria Mikro Systeme	18%	19%	16%
Ericsson Components	13%	15%	15%
European Silicon Structures	17%	22%	15%
Eurosil	13%	12%	14%
Fagor Electrónica	7%	10%	11%
GEC Plessey Semiconductors	11%	9%	9%
Matra-MHS	14%	13%	13%
MEDL	13%	NA	NA
Mietec	15%	24%	25%
Philips	17%	15%	14%
Semikron International	8%	10%	10%
SGS-Thomson Microelectronics	18%	19%	18%
Siemens	16%	14%	13%
STC Components	11%	11%	10%
TAG Semiconductors	9%	12%	12%
Telefunken	13%	14%	16%
TMS	44%	31%	25%
Total Merchant	16%	15%	

NA = Not Applicable
Source: Dataquest (March 1991)

Table 3

Estimated European Companies Woldwide Capital Expenditure (Millions of ECUs)

Company	1989 (ECU M)	1990 (ECU M)	AGR 1990/1989
ABB-HAFO	5	4	-13.4%
ABB-IXYS	6	5	-14.6%
Austria Mikro Systeme	9	9	-3.7%
Ericsson Components	6	7	3.0%
European Silicon Structures	3	5	71.7%
Eurosil	4	4	0.5%
Fagor Electrónica	2	2	28.8%
GEC Plessey Semiconductors	24	27	12.3%
Matra-MHS	11	10	-7.0%
MEDL	7	0	-100.0%
Mietec	7	17	137.0%
Philips	269	229	-14.8%
Semikron International	7	9	15.9%
SGS-Thomson Microelectronics	221	220	-0.5%
Siemens	178	138	-22.1%
STC Components	2	2	13.3%
TAG Semiconductors	2	2	28.8%
Telefunken	36	36	1.7%
TMS	18	11	-39.9%
Total	817	738	
Percent Change		-10%	

AGR = Annual growth rate
Source: Dataquest (March 1991)

1.1 R&D Investment

R&D EXPENDITURE BY MERCHANT EUROPEAN COMPANIES

Dataquest surveys the European merchant semiconductor manufacturers on an annual basis to track their R&D spending plans. Table 1 supplies a summary of the history of worldwide R&D spending in US dollars by European-owned companies for 1989 and 1990. Table 2 expresses European companies' R&D expenditures as a percentage of their worldwide sales. It also includes an R&D spending forecast for 1991. Table 3 shows R&D expenditure by European-owned merchant companies in European Currency Units (ECUs).

Table 1

Estimated European Companies Woldwide R&D Expenditure (Millions of US Dollars)

Company	1989 ($M)	1990 ($M)	AGR 1990/1989
ABB-HAFO	4	5	26.0%
ABB-IXYS	5	7	39.2%
Austria Mikro Systeme	7	8	9.6%
Ericsson Components	6	7	12.0%
European Silicon Structures	8	9	12.5%
Eurosil	3	5	56.0%
Fagor Electrónica	2	2	20.0%
GEC Plessey Semiconductors*	25	36	44.0%
Matra-MHS	9	21	133.3%
MEDL	6	0	-100.0%
Mietec	7	13	84.0%
Philips	395	425	7.6%
Semikron International	5	8	51.2%
SGS-Thomson Microelectronics	210	240	14.3%
Siemens	315	335	6.3%
STC Components	1	2	92.0%
TAG Semiconductors	2	2	0.0%
Telefunken	28	26	-5.7%
TMS	7	7	-3.6%
Total	1,045	1,158	
Percent Change		10.7%	

* 1989 expenditure is for Plessey Semiconductors only.
AGR = Annual growth rate
Source: Dataquest (March 1991)

Table 2

Estimated European Companies Woldwide R&D Expenditure As a Percentage of Worldwide Semiconductor Revenue

Company	1989	1990	1991
ABB-HAFO	11%	12%	13%
ABB-IXYS	10%	12%	13%
Austria Mikro Systeme	13%	13%	14%
Ericsson Components	11%	12%	10%
European Silicon Structures	44%	33%	14%
Eurosil	10%	12%	11%
Fagor Electrónica	7%	8%	8%
GEC Plessey Semiconductors	10%	9%	13%
Matra-MHS	11%	21%	20%
MEDL	10%	NA	NA
Mietec	13%	14%	14%
Philips	23%	22%	13%
Semikron International	5%	7%	7%
SGS-Thomson Microelectronics	16%	16%	18%
Siemens	26%	27%	26%
STC Components	5%	8%	8%
TAG Semiconductors	9%	8%	9%
Telefunken	9%	8%	10%
TMS	16%	15%	13%
Total Merchant	19%	19%	

NA = Not Applicable
Source: Dataquest (December 1990)

Table 3

Estimated European Companies Woldwide R&D Expenditure (Millions of ECUs)

Company	1989 (ECU M)	1990 (ECU M)	AGR 1990/1989
ABB-HAFO	4	4	8.2%
ABB-IXYS	5	5	19.5%
Austria Mikro Systeme	6	6	-5.9%
Ericsson Components	6	5	-3.8%
European Silicon Structures	7	7	-3.4%
Eurosil	3	4	34.0%
Fagor Electrónica	2	2	3.0%
GEC Plessey Semiconductors	23	28	57.0%
Matra-MHS	8	17	100.4%
MEDL	6	0	-100.0%
Mietec	6	10	58.0%
Philips	363	336	-7.6%
Semikron International	5	6	29.8%
SGS-Thomson Microelectronics	193	190	-1.9%
Siemens	290	265	-8.7%
STC Components	1	2	64.9%
TAG Semiconductors	2	2	-14.1%
Telefunken	26	21	-19.0%
TMS	6	5	-17.2%
Total	962	915	
Percent Change		-5%	

Source: Dataquest (December 1990)

1.2 Government R&D

INTRODUCTION

In Western Europe there are two main sources of government funding for research and development in semiconductor technology and its applications: a European Community (EC) budget administered by the Commission in Brussels; and funding at national government level. Clearly, the EC budget is directed towards pan-European programmes such as ESPRIT; typically, the projects involve companies from several EC countries and may well include companies from EFTA countries. By comparison, a national govenment's support is directed towards companies in its own country, though these companies may well be participating in EC or even global research programmes.

In Europe, the primary semiconductor research programmes are ESPRIT and JESSI. ESPRIT is an EC programme; JESSI is not. JESSI is part of EUREKA, which was developed from a French–German initiative started in 1985 and relies on national government money. It has developed in parallel to EC research, but coordinates with EC programmes. Whereas EC research is mainly concerned with precompetitive and basic research, EUREKA projects are nearer to the market. In the case of JESSI (now the biggest EUREKA programme) there is considerable synergy with many of the ESPRIT projects. This coordination centralizes funds, enabling both EC and national government money to be used on the same projects.

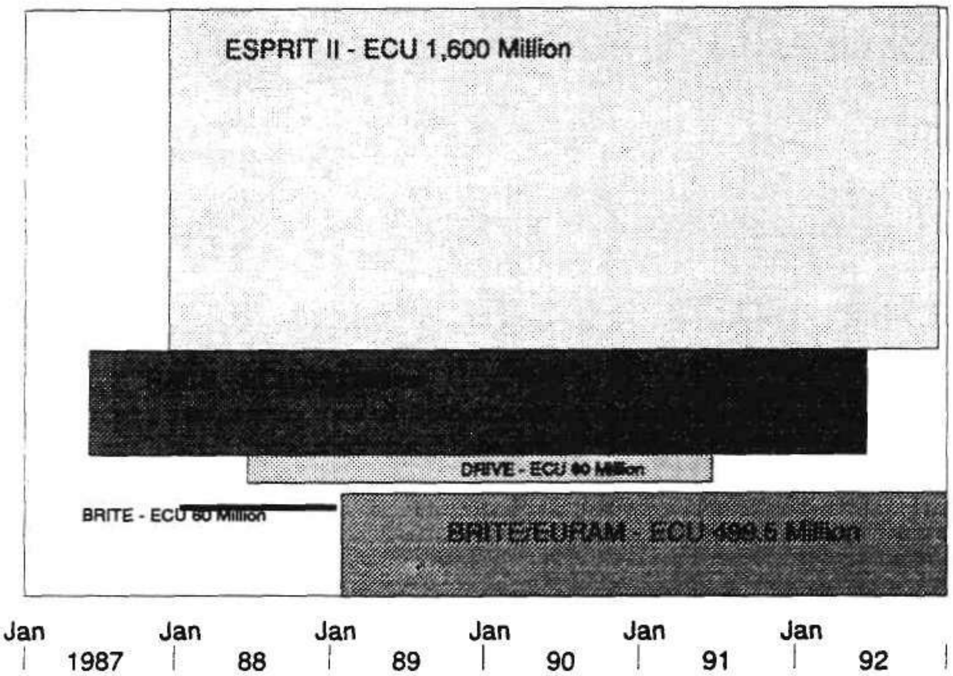
In addition to ESPRIT, there are three other EC programmes that directly benefit the European semiconductor industry. These are RACE, DRIVE, and BRITE/EURAM. RACE and DRIVE have subprogrammes that involve applications for semiconductors. RACE is involved in telecommunications, and DRIVE in transportation. BRITE/EURAM is concerned with research into basic raw and advanced materials. Several of its subprogrammes are of interest to the semiconductor industry.

The EC programmes so far mentioned form part of the Information and Communications, and Industrial Technologies programmes. Figure 1 illustrates the relative durations and scale of funding of the programmes. From it, the enormity of ESPRIT II is clear; indeed, ESPRIT II is the largest of all the EC research programmes.

STRUCTURE OF THE DOCUMENT

Each section has a Contents list of the semiconductor-related projects within each main programme. The sections then go on to describe these projects where there is semiconductor interest.

Figure 1
Information, Communication and Industry Technology Programmes



Source: Commission of the European Communitites, Dataquest (November 1990)

SOURCES OF INFORMATION

The information used in this section was drawn from the following publications:

- *EC Research Funding—A Guide for Applicants*
  Published by the Commission of the European Communities DGXII
  Prepared by Lieselotte Krickau-Richter and Otto Von Schwerin
  January 1990
- *ESPRIT—Synopses of Microelectronics Projects*
  Volume 2 of a series of 8
  Published by the Commission of the European Communities
  September 1990
- *BRITE/EURAM Programme*
  Synopses of current projects 1989-1990
  Published by the Commission of the European Communities
- *Research and Development in Advanced Communications Technologies in Europe—RACE '90*
  Published by the Commission of the European Communities
  March 1990

- *R & D in Advanced Road Transport Telematics in Europe—DRIVE '90*
  Published by the Commission of the European Communities.
  March 1990
- *EUREKA Secretariat*
  19 H Avenue des Arts, Bte. 3
  B1040 Brussels
  Belgium

KEY TO ABBREVIATIONS

EC Member States

B	Belgium
D	Germany
DK	Denmark
E	Spain
F	France
GR	Greece
I	Italy
IRL	Ireland
L	Luxembourg
NL	Netherlands
P	Portugal
UK	United Kingdom

EFTA Member States

A	Austria
CH	Switzerland
ISL	Iceland
N	Norway
S	Sweden
SF	Finland

Roles (ESPRIT)

M	Main Contractor
C	Coordinator
P	Partner
S	Subcontractor
A	Associate Contractor

ESPRIT

CONTENTS

Introduction to ESPRIT

ESPRIT was launched in 1984 and is planned to run for a ten-year period. It has three main objectives:

- To contribute towards providing the European IT industry with the basic technology it needs to meet the competitive requirements of the 1990s.
- To promote European industrial cooperation in IT.
- To contribute to the development of internationally accepted standards.

Based on these objectives, the first phase of ESPRIT was commenced in 1984—ESPRIT I. This consisted of 49 projects, most of which have now been completed. In 1988 the second phase of ESPRIT commenced—ESPRIT II. There are 55 projects now running. The projects in ESPRIT II can be divided into six categories:

- Silicon technology
- III–V and other non-silicon technologies
- Materials
- Equipment and manufacturing
- CAD
- Peripherals

In this section the important semiconductor programmes are listed. First the ESPRIT I projects are given, then an introduction to ESPRIT II is provided, followed by the key ESPRIT II projects. Dataquest has grouped the projects into Integrated Circuits, Semiconductor Equipment and Materials, CAD, and Miscellaneous.

INTEGRATED CIRCUITS

Submicron Bipolar Technology—I

Project Number: 243

The overall objective of this programme is to develop specific bipolar submicron technology suitable for manufacturing very high-performance integrated circuits, such as high-speed circuits for electronic data processing (EDP) and digital signal processing (DSP).

Two main milestones were scheduled:

- End of year 3 (March 1988): demonstration of a gate delay capability of 100 ps at a complexity level of 10,000 gates.
- End of year 5 (March 1990): demonstration of a gate delay capability of 50 ps at a complexity level greater than 20,000 gates.

Three of the partners intend to implement the developed technologies progressively following the achievement of the major milestones in 1988 and 1990. Likely applications are:

- Gate arrays and programmable ROM, microcells for DSP ASICs and high-speed A/D and D/A converters
- Very high-speed ASICs for high bit rate telecommunications

Participants	Country	Role
Plessey Company plc	UK	M
SGS-Thomson Microelectronics SRL	I	P
Cemota	F	P
Thomson-CSF	F	P
Technische Universität Berlin	D	P
Telefunken Electronic GmbH	D	P

Start Date	Duration	Status
1 March 1985	60 months	Finished

Submicron Bipolar Technology—II

Project Number: 281

The objective is the development of a bipolar technology for high-speed data and signal processing products. The generation of bipolar technology in production at the start of the project was characterized by minimum feature size of 2 μm, a delay time of about 350 ps and an integration level for gate arrays of about 2,500 gates.

The production of the ECL gate arrays was started in a new pilot line at Siemens in the first quarter of 1987. These circuits are primarily intended to be used in advanced computers and are now available for all other user companies.

The results achieved under this project have enabled Siemens to start the development of a new family of gate arrays based on an improvement of the design rules previously used to assess the maturity of the developed technology to produce bipolar gate arrays with 10,000-gate complexity. These new design rules enable a reduction of the speed-power product by approximately 40 percent and an increase in the packing density of approximately 30 percent. This new gate array family provides a programmable speed-power product with 3 power steps where power dissipation amounts to 1W per 1,000 gate functions. The complexity of these arrays varies from 1,500 to 13,000 gate functions. The 13,000 gate array has been available since September 1988.

Participants	Country	Role
Siemens AG/Semiconductor Group	D	C
RTC-Compelec	F	P

Start Date	Duration	Status
1 January 1985	60 months	Finished

Submicron CMOS Technology (SPECTRE)

Project Number: 554

The objective is to develop the necessary building blocks for a 0.7 μm CMOS process, primarily dedicated to the production of high-speed (within the limitations imposed by MOS) digital circuits.

In order to allow the programme to proceed with the best chances of success, two main phases have been identified and organized: the first refers to an intermediate step at the 1 μm level; the second to the final 0.7 μm CMOS family. Two additional tasks were added to the original project at the end of the first year, making eight tasks now identified to meet the final goal of the project. These address the topics of architecture (T1), optical and electron-beam (e-beam) lithography (T2, T3), MOS structures (T4), isolation (T5), interconnect (T6, T7) and refractory metal gates (T8). It is the responsibility of Task 1 to arrange the pilot-line demonstration of the 1 μm and submicron demonstrators. Tasks 2 to 8 provide the technology inputs for this.

At the end of December 1987, the 1 μm CMOS process results were disseminated throughout eleven companies and research laboratories located in five European countries.

Additionally, Matra-MHS successfully transferred the SPECTRE CMOS technology into its fast SRAMs and microprocessor fabrication lines, and selected process steps are being integrated in the fabrication process of a 1M EPROM by SGS-Thomson.

The above are indications of the uses to be made of the technological results which will be exploited as a result of this project. The objectives are in line with worldwide state-of-the-art expectations for high-density ICs.

Participants	**Country**	**Role**
CNET	F	C
British Telecommunications plc	UK	P
Bull SA	F	P
Matra-MHS	F	P
SGS Thomson Microelectronics SRL	I	P
Université Catholique de Louvain	B	P
Interuniversitair Micro-Electronika Centrum vzw (IMEC)	B	P
AERE-Atomic Energy Research	UK	S
Aarhus Universitet	DK	S
Telettra SpA	I	S
CNR-Istituto Lamel	I	S

Start Date	**Duration**	**Status**
31 December 1984	60 months	Finished

High-Performance VLSI Packaging for Complex Electronic Systems

Project Number: 958

The objective was to exploit the potential advantages of high-density structures on which VLSI chips will be connected with very dense (100 to 125 μm pitch) tape automated bonding (TAB) interconnects on a high-performance multichip substrate.

This project was complementary to project number 830 as part of the "Advanced Packaging" workprogramme.

Two TAB technologies have been developed: bumped chip TAB and bumped tape TAB (BTAB). Bumped chip requires additional wafer processing; bumped tape requires an additional photolithography stage for the tape.

The main application areas for the TAB technology within the telecommunication and industrial segments are for high-speed switches and processors, display drivers and high-speed transmission systems.

TAB offers a packaging technique allowing the assembly of VLSI chips in compact modules, where electrical signals are closely monitored and heat can be efficiently evacuated.

Participants	Country	Role
Bull SA	F	C
British Telecommunications plc	UK	P
GEC Research Ltd Laboratories	UK	P

Start Date	Duration	Status
31 January 1986	36 months	Finished

Integrated Optoelectronics on Indium Phosphate (InP)

Project Number: 263

The general objective is significantly to increase the data rate in optical transmission systems, by the use of high-performance devices with a variety of multiplexing techniques, mainly with the use of different wavelengths.

The first integrated structure, a distributed feedback (DFB) laser with a tuning section, has been realized. Good control on laser manufacturing has been demonstrated (threshold current density <1.5 $kA.cm^{-2}$, wavelength dispersion <3 nm) and short cavity lasers with bandwidth higher than 8 GHz have been fabricated.

Finite element techniques have been integrated into user-friendly packages to model optically integrated devices easily and precisely, and applied to:

- Design of an optical demultiplexer
- Evaluation of the guiding properties of the very low-loss structure (0.04 dB/cm), previously demonstrated.

This is forging a strong link also between the modelling and fabrication partners.

Important results have been obtained on operating integrated receiver circuits. The sensitivity of an optoelectronic IC (OEIC) consisting of an InGaAs PIN detector with a JFET achieved a world record in sensitivity of -32.5 dBm at 560 Mbit/s. This is a very important result because the gap between hybrid and monolithic OEIC is beginning to be eroded.

This project, in debugging the optoelectronic monolithic integration which has been found more difficult to achieve than forecast, is playing a pilot role in a wide range of projects, dealing with low-cost optical systems, in the RACE programme.

Participants	Country	Role
Centro Studi e Laboratori Telecomunicazioni SpA (CSELT)	I	C
CNET	F	P
GEC Research Laboratories	UK	P
STC Technology Ltd	UK	P
Thomson-CSF	F	P
Standard Elektrik Lorenz AG	D	P
CGE-Laboratoires de Marcoussis	F	P
Heinrich Hertz Institut	D	P

Start Date	Duration	Status
15 December 1984	60 months	Finished

SEMICONDUCTOR EQUIPMENT AND MATERIALS

Compound Semiconductor Materials and Integrated Circuits—I

Project Number: 232

The overall objective of this project was to establish technologies for gallium arsenide digital integrated circuits technologies using the GaAs MESFET, high electron mobility transistors (HEMT/TEGFET) and heterojunction bipolar transistors (HBT) as the active circuit elements. These circuits will be configured to enable the speed and power advantages of GaAs over silicon to be suitably demonstrated.

This project is now successfully completed.

Participants	Country	Role
Plessey Company plc	UK	C
Philips-LEP	F	P
Siemens AG	D	P
Thomson-CSF-DCI	F	P

Start Date	Duration	Status
1 November 1984	12 months	Finished

Compound Semiconductors Materials and Integrated Circuits—II

Project Number: 522

The general objective of the project was to develop advanced aspects of process technology for GaAs digital integrated circuits and associated expertise to enable the fabrication of fast, high-performance digital circuits. Demonstrator digital ICs have been developed to evaluate the performance of the various logic circuit technologies.

There were some good results at the technological level:

- Assessment of refractory metal gate MESFET process
- In-depth evaluation of electron resist
- Demonstration of transistor effect in gallium indium arsenide indium phosphide (GaInAs-InP) structures
- Comparison between numeric model and experience for short-gate MESFET and HEMT.

However, the major milestones on demonstrator circuits were missed and the overall objective of the project was not reached. Consequently the project was discontinued, but some effort has been made by the partners to achieve the missing milestones on their own resources.

Participants	Country	Role
General Electric Co. plc (GEC)	UK	C
Bell Telephone Mfg. Co. NV	B	P
STC Technology Ltd	UK	P
Telefunken Electronic GmbH	D	P
Farran Technology Ltd	IRL	P
CNET	F	P

Start Date	Duration	Status
1 January 1985	12 months	Finished

Automatic Design Validation of Integrated Circuits Using E-Beam

Project Number: 271

The objective is to produce a prototype system capable of automatic error diagnosis of VLSI devices.

The chosen approach is to be based on utilizing the observability facilities of e-beam equipment.

The results up until now satisfy all the realistic goals set at the beginning and following the first phase. These results are at least state-of-the-art as exemplified at the various presentations and demonstrations given by the partners.

The e-beam design validation and testing technique is a new and very promising one. Its impact and time horizon for industrial applications depends strongly on the refinement of this or other competing techniques (e.g. scan design) that may emerge. Approaches have been received from two independent vendors of such systems with a view to marketing a product based on the prototype system developed in the project. British Telecom is meanwhile selling waveform averaging equipment based on one of the results of the project.

Participants	Country	Role
CSELT	I	C
British Telecommunications plc	UK	P
University of Dublin (TCD)	IRL	P
IMAG/LGI	F	P
CNET	F	P

Start Date	Duration	Status
1 December 1984	60 months	Running

Substrates for CMOS VLSI Technology

Project Number: 509

The objectives of this project consisted of two parts:

- To set up an intrinsic gettering (IG) process for wafers with medium to high oxygen concentration. The process was to have been independent of the type (p or n) of the substrate and able to produce:
  - A highly defective bulk region.
  - A defect-free denuded zone. A thickness of this zone around 1 to 10 µm was identified as an optimum compromise for several factors (such as leakage current and insensitivity to latch up a soft error).
- To characterize epi wafer diameters of 4 and 6 inches. The thickness of the epi layer was to have been in the range 5 to 10 µm, both for p and n substrates. This thickness range is suitable for submicron CMOS. Finally, IG and epi processes were eventually to match in order to have intrinsically gettered, low leakage epi wafers for submicron CMOS devices insensitive to soft errors.

Participants	Country	Role
SGS-Thomson Microelectronics SRL	I	C
IMEC vzw	B	P
Matra-MHS	F	P

Start Date	Duration	Status
1 January 1985	24 months	Finished

0.5 Micron X-Ray Lithography: Sources, Masks, Resist and Transferred Image

Project Number: 1007

The project aimed at a technology compatible with x-rays from 7 Å to about 13 Å, so that resolution down to 0.25 µm may be eventually achieved.

The main tasks of this project were masks, resists and the X-ray lithography process.

Participants	**Country**	**Role**
CNR-IESS	I	C
CNRS	F	P
King's College London	UK	P
Thomson-CSF	F	P
SGS Thomson Microelectronics SRL	I	P

Start Date	**Duration**	**Status**
1 January 1986	30 months	Finished

CAD

High-Level CAD for Interactive Layout and Design

Project Number: 10

The objective was to define and demonstrate a CAD system for the design and layout of VLSI integrated circuits from the initial specification to the masks. Circuit complexity up to 1 million transistors was to be addressed. Reduced design times were the overall aim. The main topics under investigation included high-level design methodology based on Petri nets, hierarchic floorplanning with a high degree of automation, analog and general cell design, data modelling and database management.

Overall, the project has achieved its stated objectives in terms of the design and production of a CAD design. Validation of its performance, however, has not been demonstrated.

The feasibility of describing systems using the Petri net notation and the fact that this can be automatically translated into circuits and layout has been demonstrated. This translation can substantially reduce the design time for complex chips.

The work on analog circuits carried out has also made a valuable contribution to the state-of-the-art knowledge in this area, the more so as the mixed analog/digital circuit is gaining in importance.

Participants	Country	Role
GEC	UK	C
AEG Aktiengesellschaft	D	P
Bull SA	F	P
Plessey Company plc	U	P

Start Date	Duration	Status
1 October 1983	42 months	Finished

CAD for VLSI Systems (CVS)

Project Number: 802

The objective is to implement an integrated CAD system capable of coping with the needs of the 1990s, where improvements in semiconductor technology will allow the production of chips with about 1 million transistors. Such a CAD system must lead to an improvement in design time to a factor of 10, based on novel tools for automatic construction of designs at the level of system which have themselves been constructed automatically from a set of given parameters.

The areas of work therefore include architecture synthesis, digital cell building, analog cell design, integration of tools and design of demonstration chips. The first prototypes of tools were to be delivered by the end of 1989.

In order to have maximum impact on industry in general, in addition to internal use by the partners, it was agreed that the resulting software will be made available to third parties (e.g. software houses) for the marketing of results. One company (ANACAD) in Germany has already taken steps to bring some of the results to the marketplace.

Participants	Country	Role
CSELT	I	C
AEG Aktiengesellschaft	D	P
CIT-Alcatel	F	P
Italtel Telematica SpA	I	P
SGS-Thomson Microelectronics SRL	I	P
Matra-MHS	F	P
GMD	D	P
CNET	F	P
British Telecommunications plc	UK	P

Start Date	Duration	Status
1 March 1986	54 months	Finished

European CAD Integration Project (ECIP)

Project Number: 887/2072

ECIP investigates the area of data exchange and infrastructure standards with the objective of defining and promoting standards within the European IT industry. The ability to readily interchange data and CAD tools between companies is a key area for bringing into practical reality many of the benefits of collaborative tool development in Europe and for making available the results of ESPRIT to the wider European IT community. The final goal of ECIP is the definition of a multilayered open model for CAD systems with recommendations for rules and/or standards at each level.

Following a succesful proposal in 1988, a new ECIP project (2072) with some new partners and broader terms of reference was started. In addition to amplifying the work started in ECIP1, ECIP2 will add the important standardization of high-level description languages, and of providing objective ways of measuring the performance of CAD modules. The work on CAD frameworks, started in ECIP1, will be greatly expanded covering user interfaces, database interfaces and data interchange interfaces. In all cases, tools to implement and check the recommended standards will be provided and these recommendations will be validated in real design environments.

The direct involvement of six major European microelectronics companies and the indirect involvement of many other projects will provide the basis to ensure the successful adoption of the standards on a wide scale. Some impact (adoption of interim recommendations) can be expected during the project, but the main impact will be on later generations of CAD systems five years from 1989.

Participants	Country	Role
Bull SA	F	C
ICL	UK	P
Nixdorf Computer AG	D	P (2072 only)
Nederlandse Philips Bedrijven BV	NL	P
SGS-Thomson Microelectronics SA	F	P
Siemens AG	D	P
Thomson-CSF	F	P (2072 only)
SGS-Thomson Microelectronics SRL	I	P
Alcatel	F	P (887 only)
Institut National Polytechnique de Grenoble (INPG)	F	A
Thomson-CSF/Sintra-ASM	F	A
UCI Microélectronique	F	A
SGS-Thomson Microelectronics SA	F	A
Institut Méditerranéen de Technologie	F	A
Instituto de Engenharia de Sistemas e Computadoras (INESC)	P	A

Start Date of ECIP1	Duration	Status
1 January 1986	36 months	Finished

Start Date of ECIP2	Duration	Status
1 January 1989	60 months	Running

MISCELLANEOUS

Wafer-Scale Integration

Project Number: 824

The objective is to use the wafer-scale integration (WSI) approach to build systems of up to 25 million transistors on a 4-in. wafer using a hierarchical approach to implement tolerance to end-of-manufacturing defects.

Additionally, two WSI architectures—for a memory and a systolic array—have been proposed with solutions to the difficult problem of reconfiguration and testability. The first silicon demonstrating WSI implementation was to be foreseen in early 1989.

The developed know-how in technology will allow correction of end-of-manufacturing defects and hence improve the ability to realize full custom, one million transistor chips for the ASIC sector.

From the system point of view, the developed systolic array, as it is more compact and can contain more processors than any other available system, is opening up a whole new range of uses, notably for signal processing functions in video applications.

Participants	Country	Role
SGS-Thomson Microelectronics SA	F	C
British Telecommunications plc	UK	P
INPG	F	P
National Microelectronics Research Centre (NMRC)	IRL	P
CEA/LETI	F	P
Technische Hochschule Darmstadt	D	P

Start Date	Duration	Status
14 May 1986	58 months	Finished

High-Density Mass Storage Memories for Knowledge and Information Storage

Project Number: 957

The objective was to develop vertical and magneto-optical recording technologies for mass storage on rotating disks. Compared with classical recording techniques, these technologies are potentially capable of providing much higher storage densities, as well as higher storage reliability and more competitive storage costs.

Vertical recording technology was investigated and developed for both floppy and rigid disks. Addressed topics include media and substrates and read/write heads. A new optical pickup was designed for magneto-optical recording. In addition to the development of basic components and technologies, work was carried out for simulation of the mechanical dynamics of the flying heads.

The specific technical objectives achieved in the case of vertical recording were a linear density of 40,000 fci and a radial density of 1,500 tpi for rigid disks. The magneto-optical system should provide a linear density of 20,000 bpi and a radial density of 10,000 tpi. In terms of the capacities, these results for 5.25-in. drives correspond to 150 to 200 MB for vertical rigid disks, and 400 to 500 MB for magneto-optical disks.

Some of the results pave the way to industrial products in the near future (such as BaFe floppy disks). The other results, especially on magneto-optical discs and heads, give the partners a strong background to be used in the ESPRIT II project (number 2013) on magneto-optical disk drives.

Participants	Country	Role
Bull SA	F	C
BASF AG	D	P
CEA/LETI	F	P
Thomson-CSF	F	P
Simulog SA	F	P
Glaverbel SA	B	P
Bogen Electronic GmbH	D	P

Start Date	Duration	Status
1 Feburary 1986	36 months	Finished

1.4 The European Economic Environment

THE EUROPEAN ECONOMY

Economic Growth

The world stock markets' crash of October 1987 has had less effect on the economies of Western Europe than anticipated at the beginning of 1988. According to the IMF (International Monetary Fund), the crash will reduce the industrial countries' growth rates in 1988 and 1989 by only a quarter of a percentage point. However, Western Europe's growth performance over the next five years will remain poor compared with other regions.

Real GNP in OECD (Organization for European Cooperation and Development) Europe grew 2.80 percent in 1987, slightly more than previously forecast, but less than the United States' growth rate of 2.90 percent. Japan's economy expanded by 4.20 percent in 1987, much more than previously forecast. Nineteen eighty-seven was the fifth consecutive year that Europe has lagged behind the United States and Japan in GNP growth. In 1988 and 1989, real GNP in Europe will grow 2.50 percent and 2.00 percent, respectively, whereas the U.S. economy is expected to grow 2.75 percent in 1988 and 2.50 percent in 1989. Japan anticipates 4.25 percent growth in 1988 and 3.75 percent in 1989.

Among the four major European countries, the United Kingdom's growth rate outranked those of the others in 1987 with 4.50 percent, followed by Italy with 3.10 percent, France with 1.90 percent, and West Germany with 1.70 percent. The United Kingdom will continue to set the pace, with a 3.50 percent growth rate projected for 1988 but only 2.25 percent forecast for 1989. Italy is expected to grow by about 2.50 percent in 1988 and just more than 2.00 percent in 1989. West Germany and France will experience slower growth of about 2.00 percent in 1988, but less than 2.00 percent growth is expected for these two countries in 1989.

In Scandinavia, Finland will achieve growth rates above the European average in 1988 and 1989, followed by Sweden with rates just below the European average. Denmark and Norway will experience the lowest growth rates in Europe, with 0 to 1 percent growth projected for 1988 and 1989.

The Benelux countries anticipate growth rates below the European average—from 1.50 percent to 2.00 percent for 1988 and 1.75 percent for 1989.

Spain and Portugal have the fastest-growing economies in OECD Europe, with growth rates of 5.0 percent in 1987, approximately 4.0 percent expected for 1988, and 3.5 percent projected for 1989.

Unemployment

The European economies are not generating sufficient economic growth to reduce unemployment. Between 1980 and 1987, no net new jobs were created in Europe as a whole, although the labor force increased by more than 6.0 percent. Unemployment in

Europe continues to affect 11.0 percent of the labor force. The United States records only half that rate at 5.5 percent, whereas Japan's unemployment rate of 2.5 percent in 1988 is less than half the rate of the United States. No major changes are anticipated in these rates for 1989.

To achieve a significant reduction in the jobless total, growth in employment will have to rise by between 1.5 percent to 2.0 percent a year. The EC Commission estimates that such employment gains could only be achieved with an overall economic growth rate from 3.0 to 3.5 percent per annum, provided this growth were employment intensive.

Only in the United Kingdom is unemployment showing a clear downward trend. The United Kingdom's unemployment rate of 10.4 percent in 1987, below the European average for the first time since 1979, is expected to decrease further in 1988 to 9.5 percent of the labor force. West Germany's unemployment rate is predicted to show a slight increase, from 7.9 percent in 1987 to 8.1 percent in 1988. In France, unemployment is forecast to increase from 10.8 percent in 1987 to 11.3 percent in 1988. Italy has the highest unemployment rate among the four major European countries, with its 11.7 percent rate in 1987 expected to rise to 11.8 percent in 1988.

Only the Scandinavian countries, with the exception of Denmark, as well as Switzerland and Austria, registered low unemployment rates. Spain and Ireland show the highest unemployment rates in OECD Europe at approximately 20 percent, followed by the Netherlands with more than 12 percent and Belgium with 11 percent.

Long-term unemployment has grown more rapidly than the government measures implemented to deal with it. In major European countries, the long-term unemployed (those out of work continuously for more than 12 months) constitute 30 to 50 percent of the total unemployed, whereas the equivalent proportion in the United States is 10 percent or less. Belgium has been hit the hardest by long-term unemployment, with 68.3 percent of the jobless out of work for more than a year, followed by Italy with 63.6 percent and Ireland with 62.2 percent. The Netherlands and Spain are also above the EC average of 52.3 percent, with 56.4 percent and 56.3 percent, respectively.

The youth unemployment rate is another main area of concern ("youth" generally refers to the 15 to 24 age group). It continues to be highest in Spain with more than 40 percent in 1987, but expected to be below that rate in 1988 and 1989. Italy's youth unemployment rate is forecast to increase from 37 percent in 1987 to just more than 40 percent in 1989. Youth unemployment in France is also projected to increase from 23 percent in 1987 to 27 percent in 1989.

Investment

Business confidence seems unshaken by the October 1987 stock market crash. In Europe, however, businessmen are less optimistic about prospects for growth than those in the United States and Japan. Investment growth in Europe is expected to slow somewhat by the end of 1989, because of slower economic growth and high real interest rates.

1.4 The European Economic Environment

Business investment in Europe is anticipated to rise by an average of less than 5 percent in 1988. The slowdown of the ratio of real business investment to real GNP in Europe may be partly to blame for the persistently high unemployment.

In the United States, private nonresidential investment is projected to expand 9.50 percent in 1988, and in Japan, 10.25 percent.

European and U.S. investments are expected to grow less than 3 percent in 1989, whereas in Japan, investment growth of more than 7 percent is forecast.

Of the four major European countries, the United Kingdom's private nonresidential investment grew 7.20 percent in 1987, and is expected to increase by 8.00 percent in 1988 and 5.25 percent in 1989. Italy's investment in machinery and equipment, which expanded 11.50 percent in 1987, is anticipated to grow 5.00 percent in 1988 but only 4.00 percent in 1989. France recorded growth of 4.00 percent in 1987, and expects rates of 5.50 percent in 1988 and 4.00 percent in 1989. West Germany's investment performance in 1987 was much less positive than previously forecast, with a growth rate of 3.20 percent. In 1988 and 1989, West Germany's annual investment rate is expected to be approximately 3.00 percent.

In Scandinavia, Sweden predicts investment growth of almost 5.00 percent in 1988 but only 2.00 percent in 1989. Finland anticipates investment growth of more than 3.00 percent in 1988, and more than 2.00 percent in 1989. Denmark expects growth of negative 3.25 percent in 1988 and negative 2.25 percent in 1989, whereas Norway forecasts high investment growth of 12.00 percent in 1988 but growth of negative 1.75 percent in 1989.

Investment prospects for Spain and Portugal are very positive. Spain's investment growth is expected to expand almost 11.0 percent in 1988, following growth of 13.7 percent in 1987. Portugal recorded the highest investment growth rate in Europe of 19.0 percent in 1987, and anticipates a 10.0 percent growth rate in 1988. In 1989, Portugal's growth rate of 8.0 percent will be the highest in OECD Europe, followed by Spain with just more than 7.0 percent investment growth.

Inflation

Inflation in Europe is projected to remain stable, but is expected to increase in the United States and Japan. The average inflation rate in OECD Europe is expected to be approximately 4.00 percent in 1988 and less than 4.00 percent in 1989, whereas the U.S. rate is forecast to increase from 3.25 percent in 1988 to 4.00 percent in 1989. Japan's inflation rate will rise from 1.75 percent in 1988 to 2.50 percent in 1989.

Among the four major European countries, West Germany will continue to record the lowest inflation rate of 1.50 percent per annum in 1988 and 1989. France expects to reduce its 1988 rate of 2.75 to 2.50 percent in 1989, whereas the United Kingdom and Italy forecast inflation rates of 4.75 percent for 1988. These projections for the United Kingdom and Italy may decrease in 1989 to 4.50 and 4.25 percent, respectively.

In Scandinavia, inflation rates for 1988 and 1989 are expected to be above the European average. Only Denmark anticipates a rate below 4 percent.

Spain's inflation rate in 1988 and 1989 will be in line with the European average, but Portugal's rate, which is expected to decrease from 9.5 percent in 1987 to less than 6.0 percent in 1989, is still well above the European average.

Private Consumption

Private consumption was an important source of growth in most European countries in 1987, as household saving ratios declined and consumer borrowing rose rapidly in some countries.

For 1988, private consumption in the four major European countries will increase most in the United Kingdom at 5.00 percent, followed by West Germany with 3.25 percent. France and Italy forecast private consumption growth of 2.50 percent for 1988. These rates compare with projected consumption growth of 1.75 percent in the United States and 4.00 percent in Japan for 1988.

Private consumption rates in the United States and Japan in 1989 are forecast to increase at about the same rates as in 1988, whereas the four major European countries expect lower consumption growth of between 1.50 percent and 3.25 percent.

In Scandinavia, Sweden and Finland anticipate that private consumption will rise approximately 3 percent in 1988 and from 2 to 3 percent in 1989. Denmark and Norway forecast negative growth in 1988; this negative growth is expected to continue in Norway in 1989, but Denmark expects low growth of 1 percent in 1989.

Spain and Portugal recorded private consumption growth of 5.2 percent and 7.3 percent, respectively, in 1987, and anticipate growth rates of 4.0 to 5.0 percent in 1988 and 3.5 percent in 1989.

Foreign Trade

Trade plays a bigger role in European countries than in Japan. Japan's exports of goods and services are equivalent to only 16 percent of its GNP, but the ratio is 25 to 30 percent in West Germany, France, the United Kingdom and Italy and more than 60 percent in the Netherlands and Belgium.

Europe's economic performance depends heavily on strong foreign markets and expansion in trade. But Europe's overall real trade balance will decline over the coming years for the first time since the early 1980s because of the improvement in the external position of the United States. Export prospects within Europe are limited because no European country by itself is likely to be a source of substantially higher export growth for others.

1.4 The European Economic Environment

All European countries, except Denmark and Norway, will increase their imports of goods and services more than their exports in 1988 and 1989. This situation also applies to Japan, whereas the United States anticipates higher export than import growth. In Europe, Spain and Portugal expect imports to grow 13.0 percent and 11.5 percent, respectively, in 1988, followed by the United Kingdom with import growth of almost 8.0 percent, Italy with almost 7.0 percent, and West Germany with 6.0 percent. This compares with 14.0 percent growth in Japan for 1988.

Portugal projects imports to increase 9 percent in 1989, followed by Spain with 8 percent, then West Germany and Italy with 5 percent growth each. Japan's imports are forecast to expand almost 9 percent in 1989. Overall, all European countries, except Denmark and Norway, will experience lower import growth in 1989 than in 1988.

Export growth in Europe in 1988 will be strongest in Portugal with 7.5 percent, followed by Spain and Italy with 5.5 percent each, and West Germany and France with just more than 4.0 percent each. This compares with almost 16.0 percent export growth in the United States and 6.0 percent in Japan for 1988. For 1989, Portugal expects the highest growth rate again at more than 6.0 percent; followed by Spain with 5.0 percent growth; Norway with 4.5 percent; and Italy, France, and West Germany with about 4.0 percent each.

In the United States, exports are forecast to rise more than 11 percent in 1989, and in Japan, more than 5 percent.

The current account balance for OECD Europe is expected to show a decreasing surplus of $37.5 billion in 1987, $24.0 billion in 1988, and only $9.0 billion in 1989. Only West Germany, the Benelux countries, Switzerland, and Ireland will contribute positive current account balances in 1988 and 1989. West Germany's expected surplus for 1989 of $42 billion will be offset by the combined deficits of the United Kingdom, France, and Italy, estimated at $21 billion.

In Japan, the surplus is anticipated to decrease from $87 billion in 1987 to $80 billion in 1989, whereas the United States will continue to record a large but decreasing deficit of $150 billion in 1988 and $132 billion in 1989.

Competitiveness

Europe continues to experience higher wage increases than the United States and Japan. In 1987, EC countries' manufacturing earnings increased 5.2 percent—twice as much as Japan's at 2.6 percent and almost three times the U.S. rate of 1.8 percent.

Unit labor costs in the private sector are expected to increase 6.00 percent in 1988 and 5.00 percent in 1989 in European OECD countries, except in the four major countries. Of the four major European countries, the United Kingdom and Italy forecast annual increases of between 4.00 percent and 4.75 percent in 1988 and 1989, whereas West Germany and France expect unit labor costs to rise only 0.50 percent in 1988 and from 0.75 percent to 1.50 percent in 1989.

Japan expects similarly low increases in unit labor costs, with 1.00 percent for 1988 and 1.25 percent for 1989, whereas the United States projects rates of 3.25 percent in 1988 and 4.00 percent in 1989.

Labor productivity, measured as compound annual growth rates of real GNP/private sector employment, in the 1986 to 1989 time frame is expected to improve by 2.4 percent in the United Kingdom, 2.2 percent in France, 1.7 percent in Italy, and 1.6 percent in West Germany. These rates compare with growth of 3.1 percent in Japan, but only 0.7 percent in the United States. The largest labor productivity growth rates in Europe are forecast by Finland, with 3.4 percent, and Ireland, with 2.7 percent.

Although the European average inflation rate is expected to be slightly lower than the U.S. rate in 1989, it will still be just more than one percentage point higher than Japan's inflation rate.

The combination of the previously discussed factors and exchange rate effects will put pressure on the European countries to continue their efforts to reduce labor costs further and improve labor market flexibility.

Research and Development

Programs to stimulate basic research into industrial technologies (BRITE), information technology (ESPRIT), telecom (RACE), technology transfer (SPRINT) and high-technology products (EUREKA) have been launched within the EC. Collaboration between European countries is seen as a possibility to share high research and development costs. It is also hoped that alliances across Europe will produce a new and more flexible industrial structure.

In the spring of 1988, nearly Ecu 2 billion for high-technology joint research projects were approved by EC research ministers. The second phase of the ESPRIT program scheduled to run until 1993 has been approved. ESPRIT II involves about 500 EC companies and is the largest program in the European Commission's overall Ecu 5.8 billion research budget for the next four years.

The industrial technology program BRITE is to be funded an extra Ecu 60 million in addition to the Ecu 65 million for the 1985 to 1989 period. The new funding will be drawn from the program's Ecu 400 million second stage, which is scheduled to run from 1989 to 1991.

The West German and Dutch governments, scientific institutes, and about 50 West European companies are involved in a proposed research and development scheme worth DM3 billion to DM4 billion. This scheme, Joint European Semiconductor Silicon (JESSI), would be the biggest project jointly undertaken by governments and industry to promote Europe's competitive position in semiconductor devices.

JESSI, scheduled to start at the end of 1988, would run until 1995. Most of the cost would be borne by industry, but substantial funding is expected to be provided by the West German and Dutch governments and the EC.

1.4 The European Economic Environment

Venture Capital

The European venture capital industry continues to grow, and it is nearly half as big in the EC as it is in the United States, according to the European Venture Capital Association. The United Kingdom still represents the largest venture capital industry in Europe, followed by the Netherlands and France. Italy's venture capital industry shows the fastest rate of growth, but its industry is still small.

The EC decided to provide Ecu 1.9 million in 1987 to fund the Venture Consort scheme, aimed at promoting cross-border business agreements. The European Commission is working on the details of a package of tax reforms, investment incentives, and easier accounting rules to help boost cross-frontier collaboration between small high-technology businesses. The aim is to attract more private-sector venture capital. An EC-funded guarantee would insure private venture capital groups against 50 percent of the investment losses caused by companies qualifying for the scheme. The guarantee would be partly funded by an insurance-type premium, partly paid by the Commission.

Industrial and Entrepreneurial Initiatives

The trend toward closer technological collaborations continues, as the EC pushes ahead with measures to open up its internal market. Siemens, Bull, and ICL are making a joint bid for an Ecu 85 million collaborative research project funded by the EC. This program is planned under the second phase of the ESPRIT research of information technology.

CGE of France acquired a controlling interest in the wide-ranging European telecommunications businesses of ITT.

CGCT, the French public exchange manufacturer, was sold to Ericsson and Matra.

SGS-Ates merged with the nonmilitary semiconductor operations of Thomson to create a group that can compete internationally. Olivetti took over Triumph-Adler of West Germany.

Toshiba went into full-scale assembly of its 1 megabit memory device in Braunschweig, West Germany, in 1987. Toshiba invested DM60 million and manufactures about 1.8 million devices a year. A fourth design office operates from Braunschweig; the other three offices are in Dusseldorf, Stockholm, and the United Kingdom. About 70 percent of the memory products Toshiba sells in Europe now come from this plant.

ES2, the pan-European semiconductor company, is planning to expand by bringing in more large industrial shareholders. It would like links with a leading company from West Germany, where it has no shareholders, and with the United States. In the summer of 1987, ES2 took over Lattice Logic, which is a U.K. company based in Edinburgh and is world leader in silicon compilers.

1.4 The European Economic Environment

The Roundtable of European Industrialists with 29 members set up 6 industrial "working task forces" in the summer of 1987 to examine issues related to the group's mission to achieve the kind of European market that industry wants. The group believes that it is crucial to agree to EC-wide standards before 1992 and to abolish national standards that inhibit free trade in the EC. It also proposes to remove all barriers to cross-border mergers and acquisitions and to extend EC research programs beyond the precompetitive stage to cover products with market potential. The Roundtable group wants remaining telecommunications monopolies to be abolished.

1.5 Channel of Distribution

INTRODUCTION

The two fundamental reasons that semiconductor vendors sell through franchised distributors are as follows:

- To reduce sales costs
- To improve service levels to small and medium-size companies

1980 TO 1987

Semiconductor distribution in Europe has grown from $1,073 million in 1980 to $1,919 million in 1987. As such, it represented 30.2 percent of the estimated $6,355 million European semiconductor market in 1987.

The present market structure in Europe is highly nationalized, with very few distributors operating in a pan-European mode. Since the early 1980s, distribution has undergone substantial restructuring caused by a combination of factors including profit squeezing by manufacturers, manufacturer mergers, and the threat of North American distribution being brought into the network.

As shown in Table 1, the European distribution market has grown from $1,073 million in 1980 to $1,919 million in 1987, a compound annual growth rate (CAGR) of 9.75 percent. Distribution as a percentage of the total European semiconductor market has ranged from 29.1 percent in 1980 to 32.7 percent in 1986.

Table 1

Estimated European Semiconductor Distribution Market
History and Forecast
(Millions of U.S. Dollars)

	1980	1981	1982	1983	1984	1985	1986
Total Semiconductor	$3,686	$3,041	$3,167	$3,370	$4,805	$4,720	$5,532
Distribution (%)	29.1	29.6	30.3	30.9	32.5	31.8	32.7
Distribution	$1,073	$ 900	$ 960	$1,041	$1,562	$1,501	$1,809

	1987	1988	1989	1990	1991	1992	1993
Total Semiconductor	$6,355	$8,491	$9,221	$9,535	$11,127	$14,966	$17,271
Distribution (%)	30.2	28.2	28.3	29.9	31.2	32.4	33.1
Distribution	$1,919	$2,394	$2,610	$2,851	$ 3,472	$ 4,849	$ 5,717

Source: Dataquest
June 1989

However, an increase in distribution market share, which usually is seen during growth periods, has not occurred in the 1988 high-growth period. The reasons for this are outlined in the following section.

1988 SCENARIO

Dataquest estimates that semiconductor distribution will lose substantial market share in 1988. Our current estimate is that the European semiconductor marketplace will grow by 33.6 percent from $6,355 million to $8,491 million. We estimate that distribution will grow at a rate of 8 percentage points behind the market. This is significant because it will be the first high-growth year in which distribution has lost market share. Traditionally, distribution, which primarily deals with commodity product lines such as standard logic, 4000, and 74LS, has been quick to take advantage of market growth. By buying inventory at a competitive price and then selling it during the high-growth period of product famine, distributors historically have driven up their revenue. So what is the difference this time?

An analysis that was carried out during 1987's Electronica in Munich using a sample of distribution users and semiconductor distributors highlighted the following reasons why distribution is having difficulty keeping up with the market:

- Components marketed by distributors generally are profiled toward lower growth products.
- The broad-line supermarket approach to distribution is failing to adequately service the customer base.
- European distributors are concerned that American distributors might move into Europe en masse.

Regarding the lower growth portfolio, we estimate that the European semiconductor market will grow 33.6 percent in dollars in 1988, as stated previously. However, taking MOS memory and MOS micro out of the growth equation results in a remaining 17 percent growth for other product categories. Unfortunately, distribution has had limited success in selling MOS memory and micro products. MOS memory never has been really a distribution product, and during the 1988 shortages, OEM accounts clearly have been prioritized by the manufacturers.

Dataquest estimates that 16 percent of European microcomponents revenue is a result of selling via distribution. Popular architectures such as those of Motorola and Intel command a higher percentage penetration, estimated at 24 percent of combined architectural revenue during 1988. Because the popular architectures are available through only a limited number of outlets, the network as a whole has not enjoyed great success in distributing these components.

1.5 Channel of Distribution

Arguably, the low-growth portfolio is offset to some extent by a higher growth rate experienced by the smaller, more dynamic companies served by distribution. However, as our distribution user poll demonstrated, a growing number believe that distribution has lost focus and no longer meets all requirements of the traditional small businesses it was set up to service.

In the poll, we received the same complaint several times: Unless a business is of sufficient volume and value (one user mentioned 10,000 pieces or more) distributors cannot be bothered with its problems. On a number of occasions, distribution was charged with being more interested in building up OEM business than in looking after the mass market. Users preferred local specialist distributors that, both technically and commercially, were more in touch with the small user's demands.

Overall, the impression was that distribution was failing to adapt quickly enough to the changing user environment, and that the supermarket/multiline supplier was losing touch with the needs of the smaller user.

The third point regarding the move of American distributors into Europe is whether or not this will improve the performance of distributors operating in Europe. It is clear that the existing distribution network is concerned about companies such as Arrow and Future obtaining preferential terms from the major North American semiconductor vendors. These concerns were brought to a head when Future set up operations in the United Kingdom and West Germany.

Conceivably, an American distributor, given the right acquisition and a solid local management team, could achieve efficiency and service levels on a pan-European scale that would allow effective competition with the existing network. A good analogy is shown in how Texas Instruments, Motorola, and National Semiconductor gained market share from Philips, Siemens, and Thomson in the 1970s by setting up organizations that spanned Europe with synchronized systems and procedures, but with local management attuned to local needs. Another example is shown in the computing industry, where American companies are organized to tackle the European market as a whole, and leading European companies' revenue overwhelmingly generates from their own national base.

CHANNELS OF DISTRIBUTION

Agents and Representatives

Manufacturers, in using distribution channels such as agents and representatives (reps), augment their own direct sales force. The agents and reps tend to be one- or two-person teams who are based in a European country and dealing with the larger accounts. The agent, who usually represents only one semiconductor franchise, does not hold inventory. He or she is paid a percentage of the billings that the vendor takes to the assigned account. The accounts assigned to agents or reps tend to be smaller than that serviced by the vendor's own sales force but larger than is typically handled by franchised distributors. The agent concept is most advanced in the United Kingdom, West Germany, and Scandinavia.

Franchised Distributors

Semiconductor vendors usually engage a number of franchised distributors for each country within Europe. These distributors fall into two distinct categories: "supermarket" and "specialist." The supermarket outlet generally holds a number of large franchises with strong commodity, logic, linear, and discrete lines. The specialist distribution concept has grown quickly during the past few years as customers become more technically advanced, and the need for a distributor to help in the design-in phase of very large scale integration (VLSI) becomes standard.

These specialist distributors are technically overrated, and many of them specialize in carrying innovative lines from the smaller semiconductor vendors.

Gray Market Dealers

Terminal-to-terminal communications have made it possible for a seller in the Far East to contact potential customers almost anywhere in the world and to offer products for short-term delivery at prices well below the established market price in the buyer's home territory. The seller may not even have the stock in its current inventory, or ever take physical possession of it; however, by offering competitive price and short-term delivery terms, the dealer takes advantage of world pricing differentials and, in doing so, undercuts local franchised houses.

Regional Distribution

With the move toward 1992 and the breaking down of regional boundaries, distributors and major vendors are looking at more cost-effective methods of holding inventory in Europe.

INVENTORY MANAGEMENT ISSUES

Centralized Warehousing

Centralized warehousing is gaining popularity as a method of reducing inventory holdings costs. Many distributors split their inventory into A, B, and C categories (using some form of Pareto's Law) based on sales turnover by device. The central warehouse is stocked with all three types, and branch or local warehouses hold fast-moving A and B category devices. Exceptions to this may occur because of local requirements of certain industries or specific customers. In a pan-European context, distributors limit stock volume for their entire range of franchises to one major location and invest in smaller satellite warehouses for holding faster-moving devices, instead of keeping money tied up in slow-moving inventory in each European country.

Setting Inventory Levels

Inventory level is always a point of contention between vendors and distributors. Distributors would like to see their stock rotate four or five times per year at resale price. Suppliers believe that the rotation rate should be three to three and one-half times per year. At any rate, holding inventory costs money. A balance must be struck between the cost of financing inventory and the "service level," which usually is defined as the number of line items that can be shipped from stock and expressed as a percentage of total line items ordered. Recent research indicates that distributors are moving toward a service level of 90 percent and adjusting inventory levels to meet this requirement.

Supporting Just-in-Time (JIT) Delivery Requirements

JIT deliveries are being requested by an increasing number of customers. Some customers are prepared to place long-term orders (6 to 18 months) for production programs with the expectation that the distributor will guarantee to meet the required call-offs, regardless of the current lead-time situation.

The distributor's stock must be adequate and located near the customer to ensure customer support. Earning the customer's trust is vital—the distributor must establish a close personal relationship with each customer. To offer this level of service suggests that a distributor must provide local branch distribution.

Computer Issues

Some suppliers regard unsold inventory as a contingent liability. They want to know the amount of potential liability and where it is located. Also, inventory movements and resale bookings and billings are important pieces of market intelligence for the supplier. The supplier must have real-time access to this information.

The distributor's computer software may have to be changed to meet all reporting and control requirements. Obviously, each branch must use the same software package. If the distributor is working on a computer-to-computer basis with the supplier(s), this will introduce further software and hardware compatibility requirements.

Export Control and Currency Considerations

Many devices are considered to be strategic and, as such, are under strict export control regulations. These may be imposed by local authority or NATO. The distributor must be able to comply with the regulations and demonstrate tight administrative control of the movement of such devices. In some cases, it may be necessary to establish a bonded warehouse. A bonded location can also be used for stock imported from outside the European Community while the distributor waits for a final delivery point to be established. This warehouse would form a central stocking location for the pan-European distributor.

The valuation of stock held in two or more locations that use different currencies may be handled based on the currency of the country where the main stock is held. However, tax considerations in the branch countries may involve evaluating the inventory in two currencies.

Centralized warehousing has both good and bad points for the distributor. One benefit is better control of inventory costs and the possible reduction of these costs. Better service can be offered to the customer because A and B stock is available as needed, which results in faster stock rotation. A benefit for the supplier is better visibility of inventory holdings. However, centralized warehousing requires a highly sophisticated control system, which will lead to an administrative costs increase.

For the supplier, advantages include fewer ship-to points, fewer small orders, and a single bill-to point. Selling time and costs also are reduced. The supplier could lose some visibility on stock inventory location, market use, and local market pricing. These points require closer cooperation between the distributor and the supplier to be resolved.

Centralized warehousing for multicountry distributors is on its way. The distributor must develop effective internal control techniques, satisfy the demands of his suppliers, and comply with export control regulations. This will require careful planning and execution, but the majority of participants believe that it will be worth it.

ESPRIT II Overview

ESPRIT	European Strategic Programme for Research and Development in Information Technology
Council decision:	Official Journal L118, dated 6-5-1988
Aims:	To develop basic technologies for the European IT industry; to promote European industrial cooperation in precompetitive R&D; to develop internationally accepted standards.
Duration:	5 years, December 1987 to November 1992
EC Contribution:	ECU 1,600 million, or $2,105 million
Area of Research:	A. Research and development projects with a long-term strategic impact:

- Microelectronics and peripheral technologies (including the development of application-specific integrated circuits, high-speed integrated circuits, CAD)

- Information processing systems (including total systems design, parallel architectures, signal and knowledge processing)

- IT application technologies (including industrial applications (CIM), distributed information processing, business and home systems)

B. Basic research (actions)

- Primarily molecular electronics, artificial intelligence and cognitive science, the application of solid state physics to IT, advanced systems design

C. Accompanying measures

- Coordination, information processing and exchange, standardization, technology transfer

Calls for Proposals:	Deadlines
* R & D projects, Area A	12-4-1988
* Basic research, Area B	13-6-1988
* Superconductivity	13-6-1988
* VLSI	6-1-1989
* Parallel processing	17-4-1989
* Microelectronics	4-9-1988
* R & D projects, Area A	10-1-1990
** To be decided	* Published ** Planned

Scheme of Support: Shared-cost research contracts

Particularities:

- Projects (area A): Participation of at least two independent industrial partners not established in the same Member State.
- Actions (area B): Participation of at least two research institutions not established in the same Member State.
- There are particular calls for proposals in superconductivity, in connection with the SCIENCE programme.

ESPRIT II Project Information

INTEGRATED CIRCUITS

Bipolar Advanced Silicon for Europe (BASE)

Project Number: 2016

The goal of the project is to develop and fully integrate technology expertise in the submicron range as well as design and CAD achievements.

The development plan proceeds in two phases yielding interim (Y1) and final (Y2) process versions after year 3 and year 5, with the following target specifications.

Process Characteristics	**Process (V1)**	**Process (V2)**
Emitter width (minimum)	0.7 µm	0.3 µm
Gate delay	50 ps	40 ps
Power delay product	40 fJ	10 fJ
No. interconnection layers	3	4
Via pitch (minimum)	3.5	2
Transmitter frequency (maximum)	15 GHz	25 GHz
Transmitter count (maximum)	1×10^5	5×10^5

Participants	**Country**	**Role**
Philips Gloielampenfabrieken NV	NL	C
Plessey Company plc	UK	P
SGS-Thomson Microelectronics SRL	I	P
Siemens AG/Semiconductor Group	D	P
Telefunken Electronic GmbH	D	P
SGS-Thomson Microelectronics SA	F	P
Technische Hochschule Darmstadt	D	A
Technische Universität Berlin	D	A
IMEC vzw	B	A
Royal Signals and Radar Establishment (RSRE)	UK	A
Communications and Management Systems Unit (CMSU)	GR	A
University of Dublin (TCD)	IRL	A

Start Date	**Duration**	**Status**
1 February 1989	60 months	Running

Advanced PROM Building Blocks (APBB)

Project Number: 2039

The objective of this project is the integration of a new generation of reprogrammable, read-only memory devices (PROMs) into advanced CMOS processes for the application-specific market. To do this, the necessary CAD tools required to support nonvolatile memory designs will also be developed.

The work is divided into two phases, the first from years 1 to 3 and the second from years 3 to 5, with an overlap in year 3. In phase one, existing and new memory devices will be evaluated and developed. Suitable cells will be incorporated into 1 μm and low-voltage (1.5V, 2 μm design rule) CMOS processes. In phase two, advanced devices will be integrated into increased-density, low-voltage (1.5V, 1.5 μm) and submicron (0.7 to 0.8 μm) CMOS processes.

Participants	Country	Role
Plessey Company plc	UK	C
SGS-Thomson Microelectronics SRL	I	P
SGS-Thomson Microelectronics SA	F	P
Deister Electronic GmbH	D	A
IMEC vzw	B	A
NMRC	IRL	A
Mikron GmbH	D	A
Gemplus Card International	F	A
IRIS	I	A
INESC	P	A
Eurosil Electronic GmbH	D	A

Start Date	Duration	Status
15 December 1988	36 months	Running

Analog/Digital CMOS ICs (ADCIS)

Project Number: 2193

The integration of analog and digital functions on a single chip is necessary for the development of new systems for information technology for data communication, industrial and consumer systems.

During the proposed project a 1 μm CMOS process will be adapted and characterized for mixed analog/digital function and an electrical parameter of a submicron CMOS technology will be extracted. The devices from the digital CMOS technology and the necessary analog-adapted process modules will be defined and characterized.

At the same time, the development of design tools will be started, with the goal of building a system capable of being used to produce silicon compilers involving digital and analog cells. The CAD tools will be tested and demonstrated, analog cell library and analog basic converter functional blocks will be developed, and one industrial demonstrator circuit will be designed and processed.

The circuit considered for the demonstration of the analog-digital CMOS technology is a component for the ISDN new telecommunications system.

Participants	Country	Role
Matra-MHS	F	C
ANACAD-Computer Systems GmbH	D	P
Centro Nacional de Microelectrónica (CNM)	E	P
NMRC	IRL	P
Universidad de Sevilla–AICIA	E	P
Mietec NV	B	P
Instituto Superior Tecnico	P	P
CNET	F	P

Start Date	Duration	Status
1 January 1989	36 months	Running

Combined Analog/Digital Integration (CANDI)

Project Number: 2268

The project aims at the development of the main technologies and implementation techniques needed for the fabrication of complete analog/digital (A/D) systems on silicon. This includes the development of a 0.8 μm bipolar/CMOS merged technology exploiting the specific advantages of both bipolar (high-speed components, high driving capability and high-precision analog circuitry) and CMOS (high integration density and low power consumption) technologies. The associated design techniques and the appropriate CAD tools covering both analog, digital and mixed signal A/D applications, as well as effective low-cost tools for complex A/D circuits testing, are also to be developed.

The final objective is the full integration of technology, design and CAD tools implemented in the fabrication of prototype system components for major fields of applications such as consumer electronics and telecommunications.

Participants	Country	Role
SGS-Thomson Microelectronics SA	F	C
Telefunken Electronic GmbH	D	P
AEG Olympia AG	D	A
Thomson-CSF-LER (Laboratoire Electronique de Rennes)	F	A
Université Paris Sud	F	A
Universität Dortmund	D	A
Plessey Company plc	UK	A
Thomson Consumer Electronics	F	A
DOSIS GmbH	D	A
Alcatel Standard Eléctrica SA	E	A

Start Date	Duration	Status
1 December 1988	36 months	Running

A High-Performance CMOS/Bipolar Process for VLSI Circuits (BiCMOS)

Project Number: 412/2430

The objective of the project is the development of a VLSI technology combining, on a single chip, MOS circuitry of the highest density currently obtainable with bipolar circuitry of similar density, but better suited to specific tasks, such as analog interfacing with the external world. The main effort has been on the technological side, in the development of methods which allow both bipolar and MOS transistors to be made in compatible process steps, and in dimensions comparable to those presently obtained in MOS-only technology. In parallel with the technological work, design methods for this specific type of circuit (mixed analog and digital functions) have been under development along with studies to determine, for various types of application, the most appropriate division of subsystems between the two circuit technologies.

The work is presently progressing towards the development of BiCMOS-2 (1.2 μm feature size in CMOS and 0.9 to 1.2 μm in the bipolar part). This is now being carried out within ESPRIT II Project 2430, which has, as a main objective, in a three-year time frame, the development of a more advanced process called BiCMOS-3 (0.7 to 0.8 μm design rules). A number of circuits are planned to be designed and processed. Among them, a video A/D converter (of about 200K device complexity) which would not be possible to realize by CMOS alone, and a 3K gate array with an on-chip 16K SRAM, both in BiCMOS-2, are expected at the end of the first 18-month phase.

In the following 18 months several other demonstrators will be designed and processed including a high-performance A/D converter (30K to 50K transistors), a FIR filter, a video A/D converter with added functionality and a fast data path unit (or alternatively a network for packet-switched applications) of 100K transistors complexity.

Participants	Country	Role
Philips Natuurkundig Lab.	NL	C
Siemens AG	D	P
Entwicklungszentrum für Mikroelektronik GmbH*	A	A
University of Dublin (TCD)	IRL	A
INESC*	P	A

Start Date of Project 412	Duration	Status
1 April 1985	43.5 months	Finished

Start Date of Project 2430	Duration	Status
15 November 1988	36 months	Running

*from 15-11-88

ESD Protection for Submicron Technologies

Project Number: 5005

The aim of this project is significantly to increase the electrostatic discharge (ESD) hardness of CMOS technologies in the submicron range by improving the understanding of ESD phenomena and developing technology-independent guidelines based on a detailed investigation of relevant parameters and realistic stress models.

The results of the project, in the form of guidelines for circuitry protection of submicron technologies against ESD, will be transferred to the consortia of the ESPRIT projects *ASIC 0.5 Micron CMOS (ACCES)*, project number 5048, and *SOI 0.5 Micron CMOS (SUBSOITEC)*, project number 5029. Recommendations will also be provided to ESD test equipment manufacturers.

Participants	Country	Role
Siemens AG	D	C
IMEC vzw	B	P
Nederlandse Philips Bedrijven BV	NL	P
Technische Universität München	D	A

Start Date	Duration
15 December 1989	36 months

A Very Quick Turnaround System for ASIC Design and Manufacturing Supporting Design Tools and Implementation Technologies (QUICKCHIPS)

Project Number: 5047

The QUICKCHIPS project aims to develop a low-cost quick prototyping and small-volume production system of ASICs (gate array and sea-of-gates) using a DWL-II machine for laser-based direct write on wafer personalization techniques. Activities will include the development of a DWL-II machine for very quick turnaround line (VQTL) ASIC fabrication, the development of a foundry-independent design system (the Uncommitted Design System), and the study of the commercial exploitation of project results.

Participants	Country	Role
INESC	P	C
CPRM	P	P
Milano Research Center	I	P

Start Date	Duration
To be announced	24 months

ASIC 0.5 Micron CMOS (ACCES)

Project Number: 5048

The ACCES project will provide European systems and IT users with multiple-sourced, submicron CMOS processes offering high packing densities and high speeds. The processes produced will be state-of-the-art CMOS ASIC technologies at 0.7 and 0.5 μm dimensions.

The project aims to develop Europe's capability in advanced ASIC CMOS processes. Submicron CMOS technologies will be developed, demonstrated and qualified at the 0.7 μm (after two years) and 0.5 μm (after four years) levels. The reduction in dimensions will be optimized to achieve very high density as well as very high speed for digital custom chips. Packing density targets are about 5,000 logic gates/mm^2 in 0.7 μm CMOS and over 7,000 in 0.5 μm CMOS.

The partners in the consortium aim to propose common design rules to their potential customers, resulting in a unique multisourcing capability. This approach is further enhanced by the specialization of the partners in various production levels (from short cycle time prototyping through to high-volume deliveries) and application areas (industrial, telecommunications, military, and so on).

Participants	**Country**	**Role**
European Silicon Structures SA (ES2)	F	C
CNET	F	P
IMEC vzw	B	P
Mietec NV	B	P
Plessey Company plc	UK	P
STC Components Ltd	UK	P
Matra-MHS	F	P
British Telecommunications plc	UK	A
Standard Elektrik Lorenz AG	D	A
Telefónica Investigación y Desarrollo	E	A

Start Date	**Duration**
1 February 1990	48 months

Advanced CMOS Analog/Digital and Digital/Analog Converters (AD 2000)

Project Number: 5056

The AD 2000 project aims to develop advanced analog/digital and digital/analog converter architectures for low-cost CMOS technology capable of addressing the needs of emerging systems in the communications and consumer electronics industry. As projections of the world market for ASICs show, the proportion of mixed analog/digital systems will rise steadily. The realization of high-performance, low-cost converters is crucial for the successful development of commercially viable products.

AD 2000's main targets are to stretch state-of-the-art performance limits with respect to speed and resolution, to improve CAD tools for architecture-level synthesis of the converters, and to address functional testing and characterization issues for improved quality control and reduced production costs.

The results of the project will be conveyed through a number of IC demonstrators implemented using standard CMOS technology. The results will be transferred to European semiconductor manufactures.

Participants	Country	Role
Instituto Superior Tecnico	P	C
Italtel SIT	I	P
Universidad de Sevilla–AICIA	E	P
Università di Pavia	I	P
Fujitsu España SA	E	A

Start Date
To be announced

Duration
36 months

Joint Logic Project

Project Number: 5080

The overall objective of the Joint Logic project is to develop in a coordinated way the basic fabrication concept for a competitive 0.5 µm CMOS technology suitable for logic applications. The specific goal of this project in its 18-month start-up phase is the development and adaption of future logic CMOS technologies derived from the different memory technology backgrounds of the partners, or based on applicable ESPRIT work.

According to the work-programme, a CMOS processing capability with a high commonality at the 0.5 µm level will be developed by all partners in the consortium, and the developed processes will be available for the whole range of IC production, from prototype to very high volume.

Whereas one of the technological foundations of the Joint Logic project is in part supplied by ongoing and future memory development within the context of JESSI, a second important contribution will be made by ESPRIT project 5048 (ACCES), the participants of which (ES2, Mietec, STC, MHS) are not directly involved in the JESSI Memory Project. They will develop compatible design rules for niche, high-performance or very quick turnaround applications and will cooperate with several research centers (Plessey, CNET, IMEC) in order to develop basic CMOS process modules leading to 0.5 µm processes.

Participants	Country	Role
Philips International BV	NL	C
European Silicon Structures SA (ES2)	F	P
Plessey Company plc	UK	P
Siemens AG	D	P
SGS-Thomson Microelectronics SRL	I	P
Telefunken Electronic GmbH	D	P
STC plc	UK	P
SGS-Thomson Microelectronics SA	F	P
Mietec NV	B	P
Matra-MHS	F	P

Start Date	Duration
1 June 1990	18 months

SEMICONDUCTOR EQUIPMENT AND MATERIALS

ASIC Multichamber Rapid Thermal Processing with Microwave Enhancement

Project Number: 2319

The growing pressure on manufacturers to obtain high yields from their wafer fabrication operations is leading a trend towards single wafer processing. Rapid thermal processing (RTP) has come to be viewed as the single wafer alternative to furnace tube processing. The project aims at developing a multichamber RTP machine with improved control of the on-wafer temperature and including novel microwave-enhanced techniques for precleaning before oxidation or deposition processes.

Participants	Country	Role
Sitesa Addax	F	C
CNRS/LAAS	F	P
SGS-Thomson Microelectronics SA	F	P
University of Edinburgh	UK	P
STC Technology Ltd	UK	P
CEA/LETI	F	P

Start Date	Duration	Status
15 December 1988	36 months	Running

Mask and Reticle Technology Development for Advanced High-Density and ASIC Devices

Project Number: 5014

The purpose of the project is to develop essential mask and reticle technology required for advanced high-density and fast turnaround ASIC requirements to a device complexity level equivalent to 16M DRAM. The results will include new materials, processes and equipment, which will make a significant contribution to the ability of the European semiconductor industry to manufacture advanced devices.

Participants	Country	Role
Compugraphics International Ltd	UK	C
Balzers AG	CH	P
Polymer Laboratories Ltd	UK	P
Siemens AG/Semiconductor Group	D	P
Wild Leitz Instruments GmbH	D	P
Valvo Unternehmensbereich	D	P
Semisystems AG	CH	P
BMP Plasmatechnologie	D	P
IMEC vzw	B	P

Start Date	Duration
1 January 1990	36 months

Process Module Integration for a Multichamber Production System (PROMIMPS)

Project Number: 5041

The main aim of the PROMIMPS project is to combine and integrate process steps which are required for submicron ASIC and memory device fabrication in CMOS, bipolar or BiCMOS technology.

Using an already developed and tested multichamber equipment platform with up to nine separate process chambers, the integration of three multistep processes for the fabrication of multilayer interconnections will be realized within this project.

Participants	Country	Role
Plasmos GmbH	D	C
Alcatel CIT	F	P
Balzers AG	CH	P
Consejo Superior de Investigaciones Científicas (CSIC)	E	P
SGS-Thomson Microelectronics SRL	I	P
Siemens AG	D	P
Nederlandse Philips Bedrijven BV	NL	P
Fraunhofer-Gesellschaft IFT	D	P
CEA/LETI Atomique	F	P
AST Elektronik GmbH	D	P

Start Date	Duration
15 April 1990	36 months

Integrated Design and Production System (IDPS)

Project Number: 5075

Following the completion of the first or definition phase of IDPS (projects 2270 and 2426), the second phase is now being launched.

IDPS will provide the Community with a state-of-the-art ASIC facility, including a common library, several design systems and a choice of five foundry services. Phases two and three of the project will focus on submicron process with 0.7/0.8 µm feature sizes which will be available in time for commercial exploitation of the first IDPS results in the second half of 1992.

The key objectives of IDPS are:

- Standardization, leading to a European industry standard
- A "Common Library," recognized as a European multisource library
- Implementation of the library in the 0.7/0.8 µm processes
- Several CAD systems capable of reliable, error-free design of high complexity (1 to 2 million transistor) ASICs
- To ensure semi-second sourcing of circuits designed with the common library, and full second sourcing, at least between the very quick turn around (VQTA) and each of the quick turn around (QTA) foundries
- Short turnaround time to prototypes and "right-first-time" designs and prototypes

Participants	Country	Role
Philips International BV	NL	C
Robert Bosch GmbH	D	P
European Silicon Structures SA (ES2)	F	P
SGS-Thomson Microelectronics SA	F	P
SGS-Thomson Microelectronics SRL	I	P
Siemens AG	D	P
Plessey UK Ltd	UK	P
ICL	UK	P
Bull SA	F	P

Start Date	Duration
To be announced	30 months

CAD

Interactive Silicon Compilation for High-Performance Integrated Systems (SPRITE)

Project Number: 2260

The goal of this project is the development of a CAD system used in the realization of real-time information processing subsystems such as image and graphics processing, post-ISDN home and business peripherals, HDTV, coprocessors, data compression, and so on.

Participants	Country	Role
IMEC vzw	B	C
Nederlandse Philips Bedrijven BV	NL	P
Racal Research Ltd	UK	P
Siemens AG	D	P
INESC	P	A
RSRE	UK	A
Praxis Systems plc	UK	A

Start Date	Duration	Status
1 December 1988	60 months	Running

Application-Specific Architecture Compilation (ASAC)

Project Number: 2394

The ASAC project will explore techniques for the creation of system-level design tools to ensure optimization of hardware performance and hardware/software partitioning.

The goal of the one-year definition phase is to achieve a joint understanding between all partners of system design problems, which will form the basis upon which to define the requirements for CAD tools and systems at the system design level.

The results of the ASAC project are to provide a tools bridge between the system design projects, the lower-level CAD tools and semiconductor process development.

Participant	Country	Role
ICL	UK	C
Bull SA	F	P
Olivetti	I	P
SGS-Thomson Microelectronics SA	F	P
Siemens AG	D	P

Start Date	Duration	Status
1 January 1989	12 months	Finished

JESSI CAD-Frame (JCF)

Project Number: 5082

The goal of the project is to provide a standardized framework for CAD tools which will serve as a general, common software infrastructure for efficiently building, maintaining and configuring open integrated CAD environments.

The JCF project will provide the JESSI framework to all JESSI CAD projects as a series of consecutive, stepwise-enhanced releases, which will offer a growing set of services and continuous increase of performance and efficiency. The project will also offer support to safeguard the effective use of the JESSI framework. Moreover, the JESSI framework will be available to ESPRIT projects and external users (under conditions to be specified).

The project is divided into start-up, main and completion phases. The overall goals of the start-up phase (mid-1990 to mid-1991) are to:

- Ensure the European advantage in framework technology
- Start, as quickly as possible, on the development of the JESSI framework
- Prepare for the main phase of the project

More specifically, the goals of the start-up phase are to:

- Evaluate existing frameworks and framework components
- Specify framework requirements for future frameworks
- Define a common JESSI framework architecture
- Define the first working interfaces
- Develop a first JESSI framework prototype

The specification of framework requirements will occur in close contact with international standardization efforts.

Participant	Country	Role
Nixdorf Computer AG	D	C
Technische Universiteit Delft	NL	P
ICL	UK	P
Swedish Telecom	S	P
Siemens AG	D	P
SGS-Thomson Microelectronics SRL	I	P
Nederlandse Philips Bedrijven BV	NL	P
Bell Telephone Mfg. Co. NV	B	A
University of Manchester	UK	A
Universität Paderborn	D	A
Fernuniversität Gehamthoogschule in Hagen	D	A
Swedish Institute of Microelectronics	S	A

(Continued)

Participant	Country	Role
Plessey Company plc	UK	A
Universität Karlsruhe	D	A
IMEC vzw	B	A
GMD	D	A
CNET	F	A
Robert Bosch GmbH	D	A

Start Date	Duration	Status
1 May 1990	15 months	Running

MISCELLANEOUS

Development of European Magneto-Optical Drives

Project Number: 2013

Market research undertaken by the consortium showed that the erasable optical data storage market will grow in 1991 to 1992 and will be worth ECU 1.5 billion by the mid-1990s, with mainframe backup and CAD/CAM as key applications. These markets should exceed ECU 150 million each in 1991 to 1992 with a large part of them presently in the hands of overseas competitors, and will increase exponentially after this.

In the case of CAD/CAM, a data capacity greater than 1 GB is required to cope with the higher resolution pictures of up to 30 MB per page which will be used. Access time of less than 50ms and data transfer rate of at least 20 Mbit/s are also required.

The objective of this project is to establish the technologies to develop two erasable optical drives and to give to European companies new opportunities to restore their position in the mass storage area.

Participants	Country	Role
SAGEM	F	C
Hoechst AG	D	P
Lexikon	I	P
Olivetti	I	A
Coventry Polytechnic	UK	P
CEA/LETI	F	P
National Institute for Higher Education (NIHE)	IRL	A

Start Date	Duration	Status
1 June 1989	60 months	Running

Optoelectronics with Active Organic Molecules

Project Number: 2284

Future optical processing and computing systems will require new materials exhibiting faster and more efficient nonlinear optical properties than presently available. The purpose of this project is to exploit the vast potential of organic molecular and polymeric materials for applications such as frequency conversion, parametric amplification and emission, optical bistability, electro-optic modulation, real-time holography and beam steering.

Participants	Country	Role
Thomson-CSF	F	C
CEA/LETI	F	P
Facultés Universitaires Notre-Dame de la Paix (FUNDP)	B	P
ICI	UK	P
CNET	F	P

Start Date	Duration	Status
24 January 1989	36 months	Running

RACE

CONTENTS

RACE Overview

RACE	Research and Development in Advanced Communications Technologies for Europe
Council decision:	Official Journal L16, dated 21-1-1988
Aims:	To contribute towards the introduction of integrated broadband communication (IBC) taking into account the evolving Integrated Services Digital Network (ISDN) and natural introduction strategies; new and improved information services; to prepare for international standards; to develop joint functional specifications for operators.
Duration:	5 years, June 1987 to May 1992
EC Contribution:	ECU 550 million/$723.7 million
Areas of Research:	IBC development and implementation strategies

IBC development and implementation strategies

- IBC strategies
- IBC realization (systems analysis and functional specifications)
- BC use
- Common operational environment

IBC technologies

- IBC system function techniques
- IBC programmeming infrastructure
- IBC usability engineering
- Technologies enabling network evolution

Prenormative functional integration

- Verification tools enabling operational IBC components and subsystems to be developed
- Development of pilot schemes for IBC applications

Calls for Proposals:	Deadlines
* Definition phase Call for a reserve list	1-10-1987
* Complementary phase	3-10-1988
** To be decided	1990
	* Published ** Planned

Scheme of Support: Shared-cost research contracts

Within the European Community, 11 telecommunications administrations, 89 universities and research establishments and over 230 companies (90 of them small companies) are now involved in the RACE consortia. Organizations from 11 of the 12 European Community countries are represented. Organizations from several countries in EFTA are also involved. In addition, 32 organizations from Austria, Finland, Norway, Sweden and Switzerland participate in 39 consortia.

LIST OF RACE ABBREVATIONS

ATM	asynchronous transfer mode, or automated teller machine
BCPN	broadband customer premises network
BLNT	broadband local network technology
CAC	customer access connection
CATV	cable television
CMC	coherent multichannel
CPN	customer premises network
DCPN	domestic customer premises network
IBC	integrated broadband communications
IBCN	integrated broadband communications network
WTDM	wavelength and time-division multiplexed

RACE Project Information

Electro-Luminescent Flat Panel Display for Terminal Applications

Project Number: R1004

The overall objective is to ensure the availability of high-performance, fully European, flat panel terminals for future telecommunications applications.

Participants	Country
Lohja Corporation Electronic Industries*	SF
SGS-Thomson Microelectronics SRL	I
University of Ghent	B
Matra Communication	F

Start Date	Duration
1 January 1988	4 years

Estimated Costs
ECU 1.63 million/$2.14 million

* Prime contractor

Subscriber Coherent Multichannel System

Project Number: RI010

The main objective of this project is to demonstrate the technical and techno-economic feasibility of coherent multichannel (CMC) in the customer access connection (CAC) and the customer premises network (CPN). The results of the project are intended to show that the use of coherent transmission allows for a very transparent and flexible evolution from a first generation of optical local networks to future generations, at the same time accepting almost any service scenario.

Apart from providing evidence for the technical feasibility, the project also participates in discussions on the introduction and evolution of optical networks, based on the available expertise in system-related issues. The transparency and flexibility mentioned above is the basis of these ongoing discussions.

Participants	Country
Nederlandse Philips Bedrijven BV*	NL
Heinrich Hertz Institut	D
Plessey UK Ltd	UK
Siemens AG	D
IMEC vzw	B
Laboratoires d'Electronique Philips (LEP)	F

Start Date	Duration
1 January 1988	4 years

Estimated Costs
ECU 15.23 million/$20.02 million

* Prime contractor

BLNT—Broadband Local Network Technology

Project Number: R1012

The objective of the project is to develop a low-cost local loop and switch technology which is capable of supporting a range of narrow-band and broadband services in a flexible and efficient manner.

Participants	Country
Plessey Research Roke Manor Limited*	UK
Società Italiana Telecomunicazioni SpA	I
Siemens AG	D

Start Date	Duration
1 January 1988	3 years

Estimated Costs
ECU 15.28 million/$20.11 million

* Prime contractor

ATMOSPHERIC

Project Number: R1014

ATMOSPHERIC is concerned with the architecture, techniques and technologies which are required to implement switching and multiplexing functions within an IBCN. Its focus is the transition phase leading to the ATM-based network.

The main objective of the ATMOSPHERIC project is to identify network configurations and solutions which will accommodate the uncertain service growth and mix arising during the introductory phase, interwork with existing public networks and support access from existing terminals and subscriber premises networks. They will allow reuse of resources to permit economic introduction and evolution strategies.

In particular, these strategies will permit the early introduction of a limited amount of revenue funding broadband services in markets whose needs can be economically met prior to the implementation of major technical advances.

Verification and evaluation of the recommended solutions will be supported by the construction of a Demonstrator model in order to assess:

- Technology performance requirements of switching and multiplexing elements of the IBCN
- The flexibility and compatibility of the network architectural concepts and design options to meet the needs of the configuration required to support evolving market demand
- The ability of ATMOSPHERIC solutions to address economically the key aspect of upgrading the local distribution network to provice IBC capability

Participants	Country
Matra-Ericsson Telecommunications (MET)*	F
Telefonaktiebolaget L M Ericsson (Ericsson Telecommunication)	S
Televerket (Swedish Telecommunications Administration)	S
General Electric Company plc	UK
Matra-Space	F
Aktieselskabet Nordiske, Kabel & Traadfabriker	DK
EMI Electromagnetics Institute	DK
National Technical University of Athens	GR
STC plc	UK
Telefónica de España SA	E
SGS-Thomson Microelectronics SRL	I

Start Date	Duration
1 January 1988	3 years

Estimated Costs

ECU 6.56 million/$8.63 million

* Prime contractor

Domestic Customer Premises Network (DCPN)

Project Number: R1015

The domestic CPN is a strategic area for the whole IBCN, because a rapid penetration of broadband services in the domestic environment will be the main motivation for a new public telecommunication network.

The main intention of the project is to prepare economic, technically practical, and ergonomic solutions for the future CPNs in the domestic area.

Participants	**Country**
Thomson-CSF*	F
Standard Elektrik Lorenz AG	D
FATME SpA	I
Systek	D
HUSAT	UK
BED	D
Thomsen LEREA	F

Start Date
1 January 1988

Duration
2 years

Estimated Costs
ECU 3.07 million/$4.04 million

* Prime contractor

Development of Improved Indium Phosphide (InP) Substrate Material for Optoelectronic Device Production

Project Number: R1029

This project is directed at the development of improved InP substrate manufacturing technology, with demonstrated benefits for discrete and integrated optoelectronic device yield and hence cost.

Participants	Country
MCP Wafer Technology Ltd*	UK
Thomson-CSF	F
Thomson Hybrides et Microondes SA	F
Université de Sciences et Techniques du Languedoc	F

Start Date
1 January 1988

Duration
3 years

Estimated Costs
ECU 1.09 million/$1.43 million

* Prime contractor

ACCESS—Advanced Customer Connections, an Evolutionary Systems Strategy

Project Number: R1030

The main objectives of the ACCESS project is to investigate the CAC based on digital transmission on single-mode optical fibre, with a view to implementation in the early phases of the IBCN. The investigation will lead to identification of one or more preferred CAC implementations. The main criterion used is the minimal total cost of the CAC. An additional objective is to study alternative means for enabling early broadband connections to the domestic customers for provision of CATV and telephony services only.

Participants	Country
Aktieselskabet Nordiske Kabel & Traadfabriker*	DK
AEG Kabel AG	D
ANT—Nahrichtentechnik GmbH	D
British Telecommunications plc	UK
Thomson Hybrides et Microondes SA	F
Telefónica de España SA	E
Souriau et Cie.	F
Société Anonyme de Télécommunications	F
Etat Francais—Ministère des PTT	F
Centre National d'Etudes des Télécommunications	F
General Electric Company plc	UK
SGS-Thomson Microelectronics SA	F
Telefonaktiebolaget L M Ericsson	S
Televerket (Swedish Telecommunications Administration)	S

Start Date	Duration
1 January 1988	4 years

Estimated Costs

ECU 17.15 million/$22.57 million

* Prime contractor

Low-Cost Optoelectronic Components

Project Number: R1031

The project's objective is the development of manufacturing technologies and device designs compatible with the production of large volumes of low-cost active optoelectronic components in line with the IBC network requirements.

Participants	Country
Standard Elektrik Lorenz AG*	D
STC plc	UK
AT&T en Philips Telecommunicatie Bedrijven BV	NL
Nederlandse Philips Bedrijven BV	NL
RTC-Compelec	F
Siemens AG	D
ANT—Nahrichtentechnik GmbH	D
Compagnie Deutsch	F

Start Date
1 January 1988

Duration
4 years

Estimated Costs
ECU 9.67 million/$12.72 million

* Prime contractor

OSCAR—Optical Switching Systems, Components and Applications Research

Project Number: R1033

OSCAR aims to develop the key switching technologies required for the evolution towards integrated optical networks. In particular, building blocks with zero optical loss are expected to be realized. OSCAR is making extensive use of practical test beds as tools to verify its results both at the components and the system concept level.

Participants	Country
Philips—LEP*	F
General Electric Company plc	UK
Thomson-CSF	F
Thomson-Sintra	F
IMEC vzw	B
British Telecommunications plc	UK
Dr Neher Laboratories	NL
Standard Elektrik Lorenz AG	D
Universität Dortmund	D
AT&T en Philips Telecommunicatie Bedrijven BV	NL
Plessey UK Ltd	UK
Swiss Federal Institute of Technology	CH
Ascom Holding Ltd (Research and New Technologies Division)	CH
Telefonaktiebolaget L M Ericsson	S
Televerket (Swedish Telecommunications Administration)	S

Start Date	Duration
1 January 1988	4 years

Estimated Costs
ECU 6.14 million/$8.09 million

* Prime contractor

Wavelength and Time-Division Multiplexed (WTDM) Broadband Customer Premises Network

Project Number: R1036

The aim of this project is to develop a broadband customer premises network (BCPN) suitable for broadband service providers and for a wide range of other corporate applications.

Participants	Country
British Broadcasting Corporation*	UK
STC plc	UK
Research Neher Laboratories of the Netherlands PTT	NL
General Electric Company plc	UK
Alcatel Standard Eléctrica SA	E
Thomson-CSF	F
Instruments SA	F
SGS-Thomson Microelectronics SA	F
STC Technology Ltd	UK

Start Date	Duration
1 January 1988	3 years

Estimated Costs
ECU 3.63 million/$4.78 million

* Prime contractor

DRIVE

DRIVE Overview

DRIVE	**Dedicated Road Infrastructure for Vehicle Safety in Europe**
Council decision:	Official Journal L206, dated 30-7-1988
Aims:	The development of information technologies to improve road transport efficiency and road safety; to reduce the environmental impact of road transport.
Duration:	3 years, June 1988 to May 1991
EC Contribution:	ECU 60 million, or $78.9 million
Areas of Research:	Road transport informatics (RTI) technologies

- Enabling and supporting RTI technologies (specific components, communications options, vehicle-to-vehicle communications)
- RTI software technologies (software systems, development tools)
- The human factor and the human/machine interface
- Fault tolerance

Evaluation of strategic options

- Refinement of objectives
- Evaluation tools
- Outline of implementation scenarios

Specifications, protocols and standardization proposals

- Definition of requirements and specific objectives
- Use of the evaluation tools
- Development of functional specifications and standardization proposals
- Drafting guidelines for drawing up regulations

Calls for Proposals:	Deadline
* General call	17-10-1988
* Partial call	12-5-1989
** To be decided	* Published ** Planned

Scheme of Support: Shared-cost research contracts

BRITE/EURAM

BRITE/EURAM Overview

BRITE/EURAM	Basic Research in Industrial Technology for Europe/ EUropean Research in Advanced Materials
Council decision:	Official Journal L98, dated 11-4-1989
Aims:	To strengthen the competitiveness of the European manufacturing industry, including small and medium-size enterprises (SMEs), in world markets; to establish the necessary technological base for the development of new products and processes.
Duration:	4 years, 1989 to 1992
EC Contribution:	ECU 499.5 million, or $657.2 million
Areas of Research:	I. Advanced materials technologies

- Metallic materials and metallic matrix composites
- Materials for magnetic, optical, electrical and superconducting applications
- High-temperature nonmetallic materials
- Polymers and polymer matrix composites
- Materials for specialized applications

II. Design methodology and quality assurance for products and processes

- Quality, reliability and maintainability in industry
- Reliability of processes and products

III. Application of manufacturing technologies

- Advancing conventional manufacturing practices
- Manufacturing processes for flexible materials

IV. Technologies for manufacturing processes

- Surface techniques
- Shaping, assembly and joining
- Chemical processes
- Powder processes and powder metallurgy

V. Aeronautics

- Aerodynamics
- Acoustics
- Airborne systems and equipment
- Propulsion systems

Calls for Proposals:	Deadlines
* Expressions of interest (26.7.1988)	3-1989
* Feasibility awards	14-4-1989
* Areas I to IV (Types 1 and 2)	12-5-1989
* Area V Aeronautic research	9-6-1989
** Areas I to IV	31-8-1990
* Feasibility	2-3-1990
** To be decided	* Published ** Planned

Scheme of Support:

Shared-cost research contracts
Concerted actions
Scholarships

Particularities:

- Type 1 projects, applied industrial research: participation of at least two industrial enterprises from different Member States

- Type 2 projects, focused fundamental research: participation of at least two universities from different Member States with endorsement by two industrial enterprises

- Feasibility awards for SMEs (Area I to IV): grants of up to 75 percent (to a maximum of ECU 25000) of the cost of research projects, which can last up to 6 months and must serve to establish the feasibility of a device, process or concept.

EUREKA

EUREKA

CONTENTS

EUREKA Overview

EUREKA	**EU**ropean **RE**search Coordination Agency
	Created in 1985 as the result of a French–German initiative. With the active participation of the European Commission, EUREKA has developed parallel to EC research. Both initiatives have the same basic aims: the promotion of cross-border cooperation in European research and technology. However, their procedures are different. This is intentional; Community research and EUREKA should complement, not compete with each other.
Basic approach:	Whereas EC research is mainly concerned with precompetitive and basic research, EUREKA projects are nearer to the market. However, there are certain EUREKA projects concerned with basic research.
Countries involved:	EUREKA consists of the EC countries and the Commission, as well as the EFTA countries and Turkey (a total of 20 partners).
Organization:	Whereas EC research is based on fixed institutional rules and jointly agreed long-term specific aims, EUREKA projects arise spontaneously without detailed overall planning.
Financing:	The national governments of the partners concerned decide whether support will be given, and fix the extent of the subsidy. This offers the advantage of greater flexibility, but there are limits on the degree to which a coherent strategy is possible. The funding given to EUREKA projects has now reached the sum of approximately ECU 1 billion per annum ($1.3 billion).
	From the beginning, the Commission of the European Communities has supported this new form of European cooperation in research work, and has also participated financially, for example, in two of the most important EUREKA projects: HDTV (European standard for high-definition television) and JESSI (Development of 64M memories and their applications).

INTEGRATED CIRCUITS

New Designs and Technologies for High-Power Semiconductor Devices

Project Number: 97

Technological constraints of semiconductor devices are preventing not only further optimization in existing applications, but also the penetration of power semiconductors in the field of energy utilization; for example, in cases where the power control of motors could be introduced to advantage.

In order to achieve further development in power semiconductor technology and thus a possible breakthrough in the application of these elements in the environmentally acceptable utilization of energy, new techniques and new designs of components must be introduced. These are already available to some extent in the IC industry, but require considerable investment to adapt them; other techniques and structures have to be newly developed to achieve the desired functions and combinations of parameters economically.

Participants	Country
Asea Brown Boveri AG*	CH
Asea Drives	S
Institut for Mikrovacsteknik	S
Centre Suisse d'Electronique et de Microtechnique SA (CSEM)	CH

Estimated Costs
Revised estimate as at 1/4/89; ECU 2.5 million (approx. $3.28 million)

Time Scale
Revised estimate as at 1/4/89; April 1987 to December 1989

* Main contractor

ATA—Analog Transistor Array

Fast Prototypable Analog Transistor Array

Project Number: 222

An analog ASIC will be developed which:

- Is prototypable by direct write laser (DWL), and therefore guarantees extremely short prototype and production turnaround time.
- Is of different layout philosophy than existing analog transistor arrays (ATAs). This enables a considerable speed-up of layout time, more effective use of standard analog cell libraries and a better use of silicon area. The first two arguments speed up chip development time, the third decreases production cost for both small and large production volumes.

Analog microelectronics is indispensable in instrumentation (all measurements, sensor interfaces), telecommunications, power electronics and interfacing computers to the "real world."

Participants	Country
Lasarray SA*	CH
Interest expressed by Favag SA Microelectronic	CH

Estimated Costs
Total value of project as at 1/4/89: ECU 1.8 million ($2.37 million)

Time Scale
16 months

* Main contractor

EPROM—Multi-Megabit Nonvolatile Memories

Project Number: 102

This project has two major objectives:

- Study, development and industrialization of integrated circuit nonvolatile memory (EPROM) having a storage capacity of 4M
- Feasibility study of technology and architecture of integrated circuit nonvolatile memory (EPROM) having a storage capacity of 16M

Participants	Country
SGS-Thomson Microelettronica SpA	Italy

Estimated Costs
Over a 5-year period
Revised total as at 1/4/89: ECU 227.5 million
(approx. $299.34 million)

Time Scale
April 1987 to December 1991

JESSI Overview

JESSI

Joint European Submicron SIlicon Programme

Project Number: 127

The JESSI programmes should be viewed in relation to the work done before in the field of semiconductors at the Community level (ESPRIT I and II) as well as through binational initiatives. Moreover, JESSI will support the achievements of applications programmes (e.g. HDTV).

JESSI follows the MEGA project, which is an independent research programme between Philips and Siemens, with the participation of the Dutch and German governments. The timescale was five years, ending in 1989 with an investment of $1.2 billion over that period. The objective was to develop the submicron process, 1M SRAM by Philips and 4M DRAM by Siemens and design, manufacturing and test automations.

Achievements of the MEGA Project

- 8K×8 SRAM—in production
- 256K SRAM production using MEGA Process—mid-1990
- 4M DRAM—into production 1989

OVERVIEW

In 1986, European companies found themselves in a situation where, with no effective advantage in their home market, they were having to compete against companies who not only had more money to spend individually but who also had access to the results of nationwide, coordinated R&D efforts which were also becoming much more vertically integrated and cross-disciplinary.

It was under these conditions that JESSI was established, to meet the challenge from outside Europe and to guarantee future technology which would support not just the electronics industry but all of Europe's industry in its entirety.

The project was first outlined in March 1986, and by the end of that year JESSI received the EUREKA approval for its definition phase. The next two years were taken up in the planning phase. In 1988 the JESSI Green Book was released and defined a project which is the most ambitious within the EUREKA programme. From a cost point of view alone, it is equal to all the other EUREKA projects put together.

After publication of the Green Book, JESSI was declared a EUREKA project in 1989. It is a research and development programme targeted on the technologies and equipment needed to integrate advanced systems on silicon and their applications into advanced systems.

The JESSI programme has been allocated a total budget of over ECU 3.8 billion ($5 billion) for its eight-year life span. The JESSI programme will involve 21,400 man-years split between technology, equipment and materials, applications, and basic and long-term research.

JESSI aims to help the whole of the European electronics industry to grow in a unified and coordinated way: from basic research to materials; from production equipment to CAD; and to the final application of devices within electronics systems.

The basic structure of JESSI has thus been set to facilitate industry-wide coordination and growth with four major areas being specifically designated. These areas are addressed by four separate subprogrammes to cover:

- Technology
- Equipment and materials
- Applications
- Basic and long-term research

These four subprogrammes, operating at an industry level, all report to the JESSI board which, with the help of a special support group and office is responsible for acceptance of projects and the overall administration of the programme.

Within this basic framework, JESSI has the following objectives:

- Development of the advanced process steps, advanced devices architectures and implementation of competitive production technologies for submicron CMOS technologies to be ready for the mid-1990s.
- The realization of flexible tools and procedures, applicable throughout Europe, for the development of high-complexity integrated circuits and their implementation in electronic systems.

- Long-term applied research convergent on industrial objectives in the areas of materials, technologies and CAD.
- Development of advanced microelectronics production equipment and methodologies in selected sectors of the European industry.

Before its completion, JESSI will give Europe its own submicron technology within a time frame that will allow Europe to become and remain truly competitive with the rest of the world. Starting from 0.7 μm technology, the ultimate aim of the programme is to realize a 0.3 μm technology using 64-Mbit memories as the test vehicle.

In July 1989 the JESSI board was designated. To date the four subprogramme management boards within the JESSI programme have examined a total of 224 projects covering technology, equipment and materials, applications and basic long term research. Of these, 53 have already been given the JESSI label which entitles them to financing from individual governments and the European Commission.

Definition Phase:
People from 29 institutions and companies from 6 European countries took part (Belgium, France, West Germany, Italy, the Netherlands and the United Kingdom).

Execution Phase:
More than 100 companies, including among others:

Participants	**Country**
Philips, Nederlandse Philips Bedrijven BV*	NL
Robert Bosch GmbH	D
Siemens AG	D
Philips, Unternehmensbereich Bauelemente	D
SGS-Thomson Microelectronics SA	F
SGS-Thomson Microelectronics SRL	I
Plessey Company plc	UK
Interest expressed by Belgium	

* Main contractor

Estimated Costs

The overall JESSI programme cost is ECU 3.8 billion (approx. $5 billion). The 4 sub-programmes will respectively represent 41 percent, 13 percent, 32 percent and 14 percent of this cost (ECU 1,550, 500, 1,200, and 550 million).

Time Scale

8 years, 1989 to 1996

Major Events

March 1986	Plans for JESSI first outlined.
Jan.-Dec. 1988	Definition and Planning phases Four subprogrammes established: Technology, Equipment and Materials, Application, and Basic and Long-Term Research
June 1989	JESSI is declared an official EUREKA project.
July 1989	JESSI board designated.
Feb 1990	JESSI acknowledges IBM-Siemens joint development project for 64M DRAM.
March 1990	JESSI and SEMATECH start common projects.
April 1990	Dr. Ing. Raimondo Paletto is nominated as the new Chairman of the JESSI Board.
April 1990	Nine new JESSI projects approved.
May 1990	JESSI and JEMI (Joint Equipment Manufacturers Initiative), France focus on common goals—the Equipment and Materials subprogramme was backed by JEMI.
June 1990	CAD Project starts under ESPRIT The first and central CAD Project of the JESSI programme is started as an ESPRIT Project (number 5082).
July 1990	JESSI decides on more projects—start-up programme nearly completely launched. A further 13 projects have been selected in the area of applications of microelectronics, bringing the total to 49.
Sept 1990	Philips withdraws from the Joint Memory Project This will not have a major impact on the overall JESSI programme. The Joint Memory Project was quite a large programme which had 1,535 man-years allocated over 3 years; the withdrawal has reduced this to 1,000 man-years and should be considered in the light of the total of 21,400 man-years so far allocated to the programme. Philips' lack of participation is capable of being supplemented by inputs from companies such as SGS-Thomson or Matra-MHS.

JESSI Subprogramme Technology—JESSI Labelled Projects

ID No.	Title	JESSI Label Date	No. of Partners	Countries	Man-Years 1990–92
Technology					
T1	Joint Memory Project	8-11-89	3	F, D, I, NL	1,535
T2	Joint Logic Project	23-1-90	9	B, F, D, I, NL, UK	588
T3	Manufacturing Science and Technology	23-1-90	9	B, F, D, I, NL, UK	567
Equipment and Materials					
E2A	Ultra Pure Wet Chemicals and Supply Systems for Semiconductor Processing	3-4-90	11	F, D	
E2B	Gases Technology: Ultra Clean Technology in Gases and Chemicals for Ultra Large-Scale Integrated Semiconductor Manufacturing	3-4-90	10	F, D, UK	80
E5	Planarized Metallization Based On Al, Cu and TiN CVD	23-1-90	12	F, D, I, NL, UK	90
E9	High Lead Count Ceramic Package for High Reliability	13-6-90	3	D	42
E11	Equipment for the production of Si crystals by the CCZ/MCZ Process	23-1-90	1	D	23
E15	Elymat Technique for In-Line Monitoring of Metal Contamination	23-1-90	4	D, I	25
E20	MEGA Clean—Fully Automated ULSI Cleaning System	23-1-90	7	F, D	31
E29	Advanced Chip Encapsulation	23-1-90	2	NL	53
E31	Thermal Vertical Reactor	23-1-90	4	D	36
E39	New Technologies for Half Micron and Subhalf Micron Stepper Optics	23-1-90	2	D	56
E60	I-Line Production Lithography for 0.5 Micron	23-1-90	8	B, D, I, NL	235
E64A	Automatic Metrology Tool for the 0.3 Micron ICs	13-6-90	5	F, D, I	53
E66	Silicon Wafers for Submicron Technology	3-4-90	2	D	176
E74	Target Materials for Submicron Metallization	3-4-90	6	D, I, NL	27
E77C	Development of Contamination Free Distribution Components for the Transport of Ultra Pure Chemicals	6-7-90	6	F, D	25
E104	Electron Beam Metrology System	13-6-90	4	D, NL, UK	61

JESSI Subprogramme Technology—JESSI Labelled Projects (Continued)

ID No.	Title	JESSI Label Date	No. of Partners	Countries	Man-Years 1990–92
E106	Wavelength-Dispersive X-Ray Fluorescence Wafer-Analyzer	13-6-90	4	B, F, I, NL	47
E183B	Automatic Mixed VLSI Tester	6-7-90	5	F, D, UK	66
E186	Ultra Clean Process Environment in the Precleaning Oxidizing, Nitriding and Metalization Steps of ULSI Chips Manufacturing	6-7-90	3	F, I, UK	6
Applications					
AC1	JESSI CAD-Frame	8-11-90	16	B, F, D, I, NL, UK	362
AC3	HDL Component Modelling and Libraries	23-1-90	10	F, D, I, NL, UK	299
AC4	High-Performance Simulation Environment	23-1-90	7	F, D, I, NL, UK	165
AC5	Development of a EMC Workbench for Microelectronic Application	3-4-90	24	B, F, D, I, NL, UK	109
AC6	Test Generation and Design for Testability Support	23-1-90	7	F, D, I, NL, UK	253
AC8	Synthesis, Optimization and Analysis	23-1-90	16	B, F, D, I, NL, UK	287
AC12	Analog Expert Design System	3-4-90	11	F, D, NL, UK	244
AC41	Technology Assessment (prev. AE41)	3-4-90	9	B, F, D, NL	112
AC50	Layout Verification System for Submicron Designs	6-7-90	8	B, D	67
AC61	Euro-CAD Project for Board Design	6-7-90	4	F, D, UK	177
AE10	HDTV	3-4-90	6	F, D, NL	210
AE11	Ultra Large-Scale Integration of a Control Unit for Safety-Critical Systems	23-1-90	8	F, D	189
AE13B	Advanced VLSI Components for the GSM Pan-European Digital Cellular Radio System	6-7-90	4	B, F	83
AE14	Implementation of Prototype Building Blocks for a DAB Standard	23-1-90	8	F, D, NL	140
AE15	Advanced VLSI Components for B-ISDN ATM Networks	23-1-90	5	B, F, D	82
AE23	Small and Medium-Size Industries Support	23-1-90	8	F, D, I, NL, UK	220

JESSI Subprogramme Technology—JESSI Labelled Projects (Continued)

ID No.	Title	JESSI Label Date	No. of Partners	Countries	Man-Years 1990–92
AE31B	Mobile Cellular Radio	6-7-90	2	CH, F, SW, UK	61
AE36	Digital Control for High-Resolution Display	6-7-90	4	F, D, I	63
AE45B	Improved Quality Television	6-7-90	3	D, I	84
AE55B	Advanced VLSI Chip Set for ISDN Videophone	6-7-90	6	F, D	91
AE56	Europroject Signal Processing for SD/HD VCR	6-7-90	5	F, D, NL	93
AE60	High-Density Reconfigurable Computer Memory Components	6-7-90	3	F, D, UK	75
Bacis and Long-Term Research					
BD2	System and Technology Related Circuit Design	23-1-90	22	F, D, I, NL, UK	346
BD4	Circuit Simulation	3-4-90	15	F, D, NL, UK	116
BD5	Advanced Neural Circuits and Networks	6-7-90	12	CH, F, D, I, NL	65
BT1	Advanced Technology for 0.25 Micron CMOS and Below	23-1-90	26	B, F, D, I, NL, UK	1086
BT2	Alternative Devices	23-1-90	11	B, F, D, I, NL, UK	263

SEMICONDUCTOR EQUIPMENT AND MATERIALS

The Development of an All-Dry Single-Layer Photolithography Technology for Submicron Devices

Project Number: 38

With the planned production of megabit and multimegabit devices, an urgent need exists for a relatively simple, economically attractive and reliable photolithography process in the submicron region. Processes such as e-beam or X-ray lithography have a disadvantage of high investment, low throughput or delicate mask making. Multilayer photolithography allows the use of conventional exposer equipment in order to achieve submicron resolution but due to process complexity, suffers from uneconomic low yields.

UCB has applied for a worldwide patent covering a single-layer photoresist, which after irradiation is submitted to a gas-phase silylation reaction followed by treatment with a reactive oxygen ion plasma.

Preliminary results have shown that submicron resolution can be achieved and reproduced to a level of 0.5 µm without significant yield loss.

The objective of this EUREKA project is an optimization of:

- Chemical structures of the photoresist and silylation agent
- Synthesis and purification
- Exposure, silylation, dry development and resist-stripping steps
- Silylation equipment
- Plasma equipment

This optimlization is a prerequisite to the potential exploitation of this photolithography process.

Participants	Country
UCB Electronics NV*	B
Interuniversitair Micro-Elektronica Centrum vzw (IMEC)	B
Plasma Technology UK Limited	UK

Estimated Costs
Revised cost at 1/4/89: ECU 35 million ($46.0 million)

Time Scale
3 years

* Main contractor

Automatic Design and Production of Custom Chips Using Direct Printing on Silicon Wafers

Project Number: 16

The aim of the project is to offer a new service to the market which will enable engineers designing electronic systems to carry out electronic operations on the basis of custom chips defined using specialized software (silicon compilers); these chips are to be produced in a semiconductor fabrication plant organized in such a way as to minimize the production cycle time by means of direct printing on silicon wafers. It is aimed to supply the chips in under two weeks.

Participants	Country
European Silicon Structures (ES2)*	F
Nordic VLSI AS	N
Asea Brown Boveri AG	CH
European Silicon Structures	UK
Interest expressed by Ireland and Turkey	

Estimated Costs

ECU 81.4 million ($107.1 million)

* Main contractor

0.1 Micrometer Ion Projection

Project Number: 50

The development in telecommunications and data processing systems for applications such as robots calls for an increasing degree of integration of electronic components, aiming at cost reduction and improved systems reliability.

The aim is to develop ion projection lithography for use in integrated circuit manufacture and to overcome the limitations of conventional optical, e-beam or X-ray lithography by using ion projection. The ion projection technique would allow the throughput of conventional optical or X-ray lithography, with a resolution of 0.1 μm for suitably large chip sizes.

Participants	Country
Ionen Mikrofabrikations Systeme GmbH (IMS)*	A
Technische Universität Wien	A
Fraunhofer Institut für Mikrostrukturtechnik	D
Siemens AG	D
Interest expressed by EC	

Estimated Costs
Total amount: ECU 5 million (approx. $6.58 million)

Time Scale
Project dates: July 1986 to June 1989

* Main contractor

ESPRIT

European Strategic Programme for Research and Development in Information Technologies

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EUREKA—DATABASE (free of charge)

Detailed information on projects carried out in the framework of the EUREKA programme; sharing of the financing participants; status of agreement between participants; location of work; application/market; partners sought; status of the project; and so on.

Database Producer: EUREKA Secretariat in collaboration with national project coordinators.

Coverage: Approx. 250 project records. Regular updating.

User Aids: Online guidance with the command INFO EUREKA.

Access to all listed databases through the ECHO_HOST Service of the Commission of the European Communities.

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DRIVE

Dedicated Road Infrastructure for Vehicle Safety in Europe

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Dataquest

European Semiconductor Consumption Forecast 1985-1995

European Semiconductor
Consumption History and Forecast
1985-1995

Published by Dataquest Europe Limited

September 1991

0009897

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European Currency Exchange Rates
Against the Dollar

Region	Currency	1985	1986	1987	1988	1989	1990
Benelux	Gulden (F)	3.32	2.45	2.03	1.98	2.12	1.82
France	France (FF)	8.98	6.92	6.01	5.96	6.39	5.44
Italy	Lire (L)	1.91	1.49	1.30	1.30	1.37	1.20
Nordic	Swedish Krona (SKr)	8.60	7.12	6.34	6.13	6.45	5.92
UK/Eire	UK Pound (£)	0.77	0.68	0.61	0.56	0.61	0.56
W. Germany	Deutsche Mark (DM)	2.94	2.17	1.80	1.76	1.88	1.62
ROE	Peseta (Pta)	170.05	139.97	123.56	116.96	118.55	102.03
ECU		1.32	1.02	0.87	0.85	0.91	0.78

Region	Currency	1991	1992	1993	1994	1995
Benelux	Gulden (F)	1.90	1.96	1.96	1.96	1.96
France	France (FF)	5.70	5.87	5.87	5.87	5.87
Italy	Lire (L)	1.26	1.30	1.30	1.30	1.30
Nordic	Swedish Krona (SKr)	6.13	6.31	6.31	6.31	6.31
UK/Eire	UK Pound (£)	0.57	0.59	0.59	0.59	0.59
W. Germany	Deutsche Mark (DM)	1.68	1.73	1.73	1.73	1.73
ROE	Peseta (Pta)	105.20	109.10	109.10	109.10	109.10
ECU		0.82	0.85	0.85	0.85	0.85

Source: Dataquest (September 1991)

European Semiconductor Consumption History and Forecast 1985-1995

Introduction

This booklet presents Dataquest's European regional history and forecast for semiconductor products for the period 1985 to 1995. For the first time, the European history and forecast is given in European currency units (ECU), as well as US dollars. The ECU is used to reflect local trading conditions, and will indicate underlying trends independent of exchange rate variations against the US dollar. There are of course variations between the local currencies and the ECU, but these are small. This data is given in the exchange rate table opposite.

Dataquest defines the semiconductor market as representing all merchant market business, plus the in-house business that exists for those semiconductor manufacturers which also participate in the merchant market. This element of in-house business between a manufacturer and its equipment divisions or subsidiaries is valued at merchant market prices. This gives a true reflection of the total available semiconductor market to merchant semiconductor suppliers. Figure 1 shows the shipment model used by Dataquest in the definition of the total semiconductor market.

Assumptions

The semiconductor forecast is made assuming certain factors and conditions. The size of the semiconductor market may alter as a result of changes in our basic assumptions, which include:

- Exchange rates
- Political environments
- Economic conditions
- Technologies
- Semiconductor production capacity
- End-use applications

Table 1 gives semiconductor consumption by country for 1990.

Exchange Rates

The exchange rates used for the forecast are those in place during the third quarter of 1991. These rates are assumed to be unchanged for the duration of the forecast. Table 2 shows the effects of the exchange rate variations on market growth when calculated in both dollars and ECU.

Table 1

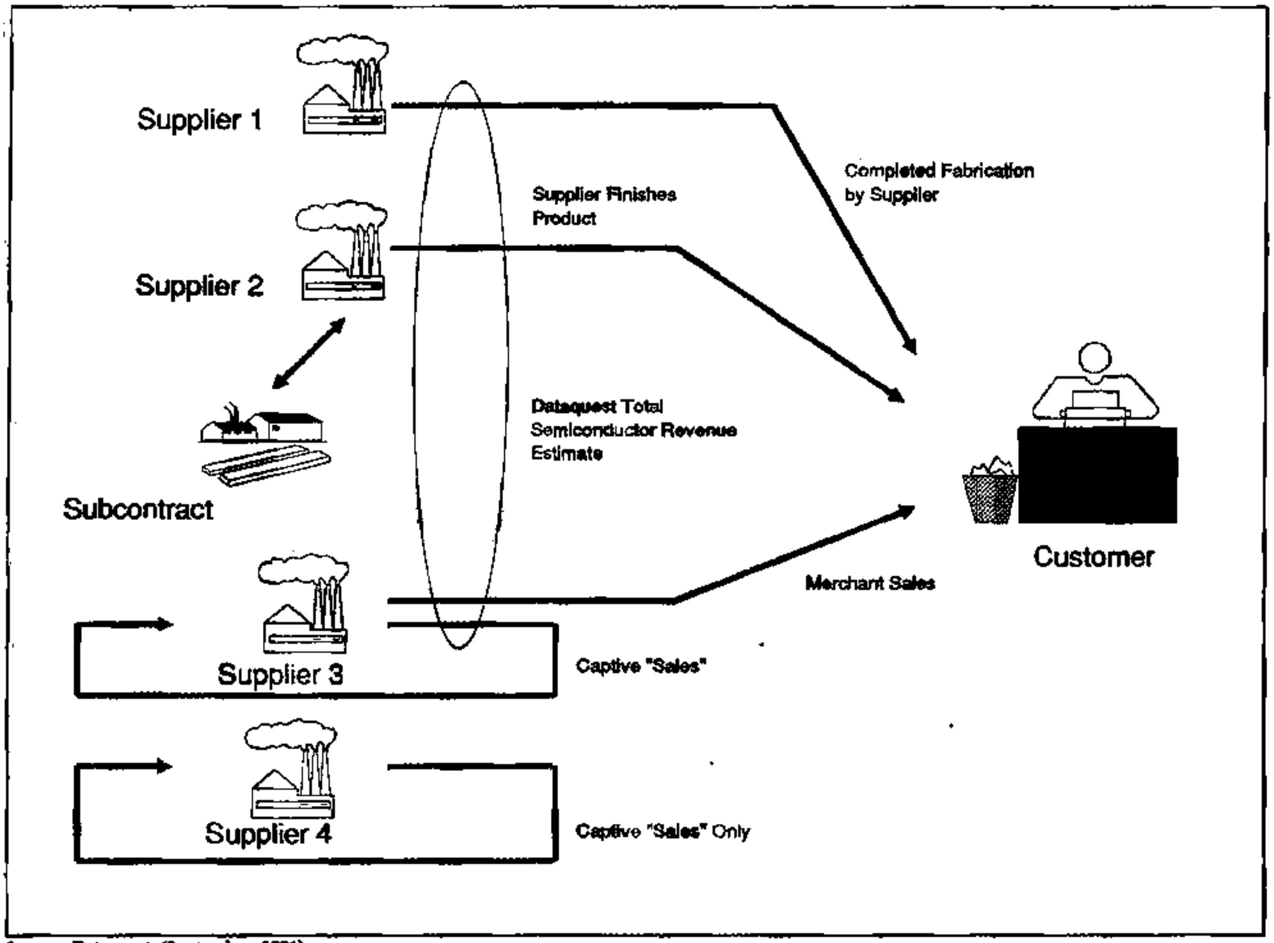
European Semiconductor Market by Country

Region	1990 ($M)	1990 (LC M)
Total Europe	$10,661	
Benelux	$559	
Belgium	190	BF 6,346
Netherlands	358	F 652
Luxembourg	11	F 367
France	$1,531	FF 8,329
Italy	$1,179	(L K) 1,411
Nordic Countries	$691	
Denmark	59	DKr 365
Finland	84	FMk 321
Iceland	0	IKr 0
Norway	33	NKr 206
Sweden	515	SKr 3,049
UK and Eire	$2,730	
England	1,884	£1,055
Scotland	546	£306
Wales	109	£61
Northern Ireland	27	£15
Eire	164	£98
Germany	3,077	DM 4,985
Rest of Europe	$894	
Austria	224	S 2,554
Greece	36	Dr 6,624
Malta	18	LM 57
Portugal	11	Esc 1,566
Spain	197	Pta 20,094
Switzerland	265	SFr 368
Turkey	143	Lt 373,030

LC = Local currency
Source: Dataquest (September 1991)

Figure 1

Semiconductor Shipment Model



Source: Dataquest (September 1991)

Political Conditions

Political conditions can include the unification of east and west Germany, the Gulf war, or reference prices for memory devices. Those factors likely to affect products (such as reference prices) are explained in the product analysis. It is assumed that there will be no major political changes within Europe. The changes that are in place, and are likely to have a notable impact on the European semiconductor market, are the unification of east and west Germany, the liberalization of the rest of Eastern Europe, possible new members of the European Community (Sweden, Turkey, Austria), the results of the General Agreement on Tariffs and Trade (GATT) discussions, and trade barriers. Assumptions associated with these factors are dealt with in the regional and product analysis.

Economic Conditions

Economic conditions vary significantly, and the expected changes in these conditions are explained in the regional analysis of this text. The basis for the economic growth of the relevant countries is shown in Table 3. This is the economic forecast prepared by our parent company, Dun & Bradstreet, in July 1991.

Other economic factors include the ability of the various governments to attract foreign investment into their countries. The growth of the electronic production segment of the GDP for these countries is more related to this foreign investment than the general growth of the country. Much of the current and future foreign investment will have a large impact on the potential growth of this country. Dataquest's view of the relative success

Table 2

European Quarterly Semiconductor Revenues
(Millions of Dollars and ECUs)

	Q1	QGR	Q2	QGR	Q3	QGR	Q4	QGR	Total Year	AGR
1990										
Dollars	2,552	8.2%	2,657	4.1%	2,658	0.0%	2,794	5.1%	10,661	9.3%
ECU	2,118	-3.0%	2,179	2.9%	2,047	-6.1%	2,040	-0.3%	8,383	-6.1%
Rate	0.83		0.82		0.77		0.73		0.78	
1991										
Dollars	2,975	6.5%	2,789	-6.3%	2,491	-10.7%	2,573	3.3%	10,828	1.6%
ECU	2,233	9.5%	2,361	5.7%	2,113	-10.5%	2,183	3.3%	8,890	6.0%
Rate	0.75		0.85		0.85		0.85		0.82	
1992										
Dollars	2,748	6.8%	2,889	5.1%	2,847	-1.5%	3,074	8.0%	11,558	6.7%
ECU	2,330	6.7%	2,449	5.1%	2,414	-1.4%	2,606	8.0%	9,799	10.2%
Rate	0.85		0.85		0.85		0.85		0.85	

QGR = Percent quarterly growth rate
AGR = Percent annual growth rate
Source: Dataquest (September 1991)

Table 3

International Economic Forecast
GNP/GDP Growth Rates

	In or Near			AGR			
Region	Recession?	1989	1990	1991	1992	1993	1994
United States	Yes	2.5%	1.0%	0.0%	2.5%	3.0%	2.4%
Japan		4.7%	5.7%	3.8%	4.0%	4.6%	5.0%
France	Yes	4.5%	2.8%	1.4%	2.5%	3.3%	3.0%
Germany (west)		3.9%	4.5%	3.1%	3.0%	3.4%	3.7%
Italy	Yes	3.2%	2.0%	1.4%	2.5%	2.7%	2.8%
Netherlands		4.1%	3.5%	2.4%	3.0%	3.3%	3.1%
Spain		4.9%	3.5%	2.6%	3.2%	3.9%	3.7%
Sweden	Yes	2.1%	0.3%	-0.6%	1.2%	1.6%	2.3%
United Kingdom	Yes	1.7%	0.5%	-1.8%	1.9%	2.9%	3.4%

AGR = Annual growth rate
Source: Dun & Bradstreet Corporation Economic Analysis Department (July 1991)

of countries in attracting foreign investment, and the outlook for these countries in attracting future foreign investment is shown in Table 4.

Applications

The strength of the applications within a region can also have a modifying effect on the overall market size, and cause a country to grow in a manner not related to its GDP. The data processing segment, for example, has been a major growth application in the past; and the strength of the UK and Eire electronics market is partly related to its production of data processing equipment within the region. Table 5 shows the applications splits in 1990 that have been used as the basis for this forecast.

Technologies

The basic technologies used for semiconductor manufacture are silicon bipolar, BiCMOS and MOS. Gallium arsenide and other III-V materials are growing in use, but these are unlikely to have a major impact on the semiconductor market.

Table 4

Attraction of Foreign Investment in Electronics Production

Region	Past Performance	Future Outlook
Benelux	Low	Increasing
France	Low	Low
Germany (west)	Medium	Medium
Italy	Low	Low
Nordic	Low	Low
UK and Eire	High	High
Rest of Europe		
Spain/Portugal	High	High
Austria/Switzerland	Low	Low

Source: Dataquest (September 1991)

Production Capacity

Capacity of worldwide semiconductor production is expected to remain above semiconductor demand throughout the duration of this forecast, though Europe is expected to remain a substantial net importer of semiconductors for the next five years.

Changes from 1990 Forecast

The previous forecast for the European semiconductor market, July 1990, gave a growth of 9.5 percent in US dollars for 1990, and a compound annual growth rate (CAGR) out to 1995 of 18.2 percent. The 1990 actual growth in US dollars was 9.3 percent, and the forecast for the CAGR 1990 to 1995 has been reduced to 9.0 percent.

The long-range forecast made in 1990 was based on a certain set of assumptions, and these assumptions have now changed for the following reasons:

- The economic gloom, apparent in the United States in 1990, spread to the United Kingdom in 1991. This had an effect on economic growth, and from the fourth quarter of 1990 the United Kingdom has been in economic recession. This is expected to improve by the end of 1991, but the rise out of recession is expected to be slow. The recession is spreading into mainland Europe, with France, Italy and Sweden also suffering from low economic growth.
- The unification of Germany is proving to be very expensive. There are signs of inflationary pressures creeping into the German economy; as a result, the German government has increased taxes, and the Bundesbank is increasing interest rates. This will impact further on the European economies as the ECU is heavily weighted towards the value of the deutsche mark.
- Over the past two or three years, Europe has experienced a considerable influx of electronics manufacturing from the Far East. This has included printers, computers, and televisions. However, local purchasing of semiconductors has not increased as fast as was originally expected.

Table 5

Applications Split by Region—1990 (Percent of Total Semiconductor)

Region	EDP	Comms.	Ind.	Cons.	Mil.	Trans.
Benelux	25%	27%	25%	16%	6%	1%
France	24%	24%	18%	15%	12%	7%
Germany	23%	22%	21%	19%	1%	14%
Italy	40%	23%	15%	13%	4%	5%
Nordic	15%	44%	23%	11%	6%	1%
UK and Eire	39%	19%	18%	15%	5%	4%
Rest of Europe	18%	15%	7%	45%	4%	11%

EDP = Electronic Data Processing
Comms. = Communications
Ind. = Industrial
Cons. = Consumer
Mil. = Military
Trans. = Transportation
Source: Dataquest (September 1991)

- The uptake of the 4M DRAM has been a lot slower than expected. This has been partly caused by a slowdown in demand for DRAMs because of the soft PC market, which has extended the life of the 1M DRAM. Prices of the 1M DRAM have fallen, delaying the point at which the 4M becomes economically desirable.
- ASIC revenue per design is lower than was previously projected. This is because of severe price competition for low gate-count gate arrays, coupled with the increasing integration of several smaller ASICs into one ASIC. This, combined with the lower-than-expected number of designs, has led to a reduction in the ASIC revenue forecast.
- The demand for consumer goods has slowed because of economic conditions, causing consumer analog demand to decline. Thomson, one of Europe's major consumer goods manufacturers, is also moving consumer goods manufacturing out of Europe because of the lower costs possible in Far Eastern labor markets. We expect this trend to continue as Philips and Nokia also move some manufacturing out of Europe.
- In spite of the success of military electronics in the Gulf war, the outbreak of peace in Eastern Europe is resulting in major cutbacks in military spending. The military market accounts for only 4.4 percent of the total European semiconductor market, but much process and product research and development is military-funded.

All these factors have combined to reduce the expected 1995 European semiconductor market to $16,368 million. This is a CAGR of 9.0 percent over the period 1990 to 1995.

Product Analysis

Bipolar Memory

The bipolar memory market peaked in 1986, and has been declining ever since. The main reason for the use of bipolar memory is speed; and the advantage gained through the use of bipolar is rapidly declining as CMOS and BiCMOS memories achieve similar speeds. The major bipolar memory market of mainframes has also had very slow growth. The bipolar memory market will decline significantly over the next five years.

Bipolar Logic

The bipolar logic market is gradually being superseded by MOS, as the power and integration advantages offered by CMOS outweigh the speed advantages provided by bipolar. The standard logic market is losing share to the CMOS alternatives to 74LS products, and to CMOS and bipolar ASICs.

Bipolar ASICs will also decline, with emitter-coupled logic (ECL) gate arrays being replaced by BiCMOS arrays in many speed-critical applications. Bipolar programmable logic devices (PLDs) are also in decline, with MOS PLDs now offering comparable speeds for many PLD applications. In 1990, the CMOS PLD market exceeded the bipolar PLD market for the first time.

The other logic market is also in decline. This category includes application-specific standard products, bit-slice arithmetic logic units (ALUs), multipliers, floating-point processors, and digital filters.

In general, the bipolar market will decline, as CMOS and BiCMOS products replace bipolar products in all but the most speed-critical applications. The biggest threat to the bipolar market comes from BiCMOS, which offers a better compromise of speed and power than bipolar in most applications. Only some special, very high-speed applications will maintain the ECL market, where BiCMOS is unable to compete.

MOS Memory

The MOS memory market is the most volatile of all of the semiconductor market segments. The high return required on the massive investment in manufacturing plants needed to participate in much of the MOS memory market, together with the number of suppliers, make memory prices very unstable. An effort to introduce some stability, and give European suppliers a chance to compete in the memory market, was attempted when the European Commission introduced price controls for Japanese memory suppliers. This has allowed European suppliers to compete and gain market share, but has failed to stabilize prices.

MOS memory represented 20 percent of the European semiconductor market in 1990, a decline from 1989, where MOS memory represented 26 percent of the market. The decline is due to the fall in unit prices, as bit growth rates remained strong. The MOS memory market will grow at an above-average rate, increasing its share to 23 percent by 1995.

The largest product group in MOS memory is DRAM; and it is also the most volatile. The large revenue decline in the MOS memory market is due to the fall in DRAM prices. The delay in the take-up of 4M DRAMs by users forced 4M unit prices down, and hence the overall market size. The outlook for the DRAM market is, however, more optimistic, with above-average growth for the next five years.

The future of DRAM supply will be dictated by a combination of new product introductions and local manufacture. The 16M DRAM is expected by the end of 1992, and the 64M by 1996. Prior to this, Europe will be able to supply around half of its DRAM consumption, as seven DRAM suppliers will have fabs on stream by the end of 1993.

The largest user of DRAM is the ubiquitous PC, and the growth in the use of the PC is one of the major drivers to this market. However, the PC growth is slowing, and this is one of the reasons why the growth of the DRAM market is now expected to be lower than previously forecast.

The SRAM market is about one-third the size of the DRAM market, but has many more suppliers. The market is typified by the quest for speed and low power. The products with the highest margins are those with the highest speed. Low-power SRAMs find applications in portable products such as laptop and hand-held PCs. Competition for slower devices is fierce, and there have been several casualties in this market in recent years.

This market grew in 1990, but is expected to decline by 2 percent in US dollars in 1991. The five-year growth for the SRAM market is above DRAM, and above the average for MOS memory.

The nonvolatile memory market is composed of EPROM, EEPROM, ROM and flash memory. Of these, EPROM represents more than 80 percent of the total nonvolatile memory market. The decline in the market in 1991 is mainly due to price erosion on 1M devices.

MOS ROM consumption in Europe is only 2 percent of the world market. The main application for MOS ROM is in games cartridges and font cartridges for laser printers, the majority of which are made in Japan. This market is expected to remain stable throughout the duration of this forecast.

Flash memory is emerging as a popular nonvolatile memory, and is expected ultimately to replace EPROMs and EEPROMs as the cost per bit for flash continues to drop. Some major applications include zero-power memory cards, solid-state replacement for floppy-disk drives in portable computers, and ROM BIOS in PCs.

MOS Microcomponent

MOS microcomponent is composed of microprocessor, microcontroller and microperipheral. The microcomponent market has enjoyed high growth to date, and this high growth is forecast to continue.

The microprocessor market is dominated by a few suppliers, and this lack of competition between the suppliers has kept prices relatively higher than is apparent in the memory market. The largest single use of microprocessors, the PC, has stimulated very high growth in this market. The unit growth of PC sales is slowing, however, but the price of the processor used in this device is increasing, as PC users opt for more powerful machines. This market will continue to grow well above the European semiconductor average, and the dominance of the few suppliers is set to continue.

The microcontroller market will also grow well above the European semiconductor average. The increase in the use of more powerful 8-, 16- and 32-bit microcontrollers in control applications will stimulate market growth. The largest unit shipments in Europe are for 4-bit controllers, but the higher prices commanded by 8- and 16-bit controllers mean they achieve higher revenue. The lower unit shipments for devices of longer word length give greater capacity for growth, and this will come especially in telecoms, consumer and automotive applications.

The microperipheral market will exhibit the lowest growth of the microcomponent market. Most microperipheral devices are attached to microprocessors, and the increased integration capabilities of microprocessors allows the inclusion of the microperipheral devices into the microprocessor chip. However, growth is provided through the development of new, highly integrated, graphics chip sets; and the increase in the use of local area networks gives a high growth to the market for LAN chips. The high growth in the past has come from the development of PC chip sets, but competition here is cutting prices, and the development of processor chip sets such as Intel's laptop 386SL is also reducing the market size.

MOS Logic

The MOS logic market is composed of ASIC, standard logic and other logic. The ASIC market is forecast to continue its high growth, with a growth rate above the European average. Much of this growth comes from cell-based ICs (CBIC) and PLD, with PLD showing the highest growth. In 1990, MOS PLD revenue overtook bipolar PLD revenue for the first time. The new field-programmable gate arrays will show the highest growth, and will become the preferred choice for many low gate-count designs.

Standard logic includes the 7400 logic families, and this market has been suffering from price erosion. The decline in the market has, however, been balanced by the growth achieved at the expense of bipolar logic. The HC and AC logic families give a better speed and power trade-off, so are more likely to be chosen for new designs than bipolar 7400 logic families. The standard logic market is now becoming profitable, as the move away from simple gates and towards octal drivers moves the unit price up for the devices. The introduction of the BiCMOS-based BC and BCT families, which focus on the more profitable 8-, 9- and 10-bit word lengths, will also add to longer-term profitability and growth for this market.

Other MOS logic includes application-specific standard products (ASSPs), digital filters, barrel shifters, and other building blocks. Many of these products are used in DSP designs for telecoms applications, and are likely to be replaced by specialized designs targeted at specific applications. The growth of this market is forecast at average growth, as the complex, and higher-priced devices replace the lower-priced, higher-volume, building blocks.

Analog

The analog market is forecast to grow below the average rate for the semiconductor market over the five years, 1990 to 1995. Much of the analog ICs sold in Europe are for industrial, consumer and telecoms applications, and the wide variations in growth in the consumer market are balanced by the lower, and more steady growth of the telecoms and industrial markets. Much of the future of the telecoms market is with digital equipment, hence the below-average growth for the analog section. The wide range of other applications for analog ICs also gives stability, but lower-than-average growth to the analog market.

Discretes and Optoelectronics

Discretes and optoelectronics are similar to analog products in that the market has a wide range of applications. This also gives low growth and stability to the market. Over half of the discrete market is for transistors; it is composed of low-power, servo-assisted control systems, and higher-power motor control and regulators. Higher growth is seen for very high-power applications such as traction in passenger transport systems, and in automotive applications for motor control. The growth of the discrete market is below that of the semiconductor market as a whole.

Country Analysis

Dataquest has made estimates for the size of the semiconductor markets of each of the 22 countries that comprise Western Europe. These countries, grouped by region, are Belgium, the Netherlands, Luxembourg, France, Italy, Denmark, Finland, Iceland, Norway, Sweden, England, Scotland, Wales, Northern Ireland, Eire, Germany, Austria, Greece, Malta, Portugal, Spain, Switzerland, and Turkey. See Table 1 for 1990 semiconductor market sizes. Figure 2 shows European semiconductor markets by region, and Figure 3 shows European semiconductor markets by country. These and the remainder of the figures and tables have been placed at the end of the analysis for presentation purposes.

Benelux

The Belgian market has a small base of mainly telecoms and some consumer end users which grew well above the European average between 1989 and 1990. It represents approximately one-third of the Benelux market. By contrast, the Netherlands' semiconductor market, consisting of mainly consumer and some telecoms and EDP end users, represents almost two-thirds of the Benelux market, but grew below the European average in 1990. Luxembourg has very little semiconductor demand.

France

The French market is expected to grow below the European average. The current economic conditions in France are contributing to low short-term growth, and France's failure to attract foreign investment, in particular Japanese investment, is contributing to long-term lower growth. France is the home of Alcatel, the world's largest telecoms manufacturer, so the higher growth for telecoms products would be expected to increase the size of the French market. However, Alcatel has little switch manufacture in France, and switches are one of the areas of highest growth for new telecoms applications. France also has the largest military market in Europe, and the reductions in military manufacture will affect the French market significantly.

Italy

The Italian market is dominated by the EDP market, and Olivetti in particular (whose recent health was below that of the general computer market). The decline in the memory market therefore had a major impact on the Italian market. The future of the Italian market is also tied closely to the EDP sector, as Hewlett-Packard will shortly be manufacturing laser printers in Italy, and IBM is now manufacturing AS/400s there.

The weakness of the automotive sector is also affecting the Italian market, as new car sales have slumped. However, the longer-term outlook is for high growth in automotive applications as the electronic content of cars rises.

Nordic Countries

The Danish semiconductor market represents less than a tenth of the Nordic regional market. This country has a small number of consumer, telecoms, and EDP end users. However, it is distribution rather than OEM business that features here. The Finnish semiconductor market is approximately 40 percent larger than the Danish market, and has a base of telecoms, EDP and consumer manufacturers. The Norwegian market is the smallest of the four Nordic markets, with end users in telecoms and EDP. The largest and representative market of this region is Sweden. This country accounts for nearly three-quarters of the Nordic semiconductor market, with end users mainly in telecoms, but also in EDP, consumer, and industrial.

United Kingdom and Eire

The English semiconductor market has end users across a broad base of segments, but is weighted towards EDP, industrial, and telecoms. This country represents over two-thirds of the total market for this region. Scotland, the next-largest consuming country in this region, accounts for 20 percent. End users are weighted towards EDP and consumer. Wales and Northern Ireland between them account for around 5 percent of this region, and are weighted in consumer end users. Eire has mainly EDP end users, and accounts for the remaining share.

Germany

Germany is the largest semiconductor market in Europe, followed closely by the United Kingdom and Eire. The most significant event affecting the German market was the unification of east and west Germany in 1990. This gave a boost to consumer sales, as east Germans spent their new-found deutsche marks. This consumer boom is now over, however, and the German market is attempting to absorb east German demands.

The greatest area for future growth is in telecoms, as the telecoms infrastructure in eastern Germany needs considerable investment. Siemens and Alcatel will be the major beneficiaries of this. The automotive sector has been strong in the past, but growth here is slowing. This is related to lower car exports to the United States.

We forecast the German market to grow at the European average over the next five years, as the telecoms infrastructure is rebuilt in east Germany, and access to the rest of the Eastern European markets is gained through Germany.

Rest of Europe

This region comprises all other remaining Western European countries not already covered. The Austrian market is one of the larger ones in this group, accounting for around one-quarter of total semiconductor demand. End users are biased towards telecoms and industrial segments. The Greek semiconductor market is relatively underdeveloped and represents a minor market in this group, with a bias towards low-end consumer. The same applies to the Maltese market, which is half the size of the Greek market. The Portuguese market is the least substantial, with a weighting towards consumer and telecoms. Spain has a market of similar size to Austria, around one-quarter the size for the total group, with the majority of users from the consumer, telecoms, and EDP segments. The Swiss market is the largest market of this region, accounting for nearly one-third of the total group, with end users based in the segments of EDP, telecoms, and industrial. Finally, the Turkish market is biased towards consumer and telecoms, with a market nearly four times the size of Greece.

Graphical Analysis

The following figures provide a graphical analysis behind the European forecast, and give an indication of the key trends in this market.

The revenue for the European semiconductor market in both US dollars and ECU is shown in Figure 4. It demonstrates the impact of the change in exchage rates between the US dollar and the ECU on the size of the European market. (This impact is made more clear in Figure 5 showing the growth of the European market when measured in ECUs and US dollars.) The years 1986, 1987 and 1990 show revenue growth when measured in US dollars, but when measured in local currency (ECU) the market actually declined. The gradual weakening of the dollar against the ECU has masked a decline in the semiconductor market for this period. Figure 6 shows the exchange rate between the ECU and the dollar, and over the six-year period, 1985 to 1991, the dollar has declined by nearly 40 percent.

The ECU is a European currency tied to the values of the other European currencies. These curencies have all strengthened against the US dollar, but at different rates relative to each other. Figure 7 shows the relative exchange rates of the local currencies by setting their 1985 value to 100, and by monitoring the exchange rate to the dollar. The wide spread of exchange rates between the Dutch gulden and the UK pound will impact the value of each of the regions, and may also mask true local market variations. It is because of this that the regional forecasts are presented in US dollars, ECUs and local currency.

Product and Market Analysis

The Boston Consulting Group identified a method for analysing the performance of a particular product by plotting the growth and market share of this product. By drawing a growth/share matrix it is possible to classify a product, and position it against a standard product.

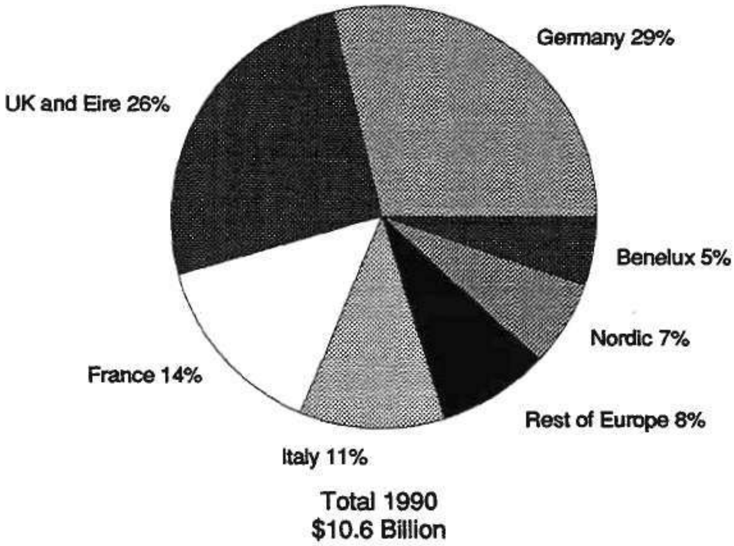
It is also possible to perform this analysis on markets, and regions. Figures 8 and 9 show the relative performance of the product categories when measured in ECUs. The growth plotted is the 1990 to 1995 CAGR, and the market share is for 1990. The average share for the products is obtained by dividing the total semiconductor market by six, for the six categories: digital bipolar, MOS memory, MOS microcomponent, MOS logic, analog, and discretes and optoelectronics. The average growth is the European total semiconductor CAGR, 1990 to 1995.

The Boston Consulting Group matrix identifies the four elements of the matrix as: Problem Children (for high growth, low share), Stars (for high growth, high share), Dogs (for low growth, low share), and Cash Cows (for low growth, high share). Analysis of the matrix gives no surprises, as the MOS memory, microcomponent and MOS digital products are the stars of the product portfolio. The dogs are bipolar digital products, the cash cows are analog, and discrete and optoelectronic products, and the problem child is logic—as the decline in standard products is offset by the rise in ASIC.

Analysis of the regions in a similar way also yields the expected result. France and Germany are the cash cows, the United Kingdom and Eire is the rising star, Italy and the Rest of Europe are the problem children, and the dogs are the Nordic and Benelux regions.

Figure 2

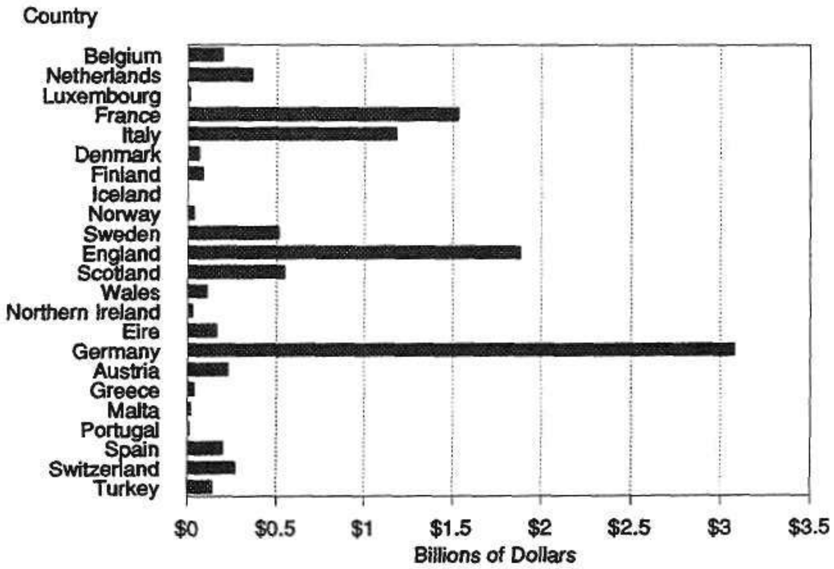
Estimated 1990 European Regional Semiconductor Markets



Source: Dataquest (September 1991)

Figure 3

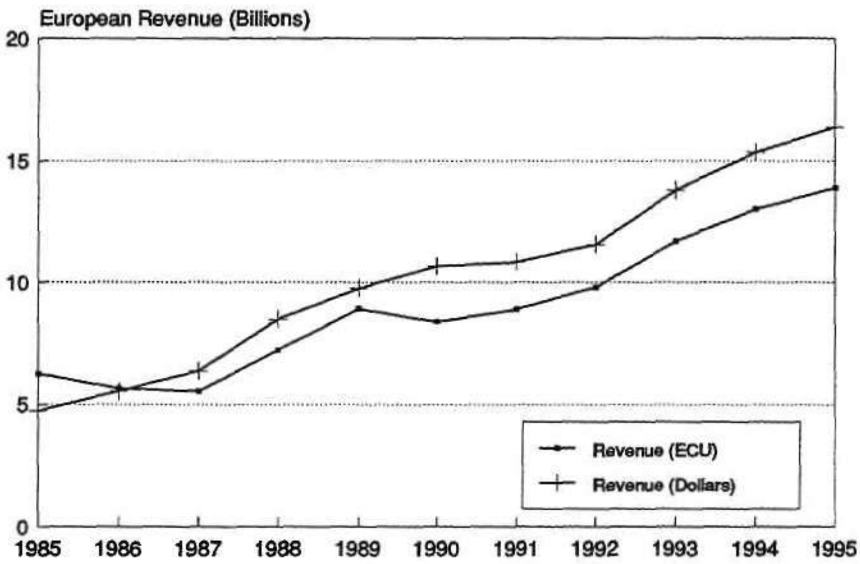
Estimated 1990 European Country Semiconductor Markets



Source: Dataquest (September 1991)

Figure 4

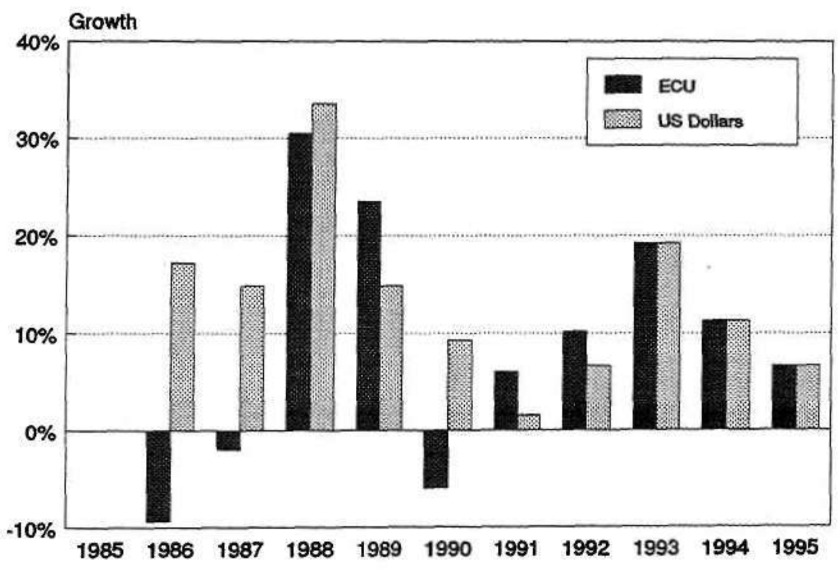
Total Semiconductor
European Market 1985-1995



Source: Dataquest (September 1991)

Figure 5

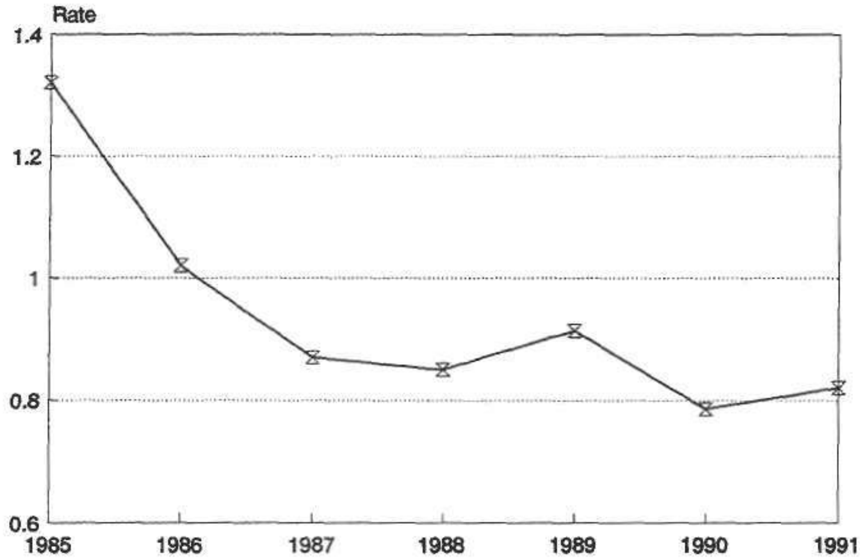
Total Semiconductor
European Growth 1985-1995



Source: Dataquest (September 1991)

Figure 6

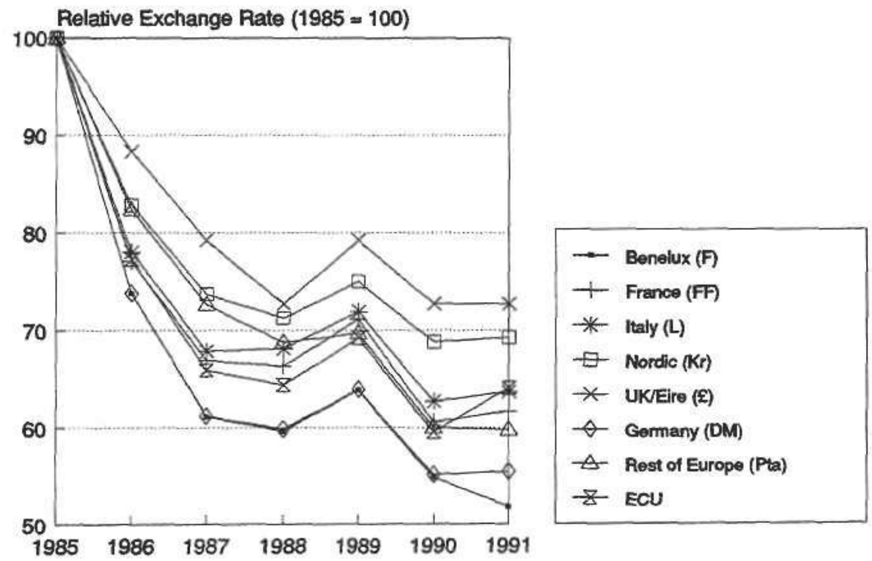
Exchange Rate
Dollars to ECU



Source: Dataquest (September 1991)

Figure 7

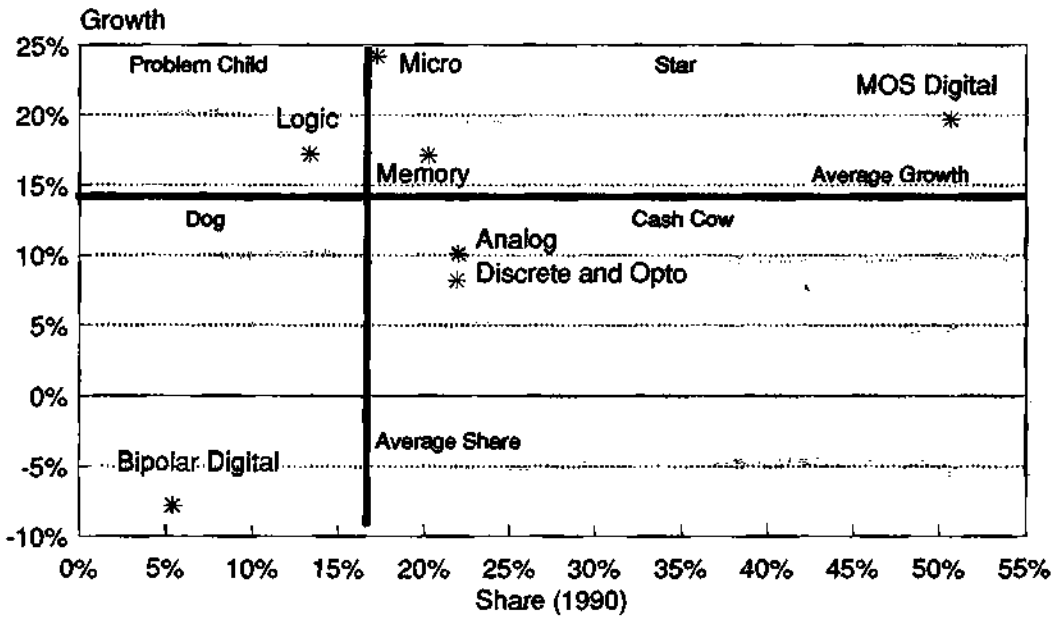
Relative Exchange Rates
Dollars to Local Currency



Source: Dataquest (September 1991)

Figure 8

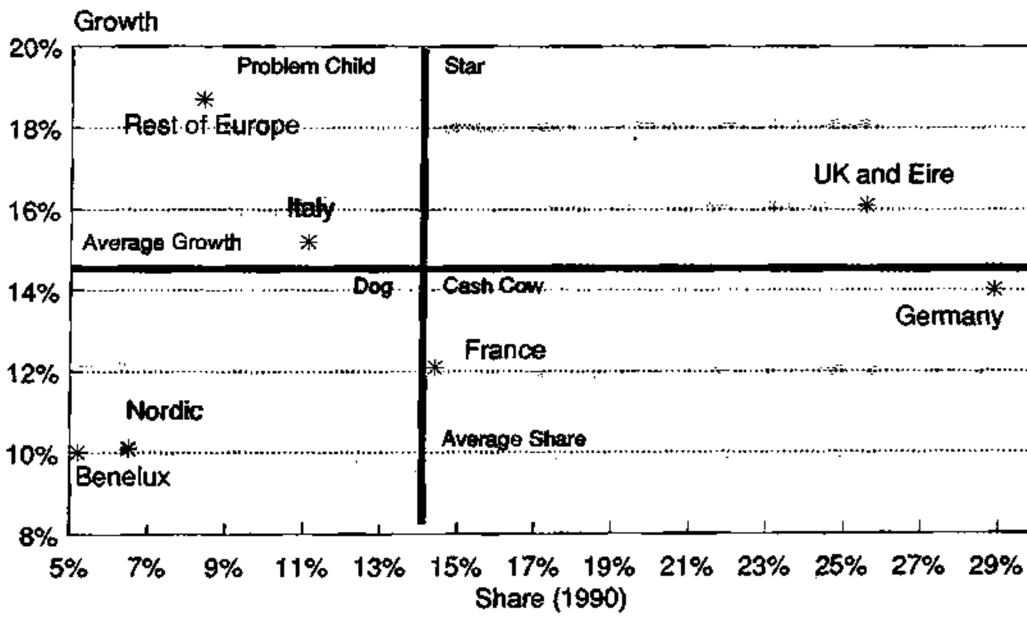
Growth Share Matrix
European Products



Source: Dataquest (September 1991)

Figure 9

Growth Rate Matrix
European Regions



Source: Dataquest (September 1991)

Table 6

Estimated Semiconductor Consumption—History
Total All European Regions
(Millions of Dollars)

History	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$4,720	$5,532	$6,355	$8,491	$9,755	$10,661	17.7%
Total Integrated Circuit	$3,556	$4,088	$4,693	$6,669	$7,794	$8,326	18.5%
Bipolar Digital	$709	$782	$725	$772	$640	$577	-4.0%
TTL	641	705	564	624	501	430	-7.7%
ECL	68	77	161	148	139	147	16.7%
Bipolar Digital	$709	$782	$725	$772	$640	$577	-4.0%
Memory	157	172	85	74	72	58	-18.1%
Logic	552	610	640	698	568	519	-1.2%
ASIC	NA	230	210	241	260	216	NA
Std. Logic	NA	376	410	394	282	248	NA
Other Logic	NA	4	20	63	26	55	NA
MOS Digital	$1,953	$2,280	$2,753	$4,364	$5,458	$5,403	22.6%
CMOS	702	976	1,284	2,491	3,412	4,032	41.9%
BiCMOS	NA	NA	24	56	60	39	NA
NMOS and Other	1,251	1,304	1,445	1,817	1,986	1,332	1.3%
MOS Digital	$1,953	$2,280	$2,753	$4,364	$5,458	$5,403	22.6%
Memory	$750	$822	$838	$1,797	$2,548	$2,154	23.5%
DRAM	NA	262	402	1,062	1,646	1,216	NA
SRAM	NA	252	117	262	368	396	NA
Nonvolatile	NA	308	319	473	519	515	NA
Other	NA	NA	NA	NA	15	27	NA
Microcomponent	$485	$578	$794	$1,212	$1,469	$1,836	30.5%
MPU	NA	95	217	341	409	511	NA
MCU inc. DSP	NA	249	339	473	640	799	NA
MPR	NA	234	238	398	420	526	NA
Logic	$718	$880	$1,121	$1,355	$1,441	$1,413	14.5%
ASIC	NA	443	485	711	877	926	NA
Std. Logic	NA	157	229	287	263	230	NA
Other Logic	NA	280	407	357	301	257	NA
Analog	$894	$1,026	$1,215	$1,533	$1,696	$2,346	21.3%
Monolithic	$894	$975	$1,153	$1,416	$1,560	$2,187	19.6%
Amplifiers	144	166	180	200	248	199	6.7%
Regulators	54	62	71	90	111	125	18.3%
Data Conversion	157	185	96	116	131	160	0.4%
Interface	80	94	120	145	151	88	1.9%
Special Consumer	318	360	417	475	525	625	14.5%
ASIC	NA	NA	NA	NA	NA	189	NA
Other	141	108	269	390	394	801	41.5%
Hybrid	NA	51	62	117	136	159	NA
Total Discrete	$954	$1,153	$1,384	$1,516	$1,594	$1,915	15.0%
Transistor	463	540	655	709	817	933	15.0%
Diode	342	432	431	473	516	618	12.6%
Thyristor	100	125	183	210	179	233	18.4%
Other	49	56	115	124	82	131	21.7%
Total Optoelectronic	$210	$291	$278	$306	$367	$420	14.9%
LED Lamp	55	76	57	46	57	79	7.5%
LED Display	62	87	48	38	43	60	-0.7%
Optocoupler	41	56	68	64	75	112	22.3%
Other	52	72	105	158	192	169	26.6%

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 7

Estimated Semiconductor Consumption—Forecast
Total All European Regions
(Millions of Dollars)

Forecast	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$10,661	$10,828	$11,556	$13,777	$15,335	$16,368	9.0%
Total Integrated Circuit	$8,326	$8,683	$9,478	$11,475	$12,897	$13,847	10.7%
Bipolar Digital	$577	$489	$425	$395	$361	$317	-11.3%
TTL	430	352	289	250	209	162	-17.7%
ECL	147	137	136	145	152	155	1.1%
Bipolar Digital	$577	$489	$425	$395	$361	$317	-11.3%
Memory	58	49	41	40	32	25	-15.5%
Logic	519	440	384	355	329	292	-10.9%
ASIC	216	189	175	176	174	170	-4.7%
Std. Logic	248	204	171	145	124	95	-17.5%
Other Logic	55	47	38	34	31	27	-13.3%
MOS Digital	$5,403	$5,777	$6,596	$8,302	$9,452	$10,260	13.7%
CMOS	4,032	4,307	4,911	6,173	7,022	7,613	13.6%
BiCMOS	39	104	189	327	473	624	74.1%
NMOS and Other	1,332	1,366	1,496	1,802	1,957	2,023	8.7%
MOS Digital	$5,403	$5,776	$6,597	$8,304	$9,455	$10,263	13.7%
Memory	$2,154	$2,094	$2,445	$3,204	$3,604	$3,832	12.2%
DRAM	1,216	1,208	1,411	1,897	2,066	2,093	11.5%
SRAM	396	389	489	630	757	852	16.6%
Nonvolatile	515	461	503	626	722	819	9.7%
Other	27	36	42	51	59	68	20.3%
Microcomponent	$1,836	$2,219	$2,529	$3,085	$3,532	$3,885	16.2%
MPU	511	615	683	833	978	1,112	16.8%
MCU inc. DSP	799	989	1,163	1,451	1,621	1,769	17.2%
MPR	526	615	683	801	933	1,004	13.8%
Logic	$1,413	$1,463	$1,622	$2,014	$2,318	$2,545	12.5%
ASIC	926	988	1,130	1,442	1,705	1,917	15.7%
Std. Logic	230	219	216	238	239	223	-0.6%
Other Logic	257	256	276	334	374	405	9.5%
Analog	$2,346	$2,418	$2,456	$2,776	$3,081	$3,267	6.8%
Monolithic	$2,187	$2,255	$2,292	$2,591	$2,877	$3,051	6.9%
Amplifiers	199	193	184	196	204	203	0.4%
Regulators	125	123	119	127	134	136	1.7%
Data Conversion	160	161	159	176	190	195	4.0%
Interface	88	87	85	91	96	97	2.0%
Special Consumer	625	646	657	743	825	873	6.9%
ASIC	189	201	211	246	281	308	10.3%
Other	801	844	877	1,012	1,147	1,239	9.1%
Hybrid	159	163	164	185	204	216	6.3%
Total Discrete	$1,915	$1,750	$1,682	$1,864	$1,954	$2,013	1.0%
Transistor	933	856	825	916	962	997	1.3%
Diode	618	565	543	603	633	651	1.0%
Thyristor	233	211	201	221	230	234	0.1%
Other	131	118	113	124	129	131	0.0%
Total Optoelectronic	$420	$395	$396	$438	$484	$508	3.9%
LED Lamp	79	72	70	75	81	83	1.0%
LED Display	60	55	54	59	65	66	1.9%
Optocoupler	112	107	109	122	136	145	5.3%
Other	169	161	163	182	202	214	4.8%

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 8

Estimated Semiconductor Consumption—History
Total All European Regions
(Millions of ECUs)

History	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	6,230	5,643	5,529	7,217	8,916	8,380	6.1%
Total Integrated Circuit	4,694	4,170	4,083	5,669	7,124	6,544	6.9%
Bipolar Digital	936	798	631	656	585	454	-13.5%
TTL	846	719	491	530	458	338	-16.8%
ECL	90	79	140	126	127	116	5.2%
Bipolar Digital	936	798	631	656	585	454	-13.5%
Memory	207	175	74	63	66	46	-26.0%
Logic	729	622	557	593	519	408	-11.0%
ASIC	NA	235	183	205	238	170	NA
Std. Logic	NA	384	357	335	258	195	NA
Other Logic	NA	4	17	54	24	43	NA
MOS Digital	2,578	2,326	2,395	3,709	4,989	4,247	10.5%
CMOS	927	996	1,117	2,117	3,119	3,169	27.9%
BiCMOS	NA	NA	21	48	55	31	NA
NMOS and Other	1,651	1,330	1,257	1,544	1,815	1,047	-8.7%
MOS Digital	2,578	2,326	2,395	3,709	4,989	4,247	10.5%
Memory	990	838	729	1,527	2,329	1,693	11.3%
DRAM	NA	267	350	903	1,504	956	NA
SRAM	NA	257	102	223	336	311	NA
Nonvolatile	NA	314	278	402	474	405	NA
Other	NA	NA	NA	NA	14	21	NA
Microcomponent	640	590	691	1,030	1,343	1,443	17.7%
MPU	NA	97	189	290	374	402	NA
MCU inc. DSP	NA	254	295	402	585	628	NA
MPR	NA	239	207	338	384	413	NA
Logic	948	898	975	1,152	1,317	1,111	3.2%
ASIC	NA	452	422	604	802	728	NA
Std. Logic	NA	160	199	244	240	181	NA
Other Logic	NA	286	354	303	275	202	NA
Analog	1,180	1,047	1,057	1,303	1,550	1,844	9.3%
Monolithic	1,180	995	1,003	1,204	1,426	1,719	7.8%
Amplifiers	190	169	157	170	227	156	-3.9%
Regulators	71	63	62	77	101	98	6.7%
Data Conversion	207	189	84	99	120	126	-9.5%
Interface	106	96	104	123	138	69	-8.2%
Special Consumer	420	367	363	404	480	491	3.2%
ASIC	NA	NA	NA	NA	NA	149	NA
Other	186	110	234	332	360	630	27.6%
Hybrid	NA	52	54	99	124	125	NA
Total Discrete	1,259	1,176	1,204	1,289	1,457	1,505	3.6%
Transistor	611	551	570	603	747	733	3.7%
Diode	451	441	375	402	472	486	1.5%
Thyristor	132	128	159	179	164	183	6.8%
Other	65	57	100	105	75	103	9.6%
Total Optoelectronic	277	297	242	260	335	330	3.6%
LED Lamp	73	78	50	39	52	62	-3.2%
LED Display	82	89	42	32	39	47	-10.5%
Optocoupler	54	57	59	54	69	88	10.3%
Other	69	73	91	134	175	133	14.0%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.78	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 9

Estimated Semiconductor Consumption—Forecast
Total All European Regions
(Millions of ECUs)

Forecast	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	8,380	8,890	9,799	11,683	13,004	13,880	10.6%
Total Integrated Circuit	6,544	7,129	8,037	9,731	10,937	11,742	12.4%
Bipolar Digital	454	401	360	335	306	269	-9.9%
TTL	338	289	245	212	177	137	-16.5%
ECL	116	112	115	123	129	131	2.5%
Bipolar Digital	454	401	360	335	306	269	-9.9%
Memory	46	40	35	34	27	21	-14.5%
Logic	408	361	326	301	279	248	-9.5%
ASIC	170	155	148	149	148	144	-3.3%
Std. Logic	195	167	145	123	105	81	-16.1%
Other Logic	43	39	32	29	26	23	-11.8%
MOS Digital	4,247	4,743	5,593	7,040	8,015	8,700	15.4%
CMOS	3,169	3,536	4,165	5,235	5,955	6,456	15.3%
BiCMOS	31	85	160	277	401	529	76.4%
NMOS and Other	1,047	1,121	1,269	1,528	1,660	1,716	10.4%
MOS Digital	4,247	4,742	5,594	7,042	8,018	8,703	15.4%
Memory	1,693	1,719	2,073	2,717	3,056	3,250	13.9%
DRAM	956	992	1,197	1,609	1,752	1,775	13.2%
SRAM	311	319	415	534	642	722	18.3%
Nonvolatile	405	378	427	531	612	695	11.4%
Other	21	30	36	43	50	58	22.5%
Microcomponent	1,443	1,822	2,145	2,616	2,995	3,294	17.9%
MPU	402	505	579	706	829	943	18.6%
MCU inc. DSP	628	812	986	1,230	1,375	1,500	19.0%
MPR	413	505	579	679	791	851	15.6%
Logic	1,111	1,201	1,375	1,708	1,966	2,158	14.2%
ASIC	728	811	958	1,223	1,446	1,626	17.4%
Std. Logic	181	180	183	202	203	189	0.9%
Other Logic	202	210	234	283	317	343	11.2%
Analog	1,844	1,985	2,083	2,354	2,613	2,770	8.5%
Monolithic	1,719	1,851	1,944	2,197	2,440	2,587	8.5%
Amplifiers	156	158	156	166	173	172	2.0%
Regulators	98	101	101	108	114	115	3.3%
Data Conversion	126	132	135	149	161	165	5.5%
Interface	69	71	72	77	81	82	3.5%
Special Consumer	491	530	557	630	700	740	8.6%
ASIC	149	165	179	209	238	261	11.9%
Other	630	693	744	858	973	1,051	10.8%
Hybrid	125	134	139	157	173	183	7.9%
Total Discrete	1,505	1,437	1,426	1,581	1,657	1,707	2.6%
Transistor	733	703	700	777	816	845	2.9%
Diode	486	464	460	511	537	552	2.6%
Thyristor	183	173	170	187	195	198	1.6%
Other	103	97	96	105	109	111	1.5%
Total Optoelectronic	330	324	336	371	410	431	5.5%
LED Lamp	62	59	59	64	69	70	2.5%
LED Display	47	45	46	50	55	56	3.6%
Optocoupler	88	88	92	103	115	123	6.9%
Other	133	132	138	154	171	181	6.4%
Rate (ECU: $)	0.78	0.82	0.85	0.85	0.85	0.85	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 10

Estimated Semiconductor Consumption History
Benelux Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$304	$358	$403	$496	$498	$559	13.0%
Total Integrated Circuit	$235	$274	$303	$361	$365	$400	11.2%
Bipolar Digital	$47	$52	$43	$45	$37	$31	-8.0%
Memory	11	12	5	4	4	3	-22.9%
Logic	36	40	38	41	33	28	-4.9%
MOS Digital	$129	$155	$184	$213	$230	$224	11.7%
Memory	49	57	42	72	77	67	6.5%
Microcomponent	33	39	64	73	78	91	22.5%
Logic	47	59	78	68	75	66	7.0%
Analog	$59	$67	$76	$103	$98	$145	19.7%
Monolithic	59	67	76	103	98	135	18.0%
Hybrid	NA	NA	NA	NA	NA	10	NA
Total Discrete	$56	$66	$82	$107	$104	$127	17.8%
Total Optoelectronic	$13	$18	$18	$28	$29	$32	19.7%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	401	365	351	422	455	439	1.8%
Total Integrated Circuit	310	279	264	307	334	314	0.3%
Bipolar Digital	62	53	37	38	34	24	-17.0%
Memory	15	12	4	3	4	2	-30.5%
Logic	48	41	33	35	30	22	-14.3%
MOS Digital	170	158	160	181	210	176	0.7%
Memory	65	58	37	61	70	53	-4.0%
Microcomponent	44	40	56	62	71	72	10.4%
Logic	62	60	68	58	69	52	-3.5%
Analog	78	68	66	88	90	114	7.9%
Monolithic	78	68	66	88	90	106	6.4%
Hybrid	NA	NA	NA	NA	NA	8	NA
Total Discrete	74	67	71	91	95	100	6.2%
Total Optoelectronic	17	18	16	24	27	25	7.9%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (F M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	1,009	877	818	982	1,056	1,017	0.2%
Total Integrated Circuit	780	671	615	715	774	728	-1.4%
Bipolar Digital	156	127	87	89	78	56	-18.4%
Memory	37	29	10	8	8	5	-31.6%
Logic	120	98	77	81	70	51	-15.7%
MOS Digital	428	380	374	422	488	408	-1.0%
Memory	163	140	85	143	163	122	-5.6%
Microcomponent	110	96	130	145	165	166	8.6%
Logic	156	145	158	135	159	120	-5.1%
Analog	196	164	154	204	208	264	6.1%
Monolithic	196	164	154	204	208	246	4.6%
Hybrid	NA	NA	NA	NA	NA	18	NA
Total Discrete	186	162	166	212	220	231	4.5%
Total Optoelectronic	43	44	37	55	61	58	6.2%
Rate (F: $)	3.3	2.5	2.0	2.0	2.1	1.8	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 11

Estimated Semiconductor Consumption—Forecast
Benelux Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$559	$551	$565	$647	$690	$704	4.7%
Total Integrated Circuit	$400	$416	$427	$491	$528	$538	6.1%
Bipolar Digital	31	27	22	21	19	16	-12.4%
Memory	3	3	2	2	2	2	-7.8%
Logic	28	24	20	19	17	14	-12.9%
MOS Digital	$224	$226	$235	$282	$312	$346	9.1%
Memory	67	60	58	68	71	87	5.4%
Microcomponent	91	108	119	142	152	164	12.5%
Logic	66	58	58	72	89	95	7.6%
Analog	$145	$163	$170	$188	$197	$176	4.0%
Monolithic	135	152	159	177	184	165	4.1%
Hybrid	10	11	12	12	12	10	0.0%
Total Discrete	$127	$108	$108	$123	$129	$131	0.6%
Total Optoelectronic	$32	$27	$30	$33	$33	$35	1.8%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	439	452	479	549	585	597	6.3%
Total Integrated Circuit	314	342	362	416	448	456	7.7%
Bipolar Digital	24	22	19	18	16	14	-11.0%
Memory	2	2	2	2	2	2	0.0%
Logic	22	20	17	16	14	12	-11.6%
MOS Digital	176	186	199	239	265	293	10.8%
Memory	53	49	49	58	60	74	7.0%
Microcomponent	72	89	101	120	129	139	14.2%
Logic	52	48	49	61	75	81	9.2%
Analog	114	134	144	159	167	149	5.5%
Monolithic	106	125	135	150	156	140	5.7%
Hybrid	8	9	10	10	10	8	1.5%
Total Discrete	100	89	92	104	109	111	2.2%
Total Optoelectronic	25	22	25	28	28	30	3.4%
Rate: (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (F M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	1,017	1,047	1,107	1,268	1,352	1,380	6.3%
Total Integrated Circuit	728	790	837	962	1,035	1,054	7.7%
Bipolar Digital	56	51	43	41	37	31	-11.1%
Memory	5	6	4	4	4	4	-4.4%
Logic	51	46	39	37	33	27	-11.6%
MOS Digital	408	429	461	553	612	678	10.7%
Memory	122	114	114	133	139	171	6.9%
Microcomponent	166	205	233	278	298	321	14.2%
Logic	120	110	114	141	174	186	9.2%
Analog	264	310	333	368	386	345	5.5%
Monolithic	246	289	312	347	361	323	5.6%
Hybrid	18	21	24	24	24	20	1.5%
Total Discrete	231	205	212	241	253	257	2.1%
Total Optoelectronic	58	51	59	65	65	69	3.3%
Rate (F: $)	1.8	1.9	2.0	2.0	2.0	2.0	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 12

Estimated Semiconductor Consumption—History
France Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$671	$801	$940	$1,210	$1,386	$1,532	18.0%
Total Integrated Circuit	$503	$591	$716	$977	$1,122	$1,217	19.3%
Bipolar Digital	$101	$114	$109	$115	$83	$78	-5.0%
Memory	23	26	13	10	8	7	-21.2%
Logic	78	88	96	105	75	71	-1.9%
MOS Digital	$276	$328	$422	$631	$777	$780	23.1%
Memory	107	121	126	232	350	300	22.9%
Microcomponent	68	82	127	182	207	262	31.0%
Logic	101	125	169	217	220	218	16.6%
Analog	$126	$149	$185	$231	$262	$359	23.3%
Monolithic	126	141	176	214	237	337	21.7%
Hybrid	NA	8	9	17	25	22	NA
Total Discrete	$135	$165	$185	$196	$220	$266	14.5%
Total Optoelectronic	$33	$45	$39	$37	$44	$49	8.2%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	886	817	818	1,029	1,267	1,204	6.3%
Total Integrated Circuit	664	603	623	830	1,026	957	7.6%
Bipolar Digital	133	116	95	98	76	61	-14.4%
Memory	30	27	11	9	7	6	-28.9%
Logic	103	90	84	89	69	56	-11.5%
MOS Digital	364	335	367	536	710	613	11.0%
Memory	141	123	110	197	320	236	10.8%
Microcomponent	90	84	110	155	189	206	18.1%
Logic	133	128	147	184	201	171	5.1%
Analog	166	152	161	196	239	282	11.2%
Monolithic	166	144	153	182	217	265	9.8%
Hybrid	NA	8	8	14	23	17	NA
Total Discrete	178	168	161	167	201	209	3.2%
Total Optoelectronic	44	46	34	31	40	39	-2.4%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (FF M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	6,026	5,543	5,649	7,212	8,857	8,334	6.7%
Total Integrated Circuit	4,517	4,090	4,303	5,823	7,170	6,620	7.9%
Bipolar Digital	907	789	655	685	530	424	-14.1%
Memory	207	180	78	60	51	38	-28.7%
Logic	700	609	577	626	479	386	-11.2%
MOS Digital	2,478	2,270	2,536	3,761	4,965	4,243	11.4%
Memory	961	837	757	1,383	2,237	1,632	11.2%
Microcomponent	611	567	763	1,085	1,323	1,425	18.5%
Logic	907	865	1,016	1,293	1,406	1,186	5.5%
Analog	1,131	1,031	1,112	1,377	1,674	1,953	11.5%
Monolithic	1,131	976	1,058	1,275	1,514	1,833	10.1%
Hybrid	NA	55	54	101	160	120	NA
Total Discrete	1,212	1,142	1,112	1,168	1,406	1,447	3.6%
Total Optoelectronic	296	311	234	221	281	267	-2.1%
Rate (FF: $)	9.0	6.9	6.0	6.0	6.4	5.4	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 13

Estimated Semiconductor Consumption—Forecast
France Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$1,532	$1,391	$1,502	$1,811	$2,037	$2,199	7.5%
Total Integrated Circuit	$1,217	$1,133	$1,248	$1,526	$1,734	$1,897	9.3%
Bipolar Digital	78	60	50	50	46	39	-12.9%
Memory	7	5	4	4	4	2	-22.2%
Logic	71	55	46	46	42	37	-12.2%
MOS Digital	$780	$757	$859	$1,089	$1,251	$1,395	12.3%
Memory	300	264	300	389	440	484	10.0%
Microcomponent	262	294	337	418	479	543	15.7%
Logic	218	199	222	282	332	368	11.0%
Analog	$359	$316	$339	$387	$437	$463	5.2%
Monolithic	337	297	318	364	413	436	5.3%
Hybrid	22	19	20	22	26	27	4.2%
Total Discrete	$266	$218	$213	$239	$253	$251	-1.2%
Total Optoelectronic	$49	$40	$41	$46	$50	$51	0.8%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	1,204	1,142	1,274	1,536	1,727	1,865	9.1%
Total Integrated Circuit	957	930	1,058	1,294	1,470	1,609	11.0%
Bipolar Digital	61	49	42	42	39	33	-11.6%
Memory	6	4	3	3	3	2	-21.0%
Logic	56	45	39	39	36	31	-10.9%
MOS Digital	613	621	728	923	1,061	1,183	14.0%
Memory	236	217	254	330	373	410	11.7%
Microcomponent	206	241	286	354	406	460	17.5%
Logic	171	163	188	239	282	312	12.7%
Analog	282	259	287	328	371	393	6.8%
Monolithic	265	244	270	309	350	370	6.9%
Hybrid	17	16	17	19	22	23	5.8%
Total Discrete	209	179	181	203	215	213	0.4%
Total Optoelectronic	39	33	35	39	42	43	2.3%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (FF M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	8,334	7,929	8,817	10,631	11,957	12,908	9.1%
Total Integrated Circuit	6,620	6,458	7,326	8,958	10,179	11,135	11.0%
Bipolar Digital	424	342	294	294	270	229	-11.6%
Memory	38	29	23	23	23	12	-21.0%
Logic	386	314	270	270	247	217	-10.9%
MOS Digital	4,243	4,315	5,042	6,392	7,343	8,189	14.1%
Memory	1,632	1,505	1,761	2,283	2,583	2,841	11.7%
Microcomponent	1,425	1,676	1,978	2,454	2,812	3,187	17.5%
Logic	1,186	1,134	1,303	1,655	1,949	2,160	12.7%
Analog	1,953	1,801	1,990	2,272	2,565	2,718	6.8%
Monolithic	1,833	1,693	1,867	2,137	2,424	2,559	6.9%
Hybrid	120	108	117	129	153	158	5.8%
Total Discrete	1,447	1,243	1,250	1,403	1,485	1,473	0.4%
Total Optoelectronic	267	228	241	270	294	299	2.3%
Rate (FF: $)	5.4	5.7	5.9	5.9	5.9	5.9	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 14

Estimated Semiconductor Consumption—History
Italy Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$451	$534	$660	$982	$1,082	$1,181	21.2%
Total Integrated Circuit	$345	$404	$493	$791	$845	$897	21.1%
Bipolar Digital	$68	$77	$79	$79	$58	$57	-3.5%
Memory	15	16	9	8	8	7	-14.1%
Logic	53	61	70	71	50	50	-1.2%
MOS Digital	$190	$225	$294	$560	$625	$612	26.4%
Memory	72	80	92	253	315	255	28.8%
Microcomponent	48	58	79	145	170	214	34.8%
Logic	70	87	123	162	140	143	15.4%
Analog	$87	$102	$120	$152	$162	228	21.3%
Monolithic	87	97	114	141	150	215	19.8%
Hybrid	NA	5	6	11	12	13	NA
Total Discrete	$88	$106	$139	$160	$205	$248	23.0%
Total Optoelectronic	$18	$24	$28	$31	$32	$36	14.9%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	595	545	574	835	989	928	9.3%
Total Integrated Circuit	455	412	429	672	772	705	9.1%
Bipolar Digital	90	79	69	67	53	45	-13.0%
Memory	20	16	8	7	7	6	-22.6%
Logic	70	62	61	60	46	39	-10.9%
MOS Digital	251	230	256	476	571	481	13.9%
Memory	95	82	80	215	288	200	16.1%
Microcomponent	63	59	69	123	155	168	21.6%
Logic	92	89	107	138	128	112	4.0%
Analog	115	104	104	129	148	179	9.3%
Monolithic	115	99	99	120	137	169	8.0%
Hybrid	NA	5	5	9	11	10	NA
Total Discrete	116	108	121	136	187	195	10.9%
Total Optoelectronic	24	24	24	26	29	28	3.6%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (L B)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	861	796	855	1,278	1,486	1,414	10.4%
Total Integrated Circuit	659	602	639	1,029	1,161	1,074	10.3%
Bipolar Digital	130	115	102	103	80	68	-12.1%
Memory	29	24	12	10	11	8	-21.8%
Logic	101	91	91	92	69	60	-10.0%
MOS Digital	363	335	381	729	859	733	15.1%
Memory	137	119	119	329	433	305	17.3%
Microcomponent	92	86	102	189	234	256	22.8%
Logic	134	130	159	211	192	171	5.1%
Analog	166	152	156	198	223	273	10.4%
Monolithic	166	145	148	183	206	257	9.2%
Hybrid	NA	7	8	14	16	16	NA
Total Discrete	168	158	180	208	282	297	12.1%
Total Optoelectronic	34	36	36	40	44	43	4.6%
Rate (L: $)	1.9	1.5	1.3	1.3	1.4	1.2	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 15

Estimated Semiconductor Consumption—Forecast Italy Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$1,181	$1,091	$1,169	$1,402	$1,566	$1,678	7.3%
Total Integrated Circuit	$897	$863	$953	$1,169	$1,318	$1,415	9.5%
Bipolar Digital	57	42	36	36	33	28	-13.3%
Memory	7	5	4	4	4	3	-15.6%
Logic	50	37	32	32	29	25	-12.9%
MOS Digital	$612	$608	$707	$894	$1,017	$1,108	12.6%
Memory	255	230	275	356	396	421	10.5%
Microcomponent	214	243	280	340	397	446	15.8%
Logic	143	135	152	198	224	241	11.0%
Analog	$228	$213	$210	$239	$268	$279	4.1%
Monolithic	215	202	199	228	253	266	4.3%
Hybrid	13	11	12	12	15	15	2.9%
Total Discrete	$248	$197	$186	$201	$212	$226	-1.8%
Total Optoelectronic	$36	$31	$30	$32	$36	$37	0.5%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	928	896	991	1,189	1,328	1,423	8.9%
Total Integrated Circuit	705	709	808	991	1,118	1,200	11.2%
Bipolar Digital	45	34	31	31	28	24	-11.9%
Memory	6	4	3	3	3	3	-14.3%
Logic	39	30	27	27	25	21	-11.6%
MOS Digital	481	499	600	758	862	940	14.3%
Memory	200	189	233	302	336	357	12.2%
Microcomponent	168	200	237	288	337	378	17.6%
Logic	112	111	129	168	190	204	12.7%
Analog	179	175	178	203	227	237	5.7%
Monolithic	169	166	169	193	215	226	5.9%
Hybrid	10	9	10	10	13	13	4.5%
Total Discrete	195	162	158	170	180	192	-0.3%
Total Optoelectronic	28	25	25	27	31	31	2.1%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (L B)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	1,414	1,370	1,520	1,823	2,036	2,181	9.1%
Total Integrated Circuit	1,074	1,084	1,239	1,520	1,713	1,839	11.4%
Bipolar Digital	68	53	47	47	43	36	-11.8%
Memory	8	6	5	5	5	4	-14.2%
Logic	60	46	42	42	38	33	-11.5%
MOS Digital	733	764	919	1,162	1,322	1,440	14.5%
Memory	305	289	358	463	515	547	12.4%
Microcomponent	256	305	364	442	516	580	17.7%
Logic	171	170	198	257	291	313	12.8%
Analog	273	268	273	311	348	363	5.8%
Monolithic	257	254	259	296	329	346	6.1%
Hybrid	16	14	16	16	20	20	4.6%
Total Discrete	297	247	242	261	276	294	-0.2%
Total Optoelectronic	43	39	39	42	47	48	2.2%
Rate (L B: $)	1.2	1.3	1.3	1.3	1.3	1.3	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 16

Estimated Semiconductor Consumption—History
Nordic Countries

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$391	$426	$458	$625	$682	$691	12.1%
Total Integrated Circuit	$306	$328	$351	$508	$549	$547	12.3%
Bipolar Digital	$60	$61	$57	$70	$52	$44	-6.0%
Memory	12	14	5	7	7	5	-16.1%
Logic	48	47	52	63	45	39	-4.1%
MOS Digital	$169	$184	$205	$313	$371	$336	14.7%
Memory	63	66	59	108	148	117	13.2%
Microcomponent	44	48	56	97	109	119	22.0%
Logic	62	70	90	108	114	100	10.0%
Analog	$77	$83	$89	$125	$126	$167	16.7%
Monolithic	77	79	84	114	115	157	15.3%
Hybrid	NA	4	5	11	11	10	NA
Total Discrete	$71	$80	$90	$96	$111	$122	11.4%
Total Optoelectronic	$14	$18	$17	$21	$22	$22	9.5%
History (ECU M)	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**CAGR**
Total Semiconductor	516	435	398	531	623	543	1.0%
Total Integrated Circuit	404	335	305	432	502	430	1.3%
Bipolar Digital	79	62	50	60	48	35	-15.3%
Memory	16	14	4	6	6	4	-24.3%
Logic	63	48	45	54	41	31	-13.5%
MOS Digital	223	188	178	266	339	264	3.4%
Memory	83	67	51	92	135	92	2.0%
Microcomponent	58	49	49	82	100	94	10.0%
Logic	82	71	78	92	104	79	-0.8%
Analog	102	85	77	106	115	131	5.2%
Monolithic	102	81	73	97	105	123	4.0%
Hybrid	NA	4	4	9	10	8	NA
Total Discrete	94	82	78	82	101	96	0.5%
Total Optoelectronic	18	18	15	18	20	17	-1.3%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	
History (SKr M)	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**CAGR**
Total Semiconductor	3,363	3,033	2,904	3,831	4,399	4,091	4.0%
Total Integrated Circuit	2,632	2,335	2,225	3,114	3,541	3,238	4.2%
Bipolar Digital	516	434	361	429	335	260	-12.8%
Memory	103	100	32	43	45	30	-22.1%
Logic	413	335	330	386	290	231	-11.0%
MOS Digital	1,453	1,310	1,300	1,919	2,393	1,989	6.5%
Memory	542	470	374	662	955	693	5.0%
Microcomponent	378	342	355	595	703	704	13.2%
Logic	533	498	571	662	735	592	2.1%
Analog	662	591	564	766	813	989	8.3%
Monolithic	662	562	533	699	742	929	7.0%
Hybrid	NA	28	32	67	71	59	NA
Total Discrete	611	570	571	588	716	722	3.4%
Total Optoelectronic	120	128	108	129	142	130	1.6%
Rate (SKr: $)	8.6	7.1	6.3	6.1	6.5	5.9	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 17

Estimated Semiconductor Consumption—Forecast
Noridc Countires

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$691	$639	$666	$776	$839	$872	4.8%
Total Integrated Circuit	$547	$518	$547	$641	$701	$741	6.3%
Bipolar Digital	44	36	29	27	25	22	-12.9%
Memory	5	5	3	3	2	2	-16.7%
Logic	39	31	26	24	23	20	-12.5%
MOS Digital	$336	$324	$355	$425	$476	$526	9.4%
Memory	117	101	113	133	144	155	5.8%
Microcomponent	119	128	139	161	192	213	12.3%
Logic	100	95	103	131	140	158	9.6%
Analog	$167	$158	$163	$189	$200	$193	2.9%
Monolithic	157	148	153	178	187	183	3.1%
Hybrid	10	9	9	12	12	13	5.4%
Total Discrete	$122	$100	$100	$111	$113	$108	-2.4%
Total Optoelectronic	$22	$21	$19	$24	$25	$23	0.9%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	543	525	565	658	711	739	6.4%
Total Integrated Circuit	430	425	464	544	594	628	7.9%
Bipolar Digital	35	30	25	23	21	19	-11.6%
Memory	4	4	3	3	2	2	-15.5%
Logic	31	25	22	20	20	17	-11.2%
MOS Digital	264	266	301	360	404	446	11.1%
Memory	92	83	96	113	122	131	7.4%
Microcomponent	94	105	118	137	163	181	14.1%
Logic	79	78	87	111	119	134	11.3%
Analog	131	130	138	160	170	164	4.5%
Monolithic	123	122	130	151	159	155	4.7%
Hybrid	8	7	8	10	10	11	7.0%
Total Discrete	96	82	85	94	96	92	-0.9%
Total Optoelectronic	17	17	16	20	21	20	2.4%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (SKr M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	4,091	3,917	4,202	4,897	5,294	5,502	6.1%
Total Integrated Circuit	3,238	3,175	3,452	4,045	4,423	4,676	7.6%
Bipolar Digital	260	221	183	170	158	139	-11.8%
Memory	30	31	19	19	13	13	-15.7%
Logic	231	190	164	151	145	126	-11.4%
MOS Digital	1,989	1,986	2,240	2,682	3,004	3,319	10.8%
Memory	693	619	713	839	909	978	7.1%
Microcomponent	704	785	877	1,016	1,212	1,344	13.8%
Logic	592	582	650	827	883	997	11.0%
Analog	989	969	1,029	1,193	1,262	1,218	4.3%
Monolithic	929	907	965	1,123	1,180	1,155	4.4%
Hybrid	59	55	57	76	76	82	6.7%
Total Discrete	722	613	631	700	713	681	-1.2%
Total Optoelectronic	130	129	120	151	158	145	2.2%
Rate (SKr: $)	5.9	6.1	6.3	6.3	6.3	6.3	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 18

Estimated Semiconductor Consumption—History
UK and Eire Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$1,198	$1,288	$1,570	$2,230	$2,614	$2,729	17.9%
Total Integrated Circuit	$959	$1,016	$1,203	$1,852	$2,225	$2,283	18.9%
Bipolar Digital	$193	$195	$188	$206	$177	$152	-4.7%
Memory	44	44	22	18	19	16	-18.3%
Logic	149	151	166	188	158	136	-1.8%
MOS Digital	$525	$565	$741	$1,294	$1,634	$1,587	24.8%
Memory	202	200	251	666	804	661	26.8%
Microcomponent	130	145	199	303	424	533	32.6%
Logic	193	220	291	325	406	393	15.3%
Analog	$241	$256	$274	$352	$414	$544	17.7%
Monolithic	241	243	260	326	387	507	16.0%
Hybrid	NA	13	14	26	27	37	NA
Total Discrete	$192	$211	$306	$312	$290	$333	11.6%
Total Optoelectronic	$47	$61	$61	$66	$99	$113	19.2%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	1,581	1,314	1,366	1,896	2,389	2,145	6.3%
Total Integrated Circuit	1,266	1,036	1,047	1,574	2,034	1,794	7.2%
Bipolar Digital	255	199	164	175	162	119	-14.1%
Memory	58	45	19	15	17	13	-26.4%
Logic	197	154	144	160	144	107	-11.5%
MOS Digital	693	576	645	1,100	1,493	1,247	12.5%
Memory	267	204	218	566	735	520	14.3%
Microcomponent	172	148	173	258	388	419	19.5%
Logic	255	224	253	276	371	309	3.9%
Analog	318	261	238	299	378	428	6.1%
Monolithic	318	248	226	277	354	399	4.6%
Hybrid	NA	13	12	22	25	29	NA
Total Discrete	253	215	266	265	265	262	0.6%
Total Optoelectronic	62	62	53	56	90	89	7.4%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (£ M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	922	876	958	1,249	1,595	1,528	10.6%
Total Integrated Circuit	738	691	734	1,037	1,357	1,278	11.6%
Bipolar Digital	149	133	115	115	108	85	-10.5%
Memory	34	30	13	10	12	9	-23.4%
Logic	115	103	101	105	96	76	-7.9%
MOS Digital	404	384	452	725	997	889	17.1%
Memory	156	136	153	373	490	370	18.9%
Microcomponent	100	99	121	170	259	298	24.4%
Logic	149	150	178	182	248	220	8.2%
Analog	186	174	167	197	253	305	10.4%
Monolithic	186	165	159	183	236	284	8.9%
Hybrid	NA	9	9	15	16	21	NA
Total Discrete	148	143	187	175	177	186	4.8%
Total Optoelectronic	36	41	37	37	60	63	11.8%
Rate (£: $)	0.8	0.7	0.6	0.6	0.6	0.6	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 19

Estimated Semiconductor Consumption—Forecast
UK and Eire Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$2,729	$2,841	$3,068	$3,704	$4,174	$4,508	10.6%
Total Integrated Circuit	$2,283	$2,425	$2,680	$3,277	$3,708	$4,021	12.0%
Bipolar Digital	152	126	114	108	96	89	-10.2%
Memory	16	12	12	12	8	6	-17.8%
Logic	136	114	102	96	88	83	-9.4%
MOS Digital	$1,587	$1,728	$1,996	$2,541	$2,902	$3,146	14.7%
Memory	661	660	787	1,040	1,165	1,212	12.9%
Microcomponent	533	649	744	918	1,055	1,173	17.1%
Logic	393	419	465	583	682	761	14.1%
Analog	$544	$571	$570	$628	$710	$786	7.6%
Monolithic	507	532	533	584	664	735	7.7%
Hybrid	37	38	38	42	47	51	6.6%
Total Discrete	$333	$310	$285	$312	$334	$349	0.9%
Total Optoelectronic	$113	$106	$103	$115	$132	$138	4.1%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	2,145	2,332	2,602	3,141	3,540	3,823	12.3%
Total Integrated Circuit	1,794	1,991	2,273	2,779	3,144	3,410	13.7%
Bipolar Digital	119	103	97	92	81	75	-8.8%
Memory	13	10	10	10	7	5	-16.6%
Logic	107	94	86	81	75	70	-8.0%
MOS Digital	1,247	1,419	1,693	2,155	2,461	2,668	16.4%
Memory	520	542	667	882	988	1,028	14.6%
Microcomponent	419	533	631	778	895	995	18.9%
Logic	309	344	394	494	578	645	15.9%
Analog	428	469	483	533	602	667	9.3%
Monolithic	399	437	452	495	563	623	9.4%
Hybrid	29	31	32	36	40	43	8.3%
Total Discrete	262	255	242	265	283	296	2.5%
Total Optoelectronic	89	87	87	98	112	117	5.7%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (£ M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	1,528	1,619	1,810	2,185	2,463	2,660	11.7%
Total Integrated Circuit	1,278	1,382	1,581	1,933	2,188	2,372	13.2%
Bipolar Digital	85	72	67	64	57	53	-9.2%
Memory	9	7	7	7	5	4	-17.0%
Logic	76	65	60	57	52	49	-8.5%
MOS Digital	889	985	1,178	1,499	1,712	1,856	15.9%
Memory	370	376	464	614	687	715	14.1%
Microcomponent	298	370	439	542	622	692	18.3%
Logic	220	239	274	344	402	449	15.3%
Analog	305	325	336	371	419	464	8.8%
Monolithic	284	303	314	345	392	434	8.8%
Hybrid	21	22	22	25	28	30	7.7%
Total Discrete	186	177	168	184	197	206	2.0%
Total Optoelectronic	63	60	61	68	78	81	5.2%
Rate (£: $)	0.6	0.6	0.6	0.6	0.6	0.6	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 20

Estimated Semiconductor Consumption—History
Germany Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$1,318	$1,628	$1,890	$2,250	$2,683	$3,078	18.5%
Total Integrated Circuit	$905	$1,095	$1,342	$1,673	$2,087	$2,345	21.0%
Bipolar Digital	$180	$211	$216	$201	$209	$195	1.6%
Memory	39	45	24	20	22	17	-15.3%
Logic	141	166	192	181	187	178	4.8%
MOS Digital	$497	$611	$735	$1,013	$1,377	$1,429	23.5%
Memory	188	220	218	359	595	529	23.0%
Microcomponent	125	154	214	315	390	504	32.2%
Logic	184	237	303	339	392	396	16.6%
Analog	$228	$273	$391	$459	$501	$721	25.9%
Monolithic	228	259	372	425	465	679	24.4%
Hybrid	NA	14	19	34	36	42	NA
Total Discrete	$343	$435	$458	$482	$480	$598	11.8%
Total Optoelectronic	$70	$98	$90	$95	$116	$135	14.0%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	1,740	1,661	1,644	1,913	2,452	2,419	6.8%
Total Integrated Circuit	1,195	1,117	1,168	1,422	1,908	1,843	9.1%
Bipolar Digital	238	215	188	171	191	153	-8.4%
Memory	51	46	21	17	20	13	-23.6%
Logic	186	169	167	154	171	140	-5.5%
MOS Digital	656	623	639	861	1,259	1,123	11.4%
Memory	248	224	190	305	544	416	10.9%
Microcomponent	165	157	186	268	356	396	19.1%
Logic	243	242	264	288	358	311	5.1%
Analog	301	278	340	390	458	567	13.5%
Monolithic	301	264	324	361	425	534	12.1%
Hybrid	NA	14	17	29	33	33	NA
Total Discrete	453	444	398	410	439	470	0.8%
Total Optoelectronic	92	100	78	81	106	106	2.8%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (DM M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	3,875	3,533	3,402	3,960	5,044	4,986	5.2%
Total Integrated Circuit	2,661	2,376	2,416	2,944	3,924	3,799	7.4%
Bipolar Digital	529	458	389	354	393	316	-9.8%
Memory	115	98	43	35	41	28	-24.8%
Logic	415	360	346	319	352	288	-7.0%
MOS Digital	1,461	1,326	1,323	1,783	2,589	2,315	9.6%
Memory	553	477	392	632	1,119	857	9.2%
Microcomponent	368	334	385	554	733	816	17.3%
Logic	541	514	545	597	737	642	3.5%
Analog	670	592	704	808	942	1,168	11.7%
Monolithic	670	562	670	748	874	1,100	10.4%
Hybrid	NA	30	34	60	68	68	NA
Total Discrete	1,008	944	824	848	902	969	-0.8%
Total Optoelectronic	206	213	162	167	218	219	1.2%
Rate (DM: $)	2.9	2.2	1.8	1.8	1.9	1.6	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 21

Estimated Semiconductor Consumption—Forecast
Germany Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$3,078	$3,347	$3,520	$4,131	$4,527	$4,761	9.1%
Total Integrated Circuit	$2,345	$2,619	$2,814	$3,357	$3,723	$3,942	10.9%
Bipolar Digital	195	179	156	136	124	109	-11.0%
Memory	17	16	12	12	8	7	-16.3%
Logic	178	163	144	124	116	102	-10.5%
MOS Digital	$1,429	$1,646	$1,868	$2,323	$2,611	$2,779	14.2%
Memory	529	556	647	862	966	1,020	14.0%
Microcomponent	504	648	734	879	993	1,057	16.0%
Logic	396	442	487	582	652	702	12.1%
Analog	$721	$794	$790	$898	$988	$1,054	7.9%
Monolithic	679	748	746	848	933	994	7.9%
Hybrid	42	46	45	51	55	58	6.7%
Total Discrete	$598	$590	$567	$623	$638	$650	1.7%
Total Optoelectronic	$135	$138	$139	$151	$166	$169	4.6%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	2,419	2,748	2,985	3,503	3,839	4,037	10.8%
Total Integrated Circuit	1,843	2,150	2,386	2,847	3,157	3,343	12.6%
Bipolar Digital	153	147	132	115	105	92	-9.6%
Memory	13	13	10	10	7	6	-15.0%
Logic	140	134	122	105	98	86	-9.2%
MOS Digital	1,123	1,351	1,584	1,970	2,214	2,357	16.0%
Memory	416	456	549	731	819	865	15.8%
Microcomponent	396	532	622	745	842	896	17.7%
Logic	311	363	413	494	553	595	13.8%
Analog	567	652	670	762	838	894	9.5%
Monolithic	534	614	633	719	791	843	9.6%
Hybrid	33	38	38	43	47	49	8.3%
Total Discrete	470	484	481	528	541	551	3.2%
Total Optoelectronic	106	113	118	128	141	143	6.2%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (DM M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	4,986	5,623	6,090	7,147	7,832	8,237	10.6%
Total Integrated Circuit	3,799	4,400	4,868	5,808	6,441	6,820	12.4%
Bipolar Digital	316	301	270	235	215	189	-9.8%
Memory	28	27	21	21	14	12	-15.2%
Logic	288	274	249	215	201	176	-9.4%
MOS Digital	2,315	2,765	3,232	4,019	4,517	4,808	15.7%
Memory	857	934	1,119	1,491	1,671	1,765	15.5%
Microcomponent	816	1,089	1,270	1,521	1,718	1,829	17.5%
Logic	642	743	843	1,007	1,128	1,214	13.6%
Analog	1,168	1,334	1,367	1,554	1,709	1,823	9.3%
Monolithic	1,100	1,257	1,291	1,467	1,614	1,720	9.3%
Hybrid	68	77	78	88	95	100	8.1%
Total Discrete	969	991	981	1,078	1,104	1,125	3.0%
Total Optoelectronic	219	232	240	261	287	292	6.0%
Rate (DM: $)	1.6	1.7	1.7	1.7	1.7	1.7	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 22

Estimated Semiconductor Consumption—History
Rest of Europe Region

History ($M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	$387	$494	$430	$690	$801	$894	18.2%
Total Integrated Circuit	$303	$377	$281	$499	$592	$639	16.1%
Bipolar Digital	$60	$72	$33	$56	$24	$22	-18.2%
Memory	13	15	7	7	4	4	-21.0%
Logic	47	57	26	49	20	18	-17.5%
MOS Digital	$167	$212	$172	$340	$444	$436	21.2%
Memory	69	78	50	107	259	225	26.7%
Microcomponent	37	52	55	97	91	113	25.0%
Logic	61	82	67	136	94	98	9.9%
Analog	$76	$93	$76	$103	$124	$181	19.0%
Monolithic	76	89	71	93	108	156	15.5%
Hybrid	NA	4	5	10	16	25	NA
Total Discrete	$69	$90	$124	$163	$184	$222	26.3%
Total Optoelectronic	$15	$27	$25	$28	$25	$33	17.1%

History (ECU M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	511	504	374	587	732	703	6.6%
Total Integrated Circuit	400	385	244	424	541	502	4.7%
Bipolar Digital	79	73	29	48	22	17	-26.2%
Memory	17	15	6	6	4	3	-28.8%
Logic	62	58	23	42	18	14	-25.6%
MOS Digital	220	216	150	289	406	343	9.2%
Memory	91	80	44	91	237	177	14.2%
Microcomponent	49	53	48	82	83	89	12.7%
Logic	81	84	58	116	86	77	-0.9%
Analog	100	95	66	88	113	142	7.2%
Monolithic	100	91	62	79	99	123	4.1%
Hybrid	NA	4	4	9	15	20	NA
Total Discrete	91	92	108	139	168	174	13.9%
Total Optoelectronic	20	28	22	24	23	26	5.5%
Rate (ECU: $)	1.32	1.02	0.87	0.85	0.91	0.79	

History (Pta M)	1985	1986	1987	1988	1989	1990	CAGR
Total Semiconductor	65,809	69,145	53,131	80,702	94,959	91,215	6.7%
Total Integrated Circuit	51,525	52,769	34,720	58,363	70,182	65,197	4.8%
Bipolar Digital	10,203	10,078	4,077	6,550	2,845	2,245	-26.1%
Memory	2,211	2,100	865	819	474	408	-28.7%
Logic	7,992	7,978	3,213	5,731	2,371	1,837	-25.5%
MOS Digital	28,398	29,674	21,252	39,766	52,636	44,485	9.4%
Memory	11,733	10,918	6,178	12,515	30,704	22,957	14.4%
Microcomponent	6,292	7,278	6,796	11,345	10,788	11,529	12.9%
Logic	10,373	11,478	8,279	15,907	11,144	9,999	-0.7%
Analog	12,924	13,017	9,391	12,047	14,700	18,467	7.4%
Monolithic	12,924	12,457	8,773	10,877	12,803	15,917	4.3%
Hybrid	NA	560	618	1,170	1,897	2,551	NA
Total Discrete	11,733	12,597	15,321	19,064	21,813	22,651	14.1%
Total Optoelectronic	2,551	3,779	3,089	3,275	2,964	3,367	5.7%
Rate (Pta: $)	170.1	140.0	123.6	117.0	118.6	102.0	

CAGR = Compound annual growth rate 1985-1990
NA = Not Available
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

Table 23

Estimated Semiconductor Consumption—Forecast
Rest of Europe Region

Forecast ($M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$894	$968	$1,066	$1,308	$1,500	$1,647	13.0%
Total Integrated Circuit	$639	$709	$809	$1,015	$1,183	$1,293	15.1%
Bipolar Digital	22	20	18	17	16	14	-8.6%
Memory	4	4	4	3	3	2	-12.9%
Logic	18	16	14	14	13	12	-7.8%
MOS Digital	$436	$487	$578	$751	$886	$964	17.2%
Memory	225	224	266	356	423	454	15.1%
Microcomponent	113	148	176	228	265	289	20.7%
Logic	98	115	136	167	198	221	17.7%
Analog	$181	$202	$213	$247	$281	$315	11.7%
Monolithic	156	175	183	213	243	272	11.8%
Hybrid	25	28	28	35	38	42	10.9%
Total Discrete	$222	$226	$223	$255	$274	$299	6.1%
Total Optoelectronic	$33	$33	$34	$38	$43	$55	10.8%

Forecast (ECU M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	703	795	904	1,109	1,272	1,397	14.7%
Total Integrated Circuit	502	582	686	861	1,003	1,096	16.9%
Bipolar Digital	17	16	15	14	14	12	-7.2%
Memory	3	3	3	3	3	2	-11.6%
Logic	14	13	12	12	11	10	-6.4%
MOS Digital	343	400	490	637	751	817	19.0%
Memory	177	184	226	302	359	385	16.8%
Microcomponent	89	122	149	193	225	245	22.5%
Logic	77	94	115	142	168	187	19.5%
Analog	142	166	181	209	238	267	13.4%
Monolithic	123	144	155	181	206	231	13.5%
Hybrid	20	23	24	30	32	36	12.6%
Total Discrete	174	186	189	216	232	254	7.8%
Total Optoelectronic	26	27	29	32	36	47	12.5%
Rate (ECU: $)	0.79	0.82	0.85	0.85	0.85	0.85	

Forecast (Pta M)	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	91,215	101,834	116,301	142,703	163,650	179,688	14.5%
Total Integrated Circuit	65,197	74,587	88,262	110,737	129,065	141,066	16.7%
Bipolar Digital	2,245	2,104	1,964	1,855	1,746	1,527	-7.4%
Memory	408	421	436	327	327	218	-11.8%
Logic	1,837	1,683	1,527	1,527	1,418	1,309	-6.5%
MOS Digital	44,485	51,232	63,060	81,934	96,663	105,172	18.8%
Memory	22,957	23,565	29,021	38,840	46,149	49,531	16.6%
Microcomponent	11,529	15,570	19,202	24,875	28,912	31,530	22.3%
Logic	9,999	12,098	14,838	18,220	21,602	24,111	19.2%
Analog	18,467	21,250	23,238	26,948	30,657	34,367	13.2%
Monolithic	15,917	18,410	19,965	23,238	26,511	29,675	13.3%
Hybrid	2,551	2,946	3,055	3,819	4,146	4,582	12.4%
Total Discrete	22,651	23,775	24,329	27,821	29,893	32,621	7.6%
Total Optoelectronic	3,367	3,472	3,709	4,146	4,691	6,001	12.3%
Rate (Pta: $)	102.0	105.2	109.1	109.1	109.1	109.1	

CAGR = Compound annual growth rate 1990-1995
Note: Figures may not add to totals due to rounding.
Source: Dataquest (September 1991)

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EUROPEAN COMPONENTS GROUP

These tables represent ESIS European regional semiconductor consumption, history and forecast, and correspond to the tables in ESIS Volume 2, Section 2.0.1 Semiconductor Device Markets.

Regional consumption is expressed in U.S. dollars to make the tables useful in comparing different regions. However, estimates in the local currency of each country can be made based on the exchange rates detailed in the Exchange Rate Quarterly Newsletter published June 1989 (ESIS Code: Newsletters 1988-1989, 1989-16).

The following changes in the technology categories have been made compared to last year:

- o Other Bipolar is now included in TTL
- o PMOS is now included in Other Bipolar
- o BiCMOS is a new category.
- o The "Appendix-A" tables include market estimates of other products ESIS analysts observe.

INDEX TO ESIS EUROPEAN SEMICONDUCTOR CONSUMPTION ESTIMATES

Table 2.0.1-1(a)

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$3,167	$3,370	$4,805	$4,720	$5,532	$6,355	$8,491
Total Integrated Circuit	$1,988	$2,323	$3,634	$3,556	$4,088	$4,693	$6,669
Bipolar	$ 434	$ 483	$ 724	$ 709	$ 782	$ 725	$ 772
TTL	394	446	659	641	705	564	624
ECL	40	37	65	68	77	161	148
Bipolar	$ 434	$ 483	$ 724	$ 709	$ 782	$ 725	$ 772
Memory	100	107	149	157	172	85	74
Logic	334	376	575	552	610	640	698
MOS	$ 948	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364
NMOS	650	824	1,443	1,232	1,294	1,434	1,759
CMOS	214	353	617	702	976	1,284	2,491
BiCMOS	0	0	0	0	0	24	56
Other IC	84	50	32	19	10	11	58
MOS	$ 948	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364
Memory	469	581	995	750	822	838	1,797
Micro	168	239	465	485	578	794	1,212
Logic	311	407	632	718	880	1,121	1,355
Linear	$ 606	$ 613	$ 818	$ 894	$1,026	$1,215	$1,533
Monolithic	606	613	818	894	975	1,153	1,416
Hybrid	0	0	0	0	51	62	117
Total Discrete	$1,011	$ 866	$ 963	$ 954	$1,153	$1,384	$1,516
Total Optoelectronic	$ 168	$ 181	$ 208	$ 210	$ 291	$ 278	$ 306

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-1(b)

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$8,491	$9,839	$10,368	$12,006	$15,481	$18,770	$20,572
Total Integrated Circuit	$6,669	$7,880	$ 8,488	$ 9,968	$13,068	$16,123	$17,664
Bipolar	$ 772	$ 762	$ 730	$ 781	$ 867	$ 965	$ 1,025
TTL	624	612	577	605	668	730	772
ECL	148	150	153	176	199	235	253
Bipolar	$ 772	$ 762	$ 730	$ 781	$ 867	$ 965	$ 1,025
Memory	74	72	65	70	73	71	67
Logic	698	690	665	711	794	894	958
MOS	$4,364	$5,518	$ 6,050	$ 7,227	$ 9,843	$12,408	$13,616
NMOS	1,759	2,023	2,104	2,222	2,555	2,836	2,893
CMOS	2,491	3,354	3,727	4,637	6,663	8,509	9,293
BiCMOS	56	106	195	351	613	1,055	1,424
Other IC	58	35	24	17	12	8	6
MOS	$4,364	$5,518	$ 6,050	$ 7,227	$ 9,843	$12,408	$13,616
Memory	1,797	2,501	2,788	3,320	4,462	6,179	6,478
Micro	1,212	1,350	1,425	1,718	2,432	2,870	3,475
Logic	1,355	1,667	1,837	2,189	2,949	3,359	3,663
Linear	$1,533	$1,600	$ 1,707	$ 1,960	$ 2,358	$ 2,750	$ 3,023
Monolithic	1,416	1,486	1,598	1,856	2,262	2,657	2,935
Hybrid	117	114	109	104	96	93	88
Total Discrete	$1,516	$1,667	$ 1,601	$ 1,740	$ 2,052	$ 2,229	$ 2,417
Total Optoelectronic	$ 306	$ 292	$ 280	$ 298	$ 361	$ 418	$ 491

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-2(a)

ESTIMATED BENELUX SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$184	$208	$306	$304	$351	$407	$504
Total Integrated Circuit	$117	$149	$237	$235	$277	$307	$369
Bipolar	$ 26	$ 31	$ 47	$ 47	$ 52	$ 43	$ 45
TTL	14	28	42	42	47	33	36
ECL	2	3	5	5	5	10	9
Bipolar	$ 26	$ 31	$ 47	$ 47	$ 52	$ 43	$ 45
Memory	6	7	9	11	12	5	4
Logic	20	24	38	36	40	38	41
MOS	$ 56	$ 79	$137	$129	$155	$184	$213
NMOS	38	53	94	82	90	91	85
CMOS	13	23	41	46	64	90	126
BiCMOS	0	0	0	0	0	2	2
Other IC	5	3	2	1	1	1	0
MOS	$ 56	$ 79	$137	$129	$155	$184	$213
Memory	28	38	65	49	57	42	72
Micro	10	15	30	33	39	64	73
Logic	18	26	42	47	59	78	68
Analog	$ 35	$ 39	$ 53	$ 59	$ 70	$ 80	$111
Monolithic	35	39	53	59	70	76	103
Hybrid	0	0	0	0	0	4	8
Total Discrete	$ 58	$ 49	$ 56	$ 56	$ 56	$ 82	$107
Total Optoelectronic	$ 9	$ 10	$ 13	$ 13	$ 18	$ 18	$ 28

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-2(b)

ESTIMATED BENELUX SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$504	$560	$590	$671	$836	$991	$1,068
Total Integrated Circuit	$369	$426	$456	$534	$674	$813	$ 867
Bipolar	$ 45	$ 44	$ 42	$ 45	$ 47	$ 51	$ 56
TTL	36	35	32	34	35	38	41
ECL	9	9	10	11	12	13	15
Bipolar	$ 45	$ 44	$ 42	$ 45	$ 47	$ 51	$ 56
Memory	4	4	4	4	4	3	3
Logic	41	40	38	41	43	48	53
MOS	$213	$266	$290	$347	$457	$564	$ 600
NMOS	85	97	97	102	114	121	130
CMOS	126	166	187	235	323	408	427
BiCMOS	2	3	6	10	20	35	43
Other IC	0	0	0	0	0	0	0
MOS	$213	$266	$290	$347	$457	$564	$ 600
Memory	72	101	112	133	171	234	235
Micro	73	81	86	104	143	167	195
Logic	68	84	92	110	143	163	170
Analog	$111	$116	$124	$142	$170	$198	$ 211
Monolithic	103	108	116	135	164	192	205
Hybrid	8	8	8	7	6	6	6
Total Discrete	$107	$110	$113	$123	$145	$159	$ 163
Total Optoelectronic	$ 28	$ 24	$ 21	$ 14	$ 17	$ 19	$ 38

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-3(a)

ESTIMATED FRANCE SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$615	$585	$690	$771	$801	$940	$1,210
Total Integrated Circuit	$412	$419	$520	$603	$591	$716	$ 977
Bipolar	$ 90	$ 87	$104	$101	$114	$109	$ 115
TTL	82	81	95	91	102	85	94
ECL	8	6	9	10	12	24	21
Bipolar	$ 90	$ 87	$104	$101	$114	$109	$ 115
Memory	21	19	22	23	26	13	10
Logic	69	68	82	78	88	96	105
MOS	$196	$221	$298	$276	$329	$422	$ 631
NMOS	135	148	203	174	187	218	266
CMOS	44	64	89	99	139	198	347
BiCMOS	0	0	0	0	0	4	8
Other IC	17	9	6	3	3	2	10
MOS	$196	$221	$298	$376	$328	$422	$ 631
Memory	97	105	142	207	121	126	232
Micro	35	43	66	68	82	127	182
Logic	64	73	90	101	125	169	217
Linear	$126	$111	$118	$126	$149	$185	$ 231
Monolithic	126	111	118	126	149	176	214
Hybrid	0	0	0	0	0	9	17
Total Discrete	$171	$134	$138	$135	$165	$185	$ 196
Total Optoelectronic	$ 32	$ 32	$ 32	$ 33	$ 45	$ 39	$ 37

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-3(b)

ESTIMATED FRANCE SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$1,210	$1,363	$1,440	$1,644	$2,088	$2,476	$2,734
Total Integrated Circuit	$ 977	$1,126	$1,199	$1,379	$1,773	$2,136	$2,382
Bipolar	$ 115	$ 114	$ 108	$ 117	$ 127	$ 140	$ 146
TTL	94	93	87	92	99	108	113
ECL	21	21	21	25	28	32	33
Bipolar	$ 115	$ 114	$ 108	$ 117	$ 127	$ 140	$ 146
Memory	10	10	9	10	10	10	9
Logic	105	104	99	107	117	130	137
MOS	$ 631	$ 770	$ 834	$ 967	$1,290	$1,581	$1,800
NMOS	266	302	305	314	345	383	414
CMOS	347	447	498	601	857	1,048	1,186
BiCMOS	8	15	27	49	86	149	199
Other IC	10	6	4	3	2	1	1
MOS	$ 631	$ 770	$ 834	$ 967	$1,290	$1,581	$1,800
Memory	232	304	335	398	523	704	747
Micro	182	200	211	241	333	388	491
Logic	217	266	288	328	434	489	562
Linear	$ 231	$ 242	$ 257	$ 295	$ 356	$ 415	$ 436
Monolithic	214	225	241	280	342	401	424
Hybrid	17	17	16	15	14	14	12
Total Discrete	$ 196	$ 202	$ 207	$ 224	$ 265	$ 283	$ 296
Total Optoelectronic	$ 37	$ 35	$ 34	$ 41	$ 50	$ 57	$ 56

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-4(a)

ESTIMATED ITALY SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$ 319	$ 320	$ 480	$ 451	$ 534	$ 660	$ 982
Total Integrated Circuit	$ 203	$ 221	$ 368	$ 345	$ 404	$ 493	$ 791
Bipolar	$ 44	$ 46	$ 74	$ 68	$ 77	$ 79	$ 79
TTL	40	42	66	61	69	62	64
ECL	4	4	8	7	8	17	15
Bipolar	$ 44	$ 46	$ 74	$ 68	$ 77	$ 79	$ 79
Memory	10	10	16	15	16	9	8
Logic	34	36	58	53	61	70	71
MOS	$ 97	$ 117	$ 212	$ 190	$ 225	$ 294	$ 560
NMOS	66	78	145	120	128	149	203
CMOS	22	34	63	69	96	141	340
BiCMOS	0	0	0	0	0	3	7
Other IC	9	5	4	1	1	1	10
MOS	$ 97	$ 117	$ 212	$ 190	$ 225	$ 294	$ 560
Memory	48	55	101	72	80	92	253
Micro	17	23	47	48	58	79	145
Logic	32	39	64	70	87	123	162
Linear	$ 62	$ 58	$ 82	$ 87	$ 102	$ 120	$ 152
Monolithic	62	58	82	87	102	114	141
Hybrid	0	0	0	0	0	6	11
Total Discrete	$ 99	$ 81	$ 92	$ 88	$ 106	$ 139	$ 160
Total Optoelectronic	$ 17	$ 18	$ 20	$ 18	$ 24	$ 28	$ 31

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-4(b)

ESTIMATED ITALY SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$ 982	$1,133	$1,161	$1,394	$1,828	$2,253	$2,512
Total Integrated Circuit	$ 791	$ 938	$ 964	$1,179	$1,575	$1,972	$2,202
Bipolar	$ 79	$ 78	$ 74	$ 79	$ 88	$ 97	$ 107
TTL	64	63	59	61	68	75	81
ECL	15	15	15	18	20	2	26
Bipolar	$ 79	$ 78	$ 74	$ 79	$ 88	$ 97	$ 107
Memory	8	8	7	7	8	7	7
Logic	71	70	67	72	80	90	100
MOS	$ 560	$ 701	$ 719	$ 905	$1,252	$1,601	$1,787
NMOS	203	234	243	270	316	356	340
CMOS	340	448	448	586	852	1,103	1,268
BiCMOS	7	13	24	46	82	141	178
Other IC	10	6	4	3	2	1	1
MOS	$ 560	$ 701	$ 719	$ 905	$1,252	$1,601	$1,787
Memory	253	340	335	414	566	797	907
Micro	145	161	162	206	297	356	427
Logic	162	200	222	285	389	448	453
Linear	$ 152	$ 159	$ 171	$ 195	$ 235	$ 274	$ 308
Monolithic	141	148	160	185	226	265	299
Hybrid	11	11	11	10	9	9	9
Total Discrete	$ 160	$ 166	$ 169	$ 184	$ 217	$ 239	$ 260
Total Optoelectronic	$ 31	$ 29	$ 28	$ 31	$ 36	$ 42	$ 50

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-5(a)

ESTIMATED SCANDINAVIA SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$ 229	$ 245	$ 395	$ 391	$ 426	$ 458	$ 625
Total Integrated Circuit	$ 141	$ 170	$ 310	$ 306	$ 328	$ 351	$ 508
Bipolar	$ 31	$ 6	$ 60	$ 60	$ 61	$ 57	$ 70
TTL	28	3	54	54	55	46	57
ECL	3	3	6	6	6	11	13
Bipolar	$ 31	$ 6	$ 60	$ 60	$ 61	$ 57	$ 70
Memory	7	8	11	12	14	5	7
Logic	24	28	49	48	47	52	63
MOS	$ 67	$ 90	$ 179	$ 169	$ 184	$ 205	$ 313
NMOS	46	60	123	106	105	112	123
CMOS	15	26	54	60	78	90	176
BiCMOS	0	0	0	0	0	2	4
Other IC	6	4	2	3	1	1	10
MOS	$ 67	$ 90	$ 179	$ 169	$ 184	$ 205	$ 313
Memory	33	43	85	63	66	59	108
Micro	12	17	40	44	48	56	97
Logic	22	30	54	62	70	90	108
Linear	$ 43	$ 44	$ 71	$ 77	$ 83	$ 89	$ 125
Monolithic	43	44	71	77	83	84	114
Hybrid	0	0	0	0	0	5	11
Total Discrete	$ 76	$ 63	$ 71	$ 71	$ 80	$ 90	$ 96
Total Optoelectronic	$ 12	$ 12	$ 14	$ 14	$ 18	$ 17	$ 21

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-5(b)

ESTIMATED SCANDINAVIA SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$ 625	$ 713	$ 755	$ 864	$1,099	$1,294	$1,399
Total Integrated Circuit	$ 508	$ 593	$ 633	$ 732	$ 943	$1,122	$1,222
Bipolar	$ 70	$ 68	$ 65	$ 64	$ 71	$ 77	$ 88
TTL	57	56	53	50	57	60	69
ECL	13	12	12	14	14	17	19
Bipolar	$ 70	$ 68	$ 65	$ 64	$ 71	$ 77	$ 88
Memory	7	6	5	6	7	6	6
Logic	63	62	60	58	64	71	82
MOS	$ 313	$ 395	$ 431	$ 510	$ 681	$ 824	$ 904
NMOS	123	144	148	154	164	162	191
CMOS	176	237	263	325	466	577	598
BiCMOS	4	8	16	28	49	84	114
Other IC	10	6	4	3	2	1	1
MOS	$ 313	$ 395	$ 431	$ 510	$ 681	$ 824	$ 904
Memory	108	153	170	202	269	359	366
Micro	97	109	114	137	182	210	262
Logic	108	133	147	171	230	255	276
Linear	$ 125	$ 130	$ 137	$ 158	$ 191	$ 221	$ 230
Monolithic	114	120	128	149	182	213	222
Hybrid	11	10	9	9	9	8	8
Total Discrete	$ 96	$ 100	$ 102	$ 111	$ 131	$ 143	$ 144
Total Optoelectronic	$ 21	$ 20	$ 20	$ 21	$ 25	$ 29	$ 33

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-6(a)

ESTIMATED U.K. & IRISH SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$ 703	$ 833	$1,240	$1,198	$1,288	$1,570	$2,230
Total Integrated Circuit	$ 439	$ 619	$ 999	$ 959	$1,016	$1,203	$1,852
Bipolar	$ 96	$ 129	$ 198	$ 193	$ 195	$ 188	$ 206
TTL	87	120	183	176	178	147	169
ECL	9	9	15	17	17	41	37
Bipolar	$ 96	$ 129	$ 198	$ 193	$ 195	$ 188	$ 206
Memory	22	29	40	44	44	22	18
Logic	74	100	158	149	151	166	188
MOS	$ 209	$ 327	$ 575	$ 525	$ 565	$ 741	$1,294
NMOS	144	220	406	331	319	385	558
CMOS	47	94	162	189	244	347	706
BiCMOS	0	0	0	0	0	6	21
Other IC	18	13	7	5	2	3	9
MOS	$ 209	$ 327	$ 575	$ 525	$ 565	$ 741	$1,294
Memory	103	155	274	202	200	251	666
Micro	37	64	128	130	145	199	303
Logic	69	108	173	193	220	291	325
Linear	$ 134	$ 163	$ 226	$ 241	$ 256	$ 274	$ 352
Monolithic	134	163	226	241	256	260	326
Hybrid	0	0	0	0	0	14	26
Total Discrete	$ 228	$ 172	$ 192	$ 192	$ 211	$ 306	$ 312
Total Optoelectronic	$ 36	$ 42	$ 49	$ 47	$ 61	$ 61	$ 66

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-6(b)

ESTIMATED U.K. & IRISH SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$2,230	$2,598	$2,784	$3,246	$4,201	$5,115	$5,627
Total Integrated Circuit	$1,852	$2,212	$2,393	$2,820	$3,695	$4,559	$5,023
Bipolar	$ 206	$ 205	$ 196	$ 217	$ 240	$ 265	$ 275
TTL	169	166	156	172	187	205	208
ECL	37	39	40	45	53	60	67
Bipolar	$ 206	$ 205	$ 196	$ 217	$ 240	$ 265	$ 275
Memory	18	18	16	18	18	19	17
Logic	188	187	180	199	222	246	258
MOS	$1,294	$1,641	$1,805	$2,152	$2,913	$3,660	$4,057
NMOS	558	645	669	695	789	836	920
CMOS	706	951	1,061	1,326	1,900	2,439	2,616
BiCMOS	21	39	71	128	222	383	520
Other IC	9	6	4	3	2	2	1
MOS	$1,294	$1,641	$1,805	$2,152	$2,913	$3,660	$4,057
Memory	666	906	1,008	1,196	1,596	2,169	2,329
Micro	303	335	355	431	603	700	857
Logic	325	400	442	525	714	791	871
Linear	$ 352	$ 366	$ 392	$ 451	$ 542	$ 634	$ 691
Monolithic	326	341	368	428	521	614	672
Hybrid	26	25	24	23	21	20	19
Total Discrete	$ 312	$ 322	$ 329	$ 358	$ 423	$ 458	$ 497
Total Optoelectronic	$ 66	$ 64	$ 62	$ 68	$ 83	$ 98	$ 107

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-7(a)

ESTIMATED WEST GERMAN SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$ 895	$ 937	$1,300	$1,318	$1,628	$1,890	$2,250
Total Integrated Circuit	$ 533	$ 572	$ 892	$ 905	$1,095	$1,342	$1,673
Bipolar	$ 116	$ 118	$ 178	$ 180	$ 211	$ 216	$ 201
TTL	105	109	163	163	190	169	159
ECL	11	9	15	17	21	47	42
Bipolar	$ 116	$ 118	$ 178	$ 180	$ 211	$ 216	$ 201
Memory	27	26	37	39	45	24	20
Logic	89	92	141	141	166	192	181
MOS	$ 254	$ 302	$ 513	$ 492	$ 611	$ 735	$1,013
NMOS	174	204	350	314	344	387	388
CMOS	57	86	154	178	264	338	594
BiCMOS	0	0	0	0	0	7	12
Other IC	23	12	9	0	3	3	19
MOS	$ 254	$ 302	$ 513	$ 497	$ 611	$ 735	$1,013
Memory	126	142	244	188	220	218	359
Micro	45	59	116	125	154	214	315
Logic	83	101	153	184	237	303	339
Linear	$ 163	$ 152	$ 201	$ 228	$ 273	$ 391	$ 459
Monolithic	163	152	201	228	273	372	425
Hybrid	0	0	0	0	0	19	34
Total Discrete	$ 310	$ 309	$ 344	$ 343	$ 435	$ 458	$ 482
Total Optoelectronic	$ 52	$ 56	$ 64	$ 70	$ 98	$ 90	$ 95

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-7(b)

ESTIMATED WEST GERMAN SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$2,250	$2,518	$2,663	$3,022	$3,818	$4,554	$4,910
Total Integrated Circuit	$1,673	$1,928	$2,068	$2,377	$3,062	$3,725	$4,027
Bipolar	$ 201	$ 198	$ 192	$ 203	$ 229	$ 255	$ 254
TTL	159	155	148	153	172	178	185
ECL	42	43	44	50	57	77	69
Bipolar	$ 201	$ 198	$,192	$ 203	$ 229	$ 255	$ 254
Memory	20	19	18	19	19	19	17
Logic	181	179	174	184	210	236	237
MOS	$1,013	$1,251	$1,365	$1,587	$2,133	$2,654	$2,905
NMOS	388	445	463	477	547	577	594
CMOS	594	771	851	1,029	1,459	1,863	1,996
BiCMOS	12	24	43	76	123	211	313
Other IC	19	11	8	5	4	3	2
MOS	$1,013	$1,251	$1,365	$1,587	$2,133	$2,654	$2,905
Memory	359	499	555	617	808	1120	1214
Micro	315	339	356	429	611	721	829
Logic	339	413	454	541	714	813	862
Linear	$ 459	$ 479	$ 511	$ 587	$ 700	$ 816	$ 868
Monolithic	425	446	480	557	672	789	844
Hybrid	34	33	31	30	28	27	24
Total Discrete	$ 482	$ 499	$ 509	$ 553	$ 645	$ 701	$ 737
Total Optoelectronic	$ 95	$ 91	$ 86	$ 92	$ 111	$ 128	$ 146

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-8(a)

ESTIMATED REST OF EUROPE SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$ 222	$ 242	$ 394	$ 387	$ 440	$ 430	$ 690
Total Integrated Circuit	$ 143	$ 173	$ 308	$ 303	$ 323	$ 281	$ 499
Bipolar	$ 31	$ 36	$ 63	$ 60	$ 72	$ 33	$ 56
TTL	28	33	56	54	64	22	45
ECL	3	3	7	6	8	11	11
Bipolar	$ 31	$ 36	$ 63	$ 60	$ 72	$ 33	$ 56
Memory	7	8	14	13	15	7	7
Logic	24	28	49	47	57	26	49
MOS	$ 69	$ 91	$ 178	$ 167	$ 212	$ 172	$ 340
NMOS	47	61	122	105	121	92	136
CMOS	16	26	54	61	91	80	202
BiCMOS	0	0	0	0	0	0	2
Other IC	6	4	2	1	0	0	0
MOS	$ 69	$ 91	$ 178	$ 167	$ 158	$ 172	$ 340
Memory	34	43	84	69	78	50	107
Micro	12	18	38	37	52	55	97
Logic	23	30	56	61	28	67	136
Linear	$ 43	$ 46	$ 67	$ 76	$ 93	$ 76	$ 103
Monolithic	43	46	67	76	93	71	93
Hybrid	0	0	0	0	0	5	10
Total Discrete	$ 69	$ 58	$ 70	$ 69	$ 90	$ 124	$ 163
Total Optoelectronic	$ 10	$ 11	$ 16	$ 15	$ 27	$ 25	$ 28

Source: Dataquest
August 1989
Ref: 0889-08

Table 2.0.1-8(b)

ESTIMATED REST OF EUROPE SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$ 690	$ 854	$ 975	$1,165	$1,611	$2,087	$2,322
Total Integrated Circuit	$ 499	$ 657	$ 774	$ 947	$1,346	$1,796	$1,941
Bipolar	$ 56	$ 55	$ 53	$ 56	$ 65	$ 80	$ 99
TTL	45	44	42	44	50	66	75
ECL	11	11	11	12	15	14	24
Bipolar	$ 56	$ 55	$ 53	$ 56	$ 65	$ 80	$ 99
Memory	7	7	6	6	7	7	8
Logic	49	48	47	50	58	73	91
MOS	$ 340	$ 494	$ 606	$ 759	$1,117	$1,524	$1,563
NMOS	136	157	179	210	281	400	304
CMOS	202	333	419	535	805	1,071	$1,202
BiCMOS	2	4	8	14	31	53	57
Other IC	0	0	0	0	0	0	0
MOS	$ 340	$ 494	$ 606	$ 759	$1,117	$1,524	$1,563
Memory	107	198	273	360	529	796	680
Micro	97	125	141	170	263	328	414
Logic	136	171	192	229	325	400	469
Linear	$ 103	$ 108	$ 115	$ 132	$ 164	$ 192	$ 279
Monolithic	93	98	105	122	155	183	269
Hybrid	10	10	10	10	9	9	10
Total Discrete	$ 163	$ 168	$ 172	$ 187	$ 226	$ 246	$ 320
Total Optoelectronic	$ 28	$ 29	$ 29	$ 31	$ 39	$ 45	$ 61

Source: Dataquest
August 1989
Ref: 0889-08

Appendix-A

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION HISTORY

(Millions of Dollars)

	1982	1983	1984	1985	1986	1987	1988
Total Semiconductor	$3,167	$3,370	$4,805	$4,720	$5,532	$6,355	$8,491
Total Integrated Circuit	$1,988	$2,323	$3,634	$3,556	$4,088	$4,693	$6,669
Bipolar	$ 434	$ 483	$ 724	$ 709	$ 782	$ 725	$ 772
TTL	394	446	659	641	705	564	624
ECL	40	37	65	68	77	161	148
Bipolar	$ 434	$ 483	$ 724	$ 709	$ 782	$ 725	$ 772
Memory	100	107	149	157	172	85	74
Logic	334	376	575	552	610	640	698
Other Logic					4	20	63
Std. Logic					376	410	394
ASIC					230	210	241
MOS	$ 948	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364
NMOS	650	824	1,443	1,232	1,294	1,434	1,759
CMOS	214	353	617	702	976	1,284	2,491
BiCMOS	0	0	0	0	0	24	56
Other IC	84	50	32	19	10	11	58
MOS	$ 948	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364
Memory	$ 469	$ 581	$ 995	$ 750	$ 822	$ 838	$1,797
DRAM					262	402	1062
SRAM					252	117	262
ROM/Other					308	319	473
Micro	$ 168	$ 239	$465	$ 485	$ 578	$ 794	$1,212
MPU					95	217	341
MCU					249	339	473
MPR (inc. DSP)					234	238	398
Logic	$ 311	$ 407	$ 632	$ 718	$ 880	$1,121	$1,355
Std. Logic					437	229	287
Other Logic						407	357
ASIC					443	485	711
Linear	$ 606	$ 613	$ 818	$ 894	$1,026	$1,215	$1,533
Monolithic	$ 606	$ 613	$ 818	$ 894	$ 975	$1,153	$1,416
Amplifiers	103	104	137	144	166	180	200
Voltage Regulators	36	37	50	54	62	71	90
Data Conversion	85	92	130	157	185	96	101
Interface	55	55	72	80	94	49	52
Special Consumer	224	227	298	318	360	417	475
Other	103	98	131	141	108	340	498
Hybrid	$ 0	$ 0	$ 0	$ 0	$ 51	$ 62	$ 117
Total Discrete	$1,011	$ 866	$ 963	$ 954	$1,153	$1,384	$1,516
Transistor	468	408	450	463	540	655	709
Diode	391	327	358	342	432	431	473
Thyristor	105	91	103	100	125	183	210
Other Discrete	47	40	52	49	56	115	124
Total Optoelectronic	$ 168	$ 181	$ 208	$ 210	$ 291	$ 278	$ 306
LED Lamps	44	45	55	55	76	57	46
LED Displays	65	66	70	62	87	48	38
Optical Couplers	28	32	40	41	56	68	64
Other	31	38	43	52	72	105	158

Source: Dataquest
August 1989

Appendix-A

ESTIMATED EUROPEAN SEMICONDUCTOR CONSUMPTION FORECAST

(Millions of Dollars)

	1988	1989	1990	1991	1992	1993	1994
Total Semiconductor	$8,491	$9,839	$10,368	$12,006	$15,481	$18,770	$20,572
Total Integrated Circuit	$6,669	$7,880	$ 8,488	$ 9,968	$13,068	$16,123	$17,664
Bipolar	$ 772	$ 762	$ 730	$ 781	$ 867	$ 965	$ 1,025
TTL	624	612	577	605	668	730	772
ECL	148	150	153	176	199	235	253
Bipolar	$ 772	$ 762	$ 730	$781	$ 867	$965	$ 1,025
Memory	74	72	65	70	73	71	67
Logic	698	690	665	711	794	894	958
Other Logic	63	60	61	64	72	82	93
Std. Logic	394	382	372	391	430	485	495
ASIC	241	248	232	256	292	327	370
MOS	$4,364	$5,518	$6,050	$ 7,227	$ 9,843	$12,408	$13,616
NMOS	1,759	2,023	2,104	2,222	2,555	2,836	2,893
CMOS	2,491	3,354	3,727	4,637	6,663	8,509	9,293
BiCMOS	56	106	195	351	613	1,055	1,424
Other IC	58	35	24	17	12	8	6
MOS	$4,364	$5,518	$6,050	$ 7,227	$ 9,843	$12,408	$13,616
Memory	$1,797	$2,501	$2,788	$ 3,320	$ 4,462	$ 6,179	$ 6,478
DRAM	1,062	1,466	1,725	2,003	2,660	3,936	4,035
SRAM	262	430	439	518	724	927	982
ROM/Other	473	605	624	799	1,078	1,316	1,461
Micro	$1,212	$1,350	$1,425	$ 1,718	$ 2,432	$ 2,870	$ 3,475
MPU	341	365	380	448	638	746	888
MCU	473	549	587	720	1,044	1,274	1,555
MPR (inc. DSP)	398	436	458	550	750	850	1,032
Logic	$1,355	$1,667	$1,837	$ 2,189	$ 2,949	$ 3,359	$ 3,663
Std. Logic	287	317	324	349	377	401	418
Other Logic	357	538	630	797	1,284	1,433	1,519
ASIC	711	812	883	1,043	1,288	1,525	1,726
Linear	$1,533	$1,600	$1,707	$ 1,960	$ 2,358	$ 2,750	$ 3,023
Monolithic	$1,416	$1,486	$1,598	$ 1,856	$ 2,262	$ 2,657	$ 2,935
Amplifiers	200	204	206	207	238	257	272
Voltage Regulators	90	91	95	101	118	130	140
Data Conversion	101	110	117	134	152	170	187
Interface	52	53	54	58	67	72	78
Special Consumer	475	496	537	634	799	918	937
Other	498	532	589	722	888	1,110	1,321
Hybrid	$ 117	$ 114	$ 109	$ 104	$ 96	$ 93	$ 88
Total Discrete	$1,516	$1,667	$1,601	$ 1,740	$ 2,052	$ 2,229	$ 2,417
Transistor	709	741	759	812	946	985	1,004
Diode	473	578	474	488	552	557	563
Thyristor	210	218	227	257	298	336	373
Other Discrete	124	130	141	183	256	351	477
Total Optoelectronic	$ 306	$ 292	$ 280	$ 298	$ 361	$ 418	$ 491
LED Lamps	46	35	28	27	28	30	32
LED Displays	38	31	23	23	24	27	29
Optical Couplers	64	54	50	51	59	66	76
Other	158	172	179	197	250	295	354

Source: Dataquest
August 1989

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Dataquest

European Semiconductor Consumption Forecast

1983–1995

EUROPEAN SEMICONDUCTOR CONSUMPTION FORECAST 1983-1995

EUROPEAN COMPONENTS GROUP

Note: This booklet replaces the last forecast dated August 1989, and should be filed in Volume II behind the 2.0 Semiconductor Device Markets tab.

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INTRODUCTION

This booklet presents Dataquest's latest European regional history and forecast for semiconductor products for the 1983 to 1995 period. Dataquest tracks local currency exchange rates for all the major European countries on a monthly basis and generates a weighted average basket of European currencies (see ESIS Exchange Rate Quarterly newsletter), which provides a translation from local currencies to US dollars.

We forecast at constant exchange rates. This forecast is based on a fixed-level exchange rate factor calculated from local currency exchange rate data for the year 1990 up to the month of June. Growth in all subsequent years is therefore effectively in local currency. Table 0 shows the exchange rates for the major European currencies. The US dollar European semiconductor market growth of 9.5 percent in 1990 is based on a local currency growth of minus 0.1 percent. See Tables 1a and 1b for our detailed forecast of the European semiconductor market.

Dataquest defines the semiconductor market as representing all merchant market business, plus the captive business that exists for those semiconductor manufacturers which also participate in the merchant market. This element of captive business between a manufacturer and its equipment division/s and/or subsidiaries is valued at merchant market prices.

FORECAST OVERVIEW

Regional Effects

The European semiconductor market over the past five years has been characterized by the dynamics of its two largest regions—West Germany, and UK and Ireland. These two regions combined account for an estimated 54 percent of the European total available market (TAM).

Investment in, and expansion of, electronic equipment manufacturing facilities by large multinationals have ensured that these two regions maintain their dominance of the European semiconductor TAM in the medium-term future.

Economic and political changes within different European countries can have significant effects on the course of semiconductor demand. Two examples are the financial incentives offered to equipment manufacturers in the form of government subsidies, and the monetary union of East and West Germany.

Product Effects

The integrated circuit (IC) has progressively replaced discrete semiconductors in electronic equipment designs. ICs represented 75 percent of the European semiconductor TAM in 1985, and is forecast to reach 85 percent by 1995. The four-year cycle of increase in density of DRAMs therefore has an increasingly profound effect on the total semiconductor forecast.

PRODUCT OVERVIEW

Bipolar Memory

The market for bipolar memory reached its peak in 1986, and has since been stagnating. The reason for this is the increasingly higher speeds and densities attainable with low-power CMOS and BiCMOS SRAMs, which have stolen a significant proportion of business from bipolar memory suppliers. Bipolar SRAMs remain popular in many supercomputing and mainframe applications, in which there is relatively small European activity, while bipolar PROMs are often used in military applications, where government spending has been cut back. Effectively, the requirement for bipolar memory in the European market is diminishing, and is characterized by a compound annual growth rate (CAGR) of minus 6 percent over the forecast period 1990 to 1995.

Bipolar Logic

The bipolar logic market comprises the product families of application-specific IC (ASIC), standard logic, and other logic. The bipolar logic market owes much of its growth to bipolar ASIC products, which have now attained the same market size as bipolar standard logic.

Bipolar ASIC

The largest product market within bipolar ASIC is in ECL gate arrays, which are reaching higher speeds and are still being used in mainframes and in fiber-optic communications. Also, TTL programmable logic array (PLA) devices are in strong demand by manufacturers of 80386-based PCs, while future demand for mixed analog-digital cell-based ICs (CBICs) is expected to increase. The five-year (1990 to 1995) CAGR for the bipolar ASIC market is 8 percent.

Bipolar Standard Logic

The bipolar standard logic market has been eroded by CMOS standard logic and CMOS gate array solutions, which has resulted in the poor performance of this market. The five-year (1990 to 1995) CAGR for bipolar standard logic is 4 percent, which is well below the average.

Other Bipolar Logic

This market includes application-specific standard products (ASSPs), bipolar bit-slice, arithmetic logic units (ALUs), multipliers, floating point, and digital filters. It is a market that is growing above the bipolar logic average, but from a small base. The five-year outlook CAGR is 8 percent.

MOS Memory

MOS memory is one of the most volatile product areas for a semiconductor vendor today, and represents an estimated 28 percent of the European IC market in 1990. Factors contributing to the instability of this segment include:

- The short life-cycle of most MOS memory product
- The rapid price erosion associated with this
- The relatively high growth of the European PC industry which consumes a large proportion of DRAM products

- The array of tariffs, dumping duties, and floor prices imposed on various MOS memory products by the European Commission and individual governments
- The huge profits (or losses) to be made in this business

DRAM

The largest single product group is DRAM, which is expected to account for nearly 13 percent of the European semiconductor TAM, or 56 percent of the MOS memory TAM, in 1990. Overwhelming demand for the 1M DRAM in 1988 was a major driving force behind the 34 percent total semiconductor market growth experienced in Europe that year. Acute shortages of the 1M DRAM had given rise to inflated prices, thereby artificially boosting the value of the DRAM market which grew by an estimated 164 percent in 1988. Conversely, when production overtakes demand the reverse occurs.

In fact, price erosion is a major factor behind our forecast of an 18 percent decline in the European DRAM TAM in 1990. The outlook for DRAM, however, is strong in the long term. We forecast a CAGR of 30 percent over the period 1990 to 1995. This is the strongest CAGR of any product tracked, and is driven by strong demand from users in the data processing segment.

SRAM

The SRAM market is about one-third the size of the DRAM market, although there are almost twice as many suppliers. This typifies the diversity of this particular market. High speed, low-power consumption, and no requirement for regular memory refresh are three of the main benefits of SRAM over DRAM, but there is a premium to pay. Roughly speaking, the price of a given density of SRAM is close to four times the price an equivalent DRAM. Therefore, SRAM is used where either high speed is a priority (such as in cache memory or high-performance computers), where low-power consumption is important (such as in laptop PCs), or where it is beneficial to avoid needing a memory refresh controller (such as in LAN cards). Growth in the SRAM TAM is strong, with a five-year outlook CAGR of 23 percent, as application segments for SRAM are generally healthy.

Nonvolatile MOS Memory

The nonvolatile (NV) MOS memory market includes EPROM, EEPROM, ROM, and Flash products. This market is also expected to grow above the European average, with a five-year outlook CAGR of nearly 19 percent. The main products of this market are discussed below.

EPROM. It is estimated that the EPROM family represents more than 80 percent of the European NV memory TAM in 1990, and is second in size after DRAM. This market has historically been stable in comparison to the volatile memory market (that is, DRAM and SRAM), but recent competition in the European market has caused the 1M EPROM price to plummet. The European Commission has been asked to investigate alleged dumping of EPROMs in the European market. If the Commission finds evidence of this, it is possible that an EPROM reference price may be introduced. Europe had the world's lowest prices for the 1M part throughout the second quarter of 1990, according to contract pricing analysis by Dataquest. Nevertheless, the outlook for the EPROM market is healthy, as applications for EPROM are in the growth equipment segments of data processing and telecommunications.

EEPROM. The EEPROM market is the next largest NV memory market after EPROM in 1990, and represents about 12 percent of the NV MOS memory TAM. The EEPROM is the most expensive type of commodity MOS memory, and is consequently implemented in equipment where either a small EEPROM can be justified (such as in advanced consumer electronics applications) or in equipment where cost is not a major issue (such as military or high-end automotive applications). The high cost of EEPROM therefore makes it most attractive in niche applications that cannot match the high-volume mass markets of its cheaper counterparts.

MOS ROM. Demand for MOS ROM in Europe is relatively weak. It is best implemented in very high-volume applications, where the initial cost of the mask can be recouped by large unit shipments. Typical applications are in laser printer font cartridges and video games machine cartridges. Bearing in mind the supplier base for these types of equipment, it is not surprising that Japan consumes more than 80 percent of the worldwide supply of MOS ROMs, and Europe less than 2 percent. The medium-term outlook for the European MOS ROM market is flat.

Flash Memory. The last product of the NV MOS memory family is Flash. This product is the youngest of all the commodity MOS memory family, first appearing in 1985, and its applications have not yet been fully identified. There are two branches of Flash memory, one based on EPROM and the other on EEPROM. The former is simpler in design, meaning it is also cheaper. Potential mass-market uses of Flash memory are as a solid-state alternative to mechanical disk drives in pocket computers and in zero-power memory cards. There are potentially many other applications for Flash that are currently served by EPROM or EEPROM. Much depends on volume demand to bring prices down to competitive levels, as well as increasing the performance and density of Flash. Dataquest believes that the European Flash memory market will grow very fast.

Microcomponent

The microcomponent market comprises three main segments: microprocessor (MPU), microcontroller (MCU and DSP), and microperipheral (MPR).

Microprocessor

The European microprocessor market is dominated by a small number of proprietary suppliers—80 percent of the market is controlled by five suppliers—and is therefore not subject to the competition and rapid price erosion that other semiconductor products experience. It is a market that is closely related to the PC industry, which is particularly healthy in Europe. Therefore, as the European PC industry outlook is fundamentally strong, the microprocessor market is expected to have an above-average five-year outlook CAGR of 20 percent.

Microcontroller

The microcontroller market, including digital signal processors (DSPs), comprises many embedded controllers. This is an area in which Europe is strong, driven by applications in automotive electronics, data processing, and telecommunications. There are also potential applications for MCUs in consumer electronics equipment such as VCRs and compact disc. As there is less concentration on supplier market shares, so competition is stronger than for the microprocessor market, and price erosion is more of an influence. However the MCU market, which is more than 50 percent larger than the MPU market, is forecast to grow at the same 20 percent CAGR as the MPU market over the period 1990 to 1995.

Microperipheral

The microperipheral market includes PC chip sets, which are increasingly popular with OEMs to reduce PC chip count. This has led to aggressively competitive price wars, and is affecting the intrinsic value of the European TAM. The medium-term outlook is for strong growth in unit shipments, but with associated price erosion which is expected to weaken the 1990 to 1995 CAGR to just about average, namely 18 percent.

MOS Logic

The MOS logic market consists of the product families of ASIC, standard logic, and other logic. The MOS logic market is almost three times the size of the bipolar logic market, and is growing three times as fast. The benefits of low power consumption and higher gate density are two of the greatest assets of MOS over bipolar in the logic area.

MOS ASIC

The European MOS ASIC market is the strongest-growing segment of the MOS logic market, with ASIC solutions continuing to replace commodity standard logic, as well as power-hungry bipolar alternatives. The MOS ASIC category consists of gate array, CBICs (or standard cells), programmable logic devices (PLDs), and full custom. MOS PLD is one of the fastest growing product categories that Dataquest tracks. CMOS gate arrays, in particular, are replacing bipolar standard logic solutions. The outlook is very healthy, with a five-year outlook CAGR of more than 21 percent.

MOS Standard Logic

The MOS standard logic market has been suffering from price erosion which has limited the growth of its TAM. The outlook for this product family is below average, with a CAGR of 11 percent over the period 1990 to 1995.

Other MOS Logic

This category includes ASSPs, digital filters, barrel shifters, and other building blocks. Many of these devices are applied in digital telecommunications (including ISDN) and consumer electronics equipment. The five-year outlook for this large category of products is for below-average growth of 13 percent.

Analog

The analog market is expected to account for 18 percent of the European semiconductor TAM in 1990, and to grow above the European average growth for this year. This market is split into monolithic analog products and hybrid analog products. Monolithic analog represents over 90 percent of the total European analog market. Our hybrid analog market estimates only represent sales by manufacturers who also supply non-hybrid semiconductor products to the merchant market, and do not count resales from non-semiconductor manufacturers.

Monolithic Analog

Applications for monolithic analog ICs are wide and diversified, which has given this market a level of stability greater than almost any other semiconductor product. Consequently, we can expect the analog market to ride above industry downturns, but below the upturns, maintaining a steady growth. The use of mixed analog-digital devices in PCs for graphics and disk drives is expected to increase strongly, as is their use in the transportation segment.

The largest application of monolithic analog is in consumer electronics equipment, which is also one of the fastest growing analog products in our forecast. Growth is also strong in mixed-mode (analog-digital) ICs, which are included in this segment when the analog component is dominant by area.

Hybrid Analog

The market for hybrid analog is primarily in the military and industrial application segments, although demand from data processing and consumer end users is growing. Major product implementations of hybrid analog are as amplifiers, power controllers, and data converters. This market is expected to grow below the semiconductor average, with a CAGR of 16 percent in the five-year outlook.

Discrete

The transistor market comprises the product families of transistor, diode, thyristor, and other discrete. The European discrete market is under attack from ICs, particularly "smart power" ICs, and is forecast to shrink from representing an estimated 17 percent of the European semiconductor TAM in 1990, to about 12 percent in 1995. However, like the analog market, there is an inherent stability in the discrete market which Dataquest believes will provide for steady positive growth at about half the European average over the period 1990 to 1995.

Transistor

The transistor market represents an estimated 50 percent of the European discrete TAM in 1990, and comprises a wide range of power-rated devices. Small signal applications include low-power servo-assisted systems for disk drives, VCRs, automatic cameras, and automotive equipment. High-power applications include motor control, regulators, power invertors, power supply switching, and traction. Traction is becoming a very important growth application for power transistors, particularly in modern passenger transport systems such as subway trains and monorail.

While some of these applications are being targeted by IC manufacturers, there are many others that cannot be targeted, due to the harsh environments in which they are required to operate, as well as the need for high current ratings. This market is expected to show the healthiest growth in the discrete segment, with a five-year outlook CAGR of almost 11 percent.

Diode

Diodes are likewise classified by power rating. Small signal diodes are found in low-current power supply rectification and as detectors in low-end frequency circuits in radios and televisions. Power diodes are used in microwave ovens and television main circuit boards. Other types of diode are the Schottky barrier diode, found in computer and peripheral power supplies, and the zener diode, found in voltage regulators, operational amplifiers and converters. The European diode market is forecast to show steady positive growth, with a five-year outlook CAGR of 10 percent, generally following the trends of the transistor market.

Thyristor

The thyristor market, including triacs and diacs, mainly serves the consumer and industrial application segments. In the industrial segment, high power ratings and harsh environments are common. Positive but unremarkable growth is forecast for this product family over the 1990 to 1995 period.

Optoelectronic

The optoelectronic market comprises light-emitting diodes (LEDs), LED displays (such as, alphanumeric), optocouplers, and other optoelectronic devices. The European optoelectronic market is relatively stable, and does not exhibit the same swings in TAM as the IC market. The 1990 optoelectronic TAM is expected to grow above the European average, although the 1990 to 1995 CAGR is forecast to be a little below the European average, at 15 percent.

LED and LED Display

LED-based devices are the commodity parts of the optoelectronic industry, and are used in a very wide range of applications for indication and data readout. They are also used in facsimile machines and printers. New developments in very bright LEDs may open further applications. A five-year outlook CAGR of between 8 and 10 percent is forecast for these two product groups.

Optocoupler

Optocouplers are used in more demanding applications, such as high-performance relays, position sensors, optical encoders, and voltage isolators for connection of sensitive logic circuits to power devices. It is the optocoupler market which is expected to show the highest growth in the optelectronics segment over the 1990 to 1995 period, with a CAGR of 18 percent.

Other Optoelectronic

Other optoelectronic products include photodiodes, phototransistors, solar cells, and semiconductor lasers. There are growing applications for these products in the application segments of compact disc equipment, remote controls for audio and visual equipment, facsimiles, photocopiers, laser printers, and fiber-optic communications.

REGIONAL OVERVIEW

Benelux

This region comprises Belgium, the Netherlands, and Luxembourg. The general five-year outlook is of below-average growth, with a CAGR of 13 percent. The exception is 1990, which is expected to grow slightly above the European average due to the fact that the Benelux countries are not affected by price erosion in DRAMs as much as other European regions. See Tables 2a and 2b.

Belgium

This country has a population equivalent to one-fifth that of West Germany or the United Kingdom. The Belgian semiconductor market is dominated by users from the telecommunications and consumer segments. Demand from this user base is expected to increase, as European telecommunications networks are upgraded or expanded and the markets in the Eastern bloc open up. Demand is also expected in the consumer electronics equipment segment as it migrates toward the high end. However, new manufacturing plants are expected to be located outside Belgium, thereby diverting much of new semiconductor requirement to other regions. The five-year outlook for Belgium is for weak growth.

Netherlands

This country's population is also approximately one-fifth that of West Germany or the United Kingdom. The Netherlands is heavily biased toward the consumer application segment. Demand for analog and discrete devices is expected to be generally above the European average, while bipolar and MOS IC devices are expected to be below. The continuing influx of Japanese and Korean consumer electronics equipment is expected to weaken the future growth of the semiconductor TAM in the Netherlands. Also, some manufacturing operations are beginning to be located outside the Netherlands to take advantage of lower wage costs. The five-year outlook for the Netherlands is therefore reasonable, but below the European average.

Luxembourg

Luxembourg is one of the smallest of the countries tracked, having a population equivalent to a small city. It is very active in the financial sector, as well as in the iron and steel industry. Although it is a wealthy country, it does not have an indigenous electronics equipment manufacturing industry of any note, nor is one expected in the medium term.

France

France is a relatively large region of Europe, having a similar population to the United Kingdom and West Germany, but with a semiconductor TAM about half the value of these regions, as shown in Tables 3a and 3b. The reasons for this are partly seated in the ability or desire for attracting foreign investment. France in particular does not appear to compete very strongly in this area, and consequently has a relatively small number of foreign electronics equipment manufacturers operating within its borders. Manufacturing strength in the domestic electronics equipment market is spread across telecommunications, military, consumer, and industrial application segments.

The telecommunications segment is strong, and the French-owned company, Alcatel, is the world's largest electronics equipment manufacturer in this segment. However, the military segment is beginning to shrink as East–West relationships improve; the consumer segment is increasingly a domain for Japanese suppliers; and the industrial segment is growing slower than other segments. Therefore, the outlook for France is generally below European average growth. Yet its strength in the analog and MOS digital product families means that the French five-year outlook CAGR is not much below the European average, at 17 percent.

Italy

Italy, like France, has a similar population to the United Kingdom and West Germany, but less than half the semiconductor TAM of these regions, as can be seen in Tables 4a and 4b. However, Italy is very much a developing region, and the prospects for future growth are optimistic. Italy's strengths lie in data processing, telecommunications, and automotive applications.

The DP and telecommunications markets in Europe are strong, as the export markets begin to open up in Eastern Europe. Therefore Italy is well placed to take advantage of these opportunities. The Italian automotive industry is now targeting the economy high-volume market for automotive electronics, as well as continuing with its traditional high end. Dataquest believes that bipolar logic and the MOS digital segment will show above-average growth in the medium term, thereby driving the overall Italian semiconductor TAM ahead of the European average, with a five-year outlook CAGR of 19 percent.

Nordic Countries

This region comprises Sweden, Denmark, Finland, Norway, and Iceland, with a combined population around one-third of the United Kingdom or West Germany. The relatively high costs of labor and materials in Nordic countries, together with the small domestic markets, has discouraged much foreign investment. This has meant that nearly all the semiconductors consumed in this region are by indigenous industries. These industries are mainly concentrated in telecommunications, as well as industrial, consumer, and some data processing. Below-average growth is expected in the five-year outlook, with a CAGR of 16 percent, as shown in Tables 5a and 5b.

Sweden

This country is the largest of the Nordic region, and represents a third of the region's population. Not surprisingly, it also has the strongest electronics industry. However, investment in domestic production capacity has been curtailed in the last few years, caused by shortages in skilled labor and increasing wage costs. Instead, investment is being made in production capacity in other European countries, which will make sales to external markets easier.

Sweden is not a member country of the European Community (EC), but is already well positioned to take advantage of the 1992 market unification. Sweden's major semiconductor end-use segments are telecommunications and industrial, which mainly consume analog and MOS logic products. However, major product families such as MOS memory and microcomponents, where most of the European semiconductor market growth is derived, are in little demand. Consequently, we see a five-year outlook below the European average growth.

Denmark

The Danish population is the next highest of the Nordic countries, although it has only a tenth of the land area of any of its neighbors. It is unusual to note that very few Danish manufacturers have pan-European operations, let alone international ones, as they are mainly small to medium-size companies. This has meant that investment in manufacturing operations have been on a scale to support domestic demand, rather than export capacity.

Denmark's major semiconductor end-use segments are consumer audio and instrumentation. Semiconductor distribution is also an important element of the market. Denmark is the only Nordic member of the EC, although it is not apparent whether it is well prepared to take advantage of this position. The five-year outlook is for limited semiconductor TAM growth.

Finland

Finland has the next highest population in the region, after Sweden and Denmark. It is also in the best position to do business with COMECON (Council for Mutual Economic Assistance) member countries as it borders with the Soviet Union. With the opening of Eastern bloc markets, there should be many opportunities for further trade, including electronics equipment.

The country's main electronics equipment markets are in data processing, consumer, and telecommunications. However, there are few indigenous equipment manufacturers, and unless they are able to penetrate the EC (Finland is not a member country) and international markets as well as COMECON ones, the medium-term outlook for the Finnish semiconductor market is for weak growth.

Norway

The Norwegian semiconductor market is very much geared towards the data processing application segment. There are three major manufacturers of data processing equipment in Norway, although by global standards they are small. This country is not a member country of the EC, although as the European PC market is growing strongly, it is expected that this will have an effect on demand for semiconductors in Norway. Therefore, the medium-term outlook for the Norwegian semiconductor market is optimistic, although from a comparatively small base.

Iceland

This country, which became independent from Denmark in 1944, has the disadvantage of being the most geographically isolated in Europe. This is compounded by the fact that it has very few natural resources except fish, which is the country's major export product. There is negligible semiconductor demand, and the outlook is flat.

UK and Ireland

This region comprises England, Wales, Scotland, Northern Ireland, and Ireland. The semiconductor markets of this region are growing more strongly than in all other European regions, with a five-year outlook CAGR of 20 percent, shown in Tables 6a and 6b. This strong growth is partly due to the manufacturing investment in this region made by some of the world's largest computer and consumer equipment manufacturers.

It is believed that one of the reasons why the UK and Ireland have attracted so much foreign investment is because English is the most commonly used language in the world, making recruitment apparently easier, and business with external markets simpler. There have also been attractive government subsidies for equipment manufacturers setting up manufacturing facilities in this region. However, strong dependence on the data processing industry means this region is forecast to be the largest market for ICs in Europe, and therefore exposed to the cyclic shortages and prices changes in DRAMs and microprocessors. Another observation is that transportation applications are only a third of the the European average proportion.

England

This country represents over 80 percent of the UK population, and consequently has the largest industrial base of the region, with a broad infrastructure to support the needs of its manufacturing base. The end-user segments are broady based, although the transportation segment is weaker than in other European regions. The telecommunications application market is partly dependent on one major domestic user, British Telecom. However, export markets for telecommunication equipment are growing strongly, especially in developing countries.

In the data processing market, some smaller manufacturing companies suffered during the DRAM shortage, and are still recovering, but the medium-term outlook is optimistic. The consumer applications market is expected to grow, as production of consumer equipment increases, helped by the growing investment from the Far East. The overall medium-term outlook is for strong growth.

Wales

The relatively small country of Wales has half the population of Scotland and is not a major user of semiconductors. However, it does have a few manufacturers which are strong in consumer and electronic printer production, as well as subcontractors providing board assembly services for the aforementioned companies. This is enough to provide Wales with strong growth from a small base in the five-year outlook period.

Scotland

The Scottish population represents about 10 percent of the UK total. There has been strong foreign investment in this country from equipment manufacturers in the data processing segment, aided by government subsidies. Plans by other data processing suppliers to locate major manufacturing facilities in Scotland could give the country a very strong demand for MOS memory and microcomponent devices. There are also several subcontracting board assembly facilities in Scotland serving the data processing segment. The medium-term outlook for semiconductor demand in Scotland is related to the European computer industry, and is therefore strong.

Northern Ireland

Northern Ireland has half the population of Wales and has little electronic equipment manufacturing capacity. The medium-term outlook is flat.

Ireland

Ireland became independent from the United Kingdom in 1922. The country's population is less than one-tenth of that of the United Kingdom, but its area is equivalent to one-third of the total UK area. Investment from semiconductor and electronics equipment manufacturers has been encouraged by government subsidies, as in the United Kingdom, and the country is now host to some of the world's largest suppliers in the field of data processing.

Consumption of memory and microcomponents is therefore a major proportion of the Irish semiconductor TAM, more probably than in any other European country. This has had the effect of providing for strong TAM growth when DRAM prices are inflating, but for decline when DRAM prices are eroding. The medium-term outlook is for strong growth, following the trends of the European computer market.

West Germany

West Germany easily has the largest semiconductor market of any single country in Europe, which can be seen in Tables 7a and 7b. Consumption is fairly evenly spread across all application segments, though transportation applications are twice the European proportional average, and military applications are only a third. There are many large electronics equipment manufacturers in West Germany, some of which have their own captive supply of semiconductors.

One of this country's main strengths is in the telecommunications segment, where business with Eastern bloc countries has been expanding recently; the data processing segment is also strong. However, application segments in which West Germany particularly excels are industrial, consumer, and automotive. This has had the effect of maintaining a very strong market for discrete and optoelectronic semiconductors. In fact, it is estimated that West Germany accounts for more than 30 percent of the European TAMs in both these product families in 1990, giving it a strong lead over any other European region. The West German IC TAM, though, is being just exceeded by that of the United Kingdom over the forecast period.

The recent monetary union of East and West Germany has major implications for the West German market, although the net effect is yet unclear, and is largely dependent on the reaction of the populations of these countries to such changes. One likely chain of events is that East Germans will purchase West German data processing and consumer electronics equipment that cannot be sourced in their own market. This will initially boost the West German electronics equipment and semiconductor markets. However, it will result in East German industries losing business to West Germany, and being faced with the prospect of cutbacks or closure.

Large subsidies from the West German government will help keep these industries afloat so that they can catch up with Western standards and compete on the open market. The subsidies will affect interest rates in West Germany, which will increase inflation and limit domestic spending; this could overbalance the influx of new spending from East Germany. This scenario suggests that the West German semiconductor market will grow at a European average rate, although the product split may alter with time due to gradual changes in the end-user base.

Rest of Europe

This region consists of all the remaining Western European countries not already covered, including Spain, Switzerland, Austria, Portugal, Greece, Turkey, and Malta. The territories are geographically, politically, and industrially diverse, which means their combined semiconductor consumption is also somewhat diverse. However, one consistent factor is that this regional category is experiencing above-average growth over the medium-term outlook, which is shown in Tables 8a and 8b. This is mainly due to investment by foreign equipment manufacturers in these countries, attracted by the relatively low wage costs.

Spain

Spain has a population about two-thirds that of West Germany, and is the major semiconductor market of this regional category. Several major data processing, telecommunications, and consumer electronics manufacturers have placed production facilities in Spain, attracted by low wages and cheap land.

Unemployment has been a major problem for Spain in recent years, and the influx of manufacturers together with the requirement for offices and homes has given a boost to one of its major industries, construction. Another boost to the Spanish economy is expected in the buildup to the Olympic Games in Barcelona in 1992, which will attract much business in support communications and data processing. Also, Europe hopes to use the event to parade its high-definition TV prototypes. Therefore, the medium-term outlook for Spain, as a newly industrializing economy, is for strong growth.

Switzerland

The population of Switzerland is about one-tenth that of West Germany or the United Kingdom, but represents the next largest semiconductor market in this region. Switzerland is not a member of the EC, but does have strong business ties with West Germany. The major application segments in this small country are industrial and consumer, and it has one of the highest national proportions of expenditure on R&D in high technology in the world. Switzerland is probably most famous for the consumer segment, where it has a worldwide reputation in sophisticated electronic watches and clocks. The medium-term outlook for Switzerland is healthy.

Austria

Austria has a similar population to Switzerland and is also not a member country of the EC. It has had a strong economy in recent years, partly through the restructuring of its larger loss-making nationalized industries and the partial privatization of some of the smaller industries. Austria's main semiconductor application segments are in the industrial, consumer and transportation segments. The country is well positioned for trade with the opening up of Eastern European markets. The medium-term outlook is for above-average growth.

Portugal

Portugal has a population about one-fifth that of West Germany or the United Kingdom, and it has benefited from an influx of investment from electronics equipment manufacturers in the segments of data processing and consumer. This newly industrializing economy is expected to show strong growth in the medium-term outlook.

Greece

The Greek population is around one-sixth that of West Germany, and has remained heavily dependent on traditonal labor-intensive industries such as textiles, clothing, agriculture, and metals. There has been little activity in technology-based industries, either domestically or through inward foreign investment. The medium-term outlook is flat.

Turkey

The population of Turkey is similar to that of West Germany or the United Kingdom, with a land area 40 percent greater than these two regions combined. Turkey has undergone substantial restructuring this century, including the replacement of its alphabet, and is still restructuring today in an effort to become more Westernized. About half its total civilian workforce is still involved in agriculture, followed by textiles, clothing, and its metal industry.

Turkey's application for membership of the EC is still pending. The government has initiated a program of privatization of nationalized industries, and there are indications that Turkey is starting to invest in high-technology industries through expansion and acquisition. The medium-term outlook for Turkey is therefore for high growth from a very small base.

Malta

The Republic of Malta has a population similar to that of Luxembourg, or less than one percent of that of West Germany or the United Kingdom. The major industry of this country is tourism, followed by textiles, clothing and agriculture. Malta plans to apply for membership of the EC in 1990. There are a few semiconductor test and assembly operations in Malta, but little semiconductor consumption. Investment from equipment manufacturers has been negligible. The five-year outlook is therefore flat.

PRODUCT AND REGIONAL GRAPHIC ANALYSIS

The following figures provide graphical analysis of key trends in the European semiconductor market by product and region.

Figure 1 tracks the size the European semiconductor market over the period 1978 to 1989, with the forecast years 1990 to 1995 added for reference. The annual growth rates of this market over the same period in US dollars and local currency are shown in Figure 2. As can be seen from this graph, Dataquest does not expect the market to experience any negative growth over the forecast period, although we do expect cycles of positive growth.

Figure 3 shows the European semiconductor market as a percentage of the worldwide semiconductor market over the period 1978 to 1994. This graph shows a sharp decline in the European representation in the worldwide market over the period 1980 to 1984, which is mainly due to the rise of the Japanese semiconductor market. In 1980, Japan represented 24 percent of the worldwide market; by 1984 this had increased to 31 percent.

The short-lived peak in 1985 was caused by the catastrophic fall of the North American semiconductor market, which was affected by the worldwide industry decline of that year more than any other region.

The European semiconductor market is forecast to gain gound in the worldwide scenario over the period 1990 to 1994, driven by strong foreign investment in equipment manufacturing facilities.

Figure 4 shows the change over time in the proportions that the three main semiconductor segments represent of the total market. As can be seen, the IC market is steadily advancing on discretes. The notable rise in the IC market in 1988 was caused by the inflation of the DRAM market.

Figures 5 through 8 analyse the movement in two variables in each of the European regions over the forecast period 1990 to 1995. The first variable is the relative market size of each region, expressed as a percentage of the total European market, and is plotted along the X-axis for 1990 and 1995. The second variable is the five-year compound annual growth rate (CAGR) for each region, which is plotted along the Y-axis for the five-year periods ending in 1990 and 1995. Therefore, a point can be plotted for each region for 1990 and 1995, and a line drawn between them to show the direction of movement. In this way, changes in size and growth of each region can be compared.

Figure 5 provides this analysis for the total semiconductor market, Figure 6 shows the IC market, Figure 7 shows the discrete market, and Figure 8 shows the optoelectronic market.

From these graphs, it can be seen that the UK and Irish market is forecast to show the greatest increase in relative market size, together with a jump in semiconductor CAGR, driven predominantly by demand in IC market. The Italian market is expected to see a slowdown in CAGR, mainly in the discrete market, although it is still expected to gain overall in relative semiconductor market size as its CAGR is maintained higher than the European average. The Nordic countries, on the other hand, are forecast to see an increase in CAGR, coupled with a decrease in relative market size. This decrease is a result of its below-average CAGR, even after the increase.

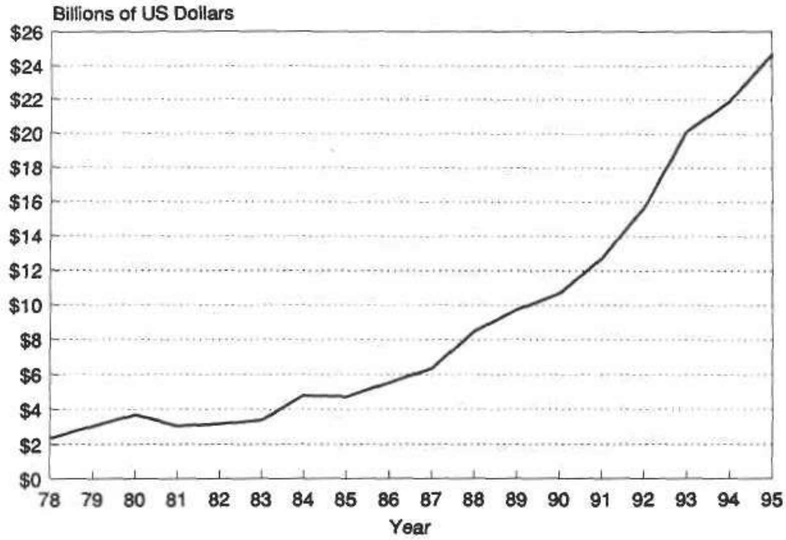
The Rest of Europe region is forecast to experience two opposing trends. Its IC market is expected to see the strongest increase in CAGR of all the European regions, with a consequential increase in relative market size. However, its discrete market is expected to see the sharpest drop in CAGR, albeit from a very high level, which allows it to gain a little relative market share. The net effect of these strong opposite trends is to leave the total semiconductor market almost entirely unchanged in terms of growth and relative market size.

The West German and UK and Irish markets are forecast to experience inverse trends in the IC segment. The West German market is expected see a slowdown in CAGR, coupled with a decline in relative market size, while the UK and Irish market is expected to see a pickup in CAGR, driving an increase in relative market size. However, both markets are forecast to have above-average CAGRs and relative market sizes in 1995.

The Benelux market is expected to see the lowest semiconductor CAGR rates and smallest relative market size of any region. It is expected to experience an increase of CAGR in the IC market, although still remaining the slowest-growing region. Meanwhile, its discrete market is forecast to see a sharp slowdown in CAGR, which is in line with the overall European trend, therefore maintaining a steady relative market size.

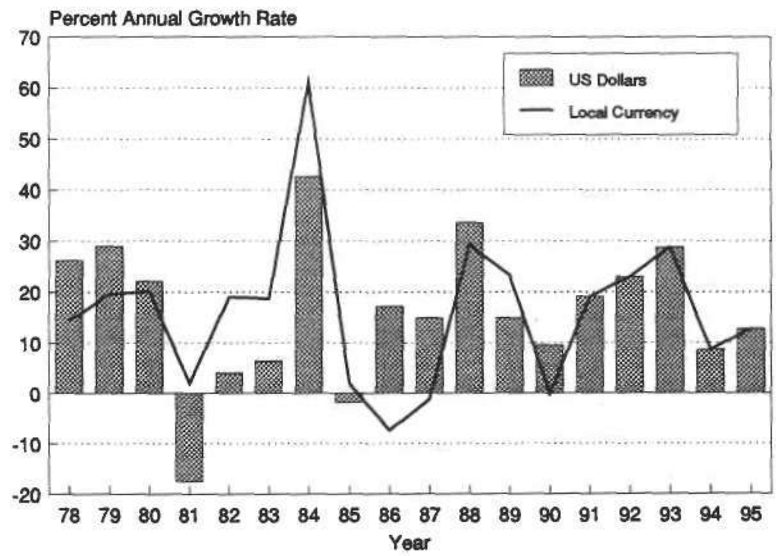
The French semiconductor market appears as the most stable region when measured by these variables. However, while its IC market shows stability, its discrete and optoelectronic markets are expected to exhibit opposite trends. Its discrete market is forecast to decline in CAGR, while its optoelectronic market is forecast to increase in CAGR, with the net effect of a balance.

Figure 1
European Semiconductor Market
1978 to 1995



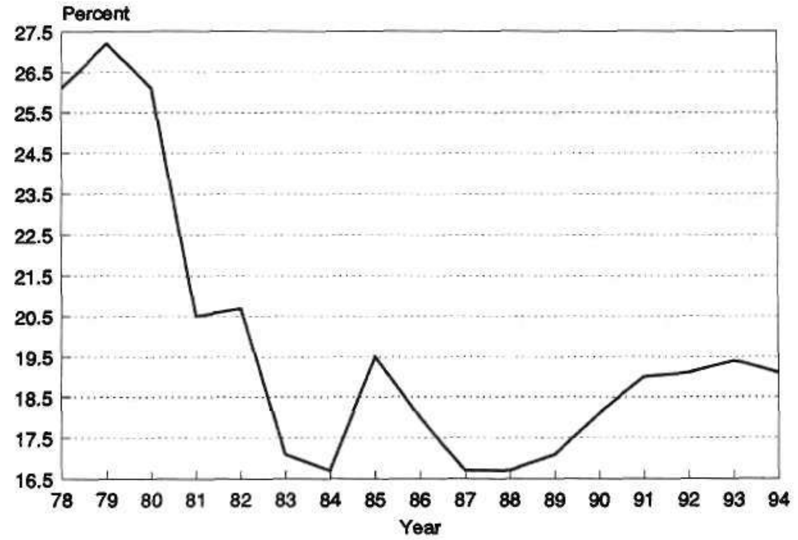
Source: Dataquest (July 1990)

Figure 2
European Semiconductor Market, Annual Growth Rates
1978 to 1995



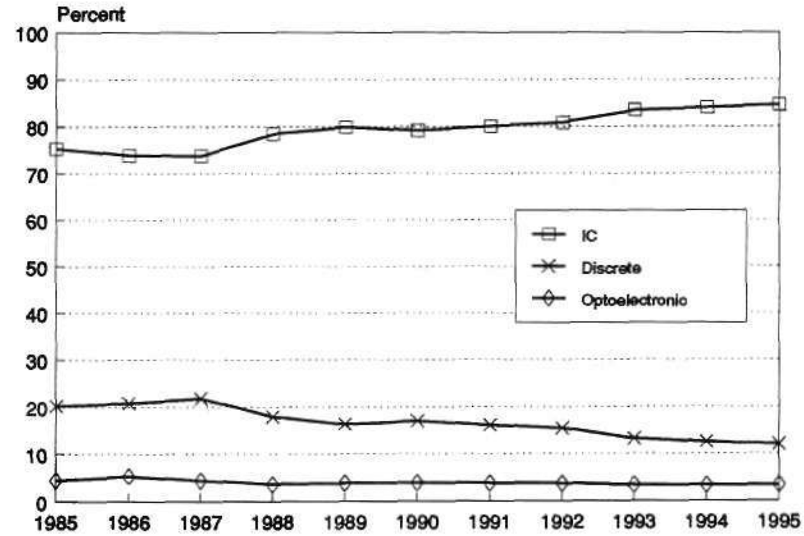
Source: Dataquest (July 1990)

Figure 3
European Semiconductor Market as a Percentage of World Market
1978 to 1994



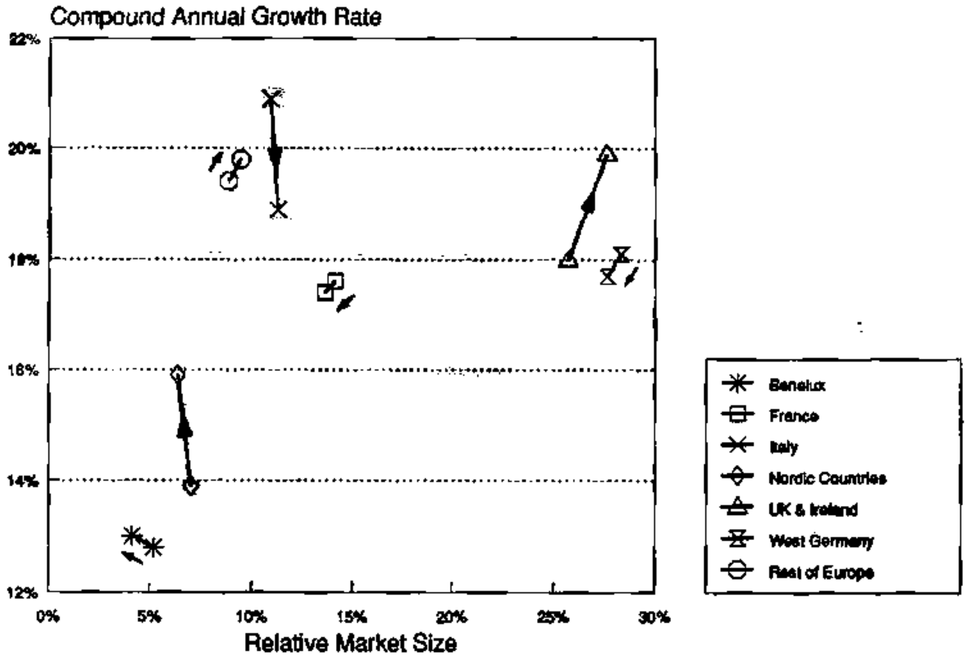
Source: Dataquest (July 1990)

Figure 4
European Semiconductor Market by Major Product Family
1985 to 1995



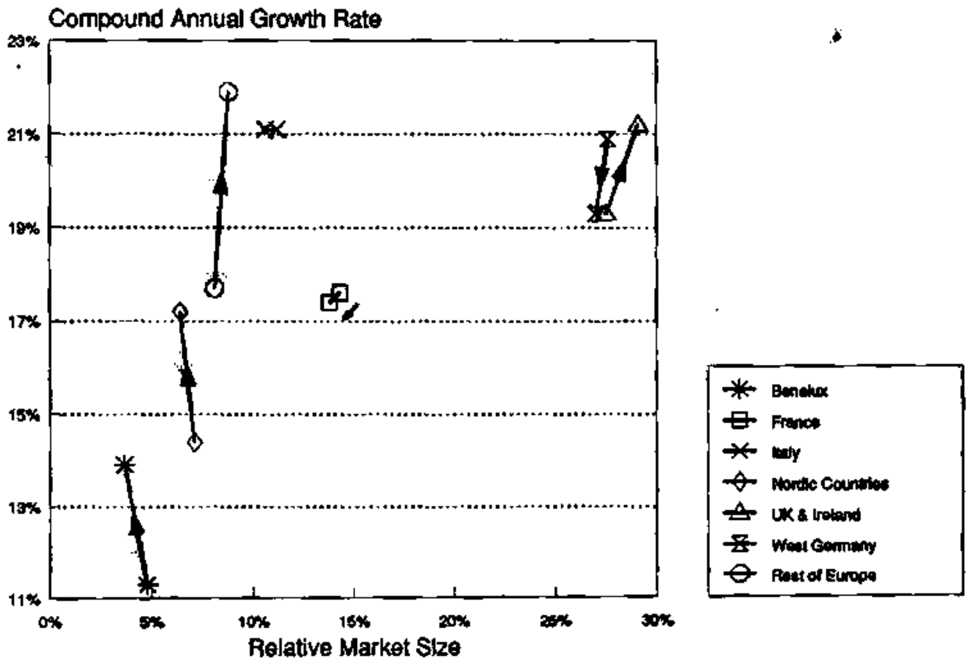
Source: Dataquest (July 1990)

Figure 5
European Semiconductor Market Trends
1990 to 1995



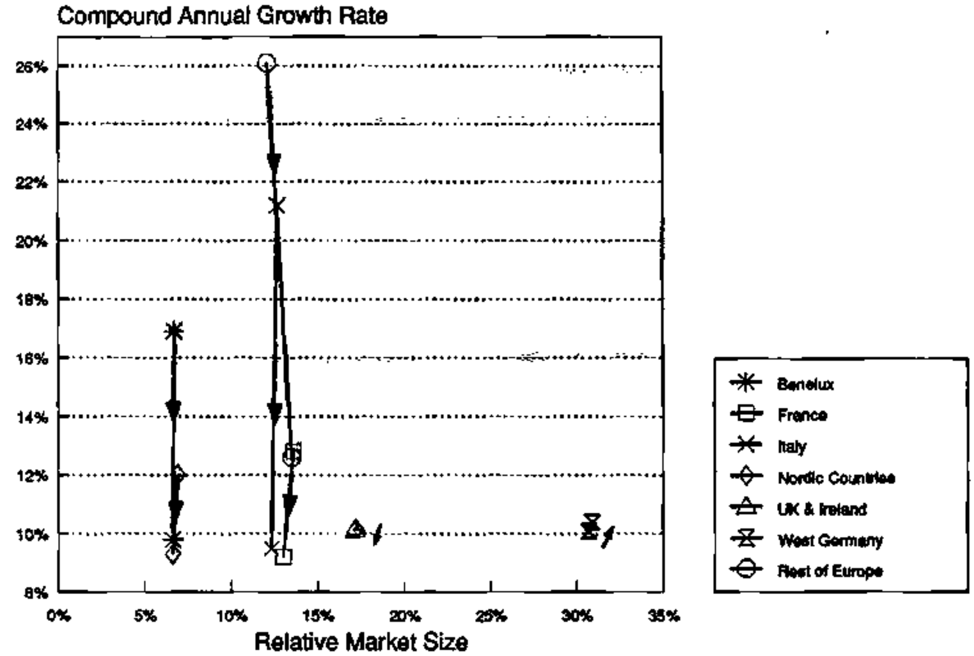
Source: Dataquest (July 1990)

Figure 6
European IC Market Trends
1990 to 1995



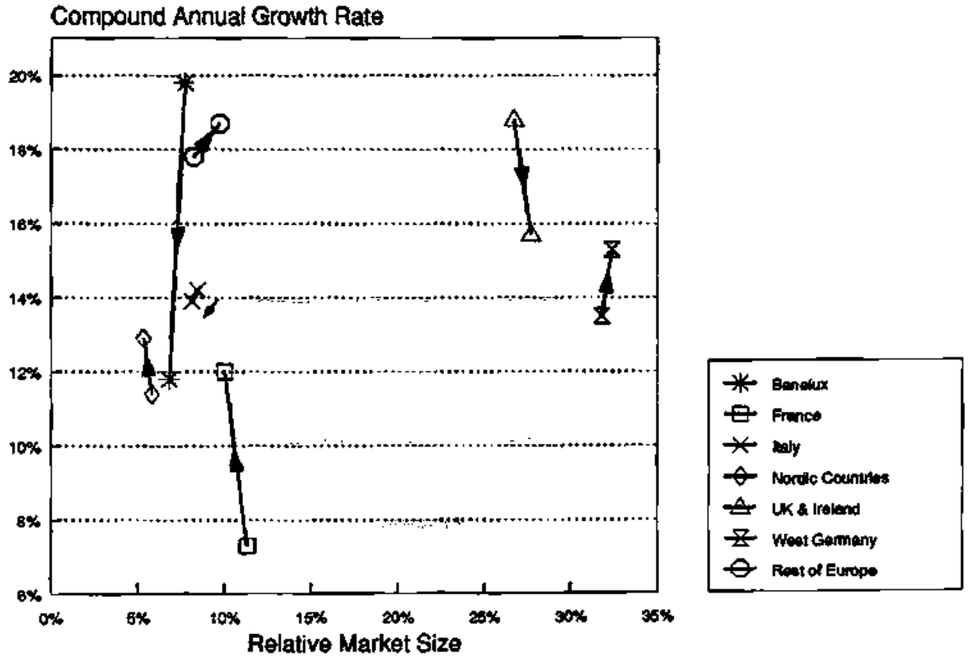
Source: Dataquest (July 1990)

Figure 7
European Discrete Market Trends
1990 to 1995



Source: Dataquest (July 1990)

Figure 8
European Optoelectronic Market Trends
1990 to 1995



Source: Dataquest (July 1990)

Table 0
European Currency Exchange Rates Against the US Dollar

Region	Main Currency	1983	1984	1985	1986	1987	1988	1989	1990*
Benelux	Dutch Florin	2.85	3.21	3.32	2.45	2.03	1.98	2.12	1.89
France	French Franc	7.62	8.74	8.98	6.92	6.01	5.96	6.39	5.67
Italy	Italian Lire	1,518.9	1,757.0	1,909.5	1,490.0	1,296.1	1,301.0	1,373.6	1,239.3
Nordic Countries	Swedish Krona	7.67	8.27	8.60	7.12	6.34	6.13	6.45	6.10
UK & Ireland	UK Pound	0.66	0.75	0.77	0.68	0.61	0.56	0.61	0.60
West Germany	Deutsche Mark	2.55	2.85	2.94	2.17	1.80	1.76	1.88	1.68
Rest of Europe	Spanish Peseta	143.43	160.76	170.05	139.97	123.56	116.96	118.55	105.64
16-Country Weighted Average (Base 1980 = 100.00)		157.59	178.06	184.70	145.89	125.52	121.46	130.20	118.77

*Estimates based on data up to June 1990
Source: IMF, Dataquest (July 1990)

Table 1a
Estimated Semiconductor Consumption—History
Total All European Regions
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$3,370	$4,805	$4,720	$5,532	$6,355	$8,491	$9,755
Total Integrated Circuit	$2,323	$3,634	$3,556	$4,088	$4,693	$6,669	$7,794
Bipolar Digital (Tech.)	$483	$724	$709	$782	$725	$772	$640
TTL	446	659	641	705	564	624	501
ECL	37	65	68	77	161	148	139
Bipolar Digital (Function)	$483	$724	$709	$782	$725	$772	$640
Memory	107	149	157	172	85	74	72
Logic	376	575	552	610	640	698	568
ASIC	NA	NA	NA	230	210	241	260
Std. Logic	NA	NA	NA	376	410	394	282
Other Logic	NA	NA	NA	4	20	63	26
MOS Digital (Tech.)	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364	$5,458
CMOS	353	617	702	976	1,284	2,491	3,412
BiCMOS	0	0	0	0	24	56	60
NMOS and Other	874	1,475	1,251	1,304	1,445	1,817	1,986
MOS Digital (Function)	$1,227	$2,092	$1,953	$2,280	$2,753	$4,364	$5,458
Memory	$581	$995	$750	$822	$838	$1,797	$2,548
DRAM	NA	NA	NA	262	402	1,062	1,646
SRAM	NA	NA	NA	252	117	262	368
Nonvolatile	NA	NA	NA	308	319	473	519
Other	NA	NA	NA	NA	NA	NA	15
Microcomponent	$239	$465	$485	$578	$794	$1,212	$1,469
MPU	NA	NA	NA	95	217	341	409
MCU inc. DSP	NA	NA	NA	249	339	473	640
MPR	NA	NA	NA	234	238	398	420
Logic	$407	$632	$718	$880	$1,121	$1,355	$1,441
ASIC	NA	NA	NA	443	485	711	877
Std. Logic	NA	NA	NA	157	229	287	263
Other Logic	NA	NA	NA	280	407	357	301
Analog	$613	$818	$894	$1,026	$1,215	$1,533	$1,696
Monolithic	$613	$818	$894	$975	$1,153	$1,416	$1,560
Amplifiers	104	137	144	166	180	200	248
Regulators	37	50	54	62	71	90	111
Data Conversion	92	130	157	185	96	116	131
Interface	55	72	80	94	120	145	151
Special Consumer	227	298	318	360	417	475	525
Other	98	131	141	108	269	390	394
Hybrid	NA	NA	NA	$51	$62	$117	$136
Total Discrete	$866	$963	$954	$1,153	$1,384	$1,516	$1,594
Transistor	408	450	463	540	655	709	817
Diode	327	358	342	432	431	473	516
Thyristor	91	103	100	125	183	210	179
Other	40	52	49	56	115	124	82
Total Optoelectronic	$181	$208	$210	$291	$278	$306	$367
LED Lamp	45	55	55	76	57	46	57
LED Display	66	70	62	87	48	38	43
Optocoupler	32	40	41	56	68	64	75
Other	38	43	52	72	105	158	192

NA = Not available
Source: Dataquest (July 1990) Ref: 0790-09

Table 1b
Estimated Semiconductor Consumption—Forecast
Total All European Regions
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$9,755	$10,682	$12,727	$15,653	$20,163	$21,889	$24,661	18.2%
Total Integrated Circuit	$7,794	$8,455	$10,194	$12,657	$16,830	$18,417	$20,882	19.8%
Bipolar Digital (Tech.)	$640	$696	$771	$834	$887	$886	$890	5.0%
TTL	501	530	570	614	650	641	638	3.8%
ECL	139	166	201	220	237	245	252	8.7%
Bipolar Digital (Function)	$640	$696	$756	$834	$887	$886	$890	5.0%
Memory	72	80	83	86	77	68	60	(5.6%)
Logic	568	616	673	748	810	818	830	6.1%
ASIC	260	286	315	362	390	400	420	8.0%
Std. Logic	282	299	325	350	380	377	365	4.1%
Other Logic	26	31	33	36	40	41	45	7.7%
MOS Digital (Tech.)	$5,458	$5,809	$7,138	$9,086	$12,576	$13,889	$15,918	22.3%
CMOS	3,412	3,679	4,765	6,296	9,143	10,227	11,814	26.3%
BiCMOS	60	100	173	283	453	675	965	57.4%
NMOS and Other	1,986	2,030	2,200	2,507	2,980	2,987	3,139	9.1%
MOS Digital (Function)	$5,458	$5,809	$7,138	$9,086	$12,576	$13,889	$15,918	22.3%
Memory	$2,548	$2,383	$3,120	$4,207	$6,250	$6,787	$7,773	26.7%
DRAM	1,646	1,346	1,886	2,651	4,210	4,467	5,100	30.5%
SRAM	368	424	515	668	897	1,018	1,210	23.3%
Nonvolatile	519	592	694	855	1,098	1,244	1,398	18.8%
Other	15	21	25	33	45	58	65	25.4%
Microcomponent	$1,469	$1,704	$1,985	$2,420	$3,244	$3,641	$4,163	19.6%
MPU	409	479	550	680	893	1,010	1,192	20.0%
MCU inc. DSP	640	750	885	1,080	1,510	1,670	1,895	20.4%
MPR	420	475	550	660	841	961	1,076	17.8%
Logic	$1,441	$1,722	$2,033	$2,459	$3,082	$3,461	$3,982	18.3%
ASIC	877	1,070	1,290	1,638	2,097	2,429	2,820	21.4%
Std. Logic	263	302	330	370	435	458	519	11.4%
Other Logic	301	350	413	451	550	574	643	12.9%
Analog	$1,696	$1,950	$2,300	$2,737	$3,367	$3,642	$4,074	15.9%
Monolithic	$1,560	$1,794	$2,116	$2,518	$3,097	$3,349	$3,742	15.8%
Amplifiers	248	250	259	278	310	315	336	6.1%
Regulators	111	116	125	140	163	165	174	8.4%
Data Conversion	131	147	164	187	224	239	262	12.3%
Interface	151	163	178	196	220	227	247	8.7%
Special Consumer	525	602	713	856	1,055	1,192	1,357	17.7%
Other	394	516	677	861	1,125	1,211	1,366	21.5%
Hybrid	$136	$156	$184	$219	$270	$293	$332	16.3%
Total Discrete	$1,594	$1,812	$2,047	$2,416	$2,657	$2,743	$2,950	10.2%
Transistor	817	932	1,058	1,254	1,390	1,441	1,554	10.8%
Diode	516	592	668	787	867	898	959	10.1%
Thyristor	179	197	221	257	272	276	299	8.7%
Other	82	91	100	118	128	128	138	8.7%
Total Optoelectronic	$367	$415	$486	$580	$676	$729	$829	14.8%
LED Lamp	57	65	69	77	88	88	94	7.7%
LED Display	43	46	50	60	65	69	73	9.7%
Optocoupler	75	84	95	125	135	155	191	17.9%
Other	192	220	272	318	388	417	471	16.4%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 2a
Estimated Semiconductor Consumption—History
Benelux Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$208	$306	$304	$361	$407	$504	$507
Total Integrated Circuit	$149	$237	$235	$277	$307	$369	$374
Bipolar Digital	$31	$47	$47	$52	$43	$45	$37
Memory	7	9	11	12	5	4	4
Logic	24	38	36	40	38	41	33
MOS Digital	$79	$137	$129	$155	$184	$213	$230
Memory	38	65	49	57	42	72	77
Microcomponent	15	30	33	39	64	73	78
Logic	26	42	47	59	78	68	75
Analog	$39	$53	$59	$70	$80	$111	$107
Monolithic	39	53	59	70	76	103	98
Hybrid	0	0	0	0	4	8	9
Total Discrete	$49	$56	$56	$66	$82	$107	$104
Total Optoelectronic	$10	$13	$13	$18	$18	$28	$29

Source: Dataquest (July 1990) Ref: 0790-09

Table 2b
Estimated Semiconductor Consumption—Forecast
Benelux Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$507	$556	$636	$736	$907	$920	$1,023	13.0%
Total Integrated Circuit	$374	$402	$467	$532	$678	$697	$772	13.9%
Bipolar Digital	$37	$38	$40	$43	$49	$47	$46	3.9%
Memory	4	4	4	4	3	3	3	(5.6%)
Logic	33	34	36	39	46	44	43	4.8%
MOS Digital	$230	$242	$268	$299	$396	$422	$495	15.4%
Memory	77	75	89	99	135	139	180	19.1%
Microcomponent	78	86	93	109	146	149	163	13.6%
Logic	75	81	86	91	115	134	152	13.4%
Analog	$107	$122	$159	$190	$233	$228	$231	13.6%
Monolithic	98	112	147	176	216	213	215	13.9%
Hybrid	9	10	12	14	17	15	16	9.9%
Total Discrete	$104	$122	$133	$159	$177	$175	$195	9.8%
Total Optoelectronic	$29	$32	$36	$45	$52	$48	$56	11.8%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 3a
Estimated Semiconductor Consumption—History
France Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$585	$690	$671	$801	$940	$1,210	$1,386
Total Integrated Circuit	$419	$520	$503	$591	$716	$977	$1,122
Bipolar Digital	$87	$104	$101	$114	$109	$115	$83
Memory	19	22	23	26	13	10	8
Logic	68	82	78	88	96	105	75
MOS Digital	$221	$298	$276	$328	$422	$631	$777
Memory	105	142	107	121	126	232	350
Microcomponent	43	66	68	82	127	182	207
Logic	73	90	101	125	169	217	220
Analog	$111	$118	$126	$149	$185	$231	$262
Monolithic	111	118	126	149	176	214	237
Hybrid	0	0	0	0	9	17	25
Total Discrete	$134	$138	$135	$165	$185	$196	$220
Total Optoelectronic	$32	$32	$33	$45	$39	$37	$44

Source: Dataquest (July 1990) Ref: 0790-09

Table 3b
Estimated Semiconductor Consumption—Forecast
France Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$1,386	$1,507	$1,757	$2,145	$2,783	$2,955	$3,354	17.4%
Total Integrated Circuit	$1,122	$1,213	$1,427	$1,752	$2,347	$2,512	$2,887	18.9%
Bipolar Digital	$83	$92	$99	$108	$121	$117	$117	4.9%
Memory	8	9	9	9	9	8	7	(4.9%)
Logic	75	83	90	99	112	109	110	5.8%
MOS Digital	$777	$828	$998	$1,242	$1,728	$1,860	$2,171	21.3%
Memory	350	327	424	547	815	857	1,013	25.4%
Microcomponent	207	240	273	332	452	491	559	18.4%
Logic	220	261	301	363	461	512	599	18.1%
Analog	$262	$293	$330	$402	$498	$535	$599	15.4%
Monolithic	237	272	304	371	460	499	563	15.7%
Hybrid	25	21	26	31	38	36	36	11.4%
Total Discrete	$220	$247	$275	$328	$361	$366	$384	9.2%
Total Optoelectronic	$44	$47	$55	$65	$75	$77	$83	12.0%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 4a
Estimated Semiconductor Consumption—History
Italy Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$320	$480	$451	$534	$660	$982	$1,082
Total Integrated Circuit	$221	$368	$345	$404	$493	$791	$845
Bipolar Digital	$46	$74	$68	$77	$79	$79	$58
Memory	10	16	15	16	9	8	8
Logic	36	58	53	61	70	71	50
MOS Digital	$117	$212	$190	$225	$294	$560	$625
Memory	55	101	72	80	92	253	315
Microcomponent	23	47	48	58	79	145	170
Logic	39	64	70	87	123	162	140
Analog	$58	$82	$87	$102	$120	$152	$162
Monolithic	58	82	87	102	114	141	150
Hybrid	0	0	0	0	6	11	12
Total Discrete	$81	$92	$88	$106	$139	$160	$205
Total Optoelectronic	$18	$20	$18	$24	$28	$31	$32

Source: Dataquest (July 1990) Ref: 0790-09

Table 4b
Estimated Semiconductor Consumption—Forecast
Italy Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$1,082	$1,165	$1,400	$1,754	$2,238	$2,452	$2,774	18.9%
Total Integrated Circuit	$845	$900	$1,108	$1,412	$1,873	$2,064	$2,345	21.1%
Bipolar Digital	$58	$67	$73	$80	$88	$88	$88	5.6%
Memory	8	9	9	9	8	8	7	(4.9%)
Logic	50	58	64	71	80	80	81	6.9%
MOS Digital	$625	$646	$815	$1,072	$1,470	$1,630	$1,871	23.7%
Memory	315	278	378	528	760	821	944	27.7%
Microcomponent	170	196	230	289	381	439	509	21.0%
Logic	140	172	207	255	329	370	418	19.4%
Analog	$162	$187	$220	$260	$315	$346	$386	15.6%
Monolithic	150	174	205	241	292	321	360	15.7%
Hybrid	12	13	15	19	23	25	26	14.9%
Total Discrete	$205	$230	$251	$294	$310	$328	$362	9.5%
Total Optoelectronic	$32	$35	$41	$48	$55	$60	$67	13.9%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 5a
Estimated Semiconductor Consumption—History
Nordic Countries
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$245	$395	$391	$426	$458	$625	$682
Total Integrated Circuit	$170	$310	$306	$328	$351	$508	$549
Bipolar Digital	$36	$60	$60	$61	$57	$70	$52
Memory	8	11	12	14	5	7	7
Logic	28	49	48	47	52	63	45
MOS Digital	$90	$179	$169	$184	$205	$313	$371
Memory	43	85	63	66	59	108	148
Microcomponent	17	40	44	48	56	97	109
Logic	30	54	62	70	90	108	114
Analog	$44	$71	$77	$83	$89	$125	$126
Monolithic	44	71	77	83	84	114	115
Hybrid	0	0	0	0	5	11	11
Total Discrete	$63	$71	$71	$80	$90	$96	$111
Total Optoelectronic	$12	$14	$14	$18	$17	$21	$22

Source: Dataquest (July 1990) Ref: 0790-09

Table 5b
Estimated Semiconductor Consumption—Forecast
Nordic Countries
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$682	$748	$878	$1,049	$1,351	$1,401	$1,566	15.9%
Total Integrated Circuit	$549	$599	$709	$851	$1,121	$1,175	$1,327	17.2%
Bipolar Digital	$52	$58	$63	$69	$76	$77	$72	4.4%
Memory	7	8	8	8	7	6	6	(5.6%)
Logic	45	50	55	61	69	71	66	5.7%
MOS Digital	$371	$390	$468	$568	$770	$820	$958	19.7%
Memory	148	140	175	231	323	333	386	22.5%
Microcomponent	109	119	138	156	207	233	278	18.5%
Logic	114	131	155	181	240	254	294	17.5%
Analog	$126	$151	$178	$214	$275	$278	$297	14.5%
Monolithic	115	140	165	199	254	256	274	14.4%
Hybrid	11	11	13	15	21	22	23	15.9%
Total Discrete	$111	$125	$141	$165	$189	$187	$195	9.3%
Total Optoelectronic	$22	$24	$28	$33	$41	$39	$44	12.9%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 6a
Estimated Semiconductor Consumption—History
UK and Ireland Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$833	$1,240	$1,198	$1,288	$1,570	$2,230	$2,614
Total Integrated Circuit	$619	$999	$959	$1,016	$1,203	$1,852	$2,225
Bipolar Digital	$129	$198	$193	$195	$188	$206	$177
Memory	29	40	44	44	22	18	19
Logic	100	158	149	151	166	188	158
MOS Digital	$327	$575	$525	$565	$741	$1,294	$1,634
Memory	155	274	202	200	251	666	804
Microcomponent	64	128	130	145	199	303	424
Logic	108	173	193	220	291	325	406
Analog	$163	$226	$241	$256	$274	$352	$414
Monolithic	163	226	241	256	260	326	387
Hybrid	0	0	0	0	14	26	27
Total Discrete	$172	$192	$192	$211	$306	$312	$290
Total Optoelectronic	$42	$49	$47	$61	$61	$66	$99

Source: Dataquest (July 1990) Ref: 0790-09

Table 6b
Estimated Semiconductor Consumption—Forecast
UK and Ireland Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$2,614	$2,745	$3,309	$4,163	$5,363	$5,998	$6,806	19.9%
Total Integrated Circuit	$2,225	$2,322	$2,829	$3,604	$4,754	$5,330	$6,072	21.2%
Bipolar Digital	$177	$182	$198	$222	$229	$234	$246	6.2%
Memory	19	22	23	25	22	19	16	(6.2%)
Logic	158	160	175	197	207	215	230	7.5%
MOS Digital	$1,634	$1,692	$2,101	$2,751	$3,785	$4,259	$4,861	23.5%
Memory	804	725	965	1,346	1,981	2,181	2,451	27.6%
Microcomponent	424	491	569	707	935	1,073	1,237	20.3%
Logic	406	476	567	698	869	1,005	1,173	19.8%
Analog	$414	$448	$530	$631	$740	$837	$965	16.6%
Monolithic	387	412	488	581	684	768	881	16.4%
Hybrid	27	36	42	50	56	69	84	18.5%
Total Discrete	$290	$312	$351	$406	$432	$467	$504	10.1%
Total Optoelectronic	$99	$111	$129	$153	$177	$201	$230	15.7%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

Table 7a
Estimated Semiconductor Consumption—History
West Germany Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$937	$1,300	$1,318	$1,628	$1,890	$2,250	$2,683
Total Integrated Circuit	$572	$892	$905	$1,095	$1,342	$1,673	$2,087
Bipolar Digital	$118	$178	$180	$211	$216	$201	$209
Memory	26	37	39	45	24	20	22
Logic	92	141	141	166	192	181	187
MOS Digital	$302	$513	$497	$611	$735	$1,013	$1,377
Memory	142	244	188	220	218	359	595
Microcomponent	59	116	125	154	214	315	390
Logic	101	153	184	237	303	339	392
Analog	$152	$201	$228	$273	$391	$459	$501
Monolithic	152	201	228	273	372	425	465
Hybrid	0	0	0	0	19	34	36
Total Discrete	$309	$344	$343	$435	$458	$482	$480
Total Optoelectronic	$56	$64	$70	$98	$90	$95	$116

Source: Dataquest (July 1990) Ref: 0790-09

Table 7b
Estimated Semiconductor Consumption—Forecast
West Germany Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$2,683	$3,023	$3,588	$4,383	$5,665	$6,108	$6,819	17.7%
Total Integrated Circuit	$2,087	$2,335	$2,798	$3,441	$4,607	$5,018	$5,639	19.3%
Bipolar Digital	$209	$232	$253	$278	$289	$286	$287	4.3%
Memory	22	23	24	24	22	19	17	(5.9%)
Logic	187	209	229	254	267	267	270	5.3%
MOS Digital	$1,377	$1,514	$1,853	$2,352	$3,297	$3,629	$4,109	22.1%
Memory	595	576	752	1,014	1,582	1,723	1,953	27.7%
Microcomponent	390	462	543	659	886	991	1,118	19.3%
Logic	392	476	558	679	829	915	1,038	16.9%
Analog	$501	$589	$692	$811	$1,021	$1,103	$1,243	16.1%
Monolithic	465	549	645	756	950	1,022	1,147	15.9%
Hybrid	36	40	47	55	71	81	96	19.1%
Total Discrete	$480	$556	$633	$754	$838	$851	$911	10.4%
Total Optoelectronic	$116	$132	$157	$188	$220	$239	$269	15.3%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990)

Table 8a
Estimated Semiconductor Consumption—History
Rest of Europe Region
(Millions of U.S. Dollars)

Product	1983	1984	1985	1986	1987	1988	1989
Total Semiconductor	$242	$394	$387	$494	$430	$690	$801
Total Integrated Circuit	$173	$308	$303	$377	$281	$499	$592
Bipolar Digital	$36	$63	$60	$72	$33	$56	$24
Memory	8	14	13	15	7	7	4
Logic	28	49	47	57	26	49	20
MOS Digital	$91	$178	$167	$212	$172	$340	$444
Memory	43	84	69	78	50	107	259
Microcomponent	18	38	37	52	55	97	91
Logic	30	56	61	82	67	136	94
Analog	$46	$67	$76	$93	$76	$103	$124
Monolithic	46	67	76	93	71	93	108
Hybrid	0	0	0	0	5	10	16
Total Discrete	$58	$70	$69	$90	$124	$163	$184
Total Optoelectronic	$11	$16	$15	$27	$25	$28	$25

Source: Dataquest (July 1990) Ref: 0790-09

Table 8b
Estimated Semiconductor Consumption—Forecast
Rest of Europe Region
(Millions of U.S. Dollars)

Product	1989	1990	1991	1992	1993	1994	1995	CAGR
Total Semiconductor	$801	$938	$1,159	$1,423	$1,856	$2,055	$2,319	19.8%
Total Integrated Circuit	$592	$684	$856	$1,065	$1,450	$1,621	$1,840	21.9%
Bipolar Digital	$24	$27	$30	$34	$35	$37	$34	4.7%
Memory	4	5	6	7	6	5	4	(4.4%)
Logic	20	22	24	27	29	32	30	6.4%
MOS Digital	$444	$497	$635	$802	$1,130	$1,269	$1,453	23.9%
Memory	259	262	337	442	654	733	846	26.4%
Microcomponent	91	110	139	168	237	265	299	22.1%
Logic	94	125	159	192	239	271	308	19.8%
Analog	$124	$160	$191	$229	$285	$315	$353	17.1%
Monolithic	108	135	162	194	241	270	302	17.5%
Hybrid	16	25	29	35	44	45	51	15.3%
Total Discrete	$184	$220	$263	$310	$350	$369	$399	12.6%
Total Optoelectronic	$25	$34	$40	$48	$56	$65	$80	18.7%

CAGR = Compound annual growth rate, 1990-1995
Source: Dataquest (July 1990) Ref: 0790-09

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European Semiconductor Market Share Estimates

Final 1989

Final 1989 European Semiconductor Market Share Estimates

European Components Group

INTRODUCTION

This booklet contains final estimates of semiconductor market shares in the European market for calendar year 1989. It is intended as reference material, with more detailed analysis to follow in the form of Research Newsletters.

SUMMARY

Figure 1 shows the European semiconductor market share by vendor base from 1978 to 1989. The North American vendors' share of the semiconductor market in Europe has been declining, while the Japanese vendors' share is rising year on year. The European vendors maintained a steady market share in their own home territory until 1987, but they too are beginning to lose their grip. This is in part due to the fact that, with the exception of Siemens, the European vendors (Philips, SGS-Thomson, plus the next sixteen largest) have no significant DRAM revenue. Since 1986 we have also seen Korean, and now Taiwanese, companies beginning to make an impact on the competitive scene in Europe. Figure 2 shows the worldwide semiconductor market share by vendor base for the same period.

It was a watershed year in 1989 in the European semiconductor market. Philips, which has held number 1 position over the past decade, was almost toppled by Siemens. Contrary to popular belief, Siemens' growth did not come from DRAMs alone; high growth also occurred in its MOS logic, analog and discrete sales. Siemens rose from position 5 to position 2 and hence displaced SGS-Thomson, Motorola, and Texas Instruments into third, fourth and fifth places respectively. Another fundamental change was the brand new entry in the top 10 of Hitachi. Yet again the contributory factors behind this growth are DRAMs in part, but also the fact that the Japanese have been diversifying away from memory products. NEC managed to regain its position over Toshiba in Europe, this time due to declining prices of DRAMs which affected Toshiba more than NEC.

In integrated circuits, the most spectacular result is that Siemens in 1989 moved up seven positions to become Europe's number 1 integrated circuit vendor, displacing Philips into second position. Texas Instruments was the third largest IC supplier, followed by SGS-Thomson. The rest of the vendor positioning remained the same, all falling by one position due to displacement by Siemens. The exceptions were Toshiba and AMD, which held their ninth and tenth positions in the IC rankings. With an average market growth of 17 percent the only other rising star was SGS-Thomson with 18.4 percent growth; this, however, was mainly due to its acquisition of Inmos.

In bipolar technology both AMD and National Semiconductor moved their position up by one, although Texas Instruments is still the clear leader. In MOS technology, Intel remained in the number 1 slot with its leadership in MOS microprocessors. In MOS memory, Siemens became a clear leader, displacing TI into second position, and Samsung became the fifth largest vendor. In analog ICs, Philips, SGS-Thomson and National Semiconductor remained as the three leading suppliers, followed by Siemens. In discrete there was no change in the top five vendors, with Philips holding the number 1 position followed by Motorola, SGS-Thomson, Siemens and ITT. International Rectifier moved up two positions to number 6. In optoelectronics Hewlett-Packard took over the number 1 slot from Telefunken Electronic, which fell two places to number 3; Siemens remained at number 2.

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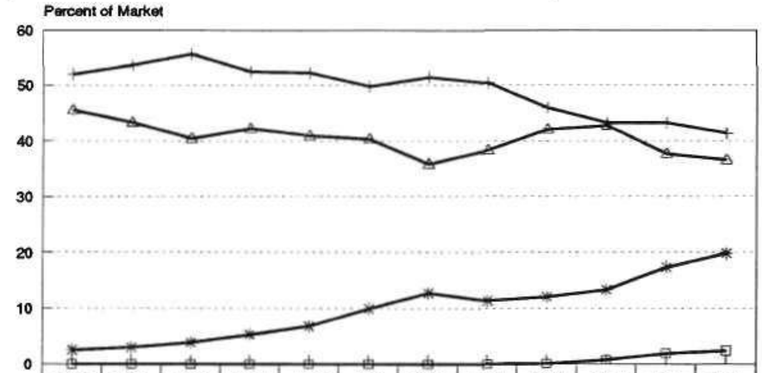
Column 9	shows percentage market share of TAM in 1989
Column 10	shows cumulative percentage market share of TAM in 1989

Each of the tables also gives a summary showing the sum of all revenues split by vendor regional base. This gives a final estimate for the TAM in each featured product category.
TAM = Toal Available Market

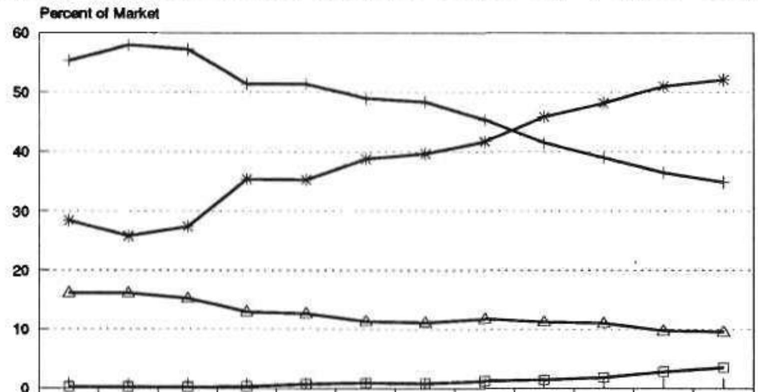
Figure 1
European Semiconductor Market Share by Vendor Base



	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
European	45.5	43.3	40.4	42.2	40.9	40.3	35.8	38.3	42	42.7	37.6	36.5
North American	52	53.7	55.7	52.5	52.3	49.8	51.5	50.4	45.9	43.2	43.2	41.3
Japanese	2.5	3	3.9	5.3	6.8	9.9	12.7	11.3	12	13.3	17.3	19.8
Asia/Pacific/ROW	0	0	0	0	0	0	0	0	0.1	0.8	1.9	2.4
Total Market $M	2,339	3,018	3,686	3,041	3,167	3,370	4,805	4,720	5,532	6,355	8,491	9,755
Sum of Percent	100	100	100	100	100	100	100	100	100	100	100	100

Source: Dataquest (June 1990)

Figure 2
Worldwide Semiconductor Market Share by Vendor Base



	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
European	16.1	16.1	15.2	12.9	12.6	11.3	11.1	11.7	11.2	11	9.7	9.5
North American	55.3	57.9	57.2	51.4	51.4	49	48.4	45.4	41.5	39	36.5	34.9
Japanese	28.4	25.8	27.4	35.4	35.3	38.8	39.7	41.7	45.9	48.2	51	52.1
Asia/Pacific/ROW	0.2	0.2	0.2	0.3	0.7	0.9	0.8	1.2	1.4	1.8	2.8	3.5
Total Market $M	8,963	11,106	14,098	14,801	15,231	19,537	28,825	24,341	30,834	38,251	50,859	57,213

Source: Dataquest (June 1990)

Table 1
1989 European Companies Worldwide Semiconductor Market Share Rankings (Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Market Share (Percent)
10	10	0	Philips	1,738	1,716	(1)	3.0
12	13	(1)	SGS-Thomson	1,087	1,301	20	2.3
20	16	4	Siemens	784	1,194	52	2.1
31	30	1	Telefunken Electronic	289	299	3	0.5
32	34	(2)	Plessey Semiconductors	284	240	(15)	0.4
62	59	3	Semikron	91	95	4	0.2
67	64	3	Matra MHS	71	85	20	0.1
72	68	4	MEDL	51	60	18	0.1
79	71	8	Austria Mikro Systeme	44	56	27	0.1
71	73	(2)	Ericsson Components	52	54	4	0.1
81	77	4	Mietec	42	52	24	0.1
143	79	64	ABB-IXYS	0	50	NA	0.1
117	82	35	TMS	0	45	NA	0.1
53	88	(35)	ABB-HAFO	113	37	(67)	0.1
92	98	(6)	Eurosil Electronic	29	30	3	0.1
97	100	(3)	Fagor Electrotécnica	27	29	7	0.1
100	109	(9)	TAG	23	22	(4)	0.0
101	115	(14)	STC Components	22	19	(14)	0.0
107	116	(9)	European Silicon Structures	13	18	38	0.0
55	0		Inmos	110	0	(100)	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 2
1989 European Semiconductor Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	1,018	964	(5.3)	964	9.9	9.9
5	2	3	Siemens	569	937	64.7	1,901	9.6	19.5
2	3	(1)	SGS-Thomson*	652	751	15.2	2,652	7.7	27.2
4	4	0	Motorola	616	658	6.8	3,310	6.7	33.9
3	5	(2)	Texas Instruments	647	648	0.2	3,958	6.6	40.6
6	6	0	Intel	485	530	9.3	4,488	5.4	46.0
8	7	1	NEC	387	429	10.9	4,917	4.4	50.4
7	8	(1)	Toshiba	390	423	8.5	5,340	4.3	54.7
9	9	0	National Semiconductor	386	381	(1.3)	5,721	3.9	58.6
12	10	2	Hitachi	246	291	18.3	6,012	3.0	61.6
10	11	(1)	AMD	277	287	3.6	6,299	2.9	64.6
11	12	(1)	ITT	246	250	1.6	6,549	2.6	67.1
13	13	0	Telefunken Electronic	217	215	(0.9)	6,764	2.2	69.3
16	14	2	Samsung	140	201	43.6	6,965	2.1	71.4
20	15	5	Mitsubishi	87	201	131.0	7,166	2.1	73.5
17	16	1	Fujitsu	135	198	46.7	7,364	2.0	75.5
41	17	24	Harris*	28	145	417.9	7,509	1.5	77.0
14	18	(4)	Plessey Semiconductors*	198	138	(30.3)	7,647	1.4	78.4
25	19	6	Hewlett-Packard	53	96	81.1	7,743	1.0	79.4
19	20	(1)	Analog Devices	96	95	(1.0)	7,838	1.0	80.3
27	21	6	Matsushita (Panasonic)	46	95	106.5	7,933	1.0	81.3
22	22	0	LSI Logic	60	73	21.7	8,006	0.7	82.1
26	23	3	Matra MHS*	52	73	40.4	8,079	0.7	82.8
21	24	(3)	International Rectifier	66	71	7.6	8,150	0.7	83.5
23	25	(2)	Oki Electric	58	69	19.0	8,219	0.7	84.3
64	26	38	Micron Technology*	2	60	2,900.0	8,279	0.6	84.9
28	27	1	Austria Mikro Systeme	44	56	27.3	8,335	0.6	85.4
24	28	(4)	Semikron	56	55	(1.8)	8,390	0.6	86.0
36	29	7	VLSI Technology	36	55	52.8	8,445	0.6	86.6
30	30	0	Mietec	42	52	23.8	8,497	0.5	87.1
39	31	8	NMB*	30	51	70.0	8,548	0.5	87.6
32	32	0	Marconi Electronic Devices	41	45	9.8	8,593	0.5	88.1
34	33	1	Ericsson Components	40	42	5.0	8,635	0.4	88.5
31	34	(3)	Siliconix	41	41	0.0	8,676	0.4	88.9
NA	35		ABB-IXYS*		40		8,716	0.4	89.3
29	36	(7)	Burr-Brown	43	39	(9.3)	8,755	0.4	89.7
NA	37		TMS*		38		8,793	0.4	90.1
35	38	(3)	IDT	39	36	(7.7)	8,829	0.4	90.5
40	39	1	Powerex	28	33	17.9	8,862	0.3	90.8

(Continued)

Table 2 (Continued)
1989 European Semiconductor Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
50	40	10	General Instrument	18	33	83.3	8,895	0.3	91.2
37	41	(4)	Sprague*	32	32	0.0	8,927	0.3	91.5
61	42	19	Sony*	9	31	244.4	8,958	0.3	91.8
18	43	(25)	ABB-HAFO*	100	30	(70.0)	8,988	0.3	92.1
44	44	0	Cypress*	21	30	42.9	9,018	0.3	92.4
38	45	(7)	Precision Monolithics	30	29	(3.3)	9,047	0.3	92.7
59	46	13	Sharp*	12	27	125.0	9,074	0.3	93.0
52	47	5	Western Digital	17	23	35.3	9,097	0.2	93.3
43	48	(5)	Fagor Electrotécnica	21	22	4.8	9,119	0.2	93.5
55	49	6	Rohm Electronics*	16	22	37.5	9,141	0.2	93.7
42	50	(8)	STC Components	21	19	(9.5)	9,160	0.2	93.9
54	51	3	Unitrode*	16	19	18.8	9,179	0.2	94.1
47	52	(5)	TAG	18	17	(5.6)	9,196	0.2	94.3
51	53	(2)	AT&T*	18	17	(5.6)	9,213	0.2	94.4
60	54	6	European Silicon Structures	12	17	41.7	9,230	0.2	94.6
45	55	(10)	Zilog	19	16	(15.8)	9,246	0.2	94.8
49	56	(7)	Rockwell*	18	16	(11.1)	9,262	0.2	94.9
48	57	(9)	Sanyo*	18	15	(16.7)	9,277	0.2	95.1
53	58	(5)	Raytheon*	17	14	(17.6)	9,291	0.1	95.2
57	59	(2)	Mitel Semiconductor*	14	14	0.0	9,305	0.1	95.4
58	60	(2)	Eurosil Electronic	13	14	7.7	9,319	0.1	95.5
63	61	2	Goldstar	4	9	125.0	9,328	0.1	95.6
46	62	(16)	Seiko Epson	19	8	(57.9)	9,336	0.1	95.7
15	NA		GE Solid State*	141		(100.0)			
33	NA		Inmos*	40		(100.0)			
56	NA		Honeywell Solid State*	15		(100.0)			
62	NA		TRW*	8		(100.0)			
			European Others	42	37	(11.9)	9,373	0.4	96.1
			North American Others	131	291	122.1	9,664	3.0	99.1
			Japanese Others	13	64	392.3	9,728	0.7	99.7
			Rest of World Others	21	27	28.6	9,755	0.3	100.0
			Total All Companies	8,491	9,755	14.9		100.0	
			Total European	3,196	3,562	11.5		36.5	
			Total North American	3,664	4,032	10.0		41.3	
			Total Japanese	1,466	1,924	31.2		19.7	
			Total Rest of World	165	237	43.6		2.4	

* See Footnotes (page 44)
NA = Not Applicable
Source: Dataquest (June 1990)

Table 3
1989 European Integrated Circuit Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
8	1	7	Siemens	373	707	89.5	707	9.1	9.1
1	2	(1)	Philips	683	649	(5.0)	1,356	8.3	17.4
2	3	(1)	Texas Instruments	602	610	1.3	1,966	7.8	25.2
3	4	(1)	SGS-Thomson	485	574	18.4	2,540	7.4	32.6
4	5	(1)	Intel	485	530	9.3	3,070	6.8	39.4
5	6	(1)	Motorola	415	460	10.8	3,530	5.9	45.3
6	7	(1)	NEC	381	410	7.6	3,940	5.3	50.6
7	8	(1)	National Semiconductor	381	376	(1.3)	4,316	4.8	55.4
9	9	0	Toshiba	321	358	11.5	4,674	4.6	60.0
10	10	0	AMD	277	287	3.6	4,961	3.7	63.7
11	11	0	Hitachi	233	278	19.3	5,239	3.6	67.2
14	12	2	Samsung	139	198	42.4	5,437	2.5	69.8
19	13	6	Mitsubishi	79	181	129.1	5,618	2.3	72.1
15	14	1	Fujitsu	135	170	25.9	5,788	2.2	74.3
13	15	(2)	ITT	143	145	1.4	5,933	1.9	76.1
12	16	(4)	Plessey Semiconductors	160	138	(13.8)	6,071	1.8	77.9
34	17	17	Harris	28	117	317.9	6,188	1.5	79.4
17	18	(1)	Analog Devices	96	95	(1.0)	6,283	1.2	80.6
18	19	(1)	Telefunken Electronic	86	82	(4.7)	6,365	1.1	81.7
20	20	0	LSI Logic	60	73	21.7	6,438	0.9	82.6
22	21	1	Matra MHS	52	73	40.4	6,511	0.9	83.5
30	22	8	Matsushita (Panasonic)	31	72	132.3	6,583	0.9	84.5
21	23	(2)	Oki Electric	57	69	21.1	6,652	0.9	85.3
56	24	32	Micron Technology	2	60	2,900.0	6,712	0.8	86.1
23	25	(2)	Austria Mikro Systeme	44	56	27.3	6,768	0.7	86.8
29	26	3	VLSI Technology	36	55	52.8	6,823	0.7	87.5
25	27	(2)	Mietec	42	52	23.8	6,875	0.7	88.2
33	28	5	NMB	30	51	70.0	6,926	0.7	88.9
27	29	(2)	Ericsson Components	40	42	5.0	6,968	0.5	89.4
24	30	(6)	Burr-Brown	43	39	(9.3)	7,007	0.5	89.9
28	31	(3)	IDT	39	36	(7.7)	7,043	0.5	90.4
37	32	5	Cypress	21	30	42.9	7,073	0.4	90.7
52	33	19	Sony	9	30	233.3	7,103	0.4	91.1
NA	34		TMS		30		7,133	0.4	91.5
32	35	(3)	Precision Monolithics	30	29	(3.3)	7,162	0.4	91.9
36	36	0	Marconi Electronic Devices	23	28	21.7	7,190	0.4	92.3
31	37	(6)	Sprague	30	25	(16.7)	7,215	0.3	92.6
43	38	5	Western Digital	17	23	35.3	7,238	0.3	92.9
51	39	12	Sharp	11	23	109.1	7,261	0.3	93.2

(Continued)

Table 3 (Continued)
1989 European Integrated Circuit Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
35	40	(5)	ABB-HAFO	25	21	(16.0)	7,282	0.3	93.4
38	41	(3)	STC Components	20	17	(15.0)	7,299	0.2	93.6
50	42	8	European Silicon Structures	12	17	41.7	7,316	0.2	93.9
39	43	(4)	Zilog	19	16	(15.8)	7,332	0.2	94.1
42	44	(2)	Rockwell	18	16	(11.1)	7,348	0.2	94.3
41	45	(4)	Siliconix	18	16	(11.1)	7,364	0.2	94.5
44	46	(2)	AT&T	17	14	(17.6)	7,378	0.2	94.7
48	47	1	Mitel Semiconductor	14	14	0.0	7,392	0.2	94.8
49	48	1	Eurosil Electronic	13	14	7.7	7,406	0.2	95.0
45	49	(4)	Raytheon	16	13	(18.8)	7,419	0.2	95.2
46	50	(4)	Sanyo	15	9	(40.0)	7,428	0.1	95.3
55	51	4	Goldstar	4	9	125.0	7,437	0.1	95.4
40	52	(12)	Seiko Epson	19	8	(57.9)	7,445	0.1	95.5
53	53	0	Unitrode	6	8	33.3	7,453	0.1	95.6
54	54	0	Rohm Electronics	6	8	33.3	7,461	0.1	95.7
NA	55		International Rectifier		1		7,462	0.0	95.7
16	NA		GE Solid State	106		(100.0)			
26	NA		Inmos	40		(100.0)			
47	NA		Honeywell Solid State	15		(100.0)			
			European Others	28	23	(17.9)	7,485	0.3	96.0
			North American Others	116	237	104.3	7,722	3.0	99.1
			Japanese Others	6	47	683.3	7,769	0.6	99.7
			Rest of World Others	17	25	47.1	7,794	0.3	100.0
			Total All Companies	6,669	7,794	16.9		100.0	
			Total European	2,126	2,523	18.7		32.4	
			Total North American	3,050	3,325	9.0		42.7	
			Total Japanese	1,333	1,714	28.6		22.0	
			Total Rest of World	160	232	45.0		3.0	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 4
1989 European Bipolar Digital IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Texas Instruments	189	142	(24.9)	142	22.2	22.2
3	2	1	AMD	112	97	(13.4)	239	15.2	37.3
4	3	1	National Semiconductor	110	79	(28.2)	318	12.3	49.7
2	4	(2)	Philips	117	66	(43.6)	384	10.3	60.0
5	5	0	Plessey Semiconductors	60	66	10.0	450	10.3	70.3
7	6	1	Siemens	28	51	82.1	501	8.0	78.3
6	7	(1)	Motorola	55	48	(12.7)	549	7.5	85.8
14	8	6	NEC	6	28	366.7	577	4.4	90.2
9	9	0	Fujitsu	12	13	8.3	590	2.0	92.2
15	10	5	Hitachi	6	8	33.3	598	1.3	93.4
12	11	1	Raytheon	9	7	(22.2)	605	1.1	94.5
NA	12		Mitsubishi		7		612	1.1	95.6
8	13	(5)	Telefunken Electronic	19	5	(73.7)	617	0.8	96.4
10	14	(4)	SGS-Thomson	11	4	(63.6)	621	0.6	97.0
13	15	(2)	STC Components	7	4	(42.9)	625	0.6	97.7
17	16	1	Toshiba	3	2	(33.3)	627	0.3	98.0
19	17	2	Goldstar	1	2	100.0	629	0.3	98.3
NA	18		AT&T		2		631	0.3	98.6
18	19	(1)	Matsushita (Panasonic)	3	1	(66.7)	632	0.2	98.8
11	NA		Intel	10		(100.0)			
16	NA		Honeywell Solid State	5		(100.0)			
			European Others	8	4	(50.0)	636	0.6	99.4
			North American Others	1	4	300.0	640	0.6	100.0
			Total All Companies	772	640	(17.1)		100.0	
			Total European	250	200	(20.0)		31.3	
			Total North American	491	379	(22.8)		59.2	
			Total Japanese	30	59	96.7		9.2	
			Total Rest of World	1	2	100.0		0.3	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 5
1989 European Bipolar TTL Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Texas Instruments	189	142	(24.9)	142	28.3	28.3
2	2	0	AMD	111	85	(23.4)	227	17.0	45.3
4	3	1	National Semiconductor	95	62	(34.7)	289	12.4	57.7
3	4	(1)	Philips	105	58	(44.8)	347	11.6	69.3
10	5	5	Plessey Semiconductors	7	47	571.4	394	9.4	78.6
5	6	(1)	Motorola	38	24	(36.8)	418	4.8	83.4
13	7	6	NEC	5	24	380.0	442	4.8	88.2
14	8	6	Siemens	4	14	250.0	456	2.8	91.0
11	9	2	Hitachi	6	7	16.7	463	1.4	92.4
NA	10		Mitsubishi		7		470	1.4	93.8
9	11	(2)	Raytheon	8	6	(25.0)	476	1.2	95.0
12	12	0	Fujitsu	6	6	0.0	482	1.2	96.2
6	13	(7)	Telefunken Electronic	19	5	(73.7)	487	1.0	97.2
7	14	(7)	SGS-Thomson	11	4	(63.6)	491	0.8	98.0
16	15	1	Goldstar	1	2	100.0	493	0.4	98.4
NA	16		AT&T		2		495	0.4	98.8
15	17	(2)	Matsushita (Panasonic)	3	1	(66.7)	496	0.2	99.0
NA	18		Toshiba		1		497	0.2	99.2
8	NA		Intel	10		(100.0)			
			European Others	5	3	(40.0)	500	0.6	99.8
			North American Others	1	1	0.0	501	0.2	100.0
			Total All Companies	624	501	(19.7)		100.0	
			Total European	151	131	(13.2)		26.1	
			Total North American	452	322	(28.8)		64.3	
			Total Japanese	20	46	130.0		9.2	
			Total Rest of World	1	2	100.0		0.4	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 6
1989 European Bipolar ECL Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	Siemens	24	37	54.2	37	26.6	26.6
3	2	1	Motorola	17	24	41.2	61	17.3	43.9
1	3	(2)	Plessey Semiconductors	53	19	(64.2)	80	13.7	57.6
4	4	0	National Semiconductor	15	17	13.3	97	12.2	69.8
12	5	7	AMD	1	12	1,100.0	109	8.6	78.4
5	6	(1)	Philips	12	8	(33.3)	117	5.8	84.2
7	7	0	Fujitsu	6	7	16.7	124	5.0	89.2
6	8	(2)	STC Components	7	4	(42.9)	128	2.9	92.1
11	9	2	NEC	1	4	300.0	132	2.9	95.0
9	10	(1)	Toshiba	3	1	(66.7)	133	0.7	95.7
10	11	(1)	Raytheon	1	1	0.0	134	0.7	96.4
NA	12		Hitachi		1		135	0.7	97.1
8	NA		Honeywell Solid State	5		(100.0)			
			European Others	3	1	(66.7)	136	0.7	97.8
			North American Others		3		139	2.2	100.0
			Total All Companies	148	139	(6.1)		100.0	
			Total European	99	69	(30.3)		49.6	
			Total North American	39	57	46.2		41.0	
			Total Japanese	10	13	30.0		9.4	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 7
1989 European Bipolar Memory Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	AMD	29	27	(6.9)	27	37.5	37.5
3	2	1	National Semiconductor	10	15	50.0	42	20.8	58.3
2	3	(1)	Philips	14	12	(14.3)	54	16.7	75.0
4	4	0	Fujitsu	7	7	0.0	61	9.7	84.7
6	5	1	NEC	3	7	133.3	68	9.7	94.4
8	6	2	Hitachi	2	3	50.0	71	4.2	98.6
7	7	0	Raytheon	2	1	(50.0)	72	1.4	100.0
5	NA		Texas Instruments	5		(100.0)			
9	NA		Motorola	1		(100.0)			
			European Others	1		(100.0)			
			Total All Companies	74	72	(2.7)		100.0	
			Total European	15	12	(20.0)		16.7	
			Total North American	47	43	(8.5)		59.7	
			Total Japanese	12	17	41.7		23.6	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 8
1989 European Bipolar Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Texas Instruments	184	142	(22.8)	142	25.0	25.0
4	2	2	AMD	83	70	(15.7)	212	12.3	37.3
5	3	2	Plessey Semiconductors	60	66	10.0	278	11.6	48.9
3	4	(1)	National Semiconductor	100	64	(36.0)	342	11.3	60.2
2	5	(3)	Philips	103	54	(47.6)	396	9.5	69.7
7	6	1	Siemens	28	51	82.1	447	9.0	78.7
6	7	(1)	Motorola	54	48	(11.1)	495	8.5	87.1
17	8	9	NEC	3	21	600.0	516	3.7	90.8
NA	9		Mitsubishi		7		523	1.2	92.1
12	10	2	Raytheon	7	6	(14.3)	529	1.1	93.1
14	11	3	Fujitsu	5	6	20.0	535	1.1	94.2
8	12	(4)	Telefunken Electronic	19	5	(73.7)	540	0.9	95.1
15	13	2	Hitachi	4	5	25.0	545	0.9	96.0
9	14	(5)	SGS-Thomson	11	4	(63.6)	549	0.7	96.7
11	15	(4)	STC Components	7	4	(42.9)	553	0.7	97.4
16	16	0	Toshiba	3	2	(33.3)	555	0.4	97.7
19	17	2	Goldstar	1	2	100.0	557	0.4	98.1
NA	18		AT&T		2		559	0.4	98.4
18	19	(1)	Matsushita (Panasonic)	3	1	(66.7)	560	0.2	98.6
10	NA		Intel	10		(100.0)			
13	NA		Honeywell Solid State	5		(100.0)			
			European Others	7	4	(42.9)	564	0.7	99.3
			North American Others	1	4	300.0	568	0.7	100.0
			Total All Companies	698	568	(18.6)		100.0	
			Total European	235	188	(20.0)		33.1	
			Total North American	444	336	(24.3)		59.2	
			Total Japanese	18	42	133.3		7.4	
			Total Rest of World	1	2	100.0		0.4	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 9
1989 European Bipolar ASIC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	Plessey Semiconductors	43	54	25.6	54	20.8	20.8
3	2	1	Siemens	28	51	82.1	105	19.6	40.4
1	3	(2)	AMD	56	49	(12.5)	154	18.8	59.2
NA	4		NEC		20		174	7.7	66.9
10	5	5	Motorola	5	15	200.0	189	5.8	72.7
4	6	(2)	Philips	24	14	(41.7)	203	5.4	78.1
7	7	0	Texas Instruments	15	12	(20.0)	215	4.6	82.7
5	8	(3)	National Semiconductor	20	11	(45.0)	226	4.2	86.9
9	9	0	Raytheon	7	6	(14.3)	232	2.3	89.2
6	10	(4)	Telefunken Electronic	19	5	(73.7)	237	1.9	91.2
12	11	1	Fujitsu	4	5	25.0	242	1.9	93.1
8	12	(4)	STC Components	7	4	(42.9)	246	1.5	94.6
13	13	0	Toshiba	3	2	(33.3)	248	0.8	95.4
NA	14		Mitsubishi		2		250	0.8	96.2
NA	15		AT&T		2		252	0.8	96.9
NA	16		Hitachi		1		253	0.4	97.3
11	NA		Honeywell Solid State	5		(100.0)			
14	NA		SGS-Thomson	1		(100.0)			
			European Others	4	4	0.0	257	1.5	98.8
			North American Others	3		260	1.2	100.0	
			Total All Companies	241	260	7.9		100.0	
			Total European	126	132	4.8		50.8	
			Total North American	108	98	(9.3)		37.7	
			Total Japanese	7	30	328.6		11.5	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 10
1989 European Bipolar Standard Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Texas Instruments	169	130	(23.1)	130	46.1	46.1
2	2	0	National Semiconductor	76	53	(30.3)	183	18.8	64.9
3	3	0	Philips	52	37	(28.8)	220	13.1	78.0
4	4	0	Motorola	49	33	(32.7)	253	11.7	89.7
5	5	0	AMD	17	11	(35.3)	264	3.9	93.6
6	6	0	SGS-Thomson	10	4	(60.0)	268	1.4	95.0
8	7	1	Hitachi	4	4	0.0	272	1.4	96.5
NA	8		Mitsubishi		4		276	1.4	97.9
11	9	2	Goldstar	1	2	100.0	278	0.7	98.6
7	10	(3)	Plessey Semiconductors	6	1	(83.3)	279	0.4	98.9
9	11	(2)	NEC	3	1	(66.7)	280	0.4	99.3
10	12	(2)	Matsushita (Panasonic)	3	1	(66.7)	281	0.4	99.6
12	13	(1)	Fujitsu	1	1	0.0	282	0.4	100.0
			European Others	3		(100.0)			
			Total All Companies	394	282	(28.4)		100.0	
			Total European	71	42	(40.8)		14.9	
			Total North American	311	227	(27.0)		80.5	
			Total Japanese	11	11	0.0		3.9	
			Total Rest of World	1	2	100.0		0.7	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 11
1989 European Bipolar Other Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	Plessey Semiconductors	11	11	0.0	11	42.3	42.3
4	2	2	AMD	10	10	0.0	21	38.5	80.8
1	3	(2)	Philips	27	3	(88.9)	24	11.5	92.3
NA	4		Mitsubishi		1		25	3.8	96.2
3	NA		Intel	10		(100.0)			
5	NA		National Semiconductor	4		(100.0)			
			North American Others	1	1	0.0	26	3.8	100.0
			Total All Companies	63	26	(58.7)		100.0	
			Total European	38	14	(63.2)		53.8	
			Total North American	25	11	(56.0)		42.3	
			Total Japanese		1			3.8	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 12
1989 European Digital MOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Intel	475	530	11.6	530	9.7	9.7
8	2	6	Siemens	243	522	114.8	1,052	9.6	19.3
2	3	(1)	NEC	372	378	1.6	1,430	6.9	26.2
3	4	(1)	Texas Instruments	308	368	19.5	1,798	6.7	32.9
6	5	1	SGS-Thomson	264	344	30.3	2,142	6.3	39.2
4	6	(2)	Toshiba	301	334	11.0	2,476	6.1	45.4
7	7	0	Motorola	255	313	22.7	2,789	5.7	51.1
5	8	(3)	Philips	285	267	(6.3)	3,056	4.9	56.0
9	9	0	Hitachi	221	264	19.5	3,320	4.8	60.8
11	10	1	Samsung	137	188	37.2	3,508	3.4	64.3
10	11	(1)	AMD	148	168	13.5	3,676	3.1	67.4
15	12	3	Mitsubishi	79	153	93.7	3,829	2.8	70.2
13	13	0	Fujitsu	123	148	20.3	3,977	2.7	72.9
12	14	(2)	National Semiconductor	131	137	4.6	4,114	2.5	75.4
14	15	(1)	ITT	102	118	15.7	4,232	2.2	77.5
17	16	1	LSI Logic	60	73	21.7	4,305	1.3	78.9
19	17	2	Matra MHS	52	73	40.4	4,378	1.3	80.2
42	18	24	Harris	10	70	600.0	4,448	1.3	81.5
18	19	(1)	Oki Electric	57	69	21.1	4,517	1.3	82.8
29	20	9	Matsushita (Panasonic)	22	67	204.5	4,584	1.2	84.0
49	21	28	Micron Technology	2	60	2,900.0	4,644	1.1	85.1
25	22	3	VLSI Technology	36	55	52.8	4,699	1.0	86.1
20	23	(3)	Plessey Semiconductors	51	54	5.9	4,753	1.0	87.1
21	24	(3)	Mietec	42	52	23.8	4,805	1.0	88.0
26	25	1	NMB	30	51	70.0	4,856	0.9	89.0
23	26	(3)	Austria Mikro Systeme	40	47	17.5	4,903	0.9	89.8
24	27	(3)	IDT	39	36	(7.7)	4,939	0.7	90.5
30	28	2	Cypress	21	30	42.9	4,969	0.5	91.0
28	29	(1)	Marconi Electronic Devices	23	26	13.0	4,995	0.5	91.5
46	30	16	Sony	5	26	420.0	5,021	0.5	92.0
34	31	3	Western Digital	17	23	35.3	5,044	0.4	92.4
40	32	8	Sharp	11	23	109.1	5,067	0.4	92.8
NA	33		TMS		23		5,090	0.4	93.3
27	34	(7)	ABB-HAFO	25	21	(16.0)	5,111	0.4	93.6
39	35	4	European Silicon Structures	12	17	41.7	5,128	0.3	94.0
31	36	(5)	Zilog	19	16	(15.8)	5,144	0.3	94.2
35	37	(2)	Telefunken Electronic	15	15	0.0	5,159	0.3	94.5
37	38	(1)	Eurosil Electronic	13	14	7.7	5,173	0.3	94.8
36	39	(3)	AT&T	15	12	(20.0)	5,185	0.2	95.0

(Continued)

Table 12 (Continued)
1989 European Digital MOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
33	40	(7)	Rockwell	18	9	(50.0)	5,194	0.2	95.2
43	41	2	STC Components	9	8	(11.1)	5,202	0.1	95.3
47	42	5	Sprague	3	8	166.7	5,210	0.1	95.5
32	43	(11)	Seiko Epson	18	7	(61.1)	5,217	0.1	95.6
44	44	0	Ericsson Components	6	7	16.7	5,224	0.1	95.7
45	45	0	Analog Devices	6	6	0.0	5,230	0.1	95.8
48	46	2	Goldstar	3	6	100.0	5,236	0.1	95.9
38	47	(9)	Sanyo	12	4	(66.7)	5,240	0.1	96.0
16	NA		GE Solid State	73		(100.0)			
22	NA		Inmos	40		(100.0)			
41	NA		Honeywell Solid State	10		(100.0)			
			European Others	18	17	(5.6)	5,257	0.3	96.3
			North American Others	66	136	106.1	5,393	2.5	98.8
			Japanese Others	4	40	900.0	5,433	0.7	99.5
			Rest of World Others	17	25	47.1	5,458	0.5	100.0
			Total All Companies	4,364	5,458	25.1		100.0	
			Total European	1,138	1,507	32.4		27.6	
			Total North American	1,814	2,168	19.5		39.7	
			Total Japanese	1,255	1,564	24.6		28.7	
			Total Rest of World	157	219	39.5		4.0	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 13
1989 European NMOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Intel	257	282	9.7	282	14.2	14.2
3	2	1	Siemens	177	233	31.6	515	11.7	26.0
2	3	(1)	Texas Instruments	194	223	14.9	738	11.2	37.2
4	4	0	SGS-Thomson	137	152	10.9	890	7.7	44.9
10	5	5	Hitachi	73	128	75.3	1,018	6.5	51.3
6	6	0	NEC	124	122	(1.6)	1,140	6.2	57.5
5	7	(2)	AMD	127	100	(21.3)	1,240	5.0	62.5
15	8	7	Mitsubishi	26	94	261.5	1,334	4.7	67.3
7	9	(2)	Philips	117	88	(24.8)	1,422	4.4	71.7
9	10	(1)	Toshiba	80	87	8.8	1,509	4.4	76.1
11	11	0	Samsung	62	52	(16.1)	1,561	2.6	78.7
12	12	0	ITT	47	52	10.6	1,613	2.6	81.3
26	13	13	Micron Technology	2	52	2,500.0	1,665	2.6	84.0
13	14	(1)	Fujitsu	44	47	6.8	1,712	2.4	86.3
8	15	(7)	Motorola	108	39	(63.9)	1,751	2.0	88.3
14	16	(2)	National Semiconductor	40	30	(25.0)	1,781	1.5	89.8
NA	17		Matsushita (Panasonic)		29		1,810	1.5	91.3
16	18	(2)	Oki Electric	22	26	18.2	1,836	1.3	92.6
18	19	(1)	Telefunken Electronic	15	15	0.0	1,851	0.8	93.3
22	20	2	Sharp	7	15	114.3	1,866	0.8	94.1
21	21	0	Austria Mikro Systeme	8	11	37.5	1,877	0.6	94.7
20	22	(2)	Plessey Semiconductors	10	10	0.0	1,887	0.5	95.2
17	23	(6)	Zilog	15	9	(40.0)	1,896	0.5	95.6
19	24	(5)	Rockwell	11	9	(18.2)	1,905	0.5	96.1
23	25	(2)	Mietec	7	7	0.0	1,912	0.4	96.4
NA	26		TMS		5		1,917	0.3	96.7
28	27	1	STC Components	1	2	100.0	1,919	0.1	96.8
NA	28		Goldstar		2		1,921	0.1	96.9
24	NA		Sanyo	5		(100.0)			
25	NA		Matra MHS	3		(100.0)			
27	NA		Inmos	2		(100.0)			
29	NA		Sprague	1		(100.0)			
			European Others	6	6	0.0	1,927	0.3	97.2
			North American Others	27	38	40.7	1,965	1.9	99.1
			Japanese Others	1	18	1,700.0	1,983	0.9	100.0
			Rest of World Others	3		(100.0)			
			Total All Companies	1,759	1,983	12.7		100.0	
			Total European	483	529	9.5		26.7	
			Total North American	829	834	0.6		42.1	
			Total Japanese	382	566	48.2		28.5	
			Total Rest of World	65	54	(16.9)		2.7	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 14
1989 European CMOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
13	1	12	Siemens	65	289	344.6	289	8.5	8.5
5	2	3	Motorola	147	274	86.4	563	8.0	16.5
1	3	(2)	NEC	230	256	11.3	819	7.5	24.0
3	4	(1)	Intel	218	248	13.8	1,067	7.3	31.3
2	5	(3)	Toshiba	221	246	11.3	1,313	7.2	38.5
6	6	0	SGS-Thomson	127	184	44.9	1,497	5.4	43.9
4	7	(3)	Philips	168	179	6.5	1,676	5.2	49.1
7	8	(1)	Texas Instruments	108	142	31.5	1,818	4.2	53.3
11	9	2	Samsung	73	136	86.3	1,954	4.0	57.3
8	10	(2)	Hitachi	99	135	36.4	2,089	4.0	61.2
9	11	(2)	National Semiconductor	90	103	14.4	2,192	3.0	64.2
10	12	(2)	Fujitsu	79	98	24.1	2,290	2.9	67.1
16	13	3	Matra MHS	49	73	49.0	2,363	2.1	69.3
14	14	0	LSI Logic	59	72	22.0	2,435	2.1	71.4
37	15	22	Harris	10	70	600.0	2,505	2.1	73.4
29	16	13	AMD	21	68	223.8	2,573	2.0	75.4
17	17	0	ITT	48	63	31.3	2,636	1.8	77.3
15	18	(3)	Mitsubishi	53	59	11.3	2,695	1.7	79.0
21	19	2	VLSI Technology	36	55	52.8	2,750	1.6	80.6
24	20	4	NMB	30	51	70.0	2,801	1.5	82.1
18	21	(3)	Plessey Semiconductors	40	44	10.0	2,845	1.3	83.4
22	22	0	Oki Electric	35	43	22.9	2,888	1.3	84.6
27	23	4	Matsushita (Panasonic)	22	38	72.7	2,926	1.1	85.8
19	24	(5)	IDT	39	36	(7.7)	2,962	1.1	86.8
23	25	(2)	Austria Mikro Systeme	32	36	12.5	2,998	1.1	87.9
28	26	2	Cypress	21	30	42.9	3,028	0.9	88.7
26	27	(1)	Marconi Electronic Devices	23	26	13.0	3,054	0.8	89.5
43	28	15	Sony	5	26	420.0	3,080	0.8	90.3
31	29	2	Western Digital	17	23	35.3	3,103	0.7	90.9
32	30	2	Mietec	17	22	29.4	3,125	0.6	91.6
25	31	(6)	ABB-HAFO	25	21	(16.0)	3,146	0.6	92.2
NA	32		TMS		18		3,164	0.5	92.7
35	33	2	European Silicon Structures	12	17	41.7	3,181	0.5	93.2
34	34	0	Eurosil Electronic	13	14	7.7	3,195	0.4	93.6
33	35	(2)	AT&T	15	12	(20.0)	3,207	0.4	94.0
45	36	9	Sharp	4	8	100.0	3,215	0.2	94.2
NA	37		Micron Technology		8		3,223	0.2	94.5
30	38	(8)	Seiko Epson	18	7	(61.1)	3,230	0.2	94.7
41	39	2	Ericsson Components	6	7	16.7	3,237	0.2	94.9

(Continued)

Table 14
1989 European CMOS IC Market Share Rankings
(Millions of U.S. Dollars) (Continued)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
44	40	4	Zilog	4	7	75.0	3,244	0.2	95.1
42	41	1	Analog Devices	6	6	0.0	3,250	0.2	95.3
38	42	(4)	Sanyo	7	4	(42.9)	3,254	0.1	95.4
46	43	3	Goldstar	3	4	33.3	3,258	0.1	95.5
39	44	(5)	STC Components	6	3	(50.0)	3,261	0.1	95.6
12	NA		GE Solid State	66		(100.0)			
20	NA		Inmos	38		(100.0)			
36	NA		Honeywell Solid State	10		(100.0)			
40	NA		Rockwell	6		(100.0)			
47	NA		Sprague	2		(100.0)			
			European Others	12	11	(8.3)	3,272	0.3	95.9
			North American Others	39	93	138.5	3,365	2.7	98.6
			Japanese Others	3	22	633.3	3,387	0.6	99.3
			Rest of World Others	14	25	78.6	3,412	0.7	100.0
			Total All Companies	2,491	3,412	37.0		100.0	
			Total European	633	944	49.1		27.7	
			Total North American	962	1,310	36.2		38.4	
			Total Japanese	806	993	23.2		29.1	
			Total Rest of World	90	165	83.3		4.8	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 15
1989 European BiCMOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	Mietec	18	23	27.8	23	38.3	38.3
NA	2		SGS-Thomson		8		31	13.3	51.7
NA	3		Sprague		8		39	13.3	65.0
7	4	3	National Semiconductor	1	4	300.0	43	6.7	71.7
5	5	0	Texas Instruments	2	3	50.0	46	5.0	76.7
6	6	0	STC Components	2	3	50.0	49	5.0	81.7
NA	7		Fujitsu		3		52	5.0	86.7
3	8	(5)	Hitachi	7	1	(85.7)	53	1.7	88.3
8	9	(1)	LSI Logic	1	1	0.0	54	1.7	90.0
NA	10		Toshiba		1		55	1.7	91.7
1	NA		NEC	18		(100.0)			
4	NA		GE Solid State	7		(100.0)			
			North American Others		5		60	8.3	100.0
			Total All Companies	56	60	7.1		100.0	
			Total European	20	34	70.0		56.7	
			Total North American	11	21	90.9		35.0	
			Total Japanese	25	5	(80.0)		8.3	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 16
1989 European Other MOS IC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	ITT	7	3	(57.1)	3	100.0	100.0
1	NA		Hitachi	42		(100.0)			
3	NA		Texas Instruments	4		(100.0)			
4	NA		Samsung	2		(100.0)			
5	NA		Siemens	1		(100.0)			
6	NA		Rockwell	1		(100.0)			
7	NA		Plessey Semiconductors	1		(100.0)			
			Total All Companies	58	3	(94.8)		100.0	
			Total European	2		(100.0)			
			Total North American	12	3	(75.0)		100.0	
			Total Japanese	42		(100.0)			
			Total Rest of World	2		(100.0)			

NA = Not Applicable
Source: Dataquest (June 1990)

Table 17
1989 European MOS Memory Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
5	1	4	Siemens	130	338	160.0	338	13.3	13.3
3	2	1	Texas Instruments	216	250	15.7	588	9.8	23.1
1	3	(2)	Toshiba	228	247	8.3	835	9.7	32.8
2	4	(2)	NEC	223	232	4.0	1,067	9.1	41.9
6	5	1	Samsung	128	186	45.3	1,253	7.3	49.2
4	6	(2)	Hitachi	138	172	24.6	1,425	6.8	55.9
9	7	2	SGS-Thomson	84	129	53.6	1,554	5.1	61.0
7	8	(1)	Fujitsu	102	120	17.6	1,674	4.7	65.7
10	9	1	Mitsubishi	71	104	46.5	1,778	4.1	69.8
8	10	(2)	Intel	97	102	5.2	1,880	4.0	73.8
11	11	0	AMD	56	71	26.8	1,951	2.8	76.6
17	12	5	Matsushita (Panasonic)	22	67	204.5	2,018	2.6	79.2
16	13	3	Motorola	25	60	140.0	2,078	2.4	81.6
29	14	15	Micron Technology	2	60	2,900.0	2,138	2.4	83.9
13	15	(2)	NMB	30	51	70.0	2,189	2.0	85.9
12	16	(4)	Oki Electric	38	48	26.3	2,237	1.9	87.8
14	17	(3)	National Semiconductor	30	30	0.0	2,267	1.2	89.0
18	18	0	Matra MHS	20	28	40.0	2,295	1.1	90.1
25	19	6	Sony	5	26	420.0	2,321	1.0	91.1
15	20	(5)	IDT	27	24	(11.1)	2,345	0.9	92.0
23	21	2	Sharp	10	22	120.0	2,367	0.9	92.9
20	22	(2)	Cypress	16	21	31.3	2,388	0.8	93.7
21	23	(2)	Philips	14	20	42.9	2,408	0.8	94.5
NA	24		ITT		9		2,417	0.4	94.9
32	25	7	Goldstar	1	4	300.0	2,421	0.2	95.0
31	26	5	Marconi Electronic Devices	1	3	200.0	2,424	0.1	95.1
NA	27		Plessey Semiconductors		2		2,426	0.1	95.2
27	28	(1)	Harris	4	1	(75.0)	2,427	0.0	95.3
26	29	(3)	VLSI Technology	4	1	(75.0)	2,428	0.0	95.3
NA	30		Sanyo		1		2,429	0.0	95.3
19	NA		Inmos		19		(100.0)		
22	NA		Seiko Epson	11		(100.0)			
24	NA		GE Solid State	8		(100.0)			
28	NA		Austria Mikro Systeme	4		(100.0)			
30	NA		STC Components	1		(100.0)			
			European Others	2		(100.0)			
			North American Others	18	61	238.9	2,490	2.4	97.7
			Japanese Others	1	39	3,800.0	2,529	1.5	99.3
			Rest of World Others	11	19	72.7	2,548	0.7	100.0
			Total All Companies	1,797	2,548	41.8		100.0	
			Total European	275	520	89.1		20.4	
			Total North American	503	690	37.2		27.1	
			Total Japanese	879	1,129	28.4		44.3	
			Total Rest of World	140	209	49.3		8.2	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 18
1989 European MOS Microcomponent Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Intel	351	416	18.5	416	28.3	28.3
2	2	0	Motorola	150	179	19.3	595	12.2	40.5
3	3	0	NEC	109	122	11.9	717	8.3	48.8
4	4	0	SGS-Thomson	77	101	31.2	818	6.9	55.7
5	5	0	Hitachi	71	75	5.6	893	5.1	60.8
7	6	1	Siemens	51	67	31.4	960	4.6	65.4
6	7	(1)	Philips	55	62	12.7	1,022	4.2	69.6
8	8	0	Texas Instruments	48	60	25.0	1,082	4.1	73.7
21	9	12	Mitsubishi	8	48	500.0	1,130	3.3	76.9
9	10	(1)	National Semiconductor	40	45	12.5	1,175	3.1	80.0
11	11	0	Toshiba	27	35	29.6	1,210	2.4	82.4
10	12	(2)	AMD	33	34	3.0	1,244	2.3	84.7
14	13	1	Western Digital	17	23	35.3	1,267	1.6	86.2
24	14	10	Harris	6	21	250.0	1,288	1.4	87.7
17	15	2	Matra MHS	14	20	42.9	1,308	1.4	89.0
15	16	(1)	Oki Electric	16	18	12.5	1,326	1.2	90.3
22	17	5	ITT	7	18	157.1	1,344	1.2	91.5
26	18	8	VLSI Technology	5	17	240.0	1,361	1.2	92.6
13	19	(6)	Zilog	19	16	(15.8)	1,377	1.1	93.7
NA	20		TMS		11		1,388	0.7	94.5
20	21	(1)	Fujitsu	9	10	11.1	1,398	0.7	95.2
19	22	(3)	Rockwell	11	9	(18.2)	1,407	0.6	95.8
25	23	2	Analog Devices	6	6	0.0	1,413	0.4	96.2
NA	24		LSI Logic		6		1,419	0.4	96.6
31	25	6	AT&T	1	4	300.0	1,423	0.3	96.9
23	26	(3)	IDT	6	3	(50.0)	1,426	0.2	97.1
30	27	3	Cypress	1	2	100.0	1,428	0.1	97.2
NA	28		Plessey Semiconductors		2		1,430	0.1	97.3
18	29	(11)	Sanyo	12	1	(91.7)	1,431	0.1	97.4
28	30	(2)	Marconi Electronic Devices	1	1	0.0	1,432	0.1	97.5
29	31	(2)	Eurosil Electronic	1	1	0.0	1,433	0.1	97.5
27	32	(5)	Sharp	1	1	0.0	1,434	0.1	97.6
12	NA		Inmos	21		(100.0)			
16	NA		GE Solid State	15		(100.0)			
			North American Others	19	31	63.2	1,465	2.1	99.7
			Rest of World Others	4	4	0.0	1,469	0.3	100.0
			Total All Companies	1,212	1,469	21.2		100.0	
			Total European	220	265	20.5		18.0	
			Total North American	735	890	21.1		60.6	
			Total Japanese	253	310	22.5		21.1	
			Total Rest of World	4	4	0.0		0.3	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 19
1989 European MOS Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	216	185	(14.4)	185	12.8	12.8
5	2	3	Siemens	62	117	88.7	302	8.1	21.0
2	3	(1)	SGS-Thomson	103	114	10.7	416	7.9	28.9
3	4	(1)	ITT	95	91	(4.2)	507	6.3	35.2
4	5	(1)	Motorola	80	74	(7.5)	581	5.1	40.3
7	6	1	LSI Logic	60	67	11.7	648	4.6	45.0
8	7	1	AMD	59	63	6.8	711	4.4	49.3
6	8	(2)	National Semiconductor	61	62	1.6	773	4.3	53.6
12	9	3	Texas Instruments	44	58	31.8	831	4.0	57.7
11	10	1	Toshiba	46	52	13.0	883	3.6	61.3
13	11	2	Mietec	42	52	23.8	935	3.6	64.9
9	12	(3)	Plessey Semiconductors	51	50	(2.0)	985	3.5	68.4
NA	13		Harris		48		1,033	3.3	71.7
15	14	1	Austria Mikro Systeme	36	47	30.6	1,080	3.3	74.9
16	15	1	VLSI Technology	27	37	37.0	1,117	2.6	77.5
20	16	4	Matra MHS	18	25	38.9	1,142	1.7	79.3
14	17	(3)	NEC	40	24	(40.0)	1,166	1.7	80.9
19	18	1	Marconi Electronic Devices	21	22	4.8	1,188	1.5	82.4
18	19	(1)	ABB-HAFO	25	21	(16.0)	1,209	1.5	83.9
24	20	4	Fujitsu	12	18	50.0	1,227	1.2	85.1
26	21	5	European Silicon Structures	12	17	41.7	1,244	1.2	86.3
23	22	1	Hitachi	12	17	41.7	1,261	1.2	87.5
21	23	(2)	Telefunken Electronic	15	15	0.0	1,276	1.0	88.5
25	24	1	Eurosil Electronic	12	13	8.3	1,289	0.9	89.5
17	25	(8)	Intel	27	12	(55.6)	1,301	0.8	90.3
NA	26		TMS		12		1,313	0.8	91.1
32	27	5	IDT	6	9	50.0	1,322	0.6	91.7
22	28	(6)	AT&T	14	8	(42.9)	1,330	0.6	92.3
29	29	0	STC Components	8	8	0.0	1,338	0.6	92.9
35	30	5	Sprague	3	8	166.7	1,346	0.6	93.4
30	31	(1)	Seiko Epson	7	7	0.0	1,353	0.5	93.9
33	32	1	Ericsson Components	6	7	16.7	1,360	0.5	94.4
34	33	1	Cypress	4	7	75.0	1,367	0.5	94.9
36	34	2	Oki Electric	3	3	0.0	1,370	0.2	95.1

(Continued)

Table 19
1989 European MOS Logic Market Share Rankings
(Millions of U.S. Dollars) (Continued)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
28	35	(7)	Samsung	9	2	(77.8)	1,372	0.1	95.2
37	36	1	Goldstar	2	2	0.0	1,374	0.1	95.4
NA	37		Sanyo		2		1,376	0.1	95.5
NA	38		Mitsubishi		1		1,377	0.1	95.6
10	NA		GE Solid State	50		(100.0)			
27	NA		Honeywell Solid State	10		(100.0)			
31	NA		Rockwell	7		(100.0)			
			European Others	16	17	6.3	1,394	1.2	96.7
			North American Others	29	44	51.7	1,438	3.1	99.8
			Japanese Others	3	1	(66.7)	1,439	0.1	99.9
			Rest of World Others	2	2	0.0	1,441	0.1	100.0
			Total All Companies	1,355	1,441	6.3		100.0	
			Total European	643	722	12.3		50.1	
			Total North American	576	588	2.1		40.8	
			Total Japanese	123	125	1.6		8.7	
			Total Rest of World	13	6	(53.8)		0.4	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 20
1989 European MOS ASIC Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	ITT	95	91	(4.2)	91	10.4	10.4
2	2	0	LSI Logic	59	67	13.6	158	7.6	18.0
9	3	6	Siemens	28	55	96.4	213	6.3	24.3
3	4	(1)	Mietec	42	52	23.8	265	5.9	30.2
4	5	(1)	Toshiba	41	50	22.0	315	5.7	35.9
5	6	(1)	Plessey Semiconductors	35	49	40.0	364	5.6	41.5
7	7	0	Austria Mikro Systeme	33	47	42.4	411	5.4	46.9
6	8	(2)	SGS-Thomson	34	40	17.6	451	4.6	51.4
10	9	1	VLSI Technology	25	37	48.0	488	4.2	55.6
11	10	1	Texas Instruments	25	35	40.0	523	4.0	59.6
8	11	(3)	National Semiconductor	30	30	0.0	553	3.4	63.1
13	12	1	NEC	23	24	4.3	577	2.7	65.8
12	13	(1)	ABB-HAFO	25	21	(16.0)	598	2.4	68.2
18	14	4	Marconi Electronic Devices	14	21	50.0	619	2.4	70.6
17	15	2	Matra MHS	14	20	42.9	639	2.3	72.9
15	16	(1)	Philips	14	19	35.7	658	2.2	75.0
NA	17		Harris		19		677	2.2	77.2
19	18	1	Fujitsu	12	18	50.0	695	2.1	79.2
21	19	2	European Silicon Structures	12	17	41.7	712	1.9	81.2
14	20	(6)	Telefunken Electronic	15	15	0.0	727	1.7	82.9
20	21	(1)	Eurosil Electronic	12	13	8.3	740	1.5	84.4
NA	22		TMS		12		752	1.4	85.7
27	23	4	Hitachi	7	11	57.1	763	1.3	87.0
22	24	(2)	Intel	11	10	(9.1)	773	1.1	88.1
25	25	0	AT&T	9	8	(11.1)	781	0.9	89.1
31	26	5	Sprague	3	8	166.7	789	0.9	90.0
26	27	(1)	Seiko Epson	7	7	0.0	796	0.8	90.8
29	28	1	Ericsson Components	6	7	16.7	803	0.8	91.6
30	29	1	Cypress	4	7	75.0	810	0.8	92.4
28	30	(2)	STC Components	6	5	(16.7)	815	0.6	92.9
33	31	2	AMD	2	5	150.0	820	0.6	93.5
16	32	(16)	Motorola	14	4	(71.4)	824	0.5	94.0
32	33	(1)	Oki Electric	3	3	0.0	827	0.3	94.3
NA	34		Goldstar		1		828	0.1	94.4
23	NA		GE Solid State	11		(100.0)			
24	NA		Honeywell Solid State	10		(100.0)			
			European Others	10	10	0.0	838	1.1	95.6
			North American Others	19	39	105.3	877	4.4	100.0
			Japanese Others	1		(100.0)			
			Total All Companies	711	877	23.3		100.0	
			Total European	300	403	34.3		46.0	
			Total North American	317	360	13.6		41.0	
			Total Japanese	94	113	20.2		12.9	
			Total Rest of World		1			0.1	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 21
1989 European MOS Standard Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	AMD	57	58	1.8	58	22.1	22.1
2	2	0	Philips	48	46	(4.2)	104	17.5	39.5
3	3	0	Motorola	40	33	(17.5)	137	12.5	52.1
NA	4		Harris		29		166	11.0	63.1
5	5	0	National Semiconductor	21	22	4.8	188	8.4	71.5
6	6	0	Texas Instruments	19	21	10.5	209	8.0	79.5
7	7	0	SGS-Thomson	18	18	0.0	227	6.8	86.3
9	8	1	IDT	6	9	50.0	236	3.4	89.7
11	9	2	Hitachi	5	6	20.0	242	2.3	92.0
13	10	3	STC Components	2	3	50.0	245	1.1	93.2
8	11	(3)	Samsung	9	2	(77.8)	247	0.8	93.9
10	12	(2)	Toshiba	5	2	(60.0)	249	0.8	94.7
14	13	1	Goldstar	2	1	(50.0)	250	0.4	95.1
NA	14		Mitsubishi		1		251	0.4	95.4
4	NA		GE Solid State	39		(100.0)			
12	NA		AT&T	5		(100.0)			
			European Others	6	7	16.7	258	2.7	98.1
			North American Others	3	3	0.0	261	1.1	99.2
			Rest of World Others	2	2	0.0	263	0.8	100.0
			Total All Companies	287	263	(8.4)		100.0	
			Total European	74	74	0.0		28.1	
			Total North American	190	175	(7.9)		66.5	
			Total Japanese	10	9	(10.0)		3.4	
			Total Rest of World	13	5	(61.5)		1.9	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 22
1989 European Other MOS Logic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	154	120	(22.1)	120	39.9	39.9
3	2	1	Siemens	34	62	82.4	182	20.6	60.5
2	3	(1)	SGS-Thomson	51	56	9.8	238	18.6	79.1
4	4	0	Motorola	26	37	42.3	275	12.3	91.4
8	5	3	National Semiconductor	10	10	0.0	285	3.3	94.7
11	6	5	Matra MHS	4	5	25.0	290	1.7	96.3
7	7	0	Intel	16	2	(87.5)	292	0.7	97.0
NA	8		Sanyo		2		294	0.7	97.7
NA	9		Texas Instruments		2		296	0.7	98.3
6	10	(4)	Plessey Semiconductors	16	1	(93.8)	297	0.3	98.7
10	11	(1)	Marconi Electronic Devices	7	1	(85.7)	298	0.3	99.0
5	NA		NEC	17		(100.0)			
9	NA		Rockwell	7		(100.0)			
12	NA		Austria Mikro Systeme	3		(100.0)			
13	NA		VLSI Technology	2		(100.0)			
14	NA		LSI Logic	1		(100.0)			
			North American Others	7	2	(71.4)	300	0.7	99.7
			Japanese Others	2	1	(50.0)	301	0.3	100.0
			Total All Companies	357	301	(15.7)		100.0	
			Total European	269	245	(8.9)		81.4	
			Total North American	69	53	(23.2)		17.6	
			Total Japanese	19	3	(84.2)		1.0	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 23
1989 European Total Analog Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	281	316	12.5	316	18.6	18.6
2	2	0	SGS-Thomson	210	226	7.6	542	13.3	32.0
3	3	0	National Semiconductor	140	160	14.3	702	9.4	41.4
6	4	2	Siemens	102	134	31.4	836	7.9	49.3
4	5	(1)	Texas Instruments	105	100	(4.8)	936	5.9	55.2
5	6	(1)	Motorola	105	99	(5.7)	1,035	5.8	61.0
7	7	0	Analog Devices	90	89	(1.1)	1,124	5.2	66.3
8	8	0	Telefunken Electronic	52	62	19.2	1,186	3.7	69.9
17	9	8	Harris	18	47	161.1	1,233	2.8	72.7
10	10	0	Burr-Brown	43	39	(9.3)	1,272	2.3	75.0
12	11	1	Ericsson Components	34	35	2.9	1,307	2.1	77.1
14	12	2	Precision Monolithics	30	29	(3.3)	1,336	1.7	78.8
11	13	(2)	ITT	41	27	(34.1)	1,363	1.6	80.4
18	14	4	Toshiba	17	22	29.4	1,385	1.3	81.7
19	15	4	AMD	17	22	29.4	1,407	1.3	83.0
NA	16		Mitsubishi		21		1,428	1.2	84.2
9	17	(8)	Plessey Semiconductors	49	18	(63.3)	1,446	1.1	85.3
15	18	(3)	Sprague	27	17	(37.0)	1,463	1.0	86.3
16	19	(3)	Siliconix	18	16	(11.1)	1,479	0.9	87.2
20	20	0	Mitel Semiconductor	14	14	0.0	1,493	0.8	88.0
31	21	10	Samsung	2	10	400.0	1,503	0.6	88.6
28	22	6	Austria Mikro Systeme	4	9	125.0	1,512	0.5	89.2
NA	23		Fujitsu		9		1,521	0.5	89.7
23	24	(1)	Rohm Electronics	6	8	33.3	1,529	0.5	90.2
22	25	(3)	Unitrode	6	8	33.3	1,537	0.5	90.6
NA	26		TMS		7		1,544	0.4	91.0
NA	27		Rockwell		7		1,551	0.4	91.5
21	28	(7)	Raytheon	7	6	(14.3)	1,557	0.4	91.8
25	29	(4)	Hitachi	6	6	0.0	1,563	0.4	92.2
26	30	(4)	STC Components	4	5	25.0	1,568	0.3	92.5
29	31	(2)	Sanyo	3	5	66.7	1,573	0.3	92.7
24	32	(8)	Matsushita (Panasonic)	6	4	(33.3)	1,577	0.2	93.0
27	33	(6)	Sony	4	4	0.0	1,581	0.2	93.2
30	34	(4)	NEC	3	4	33.3	1,585	0.2	93.5

(Continued)

Table 23
1989 European Total Analog Market Share Rankings
(Millions of U.S. Dollars) (Continued)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
NA	35		Marconi Electronic Devices		2		1,587	0.1	93.6
33	36	(3)	Seiko Epson	1	1	0.0	1,588	0.1	93.6
NA	37		Goldstar		1		1,589	0.1	93.7
NA	38		International Rectifier		1		1,590	0.1	93.8
13	NA		GE Solid State	33		(100.0)			
32	NA		AT&T	2	.	(100.0)			
			European Others	2	2	0.0	1,592	0.1	93.9
			North American Others	49	97	98.0	1,689	5.7	99.6
			Japanese Others	2	7	250.0	1,696	0.4	100.0
			Total All Companies	1,533	1,696	10.6		100.0	
			Total European	738	816	10.6		48.1	
			Total North American	745	778	4.4		45.9	
			Total Japanese	48	91	89.6		5.4	
			Total Rest of World	2	11	450.0		0.6	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 24
1989 European Monolithic Analog Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	247	276	11.7	276	17.7	17.7
2	2	0	SGS-Thomson	210	226	7.6	502	14.5	32.2
3	3	0	National Semiconductor	140	160	14.3	662	10.3	42.4
5	4	1	Siemens	94	125	33.0	787	8.0	50.4
4	5	(1)	Texas Instruments	105	100	(4.8)	887	6.4	56.9
6	6	0	Motorola	87	81	(6.9)	968	5.2	62.1
7	7	0	Analog Devices	73	72	(1.4)	1,040	4.6	66.7
8	8	0	Telefunken Electronic	49	59	20.4	1,099	3.8	70.4
16	9	7	Harris	18	45	150.0	1,144	2.9	73.3
11	10	1	Ericsson Components	34	35	2.9	1,179	2.2	75.6
13	11	2	Precision Monolithics	30	29	(3.3)	1,208	1.9	77.4
10	12	(2)	ITT	41	27	(34.1)	1,235	1.7	79.2
17	13	4	Toshiba	17	22	29.4	1,257	1.4	80.6
19	14	5	AMD	17	22	29.4	1,279	1.4	82.0
15	15	0	Burr-Brown	23	21	(8.7)	1,300	1.3	83.3
NA	16		Mitsubishi		20		1,320	1.3	84.6
9	17	(8)	Plessey Semiconductors	48	18	(62.5)	1,338	1.2	85.8
14	18	(4)	Sprague	27	17	(37.0)	1,355	1.1	86.9
18	19	(1)	Siliconix	17	16	(5.9)	1,371	1.0	87.9
31	20	11	Samsung	2	10	400.0	1,381	0.6	88.5
20	21	(1)	Mitel Semiconductor	10	9	(10.0)	1,390	0.6	89.1
26	22	4	Austria Mikro Systeme	4	9	125.0	1,399	0.6	89.7
24	23	1	Unitrode	5	7	40.0	1,406	0.4	90.1
NA	24		TMS		7		1,413	0.4	90.6
NA	25		Rockwell		7		1,420	0.4	91.0
21	26	(5)	Raytheon	6	6	0.0	1,426	0.4	91.4
23	27	(4)	Hitachi	6	6	0.0	1,432	0.4	91.8
NA	28		Fujitsu		6		1,438	0.4	92.2
22	29	(7)	Matsushita (Panasonic)	6	4	(33.3)	1,442	0.3	92.4
25	30	(5)	Rohm Electronics	4	4	0.0	1,446	0.3	92.7
27	31	(4)	STC Components	3	4	33.3	1,450	0.3	92.9
28	32	(4)	NEC	3	4	33.3	1,454	0.3	93.2
30	33	(3)	Sanyo	2	4	100.0	1,458	0.3	93.5
29	34	(5)	Sony	2	2	0.0	1,460	0.1	93.6

(Continued)

Table 24
1989 European Monolithic Analog Market Share Rankings
(Millions of U.S. Dollars) (Continued)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
NA	35		Marconi Electronic Devices		2		1,462	0.1	93.7
NA	36		International Rectifier		1		1,463	0.1	93.8
NA	37		Goldstar		1		1,464	0.1	93.8
12	NA		GE Solid State	33		(100.0)			
32	NA		AT&T	2		(100.0)			
			European Others	2	2	0.0	1,466	0.1	94.0
			North American Others	49	93	89.8	1,559	6.0	99.9
			Japanese Others		1		1,560	0.1	100.0
			Total All Companies	1,416	1,560	10.2		100.0	
			Total European	691	763	10.4		48.9	
			Total North American	683	713	4.4		45.7	
			Total Japanese	40	73	82.5		4.7	
			Total Rest of World	2	11	450.0		0.7	

NA = Not Applicable
Source: dataquest (June 1990)

Table 25
1989 European Hybrid Analog Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	34	40	17.6	40	29.4	29.4
2	2	0	Burr-Brown	20	18	(10.0)	58	13.2	42.6
3	3	0	Motorola	18	18	0.0	76	13.2	55.9
4	4	0	Analog Devices	17	17	0.0	93	12.5	68.4
5	5	0	Siemens	8	9	12.5	102	6.6	75.0
6	6	0	Mitel Semiconductor	4	5	25.0	107	3.7	78.7
9	7	2	Rohm Electronics	2	4	100.0	111	2.9	81.6
7	8	(1)	Telefunken Electronic	3	3	0.0	114	2.2	83.8
NA	9		Fujitsu		3		117	2.2	86.0
8	10	(2)	Sony	2	2	0.0	119	1.5	87.5
NA	11		Harris		2		121	1.5	89.0
11	12	(1)	STC Components	1	1	0.0	122	0.7	89.7
10	13	(3)	Unitrode	1	1	0.0	123	0.7	90.4
14	14	0	Sanyo	1	1	0.0	124	0.7	91.2
13	15	(2)	Seiko Epson	1	1	0.0	125	0.7	91.9
NA	16		Mitsubishi		1		126	0.7	92.6
12	NA		Siliconix	1		(100.0)			
16	NA		Plessey Semiconductors	1		(100.0)			
15	NA		Raytheon	1		(100.0)			
			North American Others		4		130	2.9	95.6
			Japanese Others	2	6	200.0	136	4.4	100.0
			Total All Companies	117	136	16.2		100.0	
			Total European	47	53	12.8		39.0	
			Total North American	62	65	4.8		47.8	
			Total Japanese	8	18	125.0		13.2	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 26
1989 European Total Discrete Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	313	294	(6.1)	294	18.4	18.4
2	2	0	Motorola	196	193	(1.5)	487	12.1	30.6
3	3	0	SGS-Thomson	167	177	6.0	664	11.1	41.7
4	4	0	Siemens	135	162	20.0	826	10.2	51.8
5	5	0	ITT	103	105	1.9	931	6.6	58.4
8	6	2	International Rectifier	66	70	6.1	1,001	4.4	62.8
7	7	0	Telefunken Electronic	66	66	0.0	1,067	4.1	66.9
9	8	1	Semikron	56	55	(1.8)	1,122	3.5	70.4
10	9	1	Toshiba	52	46	(11.5)	1,168	2.9	73.3
NA	10		ABB-IXYS		40		1,208	2.5	75.8
11	11	0	Powerex	28	33	17.9	1,241	2.1	77.9
19	12	7	General Instrument	18	33	83.3	1,274	2.1	79.9
14	13	1	Siliconix	23	25	8.7	1,299	1.6	81.5
NA	14		Harris		24		1,323	1.5	83.0
13	15	(2)	Texas Instruments	25	23	(8.0)	1,346	1.4	84.4
15	16	(1)	Fagor Electrotécnica	21	22	4.8	1,368	1.4	85.8
NA	17		Fujitsu		22		1,390	1.4	87.2
20	18	2	Matsushita (Panasonic)	13	21	61.5	1,411	1.3	88.5
24	19	5	Mitsubishi	6	20	233.3	1,431	1.3	89.8
18	20	(2)	Marconi Electronic Devices	18	17	(5.6)	1,448	1.1	90.8
16	21	(5)	TAG	18	17	(5.6)	1,465	1.1	91.9
27	22	5	Hewlett-Packard	4	17	325.0	1,482	1.1	93.0
22	23	(1)	Rohm Electronics	10	14	40.0	1,496	0.9	93.9
25	24	1	NEC	5	14	180.0	1,510	0.9	94.7
21	25	(4)	Unitrode	10	11	10.0	1,521	0.7	95.4
23	26	(3)	Hitachi	9	9	0.0	1,530	0.6	96.0
28	27	1	Sprague	2	7	250.0	1,537	0.4	96.4
26	28	(2)	National Semiconductor	5	5	0.0	1,542	0.3	96.7
30	29	1	Sanyo	1	4	300.0	1,546	0.3	97.0
6	30	(24)	ABB-HAFO	69	3	(95.7)	1,549	0.2	97.2
31	31	0	Samsung	1	3	200.0	1,552	0.2	97.4
29	32	(3)	STC Components	1	2	100.0	1,554	0.1	97.5
NA	33		TMS		2		1,556	0.1	97.6
32	34	(2)	Raytheon	1	1	0.0	1,557	0.1	97.7

(Continued)

Table 26
1989 European Total Discrete Market Share Rankings
(Millions of U.S. Dollars) (Continued)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
NA	35		Sony		1		1,558	0.1	97.7
12	NA		GE Solid State	27		(100.0)			
17	NA		Plessey Semiconductors	18		(100.0)			
33	NA		AT&T	1		(100.0)			
			European Others	6	6	0.0	1,564	0.4	98.
			North American Others	11	11	0.0	1,575	0.7	98.8
			Japanese Others	7	17	142.9	1,592	1.1	99.9
			Rest of World Others	4	2	(50.0)	1,594	0.1	100.0
			Total All Companies	1,516	1,594	5.1		100.0	
			Total European	888	863	(2.8)		54.1	
			Total North American	520	558	7.3		35.0	
			Total Japanese	103	168	63.1		10.5	
			Total Rest of World	5	5	0.0		0.3	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 27
1989 European Transistor Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	185	180	(2.7)	180	23.0	23.0
2	2	0	Motorola	124	127	2.4	307	16.2	39.3
3	3	0	SGS-Thomson	85	90	5.9	397	11.5	50.8
4	4	0	Siemens	66	77	16.7	474	9.8	60.6
5	5	0	Toshiba	36	34	(5.6)	508	4.3	65.0
6	6	0	ITT	32	32	0.0	540	4.1	69.1
8	7	1	Siliconix	23	25	8.7	565	3.2	72.3
7	8	(1)	Texas Instruments	25	23	(8.0)	588	2.9	75.2
9	9	0	International Rectifier	20	23	15.0	611	2.9	78.1
NA	10		Fujitsu		22		633	2.8	80.9
13	11	2	Powerex	8	18	125.0	651	2.3	83.2
11	12	(1)	Telefunken Electronic	16	17	6.3	668	2.2	85.4
NA	13		Harris		17		685	2.2	87.6
12	14	(2)	Matsushita (Panasonic)	12	14	16.7	699	1.8	89.4
19	15	4	NEC	3	11	266.7	710	1.4	90.8
14	16	(2)	Rohm Electronics	7	10	42.9	720	1.3	92.1
17	17	0	Mitsubishi	4	10	150.0	730	1.3	93.4
16	18	(2)	Marconi Electronic Devices	5	5	0.0	735	0.6	94.0
NA	19		ABB-IXYS		5		740	0.6	94.6
23	20	3	Sanyo	1	4	300.0	744	0.5	95.1
20	21	(1)	National Semiconductor	3	3	0.0	747	0.4	95.5
24	22	2	Samsung	1	3	200.0	750	0.4	95.9
18	23	(5)	Hewlett-Packard	4	2	(50.0)	752	0.3	96.2
21	24	(3)	Sprague	2	2	0.0	754	0.3	96.4
26	25	1	Hitachi	1	1	0.0	755	0.1	96.5
22	26	(4)	Semikron	1	1	0.0	756	0.1	96.7
25	27	(2)	Raytheon	1	1	0.0	757	0.1	96.8
NA	28		TMS		1		758	0.1	96.9
NA	29		Sony		1		759	0.1	97.1
10	NA		GE Solid State	20		(100.0)			
15	NA		Plessey Semiconductors	7		(100.0)			
27	NA		ABB-HAFO	1		(100.0)			
			European Others	2	2	0.0	761	0.3	97.3
			North American Others	7	9	28.6	770	1.2	98.5
			Japanese Others	3	10	233.3	780	1.3	99.7
			Rest of World Others	4	2	(50.0)	782	0.3	100.0
			Total All Companies	709	782	10.3		100.0	
			Total European	368	378	2.7		48.3	
			Total North American	269	282	4.8		36.1	
			Total Japanese	67	117	74.6		15.0	
			Total Rest of World	5	5	0.0		0.6	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 28
1989 European Diode Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	Philips	111	95	(14.4)	95	19.5	19.5
2	2	0	Motorola	59	55	(6.8)	150	11.3	30.8
3	3	0	SGS-Thomson	50	54	8.0	204	11.1	41.9
4	4	0	ITT	47	47	0.0	251	9.7	51.5
5	5	0	Siemens	35	40	14.3	291	8.2	59.8
10	6	4	General Instrument	18	33	83.3	324	6.8	66.5
6	7	(1)	Telefunken Electronic	26	26	0.0	350	5.3	71.9
7	8	(1)	International Rectifier	23	22	(4.3)	372	4.5	76.4
9	9	0	Fagor Electrotécnica	21	22	4.8	394	4.5	80.9
8	10	(2)	Semikron	21	21	0.0	415	4.3	85.2
NA	11		Hewlett-Packard		15		430	3.1	88.3
NA	12		ABB-IXYS		11		441	2.3	90.6
13	13	0	Unitrode	8	9	12.5	450	1.8	92.4
21	14	7	Matsushita (Panasonic)	1	7	600.0	457	1.4	93.8
15	15	0	Marconi Electronic Devices	4	4	0.0	461	0.8	94.7
17	16	1	Rohm Electronics	3	4	33.3	465	0.8	95.5
14	17	(3)	Powerex	5	3	(40.0)	468	0.6	96.1
16	18	(2)	Toshiba	3	3	0.0	471	0.6	96.7
18	19	(1)	National Semiconductor	2	2	0.0	473	0.4	97.1
19	20	(1)	STC Components	1	2	100.0	475	0.4	97.5
20	21	(1)	NEC	1	1	0.0	476	0.2	97.7
NA	22		TMS	1		477	0.2	97.9	
11	NA		ABB-HAFO	14		(100.0)			
12	NA		Plessey Semiconductors	11		(100.0)			
23	NA		AT&T	1		(100.0)			
22	NA		GE Solid State	1		(100.0)			
			European Others	2	2	0.0	479	0.4	98.4
			North American Others	4	2	(50.0)	481	0.4	98.8
			Japanese Others	1	6	500.0	487	1.2	100.0
			Total All Companies	473	487	3.0		100.0	
			Total European	296	278	(6.1)		57.1	
			Total North American	168	188	11.9		38.6	
			Total Japanese	9	21	133.3		4.3	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 29
1989 European Thyristor Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
2	1	1	SGS-Thomson	32	33	3.1	33	17.8	17.8
3	2	1	Siemens	19	23	21.1	56	12.4	30.3
NA	3		ABB-IXYS		23		79	12.4	42.7
4	4	0	TAG	18	17	(5.6)	96	9.2	51.9
5	5	0	Telefunken Electronic	17	16	(5.9)	112	8.6	60.5
6	6	0	Semikron	17	16	(5.9)	128	8.6	69.2
8	7	1	International Rectifier	13	13	0.0	141	7.0	76.2
7	8	(1)	Powerex	15	12	(20.0)	153	6.5	82.7
9	9	0	Philips	9	9	0.0	162	4.9	87.6
10	10	0	Marconi Electronic Devices	9	8	(11.1)	170	4.3	91.9
11	11	0	Motorola	8	6	(25.0)	176	3.2	95.1
12	12	0	Hitachi	3	3	0.0	179	1.6	96.8
13	13	0	Mitsubishi	2	3	50.0	182	1.6	98.4
14	14	0	Unitrode	1	1	0.0	183	0.5	98.9
NA	15		NEC		1		184	0.5	99.5
1	NA		ABB-HAFO	46		(100.0)			
			European Others	1	1	0.0	185	0.5	100.0
			Total All Companies	210	185	(11.9)		100.0	
			Total European	168	146	(13.1)		78.9	
			Total North American	37	32	(13.5)		17.3	
			Total Japanese	5	7	40.0		3.8	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 30
1989 European Other Discrete Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
1	1	0	ITT	24	26	8.3	26	18.6	18.6
3	2	1	Siemens	15	22	46.7	48	15.7	34.3
2	3	(1)	Semikron	17	17	0.0	65	12.1	46.4
5	4	1	International Rectifier	10	12	20.0	77	8.6	55.0
6	5	1	Philips	8	10	25.0	87	7.1	62.1
4	6	(2)	Toshiba	13	9	(30.8)	96	6.4	68.6
8	7	1	Telefunken Electronic	7	7	0.0	103	5.0	73.6
NA	8		Harris		7		110	5.0	78.6
NA	9		Mitsubishi		7		117	5.0	83.6
10	10	0	Motorola	5	5	0.0	122	3.6	87.1
11	11	0	Hitachi	5	5	0.0	127	3.6	90.7
NA	12		Sprague		5		132	3.6	94.3
7	13	(6)	ABB-HAFO	8	3	(62.5)	135	2.1	96.4
12	14	(2)	Unitrode	1	1	0.0	136	0.7	97.1
13	15	(2)	NEC	1	1	0.0	137	0.7	97.9
NA	16		ABB-IXYS		1		138	0.7	98.6
9	NA		GE Solid State	6		(100.0)			
			European Others	1	1	0.0	139	0.7	99.3
			Japanese Others	3	1	(66.7)	140	0.7	100.0
			Total All Companies	124	140	12.9		100.0	
			Total European	56	61	8.9		43.6	
			Total North American	46	56	21.7		40.0	
			Total Japanese	22	23	4.5		16.4	

NA = Not Applicable
Source: Dataquest (June 1990)

Table 31
1989 European Optoelectronic Market Share Rankings
(Millions of U.S. Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (Percent)	1989 Cum. Sum ($M)	1989 Market Share (Percent)	1989 Cum. Sum (Percent)
3	1	2	Hewlett-Packard	49	79	61.2	79	21.5	21.5
2	2	0	Siemens	61	68	11.5	147	18.5	40.1
1	3	(2)	Telefunken Electronic	65	67	3.1	214	18.3	58.3
4	4	0	Philips	22	21	(4.5)	235	5.7	64.0
7	5	2	Toshiba	17	19	11.8	254	5.2	69.2
5	6	(1)	Texas Instruments	20	15	(25.0)	269	4.1	73.3
10	7	3	ABB-HAFO	6	6	0.0	275	1.6	74.9
NA	8		Fujitsu		6		281	1.6	76.6
NA	9		TMS		6		287	1.6	78.2
11	10	1	Motorola	5	5	0.0	292	1.4	79.6
18	11	7	NEC	1	5	400.0	297	1.4	80.9
12	12	0	Hitachi	4	4	0.0	301	1.1	82.0
16	13	3	Sharp	1	4	300.0	305	1.1	83.1
NA	14		Harris	4		309	1.1	84.2	
NA	15		AT&T		3		312	0.8	85.0
13	16	(3)	Sanyo	2	2	0.0	314	0.5	85.6
15	17	(2)	Matsushita (Panasonic)	2	2	0.0	316	0.5	86.1
6	NA		Plessey Semiconductors	20		(100.0)			
9	NA		GE Solid State	8		(100.0)			
8	NA		TRW	8		(100.0)			
14	NA		Mitsubishi	2		(100.0)			
17	NA		Oki Electric	1		(100.0)			
			European Others	8	8	0.0	324	2.2	88.3
			North American Others	4	43	975.0	367	11.7	100.0
			Total All Companies	306	367	19.9		100.0	
			Total European	182	176	(3.3)		48.0	
			Total North American	94	149	58.5		40.6	
			Total Japanese	30	42	40.0		11.4	

NA = Not Applicable
Source: Dataquest (June 1990)

FOOTNOTES TO THE TABLES

European Companies

ABB-HAFO	ABB-HAFO was formerly known as Asea Brown Boveri.
ABB-IXYS	ABB-IXYS was formerly the West German-based power semiconductor division of Asea Brown Boveri.
Inmos	Inmos revenue is included in SGS-Thomson revenue from 1989 onward.
Matra MHS	Matra MHS was formerly known as Matra-Harris Semiconducteurs.
SGS-Thomson	SGS-Thomson revenue includes Inmos revenue from 1989 onward.
TMS	Thomson Composants Militaires et Spatiaux (TMS) revenue was formerly included in SGS-Thomson (30 percent) and the European Others category (70 percent).

North American Companies

AT&T	AT&T revenue was formerly included in the North American Others category.
Cypress	Cypress revenue was formerly included in the North American Others category.
Harris	Harris revenue includes GE Solid State revenue from 1989 onward.
Micron Technology	Micron Technology revenue was formerly included in the North American Others category.
Mitel Semiconductor	Mitel Semiconductor revenue was formerly included in the North American Others category.
Raytheon	Raytheon revenue was formerly included in the North American Others category.
Rockwell	Rockwell revenue was formerly included in the North American Others category.
Sprague	Sprague revenue was formerly included in the North American Others category.
Unitrode	Unitrode revenue was formerly included in the North American Others category.

Japanese Companies

NMB	Nippon Miniature Bearings (NMB) revenue was formerly included in the Japanese Others category.
Rohm Electronics	Rohm Electronics revenue was formerly included in the Japanese Others category.
Sanyo	Sanyo revenue was formerly included in the Japanese Others category.
Sharp	Sharp revenue was formerly included in the Japanese Others category.
Sony	Sony revenue was formerly included in the Japanese Others category.

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European Commission Policy Statement on the Electronics and Information Technology Industries

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Semiconductors *Europe*

European Commission Policy Statement on the Electronics and Information Technology Industries

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Semiconductors *Europe*

Preface

This document is reproduced verbatim by ESIS with the permission of the Commission of the European Communities for the benefit of Dataquest clients.

The original document was published as a Communication from the Commission SEC(91) 565 on April 3, 1991, "The European Electronics and Information Technology Industry: State of Play, Issues at Stake and Proposals for Action." As this document is reproduced *verbatim,* no responsibility is accepted for the accuracy of completeness of its contents.

Published by Dataquest Europe Limited

November 1991

0009962

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Executive Summary

A. Introduction

The purpose of this communication is to apply the concept of industrial policy as defined by the Commission in its communication of November 1990 "industrial policy in an open and competitive environment" to the *Community information technology (IT) and electronics industry*[1].

This open, horizontal and offensive approach has a natural application in the Community's IT and electronics industries, which are facing severe structural adjustment problems at present. In view of the "enabling" nature of these industries and their external effects on the economy as a whole, they are often regarded as strategic. In the run-up to the completion of the internal market and the increasingly global dimension of the economy, a better supported angle of attack could be based on the following questions: do the actual competition conditions allow the European industry to be effective? What policies are appropriate in order to stimulate our competitiveness?

The communication follows a double approach in order to enable the European industry to be more competitive on its own and on the world market:

- To contribute to the examination of the relative industrial and technological conditions of the Community's electronics and IT industries in the world context.
- To set out a consistent package of measures which the Community and the Member States would be prepared to implement, provided that they could be based on clearly defined medium- and long-term objectives set by the industry itself and on specific commitments from their side.

B. The Situation of the European Industry

These industries represent a very important sector with a turnover in Europe of ECU 175 billion and a market growing fast at close to 5% of GDP. Owing to their external effects on the whole productive fabric they also form an infrastructure which plays a major part in economic competitiveness, employment and social development.

The European industry has made significant progress in fields such as computer software and services and industrial automation. It is weak in certain key areas, however: semiconductors, peripherals and consumer electronics. It is in a precarious position as far as computers are concerned. This results in a growing trade deficit (ECU 31 billion in 1990). European firms' positions differ according to their field of activity. Many have just had poor financial results and must restructure.

C. The International Context

Historically, the development of the IT and electronics industries has been influenced by the structure of demand, features of the market and the attitude of the public authorities. Despite the present changes, the European industry is still suffering from the consequences of long-term fragmentation of its markets and its difficulties in setting medium- and long-term objectives.

The worrying situation of European industry can of course be explained by the current economic climate: a slowing down of growth and the depreciation of the yen and the dollar in relation to the ECU. Most causes are structural, however, in a world market where most public authorities hardly think twice about intervening:

- As far as demand is concerned, the Community market has inherited a high degree of fragmentation which restricts the exploitation of economies of scale and "network externalities," and suffers from a shortage of leading-edge users.

[1] These industries supply three main categories of products and services: components, which are the basic elements of any electronic equipment or system; computers, which comprise hardware and peripherals, software, and office- or industrial-automation applications; and finally consumer electronics.

- Supply and competition conditions, in a market which has become worldwide, are unequal in different areas of the world. Equally, financing conditions are less favourable in Europe for these industries which have heavy investment costs in R&TD and production capacity. There is a shortage of skilled staff.
- As regards the structure of the productive fabric, relatively limited vertical integration, all-too-infrequent cooperation within Europe and weaknesses in relations between manufacturers and users are also handicaps.
- Except in precompetitive R&TD, the industrial strategy of European firms has not taken sufficient account of the Community and world markets and has failed to make long-term forecasts. The possibilities of cooperation with Community and international partners have not been sufficiently exploited.

The economic and social importance of the IT and electronics industries has encouraged the public authorities of the major economic zones to pledge support to the industry and provide it with a competitive advantage on a local basis. In the United States, the public authorities have taken part in a heated debate on maintaining American technological supremacy using national security as the main pretext, and have widened their range of economic policy instruments. In Japan, the market is structurally protected by the very organization of the production system, supported by the public authorities. The Community has concentrated on the completion of the internal market, an essential step to make firms look, think and act beyond national frontiers. It is also committed to the strict application of a competition policy and the implementation of a policy on technological cooperation and a coordinated trade policy.

D. A Community Approach

All these measures have been unable to offset the inadequacies of industrial initiative, the failures of the market and the imperfections of competition at world level.

The measures to be taken to restore the competitiveness of the electronics and IT industry depend first and foremost on firms themselves taking the initiative and facing up to their responsibilities, and on their capacity to make the most of the new opportunities presented by the single European market. If firms can make a clear and unequivocal commitment to initiatives of this kind, it is up to the Community and the Member States, in accordance with the rules of competition and applying the principle of subsidiarity, to help create a favourable environment for them.

The Commission is proposing five types of Community action to help firms through the adjustment process which they are facing, without taking artificial measures to support them.

Demand

Computerized telecommunications links between administrations should be set up as quickly as possible and a high level of interoperability of their information systems achieved, while respecting human rights. This initiative would be accompanied by the launch of projects designed to modernize or create, with the help of computerized telecommunications facilities, infrastructures in the fields of distance learning, transport, public health and the environment. Other projects might relate to the gradual introduction of broadband services networks, and the development of pan-European high-definition television services.

Technology

The Community could consider launching a second generation of R&TD, ranging from projects at the precompetitive stage to projects geared more closely to the market. This second generation should be characterized by the concentration of work on a smaller number of better targeted and more ambitious objectives, closer cooperation with users, provision of training linked to advanced research and opening-up to international cooperation.

Mobilizing projects aimed at accelerating technology take-up on a broad scale should be carried out alongside integrating projects aimed at mastering and consolidating a selected range of interdependent technologies. Such projects could cover software, computer integrated manufacturing, microelectronics, peripherals, high-performance computing and telecommunications.

Training

Multidisciplinary training measures could be launched or stepped up. They would be targeted at training staff and at staff engaged in production and management in firms using and supplying computerized telecommunications equipment and services. Networks of excellence composed of both academic and industrial teams, geographically distributed throughout the Community, will continue to be set up.

External Relations

Trade policy will help to improve the competitiveness of the European electronics and IT industry. The Commission will seek a satisfactory conclusion for these industries in the multilateral negotiations of the Uruguay Round. It will endeavour to ensure fair conditions of competition and access to third-country markets. Where necessary, it will have recourse to bilateral measures and will fall back on its customs regulations and trade policy instruments. The Community will support international cooperation by setting up or expanding appropriate frameworks for trade and cooperation, notably with the EFTA countries, Central and Eastern Europe, the United States of America and Japan. Where appropriate, it will take the initiative of launching international cooperation programmes.

The Business Environment

Other initiatives will also help to create a healthy business environment. These concern the improvement of financing systems, faster standardization and integration of standards into products, closer involvement of the development of electronics and IT in the introduction of structural policies, and a stepping-up of the dialogue between the various parties involved, especially SMEs.

The communication summarized here is intended to serve as background for a debate with the Member States, the European Parliament, the Economic and Social Committee as well as the industries, manufacturers and users concerned, in order to analyse the situation as perceived by the Commission and discuss the action to be taken.

This should enable the Commission to enter into fruitful dialogue with industry, users and investors, to assess the situation in greater depth from a dynamic perspective and to identify conditions for a long-term recovery, while respecting the roles of the parties concerned.

State of Play, Issues at Stake and Proposals for Action—General Outline

A. Introduction

1. In November 1990 the Commission adopted a *communication on industrial policy*[2]. While placing the main responsibility for improving industrial competitiveness on firms, the Commission indicated that it was up to the public authorities to provide them with a clear and predictable framework and outlook for their activities.

The industrial policy approach adopted by the Commission and approved by the Council is based on the concept of Community interest, on past experience of industrial adjustment and on the overall industrial challenges which the Community must be prepared to tackle.

It focuses on the importance of the single market to industry and on the application of the competition rules at international level to ensure, on the basis of a balance of rights and obligations, that competitors' markets are as open as the Community market. In its industrial policy paper the Commission also comes out in favour of pursuing positive adjustment policies, including a technological development policy; such policies are regarded by the Commission as complementing the open and competitive environment needed in the context of the single European market.

2. This open, horizontal and offensive approach has a natural application in the *Community's electronics and information technology (IT) industries*, which are facing severe structural adjustment problems at present. In view of the "enabling" nature of these industries and their external effects on the economy as a whole, they are often regarded as strategic. In the run-up to the completion of the internal market and the increasingly global dimension of the economy, a better supported approach could be based on the following questions: do the actual conditions of competition allow European industry to be effective? What policies are appropriate in order to stimulate our competitiveness?

[2] Commission communication on industrial policy in an open and competitive environment (COM(90)556).

3. These industries provide three main categories of products and services: components[3], which are the basis of any electronic equipment or system; computers, consisting of hardware, peripherals, software and office and industrial automation applications[4]; and finally consumer electronics[5]. These are the industries which are the subject of this communication.

Other allied high-growth industries, e.g. the industries which provide audiovisual services, telecommunications equipment and services, and on-line data base services, are not discussed in this communication, but may be covered by separate communications.

4. Taken as a whole, these industries have certain specific features, contributing as they do towards the compilation, creation, communication and application of something which may be regarded as a new resource, namely information.

They are already important in their own right, with a worldwide turnover of ECU 700 billion in 1990 and a Community-wide turnover of ECU 175 billion. Their rapidly expanding market now represents 5% of GDP and will be nearing 10% by the year 2000.

However, they also constitute an infrastructure through the "enabling" nature of the technologies developed by them. The closely interdependent group formed by these rapidly developing new technologies provides the hardware, software and application systems now used in virtually all economic and social activities. As a result, these industries have a major part to play in the competitiveness of industry and the quality of services, in particular public services of general interest.

The impact on employment is considerable. It is estimated that between 60% and 65% of the working population is directly or indirectly affected by these technologies and their applications.

5. This communication has been written at a time when many of these industries are in difficulty, especially in Europe. This state of affairs calls for an analysis without complacency, and in a world context, of the situation in this sector, the causes of the difficulties encountered and the respective roles to be played by and the challenges to be faced by the firms and the public authorities.

The communication follows a double approach in order to enable the European industry to be more competitive on its own and on the world market:

- To contribute to the examination of the relative industrial and technological conditions of the Community's electronics and IT industries. This examination analyses the situation by looking at all the players concerned in Europe and the world as a whole, taking into account the progress towards a single European market which is still influenced by structures and behaviour bound up with the fragmentation of the Community market and subjected to international competition with very contrasting rules.
- To set out, in keeping with the industrial policy paper mentioned at the beginning, a consistent package of measures which the Community and the Member States would be prepared to implement. It must be made clear, however, that this initiative will be pointless and impracticable unless it is based on clearly defined medium- and long-term objectives set by the industry and on specific commitments from their side.

B. The Situation of the European Industry

6. Annex I contains a detailed quantitative analysis of the situation of the industry in Europe and worldwide. The following prominent features emerge from it:

- The electronics and IT industry in Europe and the world as a whole is expanding considerably, particularly on the demand side. Market studies suggest that this expansion will continue at least until the end of the decade, making this industry even more important than it is today.

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[3] **Components:** passive components, active components including memories, microprocessors, microcontrollers, application-specific integrated circuits (ASICs), etc.

[4] **Computers:**

- *hardware*: portables, microcomputers, minicomputers, workstations, mainframes, network equipment, etc.
- *peripherals*: printers, discs, screens, etc.
- *software*: packages and applications, information systems, systems engineering and services, etc.
- *office automation*: photocopiers, facsimile machines, dedicated terminals, etc.
- *industrial automation*: numerically-controlled machine tools, robots, sensors, computer-aided design, manufacturing and management, computer-integrated manufacturing systems, etc.

[5] **Consumer electronics:** TV, video tape recorders, video cameras, video disc players, compact disc players, etc.

- The background to the development of these industries in the world as a whole makes it easier to understand the current difficulties of the European industry. The causes are examined in greater detail in Section II below. As a result of them, despite the strengths and the genuine efforts made to face up to technological changes and new market conditions (establishment of the single market, and globalization) the European industry has weaknesses and shortcomings which give grounds for concern.

A Major and Rapidly Expanding Industry

7. The European electronics and IT industry has achieved great importance in a particularly short space of time. With a growth rate of around 15% per annum in the 1980s, well in excess of the GDP growth rate, it has caught up with other major Community industries such as the chemical industry and the motor industry. Between 1984 and 1989 the turnover for this industry as a whole more than doubled, rising from ECU 55 billion to ECU 130 billion. Allied to the telecommunications industry, which both drives it and is driven by it, the electronics and IT industry now represents nearly 5% of GDP in Europe compared with 5.5% in Japan and 6.2% in the United States.

The trend since 1980 in world production for all the electronics and IT industries, together with telecommunications, by main geographical areas, is as follows[6]:

- American production is pre-eminent in absolute terms but falling over time (37% in 1990 compared with 46% in 1980).
- Japanese production has increased considerably in both absolute and relative terms (24% in 1990 compared with 15% in 1980).
- The European industry's comparatively modest production level has remained fairly stable (24% in 1990 compared with 26% in 1980), although there are major differences between sectors.

Demand in Europe represented a quarter of world demand in 1984 and a third in 1989. With the single European market, the driving role of the European market will increase. The forecast for the year 2000 is for sustained demand growth in the "triad": 11% for active components, 11% for computers and 4% for consumer electronics.

Strengths and Restructuring Efforts

8. The European electronics and IT industry has considerable potential and in recent years has made significant progress in certain areas, in particular in software and computer services and in industrial automation.

There are in the Community some 13,000 computer services and engineering companies whose strengths lie in particular in the integration of customized software and systems. In 1989 Siemens, Bull, and Olivetti ranked for the first time among the top ten computer companies, though admittedly a long way behind IBM, whose turnover is nearly three times their combined turnover. The European advanced manufacturing equipment industry (numerically controlled machine tools, industrial robots, etc.) has regained its position of world leader, pursued by Japan and well ahead of the United States. Alongside the electronics and IT industry, the European telecommunications industry has considerably strengthened its competitive position, with Alcatel and Siemens in first and third places respectively in the world.

Europe's university and research structure possesses a wealth of differentiated cultural and intellectual resources. The situation as regards research and technological development has changed substantially since 1980. The Community programmes (ESPRIT, RACE, BRITE) and EUREKA have helped to mobilize human, financial and technological resources. Their catalytic effects have helped to encourage joint analyses, develop inter-firm cooperation and consolidate the technological base.

The European companies operating in these areas employ over 800,000 highly-skilled workers in the Community and approximately 1.1 million in the world as a whole.

To face up to the current difficulties, the European firms are engaged in restructuring operations: they are stepping up their efforts to reduce costs and increase their productivity, and are striving to speed up their response to rapid changes in demand. These restructuring efforts are costly and entail significant job-shedding. Many of them are refocusing their activities on markets with a promising future (Olivetti in microcomputers and

[6] Source: EIC.

workstations, Philips in consumer electronics, etc.), and adjusting their operating and distribution structures.

Weaknesses

9. Despite this growth, these strengths and this technological potential, there are worrying weaknesses and shortcomings. An analysis of the situation of the Community industry indicates a limited presence in certain key sectors: semiconductors, peripherals, consumer electronics, and a precarious situation in computers. Apart from the consequences for the balance of trade, this situation obliges European companies to obtain supplies of certain vital components from their competitors, which impedes their decision-making ability.

In semiconductors, Japan has a 49.5% share of production compared with 36.5% for the United States and 10% for Europe.

Computer peripherals (discs, printers, screens, etc.) are manufactured to a large extent in Japan (40% of world production) and to a lesser extent in the United States (25%). Production in Europe accounts for only about 15%.

In consumer electronics, Japan accounts for 55% of world production and has control over 99% of its domestic production, 27% of production in Europe and 20% of production in the United States. The Community industry accounts for nearly 20% of world production.

In computers, production in Europe only covers two-thirds of internal demand, and 60% is accounted for by firms of American origin (IBM, Digital, Hewlett-Packard)[7]. After staging a significant recovery between 1984 and 1987, the Commission industry has again lost ground in Europe.

Overall, therefore, the increased demand for electronics and IT products and services in Europe is being met only to a limited extent from European sources. Production in Europe covers about 75% of consumption in the electronics and IT sector, as compared with 140% in Japan. This imbalance has generated a trade deficit in Europe which has worsened since the start of the 1980s. For electronics as a whole, it was ECU 31 billion in Europe compared with a surplus of ECU 57 billion in Japan and a deficit of ECU 7 billion in the United States. Europe's deficit is mainly attributable to trade in components (deficit of ECU -5.6 billion), computers (deficit of ECU -15.3 billion) and consumer electronics (deficit of ECU -9.6 billion) in 1989. This balance-of-trade position indicates that the Community industry is not competitive enough in these sectors. The growing internationalization of the economy means that European firms must be able to invest increasingly abroad. These investments and cooperation arrangements should allow a further improvement in firms' competitiveness.

10. *An analysis of the situation of European firms* on the European and world markets indicates different positions depending on the areas of activity and, as a whole, major differences of scale in comparison with American and Japanese firms.

The world semiconductor market is dominated by Japanese firms (NEC, Toshiba, Hitachi, Fujitsu, Mitsubishi) which account for nearly 90% of world production of high-capacity memories, and by the American microprocessor manufacturers (Intel, Motorola) which control over 80% of world production of 16 and 32 bit microprocessors (the most popular at present).

Investing 15% of their turnover in R&TD and 13% on average in manufacturing equipment, the European firms (Philips, SGS-Thomson, Siemens—tenth, twelfth and fourteenth in the world rankings respectively) have still not achieved the critical threshold of 5% of the world market. The turnover of the second manufacturer of semiconductors in the world (Toshiba) is higher than the combined turnover of these three manufacturers.

In computers, American firms are in the lead with five of the top ten companies, the biggest of which, IBM, dominates the world market as a whole. The Japanese firm Fujitsu has moved into second place following its acquisition of ICL. The share of the European market held by IBM is greater than that of Siemens/Nixdorf, Bull, Olivetti and Philips together. The latter have increased in size as a result of outward expansion and by acquiring other firms: Bull has acquired 85% of Honeywell Electronics and 51% of the IT division of Zenith (United States). Siemens recently bought Nixdorf. The significance of the investments made is considerable: on average 10% of turnover is spent on R&TD, 10% on investments in capacity,

[7] It should be noted that American and Japanese companies create less value added per employee in Europe than in their domestic markets.

and 10% of the wage bill is made up of training costs. However, the Community industry consists of virtually the same (medium-size) firms as 10 years ago. Many of them recently had poor financial results (high losses for Bull, Nixdorf, Philips), as did the main American manufacturers in fact (Digital, Unisys, Hewlett-Packard, Wang). Unlike the computer manufacturers, the software and IT services companies (CAP-Gemini Sogeti, SEMA Group, Logica, etc.) are in a strong, though vulnerable, position.

In industrial automation, Europe has major trump cards with Siemens, Comau-Fiat, Renault, GEC, etc. and a wealth of efficient SMEs, especially in Germany and Italy.

In consumer electronics, apart from Philips and Thomson, which respectively occupy the third and sixth places worldwide, Japanese companies, with Matsushita and Sony in the lead, dominate the industry. The only other non-Japanese firms in the top dozen are Korean, Samsung and Goldstar at ninth and tenth. Philips and Thomson hold very strong positions in the United States through their subsidiaries Philips North American and RCA and are at the forefront of HDTV research there. US industry is barely represented in this sector; Zenith, the best placed American firm, ranks only sixteenth.

Despite the high rankings held by European companies, their strengths reside generally in the more mature technologies, and their shares in the newer products are declining (e.g. camcorders).

C. The International Context

I. Developments in Europe and the World

11. Historically, the development of the IT and electronics industries has been influenced by the structure of demand, features of the market and the attitude of the public authorities. Three main categories of users have shaped these features.

The *public authorities*. Public procurement, although it currently represents only 15% of the market for these industries, has long made its mark on them. It involved heavy and expensive equipment (miniaturized equipment, distributed computer systems and the liberalization of telecommunications being relatively recent phenomena). Orders placed by national public bodies, such as for mainframe computers or telephone exchanges, have created captive, protected markets throughout the world. Public procurement has thus helped national champions to emerge and proprietary standards, often incompatible, to develop. These features are blurring; public procurement is becoming more commonplace with the emergence of distributed products and systems. In Europe, with the completion of the internal market, public procurement is gradually being opened up to competition. However, European IT and electronics firms have inherited a dependence on national buyers, proprietary standards and telecommunications infrastructures which are not properly interconnected at European level. The European market is still fragmented, which limits economies of scale and reduces size and networking effects.

Firms. The products and services of the IT and electronics industry have become an essential element of productivity, flexibility and competitiveness for almost all of the productive fabric. They provide innovative elements such as electronic components for the motor industry and have now become indispensable production and design tools: computer-aided manufacturing and engineering, computerized telecommunications networks, workstations, applications software, etc.

Firms face a twofold challenge: gaining access to the most innovative IT and electronics products, with optimum price, delivery and after-sales service terms, and also organizing themselves to exploit their potential to the maximum. Trade relations between manufacturing and user firms, the existence of a large market for standardized hardware and applications, and the presence of leading-edge users, are now essential preconditions for growth in the IT and electronics industries. These conditions differ from those prevailing in the United States and especially in Japan.

Individual consumers. Their market is mainly consumer electronics and associated services, but also, increasingly, products originally designed for business use (minicomputers, etc.). It is a mass consumer market which makes severe demands on manufacturers in terms of cost and quality. This market is highly competitive, is subject to a high rate of innovation and involves taking major risks in the introduction of de facto standards. To remain competitive, firms must sustain a constant R&TD and innovation effort, and have substantial financial, production and commercial resources.

12. History also influences the conditions for the growth of these industries throughout the world.

In the United States, the power of the IT and electronics industry was built up in the '60s. Stimulated at first by the major military and space programmes, large groups consolidated their positions. The vitality and receptiveness of the American market, businesses' entrepreneurial spirit and the workings of competition allowed many medium-size firms (start-ups) to gain a foothold on the market and a rich and lively fabric of small and large firms to develop. Focusing originally on mainframe computer systems, in the '70s the American industry concentrated on minicomputers, in the '80s on personal computers and today on open and distributed systems. At the same time the software industry grew up, nourished by successive generations of hardware (the "proximity effect").

The American computer and components industry is still powerful, even though it has been experiencing difficulties since 1980 in the face of Japanese competition. On the other hand, the American consumer electronics industry has almost disappeared: the American market, which is open and competitive, is now dominated by Japanese and European firms.

In Japan, the industry has grown and gained strength along a number of different paths. Japanese growth is not solely the result of market forces, but rather of long-term strategic planning in which the public authorities play a central part. The objective was to rebuild the Japanese economy and commercial and technological interdependence with a view to achieving a very strong presence on the world market. The method used has been to consolidate and exploit an economic and political system which ensures close cooperation between the public authorities and industry, accompanied by selective public financing. It has given rise to structural protection of the domestic market and strong horizontal and vertical integration of the industrial groups, banks and distribution.

This complex "controlled market" system has created favourable conditions for the growth of new industries including IT and electronics. The industry's development strategy has relied primarily on consumer electronics. Success in this area has led to a chain reaction: technological skills and breakthroughs, success with complex production processes, quality control, rapid innovation. These advantages then ensured Japanese success in the production of memories and later, peripherals. Japanese industry seems to be implementing a strategy to gain control of the world electronics market by gradual stages: after consumer electronics, components, now computers and maybe, by the end of the century, telecommunications.

Japan has inherited from the past a technologically, industrially and financially strong industrial structure, a structurally protected national base and a strong capacity to innovate. To make up for its relative weakness in research, it launches well targeted international cooperation initiatives.

For a long time *in Europe*, in the absence of a true Community market, the development of the IT and electronics industries and the industrial and technology policies adopted by the Member States were conceived on a national basis. The confines of the national markets, the difficulty in penetrating other Community markets and a certain reluctance to tackle other markets have weakened the Community IT and electronics industry as a whole. Not only were national champions able to achieve only limited economies of scale and networking effects, but also synergies between Community manufacturers and users from different Member States failed to materialize. At the present time, no Community IT and electronics manufacturer, not even among the largest, has a European image, especially in the eyes of the major user industries. For certain countries, the defence sector has been able to create captive markets and limit the stimulating role of competition on industry's ability to innovate. In consumer electronics, the segmentation of the Community market has paradoxically been able to protect European manufacturers from the Japanese, who have concentrated on the American market which is homogeneous and open.

The European market and its industry are now undergoing radical changes. Much work has been done at both national and European level: industrial R&TD work and many restructuring initiatives have been stepped up, major national technological programmes have been launched, Community intervention has increased through the various Community programmes, EUREKA has been a mobilizing force, and markets have been opened up through the internal market. Despite these efforts, Europe is still suffering from the consequences of long-term fragmentation of its markets and its firms' difficulties in setting medium- and long-term objectives. European industry must adapt its structure to the Community and world dimension, but this cannot but be a long and costly process.

13. In addition to these difficulties rooted in the past, European industry faces the phenomenon of *globalization*. Increasingly exploited by the more powerful firms, principally American and Japanese, it allows them to make up for certain gaps in their basic expertise, meet constantly rising R&TD costs and the shortening of product life, and to benefit from the high rate of technological innovation. Globalization also allows them to take advantage of differing competition conditions on the world market. For European firms facing fiercer competition on their own domestic markets, it is becoming essential for them to weave complex webs of cooperation arrangements, in particular by creating technological and commercial cooperation networks at both Community and national level. For the Community public authorities, it is becoming important to ensure, in this context of globalization and on the basis of balanced rights and obligations, that the its competitors' markets are as open as its own.

II. The Causes of the Present Situation in this Context

14. Certain causes are of a *cyclical* nature. To begin with, the adverse effects of the economic cycle characterized by a slowing down of growth are being aggravated by the fall of the dollar and the yen in relation to the ECU. With the *depreciation of the yen and the dollar*, competitive pressure from Japanese and American goods on the European market has grown sharply.

15. Most are *structural*, however, and have been highlighted by the poor general economic climate of the '90s. They are manifold and interrelated. In order to analyse them, we will use the latest theoretical models[8] developed for the study of the competitive advantages of nations and apply them to the European IT and electronics industries. The analysis is based on four elements: demand conditions, factor conditions, related and supporting industries, and firm strategy, structure and rivalry.

In addition to these factors, unequal competition conditions are accentuated by the public authorities.

16. **Demand**. *The Community market has inherited a high degree of fragmentation* in relation to the other large markets in America and Japan. This has particularly serious consequences for the European IT and electronics industry:

The limited scope of its markets, often still confined to the national level has restricted the exploitation of economies of scale. European firms are therefore faced with higher unit production costs than their competitors. This is even more of a handicap since its effects are dynamic and cumulative.

For the same reasons, European firms have not been able to exploit "network externality" effects. These effects appear when a user's choice is influenced by the size of the firms concerned or the total number of users of the products he wishes to buy. These networks attract users and they become captive for reasons unrelated to price, but linked to the difficulty of converting existing hardware, a wide range of compatible products or services, and the life of the networks. The segmentation of the Community market has restricted the size of networks and the number of users for European firms.

The former development of proprietary standards and systems, long used to create captive national demand, becomes a handicap at a time when European firms, which have never commanded sufficiently large markets to impose their standards, are obliged to change to open standards and systems. This essential change is called for by users but it does have the effect of eroding European computer hardware manufacturers' profit margins since the markets for open systems are more competitive. It also increases their costs, since the old and new generations of equipment have to be maintained simultaneously during the transitional phase from one to the other, while maintaining compatibility with dominant proprietary systems.

17. *The lack of leading-edge users*[9] in Europe, in contrast to the United States and Japan, prevents

[8] See in particular M.E. Porter: "The Competitive Advantage of Nations," *Harvard Business Review*, March-April 1990, and *The Free Press*, New York, 1990.

[9] European demand is estimated to be two to three years behind the American and Japanese markets and is reluctant to buy until new innovative products spread onto external markets.

the European IT and electronics industry from exploiting all the advantages of being first to market in new fields. However, for the development of the IT and electronics industries, the existence of a dynamic and demanding market plays a decisive role. The quality of demand is as important as quantity. The advantages of leading-edge demand are not only technological, but also commercial and financial. Indeed, it is during the period when a product is introduced that prices are high and profit margins sufficient to release the resources needed to finance R&TD and prepare subsequent generations of products.

18. **Supply**. *Competition conditions are unequal* between different areas. On a market which, in the case of IT and electronics, is worldwide, and where certain firms must employ a global strategy to survive, these differences become economically decisive and pose a political problem. While the degree of competition and openness to direct foreign investments is increasing in Europe with the completion of the internal market, certain foreign markets are still practically closed to the penetration of Community investments and products. While European firms must step up their efforts, and invest and develop partnerships in third countries, there are many reasons why they may come up against barriers to such initiatives. At a time when competition rules are becoming stricter in the Community, in other competing areas measures relating to concentrations and aid allowed are becoming more flexible or are sometimes remaining less strict. This state of affairs facilitates or on the contrary makes very difficult, depending on the internal markets of firms, their simultaneous presence or the distribution of their products throughout the world. The same applies to the concentration and vertical integration facilities offered to them.

19. Similarly, in view of the considerable volume of investments in R&TD and production capacity, *financing conditions* militate against the IT and electronics industries in Europe. In contrast to the United States, the financial system is reluctant to invest in start-ups. In contrast to Japan, the cost of financing R&TD and capacity investment is high in Europe and access to financial resources is difficult in the case of long-term or high-risk operations[10]. This allows Japanese firms to devise a long-term development strategy and invest at lower cost.

20. *Availability of skilled staff.* Rapid technological advances have made the European IT and electronics industry heavily dependent on highly skilled staff with state-of-the-art knowledge. However, in the labour market there are not enough engineers and researchers with recent training in the production, adaptation or use of these technologies. For the same basic population, Japan trains 80,000 engineers a year as compared with 41,000 for Germany and France together. Due to a lack of qualified staff (systems engineers, staff trained in computer-aided management), user industries and small businesses in particular are unable to make the most of competitive openings arising in the IT field. This means that demand on the European market is less advanced and less receptive to innovations than in the United States or Japan.

21. **Structure of the European Productive Fabric**. The relations between the IT and electronics industry and the surrounding industrial and scientific fabric are crucial. They can take many forms: access to basic knowledge depends on relations with scientific circles; knowledge of market needs, and users' ability to develop leading-edge markets depend on relations between manufacturers and users. Relations within and between industries allow the exploitation of complementary features and technological and commercial interdependences within the IT and electronics product family, and between small and large businesses. All these relations result from the compactness, solidity and dynamism of the productive fabric around industrial and scientific poles of competitiveness.

In Europe, *vertical integration* of IT and electronics firms is relatively limited in comparison with American and especially Japanese firms. It failed in the past because European computer manufacturers tried to generate upstream business by making components, but only for their own needs. Since the markets within firms were insufficient, they were not able to reach critical production volume thresholds. On the other hand,

[10] The financial costs for R&TD in Japan are substantially less than in Europe. A recent study published by the Federal Reserve Bank of New York shows that, in the medium term, costs may vary by up to 10 percentage points. Long-term investments made by Japan simultaneously on all fronts are colossal and their origin cannot in any way be explained by profit margins on the domestic or external markets. Furthermore, in Japan the major groups are concentrated around a bank which participates directly in strategic development decisions and their financing. Access to financial resources is therefore secure and not dependent on the firms' short-term profits.

this strategy has led to beneficial results for certain American groups, notably IBM, which were large enough to guarantee sufficient outlets within the enterprise. In Japan, vertical integration has succeeded since component production by consumer electronics or IT firms was oriented towards the export market, regardless of the cost. Groups such as Toshiba, Hitachi, NEC and Fujitsu belong to the top ten companies in the world in two and sometimes three segments of the components–IT–consumer electronics chain simultaneously. Inadequate integration in European firms, in relation to their American and Japanese competitors, is a handicap, particularly as far as components are concerned.

Although there is plenty of cooperation on precompetitive research in Europe, *cooperation arrangements on the development* of new products are all too few and far between. For certain products such as memories, liquid-crystal displays (or HDTV), they are or will become indispensable, in view of the human, technological and financial resources which can only be mobilized on a European scale.

Finally, the structure of the European productive fabric also has gaps in it as far as *relations between manufacturers and users* are concerned, which is a hindrance notably for start-ups and in complementary arrangements between large and small companies. Such relations exist in software and applications—where European competitiveness is high—but are generally insufficiently developed.

22. **European Business Strategy**. With the exception of precompetitive R&D, the *industrial strategy of Community firms has failed to take sufficient account of the Community dimension and long-term prospects*. Opportunities for cooperation with Community and international partners have not been fully exploited. As regards innovation and production, European firms have failed to take full advantage of the opportunities for cooperation created by the major Community technology programmes and have not put long-term global strategies in place early enough. In this context, we should consider whether R&TD policy has not been too limited to the precompetitive area. It has, however, been Commission policy up to now to leave near market research to the companies themselves so as to maintain the incentive for them to compete through innovation.

European firms must simultaneously sustain their R&TD efforts and capacity investments, manage their change towards both the Community and world markets and assimilate the many internal and external restructuring operations which they must carry out, while losing no time in finding a place on the most promising and innovative market segments which many have yet to enter (peripherals, microcomputers and portables). This requires considerable financial resources which they can raise neither internally, as competition is fierce, nor externally, as the financial system in most Member States is not properly geared to financing long-term or high-risk operations.

The European IT and electronics industry's R&TD investment capacity needs are considerable. In the recent past European firms have made great efforts: on average they spend as much as their American or Japanese competitors *in relation to their turnover* (some 9.5% and 8.0% of sales are spent on R&TD and capacity investment respectively). The financial resources to be mobilized for the seven largest European firms amounted to around ECU 14 billion in 1989. Despite these efforts and taking account of their relatively small size, these resources are still lower than the investment expenditure of the six largest Japanese firms (ECU 22 billion) and seven largest American firms (ECU 20 billion).

23. European firms have a high-quality technological base, but *fail to bring enough innovative products onto the market quickly enough*. There is a shortage of new firms in Europe, especially small ones, to exploit the new market openings which are constantly arising through rapid technological development. There are three reasons behind this: the first is the hesitant market. The second concerns finance: firms have insufficient financial resources and banks are reluctant to take risks. The third results in particular from the shortage of skilled staff in systems management.

24. **Inequality of Competition Conditions Is Accentuated by Public Authority Involvement**. The structural characteristics of the IT and electronics market described above (substantial economies of scale and learning, high entry and exit costs) lead the most powerful firms to acquire dominant positions, build barriers to entry, form cartels or closely control the use of certain technologies, subcontracting networks and distribution systems. In addition to these imperfections of the market, various failures of the

competition mechanisms appear: external effects between activities or geographical areas, public facilities, especially R&TD where private production is insufficient and information incomplete or unbalanced. These failures call for information, coordination and stimulation functions which the pricing system alone, however "perfect" it may be, cannot provide.

These imperfections and failures of the market mechanisms, and also the economic and social importance of the IT and electronics industries have encouraged the public authorities of the major economic zones to pledge support to the industry and provide it with a competitive advantage on a local basis.

25. *In the United States* the public authorities have taken part in an intense debate on maintaining American technological supremacy using national security as the main pretext, and have widened their range of economic policy instruments. The involvement of the public authorities has taken on various forms.

Massive orders for high-tech equipment are being placed by various departments and agencies (in particular the Department of Defense), and expensive R&D programmes, backed up by the creation of university networks, are under way. The implementation of competition laws has been watered down. Special procedures apply in certain sectors with regard to foreign firms carrying out their activities in the United States. The implementation of the "Buy American Act" enables preferential treatment to be given to American firms.

Discrimination against American firms of foreign origin as regards R&TD is being practised by the Department of Defense, and Sematech is one example here. As negotiations stand at present, the GATT rules are applied in a selective fashion.

Bilateral pressures (Super 301) to obtain reciprocity, based on the 1988 Omnibus Trade and Competitiveness Act, aim to allow American firms to penetrate third countries' markets, under threat of unilateral retaliatory measures (the Community has been designated a "priority country" for telecommunications); at the same time, the United States is calling for "national treatment" from its trading partners which would like to see reciprocal opening-up of the markets.

26. *In Japan*, the policy of the public authorities is based on various instruments with mutually reinforcing effects: backing for business cooperation in terms of strategic planning and of scientific and technical cooperation; virtual closure of public procurement to foreign companies while ensuring a high degree of internal competition; support for the setting up of major diversified vertically and horizontally integrated groups, capable of sustaining for several years the losses incurred by the market launch of new products usually manufactured on the basis of technologies originally acquired externally. Japanese industry is geared to long-term strategies. The "Keiretsu" also provides a high level of cooperation and solidarity between Japanese firms.

The Japanese market is protected structurally by the way the productive system is organized, with support from the public authorities. The big Japanese conglomerates generally have a dual banking and commercial focus. The banking side takes care of the financing, according to the group's strategy, of long-term or high-risk operations such as research and the production of innovatory products. The sales and distribution side (notably in consumer electronics) deals with the promotion of products, market research and control via the captive markets created between the companies in the group.

Comparative studies show that the prices charged for certain equipment in Japan are far higher than in other parts of the world.

27. The *other Southeast Asian countries* have also greatly consolidated their foothold in the IT and electronics industries, in particular via long-term technological development programmes (such as the ten-year "Submicron Process Technology Development" programme in Taiwan) and an intensive investment strategy.

28. The *Member States* have all developed their own R&TD policies accompanied by different instruments and have launched numerous national and international initiatives (such as the European Space Agency, the EUREKA initiative and aeronautical and military cooperation projects).

The *Community*, so far with very limited powers in the field of defence, has concentrated on the completion of the internal market, an essential step to make firms look, think and act beyond national frontiers. It is also committed to the strict application of the law concerning the competition conditions set out in the Treaty, the liberalization of telecommunications in the same spirit, and in particular the implementation of a major technological cooperation policy, more for the stimulus it provides than for the scale of financing involved.

Committed to a policy of opening up to competition, it has actively promoted a standardization policy in favour of open systems geared towards hardware compatibility. It has decided to promote the development of trans-European networks which, through their structural effects, will ensure that full economic and social advantage is taken of the completion of the internal market. These trans-European networks relate in particular to computerized communications service vocational training networks.

As far as trade is concerned it has endeavoured, so far with limited success, to obtain from its main trading partners an open, multilateral international trade system, ensuring, on the basis of the principle of balanced rights and obligations, that its competitors' markets are as open as its own.

It has also been concerned to continue the integration of the European markets by new agreements with the EFTA and east European countries.

These are all positive measures. They have not yet managed, however, to offset the failures of the market and imperfections in competition which characterize the IT and electronics market.

D. A Community Approach

I. A Reference Framework

29. *Measures to be taken to restore the competitiveness of the electronics and IT industry depend on firms themselves taking the initiative and facing up to their responsibilities, and on their capacity to make the most of the new opportunities presented by the single European market.*

Despite their present difficulties, firms must follow a long-term strategy which allows them to maintain and step up action to increase productivity, modify their operating and distribution structures, anticipate technological developments and client needs, pool their efforts and become more complementary in certain fields, and form alliances on a European and world scale, while observing Community competition rules.

If firms can make a clear and unequivocal commitment to activities of this kind, supported by the new market conditions and in accordance with the rules of competition, it is up to the Community or the Member States, applying the principle of subsidiarity, to help create a favourable environment for them, taking into account in particular the importance of IT and electronics for the whole of society.

30. In order to back up firms' initiatives, the Community must identify the European interest before making proposals for measures to be taken in this field. One objective is to allow firms to have *access to the markets* for products, investment and technologies. The completion of the internal market is an essential contribution to this but firms will need time to take advantage of all the opportunities it offers. This may not be enough, however. In a context of the move towards global markets and substantial economies of scale, production geared to the world market has become essential. IT and electronics firms are increasingly inclined to manufacture their products on the spot, so as to take advantage of the proximity of the market and the special relations with clients which result. Access to the markets must include the *possibility for direct investment and exports* in all parts of the world.

31. As a precondition for the expansion of European industry, it must also have *access to technology*. Indeed competitiveness cannot be achieved without it and without the latest products incorporating technology, given the expansion in trade, the growing interdependence of economies and the increasingly hot pace of the marketing of new products. This applies primarily to components; firms need satisfactory access to components so as to be able to continue to place innovatory products on the market.

A second important condition, indissociable from access to markets and technologies, involves *mastery of technologies* in Europe. This may be unrelated to a firm's origins but is closely linked with the type of R&TD work it carries out in Europe and the way in which it disseminates its technologies outside. This means that the risk of a break in external sources of supply, especially in microelectronics, is reduced by the Community's capacity to develop products to deal with that eventuality, should it prove necessary. It also means the capacity to develop these technologies in harmony with European societal development.

A third factor relates to European firms whose basic markets are largely in Europe, with the positive effects on strategic decision-making, mastery of the technology and innovation in Europe which this entails. Firms with the bulk of their activities taking place in Europe do not enjoy the same advantages as their competitors on their national markets, and face imperfections in the system of competition or failures of market mechanisms at international level.

It is against this background that the Commission is proposing Community action to help firms through the adjustment process which they are facing, and help them meet customer needs, without taking artificial measures to support them.

II. Proposals for Action

There are five proposals altogether, relating to demand, technology, training, external relations and the business environment.

32. **Demand**. The creation of *trans-European networks*, as advocated by the Commission, incorporating harmonized telecommunications services, will considerably stimulate the demand for IT and electronic equipment[11].

33. *Computerized telecommunications links between administrations* must be set up as quickly as possible and a high level of interoperability of information systems achieved, while respecting human rights, in order to speed up integration of the European market. Preparatory R&TD activities are planned under the third framework programme (1990-94)[12].

34. This action must be accompanied by the launch of projects designed to modernize or create, with the help of computerized telecommunications, infrastructures in the fields of distance learning, transport, public health and the environment. Another project might relate to the gradual introduction of broadband services networks into the Community, in particular by the implementation of an international pilot project for a broadband network between research centres. Projects relating to a pan-European high-definition television service could also be studied and business applications found.

These infrastructures for meeting user requirements will necessitate substantial investments in the Member States over the next ten years. These investments will be all the more profitable and effective if they can draw on full-scale Community-wide trials.

The Community's role will be limited to providing the necessary impetus and coherence, helping to define overall projects, coordination—especially for the exchange of results—and taking the general measures for which it is responsible, for instance harmonization of architecture and protocols. The investment necessary to implement projects drawn up and prepared in this way will have to be largely financed by the parties concerned, although this does not necessarily rule out Community support, notably through the use of the appropriate financial engineering mechanisms.

35. Intensified joint efforts will be needed to *disseminate and exploit* the results of R&TD work on IT and electronics conducted at Community or national level or in a multinational framework such as EUREKA.

The national bodies responsible for conducting these tasks will have to work together with the Commission's departments on computerized telecommunications networks and cooperation projects targeted primarily at SMEs.

36. *Increased user involvement* in the Community's technological development programmes will be sought, both in their initial phases and if they are extended, in particular in the context of EUREKA.

37. **Technology**. In order to keep pace with the extremely rapid rate of technological development in electronics and IT, satisfy the growth in demand and maintain an active role on a market which is becoming global in scale, the Community could consider launching *a second generation of R&TD*, ranging from projects at the precompetitive stage to projects geared more closely to the market.

[11] "Towards trans-European networks—for a Community action programme" (COM(90)585 final).

[12] Proposal for a specific programme on the development of telematics systems in areas of general interest.

This second generation, which is already emerging through the pilot projects being conducted under the third Community R&TD framework programme (1990-94) adopted by the Council on 23 April 1990, will be characterized in particular by the concentration of work on a smaller number of better targeted projects, closer cooperation with users, provision of training linked to advanced research and opening-up to international cooperation.

38. The guiding principles of the technology projects would rest on the following considerations:

- It would make eminent sense to build further on points of strength in as far as they continue to offer, like software and CIM, potential for growth.
- The frontier between computer software and hardware, predicated by the need to optimize the cost/benefit ratio, keeps moving towards ever more powerful systems, thanks to progress in microelectronics technologies, which allow more and more functions to be integrated onto one chip.

  In a sense, it can be said that today's systems will be tomorrow's chips. It is therefore essential to master the technologies on which these components are based in order to secure the continued growth of the software and systems industries.
- Most technologies are on the brink of radical change or a new generation, which offer opportunities for bridging existing gaps and taking the lead again. This is the case in priority areas, like microelectronics, peripherals and high-performance computing.

  Projects implemented towards this end would need to be of different nature depending on the objective pursued. *Mobilizing projects* aimed at accelerating technology take-up on a broad scale would thus need to be carried out alongside *integrating projects* aimed at mastering and consolidating a selected range of interdependent technologies.

These major projects, that would involve participation from all over the Community, would represent the core of R&TD effort and would have to be funded from the Community budget and as appropriate by national, regional or local sources, in particular within the context of EUREKA.

Among the main objectives to be pursued, one could mention the following.

For *software*, to increase productivity by concentrating on production methods and tools and their early transfer to users in the framework of mobilizing project(s), involving notably SMEs. Emphasis will be on software reusability well as on precompetitive work on both systems and applications interfaces.

The creation of a Trans-European Software Institute at the initiative of Community industry could receive Community support. Provision is made in the third framework programme for a pilot experiment (European Systems and Software Initiative).

For *computer-integrated manufacturing (CIM) and engineering*, to strengthen European manufacturing capabilities by the timely provision of the most powerful technologies of the IT and electronics industries. These will help to shorten design-to-product time, implement just-in-time strategies, and make for more flexible production, especially small, diversified runs under severe time constraints. These technologies are also essential for achieving decisive quality improvements.

For *microelectronics*, to develop integrated-circuit design and manufacturing technologies for both standard components (memories and logic circuits) and custom integrated circuits (ASICs), R&TD work building on and carrying further the collaboration established under JESSI. To supplement the above, efforts would need to be undertaken to provide *microprocessor* capabilities with particular emphasis on the definition of a family of new-generation architectures, securing compatibility and the transition from current-generation machines.

For *peripherals*, to establish capabilities for developing input/output devices and subsystems. Special attention should be given to high-resolution flat-panel display technology currently based on liquid crystals (LCD). A specific industrial commitment should be obtained on this. It is also essential for the development of consumer electronics.

For *high-performance computing (HPC)*, to take advantage of the possibilities offered by progress in the field of parallel processing, through which computing power is expected to be increased by a factor of 1,000 by the end of the century. This will revolutionize the field and open horizons to applications for new users. This represents a major challenge in software. Once the complex software problems have been overcome, there should be rapid exploitation in many fields, such as simulation, forecasting and optimization in manufacturing industry, environment and meteorology. A project lasting ten years will probably be needed to master this new approach and all its implications. A preparatory phase is planned under the new programme on IT within the third Framework Programme.

For *telecommunications*, to respond to the growing demand for improved user friendliness, better economic return, faster response times and increasing freedom of choice and flexibility in integration of services. This should be achieved by the development "intelligent" networks, integration of flexible services, and the extension of multitasking capabilities to create or improve telecommunications networks while safeguarding data integrity and security. The objective would be to achieve response times and performance comparable to what is obtained today in companies' local area networks. Integrated broadband network technology provides both the capacity and the generic intelligence to respond to these user needs. Satisfying user demands requires a sustained effort of mobilizing and integrating technology and advancing international standardization at a rapid pace. Second-generation efforts should concentrate on the systematic development and validation of modular standardization of common parts of services enabling open service implementations to evolve with demand.

Training. 39. The Community urgently needs to train research scientists and engineers capable of developing and making maximum use of the new information technologies, where new generations are constantly emerging.

Multidisciplinary training measures could be launched or stepped up. They would be targeted at training staff and at staff engaged in production and management in firms using and supplying computerized telecommunications products and services. Training activities should also be developed to promote new forms of business management, integrating computer applications and advanced telecommunications in new management and production systems.

The Commission, in its communications to the Council on trans-European networks, has already proposed specific measures on vocational training[13]. The R&TD framework programme for 1990-94 also includes an entire specific programme devoted to developing human capital and promoting the mobility of research scientists. The Commission has also been involved for a number of years, notably since 1986, in the development of highly specialized programmes and initiatives on initial and continuing training in new technologies such as DELTA, COMETT, FORCE and EUROFORM.

Networks of excellence composed of both academic and industrial research teams, geographically distributed throughout the Community, will continue to be set up in order to provide a critical mass of complementary knowledge and expertise, and help to share limited and expensive resources.

40. **External relations**. The Community can help to sustain a competitive Community electronics and IT industry by adopting a trade policy based on the following six objectives:

- Maintenance of an open, multilateral international trade system
- The improvement of access to the markets of the main trading partners in electronics and IT (notably the United States, Japan and South Korea)
- Establishment of fair competition in international markets
- Support for scientific, technological, industrial and commercial cooperation in the international arena
- Continuing integration of European markets by means of new agreements with EFTA and Eastern European countries
- Economic restructuring aid for the Eastern European countries

41. The electronics and IT industries are directly concerned by the Uruguay Round of multilateral negotiations, and a satisfactory conclusion could

[13] "Towards trans-European networks: Objectives and possible applications" (COM(89)643 of 18 December 1989) and "Towards trans-European networks—a Community action programme" (COM(90) 585 of 5 December 1990).

make an important contribution to the achievement of the first two objectives.

The Uruguay Round "market access" negotiations are especially important for semiconductors and consumer electronics. Inconsistencies in the present tariff structure for semiconductors are liable to place the Community's processing industries at a competitive disadvantage. Within the constraints of the current global negotiations, the Commission will attempt to iron out these inconsistencies, while taking into account the respective interests of Community producers and users.

On consumer electronics, the Community has offered less substantial tariff reductions to its trading partners on certain products. In addition, the Commission will insist on the need to remove the numerous non-tariff barriers which hinder imports of consumer electronic goods to some of our partners (in particular Japan).

The Community is paying close attention to the possibility of the renewal of the bilateral agreement on semiconductors between the United States and Japan which has important direct implications for all the Community's electronics and IT industry. The Commission will not hesitate to take action—as it did when the original agreement was concluded, by calling for a GATT Panel—if the new agreement contains provisions which may be against the interests of the Community electronics and IT industries.

Moreover, in view of the damaging instability of supply prices on the world components market, the Commission believes that the OECD should be asked to set up a new consultative forum on semiconductors.

42. The Commission will seek to *ensure equitable conditions of competition and market access* for both products and technologies at world level. As international competition intensifies and as markets become global, the fact that all companies competing in the world market are not operating under the same conditions of competition may cause particular problems for specific markets and products such as those in electronics. For example, very large companies may use their extensive range of activities in the electronics sector to cross-subsidize certain products and activities and seek to gain market shares by undercutting their competitors.

Similarly, in this sector, a high degree of vertical integration and the acquisition or existence of dominant positions could give rise to abuses in particular market segments, such as discriminatory practices, predatory pricing or refusal to supply. In the Community, if such practices were proved, they would be subject to the prohibition of Articles 85 and 86. The Community must insist that its competitors and the public refrain from such practices and that the public authorities put in place an efficient system to prevent such abuses. The response to external competitive pressures must be to secure a situation in which Europe's competitors refrain from unfair practices in their own or third country markets, not to modify the application of the rules in the Community. Competition policy strengthens European companies and is not a luxury to be discarded when there is competition from outside. New Community measures to control concentrations have an important part to play.

The Commission will investigate the existence of such practices among the Community's main competitors. If abuses and unfair practices can be shown to exist, pressure will be brought to bear on the relevant authorities. Identification of specific obstacles to fair competition followed by pressure on the public authorities has brought positive results in other sectors. For example, as a result of Community pressure, access has been granted to the Tokyo Stock Exchange. Partly as a reaction to international criticism, Japanese competition policy is being reformed and strengthened. The Japanese and US authorities must be pressurized to go further in this direction so as to bring about a situation where the main international trading partners can operate under roughly equivalent competition rules.

43. While meeting its international obligations, the Community will have to fall back, where necessary, on its customs regulations (temporary suspension of the autonomous duties of the common customs tariff) and its trade policy instruments (such as antidumping measures and customs duties). In any event, the antidumping procedure can only be considered as a last resort. For this reason it is necessary to maintain detailed statistics and use all available bilateral and multilateral consultative fora in order to anticipate and avoid those situations which could result in the Community having no other choice than to take antidumping measures.

The Community applied the antidumping regulations to several electronics and IT products in the period 1985-90: semiconductors, photocopiers, printers, video recorders and television receivers. It seems that the effects of antidumping measures can vary, owing to the peculiarities of the markets for these products and the controversial impact of these measures on consumers and the industries which use components.

In any event, application of Article 115 will not be possible at the intra-Community borders once the internal market has been completed.

44. In the search for a balance between international cooperation and technological independence, firms should take responsibility for their strategic choices in this area, while the public authorities have the important role of providing appropriate frameworks for trade and cooperation.

45. The Community, in close collaboration with the industrialists concerned, has already taken part in international cooperation, for example in the field of standardization. Other opportunities are now emerging, such as the project for a programme on intelligent manufacturing systems (IMS). A number of areas of technological cooperation are currently being explored with American organizations. The Community itself should also seize the initiative in launching scientific cooperation programmes.

46. The Community will continue current negotiations with the EFTA countries with a view to creating a European economic area. The huge market which will be created in this way will offer fresh growth opportunities for the electronics and IT industries.

47. The Community must face up to its responsibilities vis-à-vis the Central and Eastern European countries and help them to bridge the technology gap and make good their inadequate infrastructure, especially in telecommunications. In time these countries will offer new opportunities and prospects for industrial cooperation. Their needs are very considerable: their production system must be adapted or changed and IT has a central part to play in their efforts to catch up.

48. **The Business Environment**. The implementation of the concept of industrial policy also calls for further measures in the field of electronics and IT designed to *create a healthy business environment*.

49. *Improving financing systems*. Given the importance of financing systems for firms which are capital-intensive and require high R&TD expenditure, the public authorities should hold discussions with banks and financial institutions on ways in which *risk capital* could be employed in conjunction with taxation measures.

Training schemes for staff in the banking sector encompassing both the financial side and computerized systems applications should also be looked into.

50. *Faster standardization and integration of standards into products* (hardware and software). Since products now become obsolete so rapidly, European firms are finding it increasingly difficult and costly to manage the evolution of standards. Ways of speeding up the procedures for drawing up standards, especially those relating to software, should be studied with European and national standards institutes.

European industry must also build new standards into its products and systems more quickly, like its foreign competitors, so as to derive maximum benefit from such standards, and must play an active role in the European, foreign and international standards bodies.

51. *Closer involvement of the development of electronics and IT in the introduction of structural policies*. The structural Funds make a significant contribution to the development of the less prosperous regions, by promoting the infrastructure for technology transfer, the dissemination and exploitation of research results, and the launching of training schemes in science, technology and management. These measures are among the priorities for development established, for each of the Community's less-favoured areas, within the Community support framework. In addition to these measures, the Commission has adopted a series of Community initiatives such as STRIDE, STAR, TELEMATIQUE and PRISMA. These initiatives help to create an environment that favours the development and dissemination of new technologies in firms, especially small businesses, in these regions. These structural measures should continue, and be better targeted where necessary, especially in the most disadvantaged areas.

52. *Developing infrastructure for cooperation.* The dialogue between the various groups involved needs to be stepped up, a move which could lead to the formation of partnerships. Special measures could be considered or stepped up to help SMEs to expand their networks and step up their activities beyond their national frontiers.

Pilot operations for cooperation between SMEs, large firms and research centres at Community and international level should be launched, multisectoral basic technologies promoted in the framework of overall technology policy and the need for major industrial investments in basic components required for future generations of data-processing and electronics products taken into consideration.

The progressive integration into components of the functions contained in information and communication systems requires an improvement in cooperation between semiconductor manufacturers and users. The Commission will continue its efforts to facilitate the formation of such cooperative partnerships.

53. This communication is intended to serve as background for a debate with the Member States, the European Parliament, the Economic and Social Committee as well as the industries, manufacturers and users concerned, in order to analyse the situation as perceived by the Commission and discuss the action to be taken.

This should enable the Commission to enter into fruitful dialogue with industry, users and investors, in order to assess the situation in greater depth from a dynamic perspective and to identify conditions for a long-term recovery, while respecting the roles of the parties concerned.

Appendixes

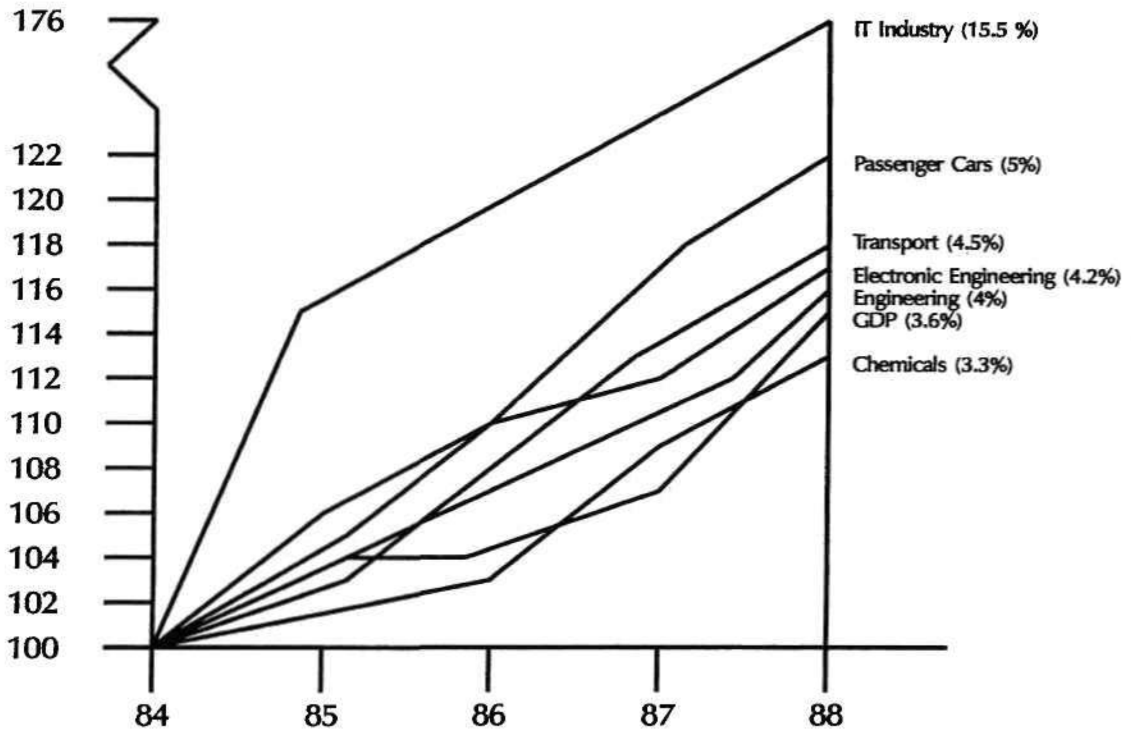
Evolution of European IT and Telecommunications Industry

Exchange Rate Trend

1980: $1 = ¥225 = ECU 0.72
1984: $1 = ¥238 = ECU 1.27
1989: $1 = ¥138 = ECU 0.91
1990: $1 = ¥146 = ECU 0.80

Figure 1

European Industrial Growth Comparison
Annual Growth (Percent)



Note: Compound annual growth rates 1984 to 1988 given in brackets.
Source: Eurostatistics Data for Short Term Analysis, Price Waterhouse: IT2000 (July 1990)

Table 1

Breakdown of World Production of the IT and Telecommunications Industries by Main Geographical Area (since 1980)

	1980	1984	1989	1990
United States	46%	47%	38%	37%
Japan	15%	21%	27%	24%
Europe	26%	21%	22%	24%
Other Countries	13%	11%	13%	14%

Source: EIC (1990)

Table 2

Consumption and Production of the IT and Electronics Industries by Main Geographical Area (Billions of Dollars)

	Consumption				Production			
1989	Europe	United States	Japan	World	Europe	United States	Japan	World
Components of which:	**26,400**	**38,700**	**40,200**	**125,600**	**20,100**	**34,700**	**54,500**	**125,600**
Active Components	13,200	21,200	26,100	73,000	8,300	18,100	37,100	73,000
Passive Components	13,200	17,500	14,100	52,600	11,800	16,600	17,400	52,600
Computers of which:	**108,100**	**164,300**	**70,200**	**391,900**	**85,200**	**168,000**	**90,200**	**391,900**
Computer Hardware	62,000	78,500	37,500	204,000	45,200	78,100	50,200	204,000
Software and Services	27,600	58,800	14,700	115,000	26,200	63,200	14,000	115,000
Office Systems	6,300	12,100	4,900	26,900	4,100	9,400	10,700	26,900
Automation	12,200	14,900	13,100	46,000	9,700	17,300	15,300	46,000
Consumer Electronics	**23,400**	**24,800**	**16,300**	**84,000**	**12,900**	**10,800**	**35,700**	**84,000**
Total in IT and Electronics	**157,900**	**226,800**	**126,700**	**601,500**	**118,200**	**213,500**	**180,300**	**601,500**
As Percentage	26%	37%	21%	100%	20%	35%	30%	100%

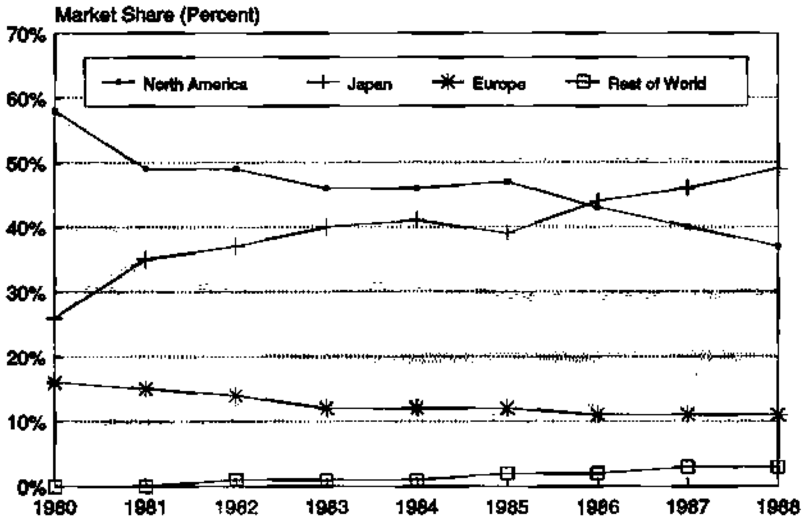
Source: EIC (1990)

Analysis of the Situation by Sector

Semiconductors

Figure 2

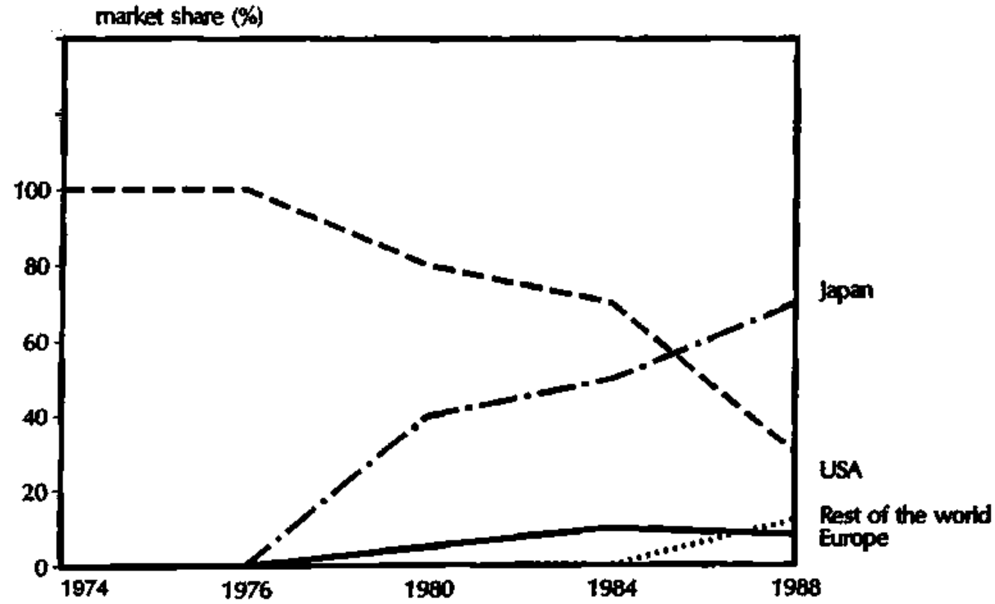
World Semiconductor Production by Region



Source: Dataquest (November 1991)

Figure 3

World Production of DRAMs by Region



Source: Dataquest (November 1991)

Table 3

Computers—Trend in Market Shares of IT Firms in Europe

	1980	1982	1984	1987	1988	1989
European Firms	33.0%	34.0%	36.5%	43.2%	42.8%	40.2%
American Firms	67.0%	66.0%	63.5%	56.8%	54.4%	56.5%
Japanese Firms	-	-	-	-	3.8%	3.2%

Source: Datamation

Table 4

Control of Production of Computer Hardware in the United States, Europe and Japan (in 1989)

	United States	Europe	Japan
Firms under American Control	92%	58%	16%
Firms under European Control	4%	34%	0%
Firms under Japanese Control	4%	8%	84%
Production	78.1	45.2	50.2

Source: EIC (1990)

Table 5

Main Statistical Data for Consumer Electronics (in 1988)
(Billions of Dollars)

	Prod.	Imp.	Exp.	Bal.	Mkt.	Imp. Ratio
EC	10.7	9.3	1.2	-8.1	18.8	49.5%
Japan	32.2	0.7	16.8	+16.1	16.1	4.3%
USA	5.4	11.2	0.9	-10.3	15.7	71.3%
Korea	7.6	0.5	5.2	+4.7	3.0	16.6%
ROW	11.1	-	-	-	12.2	-
Total	68.2	-	-	-	68.1	-

Source: BIS-Mackintosh (1990)

The Worsening European Trade Deficit

Table 6

Trends in Trade Balances for the IT and Telecommunications Industries by Main Geographical Area
(Billions of ECU)

	1986	1987	1988	1989
Europe	-14.5	-18.9	-28.0	-31.0
United States	-7.6	-6.3	-4.4	-7.0
Japan	+50.3	+47.0	+56.0	+57.0
Rest of World	-28.0	-21.9	-20.5	-18.8

Source: EIC

Table 7

European Trade Deficit in Electronics and IT
(1988 and 1989)
(Billions of ECU*)

	Trade Balance	
	1988	1989
Components, of which		
Active Components	-3.6	-4.4
Passive Components	-0.6	-1.2
Computers, of which:		
Computer Hardware	-14.3	-15.3
Computer Software and Services	-1.0	-1.3
Consumer Electronics	-9.5	-9.6

*Mean annual dollar/ECU exchange rate:
1986 $1 = ECU 1.016
1987 $1 = ECU 0.867
1988 $1 = ECU 0.846
1989 $1 = ECU 0.908
Source: EIC (1990)

Analysis of the Situation of Electronics and IT Firms

Table 8

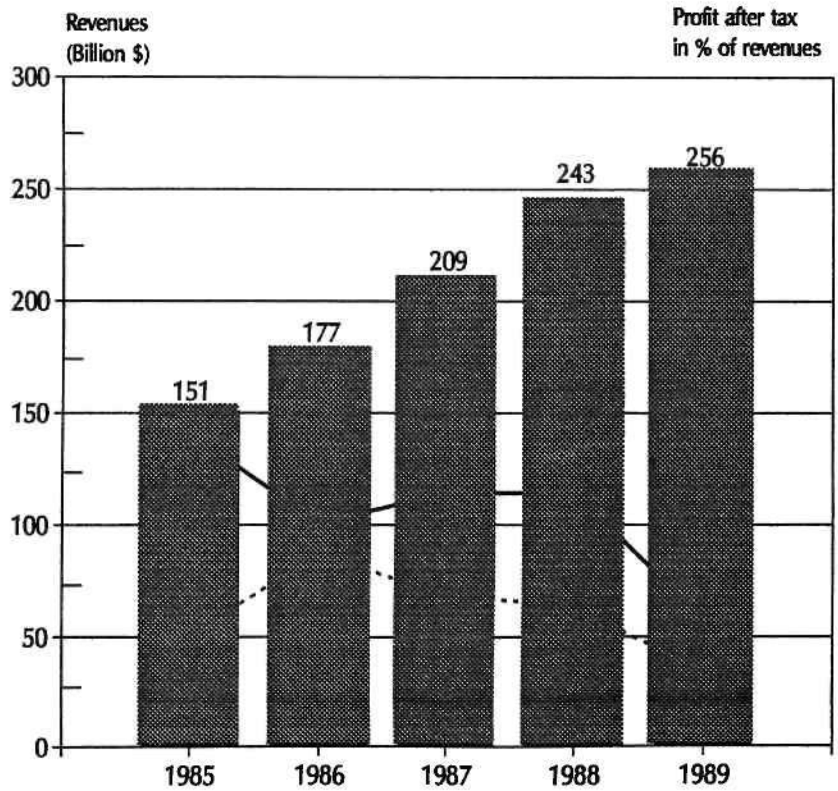
Ranking of the Top Ten Firms on the World Market

Ranking	Components[1] (1990)	Computers[2] (1990)	Consumer Electronics[3] (1989)
1	NEC	IBM	Matsushita
2	Toshiba	Fujitsu	Sony
3	Hitachi	Digital	Philips
4	Motorola	NEC	Toshiba
5	Intel	Unisys	Hitachi
6	Fujitsu	Hitachi	Thomson
7	Texas Instruments	Hewlett-Packard	JVC
8	Mitsubishi	Siemens-Nixdorf	Mitsubishi
9	Matsushita	GroupeBull	Samsung
10	Philips	Olivetti	Goldstar

Source: [1] Dataquest (November 1991)
[2] Gartner Group Inc. (1990)
[3] BIS-Mackintosh

Figure 4

Trends in Company Results (Top 100 Information Systems Firms*)
Net Profits as Percentage of Turnover



——— All Companies
- - - European Companies
* IS: Definition referring to Datamation's "Information System" includes additionally data communications equipment (digital PABX, communications processors, facsimile machines, multiplexers, word processing).
Source: Datamation

Table 9

World Ranking of Semiconductor Manufacturers (1990)
(Turnover in Millions of Dollars)

1990	1989	Company	1989 Turnover	1990 Turnover	90/89
1	1	NEC	5,015	4,952	-1%
2	2	Toshiba	4,930	4,905	-1%
3	3	Hitachi	3,974	3,927	-1%
4	4	Motorola	3,319	3,692	11%
5	8	Intel	2,430	3,135	29%
6	6	Fujitsu	2,963	3,019	2%
7	6	Texas Instruments	2,787	2,574	-8%
8	7	Mitsubishi	2,579	2,476	-4%
9	9	Matsushita	1,882	1,945	3%
10	10	Philips	1,716	1,932	13%
11	11	National	1,618	1,718	6%
12	13	SGS-Thomson	1,301	1,463	12%
13	12	Sanyo	1,365	1,381	1%
14	15	Sharp	1,230	1,360	11%
15	14	Samsung	1,260	1,315	4%
16	16	Siemens	1,194	1,221	2%
17	19	Sony	1,077	1,172	9%
18	17	Oki	1,154	1,074	-7%
19	18	AMD	1,100	1,067	-3%
20	20	AT&T	873	830	-5%

Source: Dataquest (November 1991)

Table 10

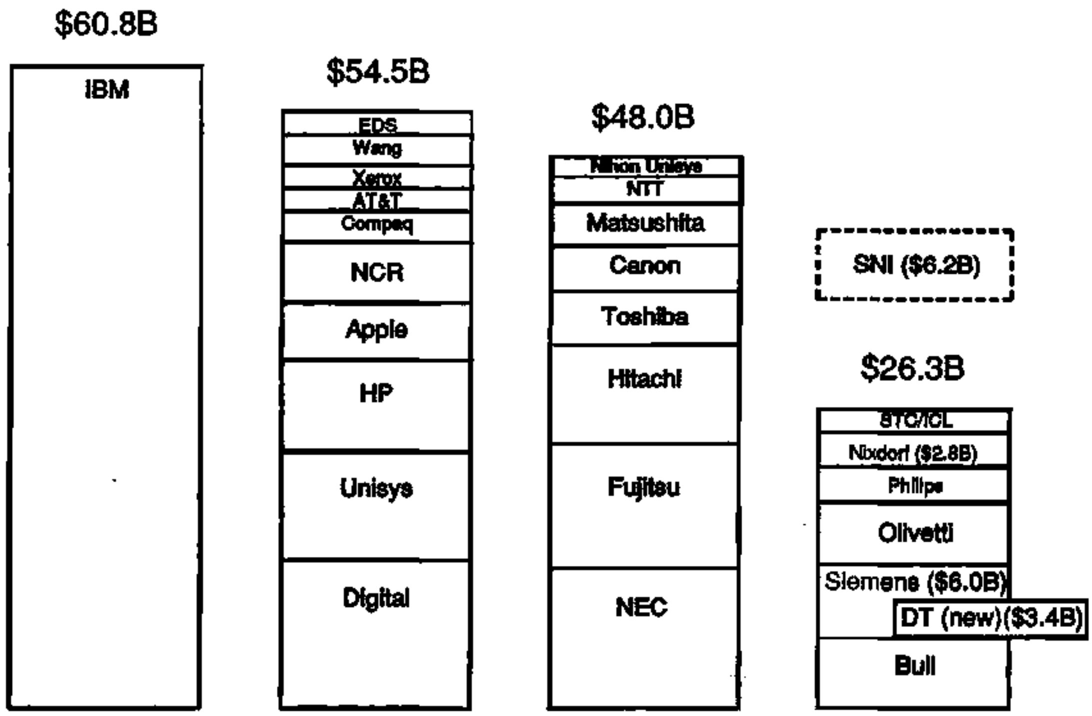
Market Shares of World Top Ten Semiconductor Firms (1979, 1984 and 1990)

	1979			1984			1990	
1	Texas Instruments	13.5%	1	Texas Instruments	9.7%	1	NEC	8.5%
2	Motorola	7.8%	2	NEC	7.5%	2	Toshiba	8.4%
3	National	7.3%	3	Motorola	6.9%	3	Hitachi	6.7%
4	Phillips	7.3%	4	Hitachi	6.4%	4	Motorola	6.3%
5	Intel	6.8%	5	National	4.9%	5	Intel	5.4%
6	Fairchild	5.5%	6	Intel	4.8%	6	Fujitsu	5.2%
7	Mostek	3.3%	7	Fujitsu	4.5%	7	Texas Instruments	4.4%
8	NEC	3.0%	8	Phillips	4.4%	8	Mitsubishi	4.2%
9	AMD	3.0%	9	Toshiba	4.2%	9	Matsushita	3.3%
10	Hitachi	2.4%	10	AMD	3.8%	10	Phillips	3.3%

Source: Dataquest (November 1991)

Figure 5

Ranking of Major World Computer Firms



* IS: Definition referring to Datamation's "Information System" includes additionally data communications equipment (digital PABX, communications processors, facsimile machines, multiplexers, word processing).
Source: Datamation (June 1990)

Table 11

World Top Ten Consumer Electronics Manufacturers (1989)
(Billions of ECU)

Ranking	Company	Turnover
1	Matsushita	19.5
2	Sony	10.7
3	Philips	10.1
4	Toshiba	7.1
5	Hitachi	6.1
6	Thomson	5.0
7	JVC	4.9
8	Mitsubishi	4.1
9	Samsung	3.4
10	Goldstar	3.1

Source: BIS-Mackintosh

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3.0 Semiconductor End-User Markets

INTRODUCTION

Dataquest's European Components Group (ECG) has developed a new module called European Semiconductor Applications Markets (ESAM) that provides a complete analysis of semiconductor consumption in Europe by application market segment. This product is intended to support decision makers who must take a tactical or strategic approach in their analysis of the semiconductor market, from either an application (or demand) side or end-use perspective.

This section gives a top-level overview of the semiconductor applications markets in Europe by the following six market segments:

- Data processing
- Communications
- Industrial
- Consumer
- Military
- Transportation

For a complete analysis of these segments, readers should refer to the ESAM module.

EUROPEAN END-USE SEGMENTS

The data processing segment comprises all equipment with the main function of information processing. Included in this segment are all types of computers, from personal computers to mainframes, and all computer peripheral equipment such as memory storage systems and data terminals.

The communications segment consists of all forms of equipment used for electronic communication. This equipment includes devices used on customers' premises (e.g., PABXs, telephones, facsimile), the public network (switches and transmission), radio, and studio and broadcast equipment.

The industrial segment covers all forms of manufacturing-related equipment including energy management, automated manufacturing systems, robotics, medical systems, and commercial aviation.

The consumer segment covers equipment that is retailed through retail stores and designed primarily for domestic or personal use, such as home audio and video equipment; white goods appliances (e.g., microwave ovens and washing machines), and personal electronics (e.g., watches, hearing-aids).

Military equipment consists of electronic equipment used for weapons or weapon-support systems and is classified by specific budget areas. To avoid double counting of items that logically belong to other segments, it excludes nonspecific electronic equipment procured by governments.

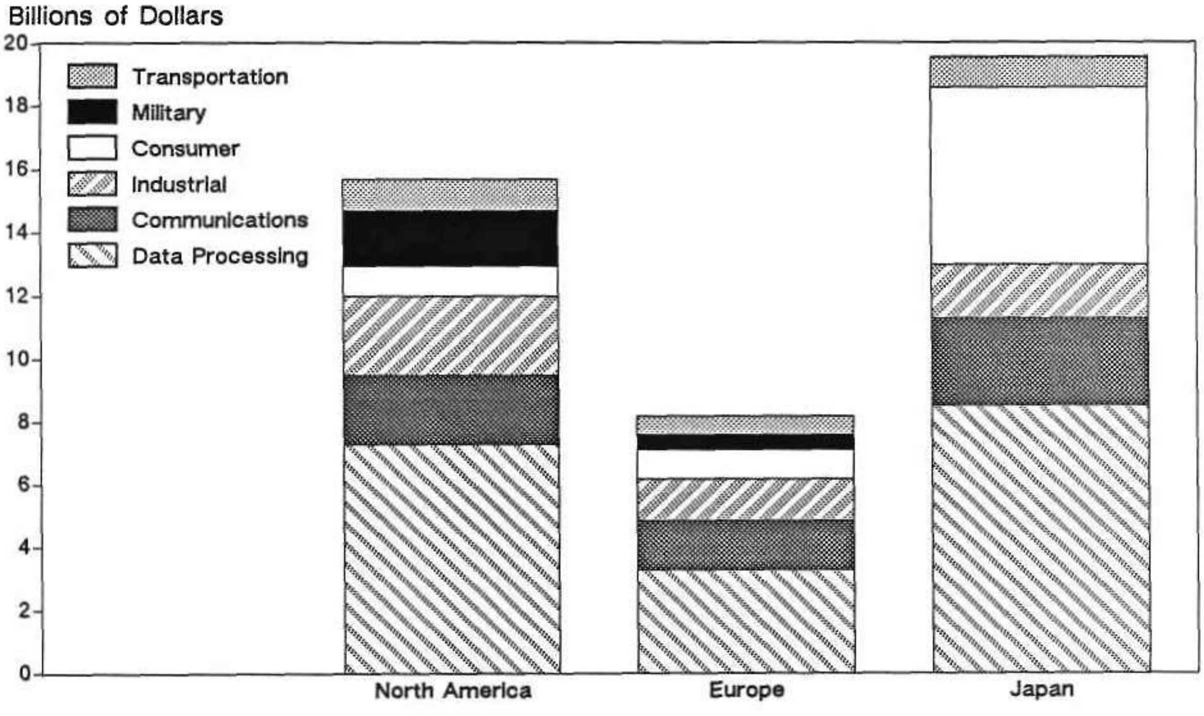
Transportation segment consists mainly of automotive and light truck electronics. This designation leaves room to analyze other markets, such as off-highway equipment, that are potentially large users of semiconductors.

EUROPEAN OVERVIEW

The European electronic market exhibits significant differences from those in the United States or Japan in terms of the percentage of consumption by end-use segment (see Figure 3.0-1).

Figure 3.0-1

1988 Semiconductor Consumption by Application Markets



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Source: Dataquest
August 1989

3.0 Semiconductor End-User Markets

In North America the emphasis lies in the data processing segment, which Dataquest estimates accounted for 49.4 percent of 1988 U.S. semiconductor consumption, in contrast with 39.8 percent in Europe (or 43.3 percent in Japan). In Europe, the communications segment continues to occupy a high, 19.2 percent share of total consumption, compared with 13.5 percent in the United States and 12.9 percent in Japan. This difference is due largely to the regulatory environment in Europe, where the Public Telephone and Telegraph (PTT) operator in each country favors local equipment suppliers.

The consumer market in Japan continues to occupy a greater proportion of semiconductor consumption, 31 percent, than either Europe (11.5 percent) or the United States (5.4 percent).

EUROPEAN SEMICONDUCTOR MARKETS

Table 3.0-1 describes Dataquest's five-year forecast by top level end-use segment for 1989 to 1994, with an overall compound annual growth rate (CAGR) of 18.9 percent predicted for this period.

Table 3.0-1

Estimated European Semiconductor Consumption by End-Use Application

	1989		1994		
Category	($B)	%	($B)	%	CAGR
Data Processing	$3.40	35.0%	$ 7.50	32.5%	17.2%
Communications	2.04	21.0	4.60	19.9	17.7%
Industrial	1.73	17.8	3.44	14.9	14.8%
Consumer	1.18	12.2	3.80	16.5	26.3%
Military	0.58	6.0	1.30	5.6	17.3%
Transportation	0.76	8.0	2.43	10.6	26.1%
Total	$9.69	100.0%	$23.07	100.0%	18.9%

Source: Dataquest
August 1989

Data Processing

Rapidly rising DRAM prices have distorted the consumption of semiconductors in this segment during the past couple of years. In 1988, data processing consumption represented 39.8 percent of the total European market. With an outlook of falling DRAM prices, we expect this fraction to drop to 35 percent this year, returning to a long-run 32.5 percent by 1994.

Table 3.0-2 shows the data processing market in Europe broken down by subsegment. Computers occupied the lion's share of this market in 1988, accounting for an estimated 78.3 percent of the semiconductor market in the data processing segment. Following this segment were data storage systems (largely hard disks) with 9.8 percent and dedicated systems with 6.3 percent.

Table 3.0-2

Estimated 1988 European Data Processing Semiconductor Consumption by Subsegment

Subsegment	Millions of Dollars	Percent
Data Processing		
Computers	$2,645	78.3%
Data Storage Subsystems	333	9.8
Terminals	28	0.8
Input/Output	165	4.8
Dedicated Systems	210	6.3
Total	$3,381	100.0%

Source: Dataquest
August 1989

Dataquest estimates that overall semiconductor consumption in the data processing segment will experience a 17.2 percent CAGR during the next five years. Laser printers and workstations represent the two most dynamic markets in this segment.

The growing affordability of laser printers, combined with tougher European local content rules that are driving greater local production, will cause this subsegment to show a 34 percent CAGR between 1989 and 1994. The growth in semiconductors consumed for the workstation market will be almost as dramatic, with an estimated 31 percent.

Communications

Table 3.0-3 shows the communications market in Europe for 1988 broken down by subsegment. Customer-premises equipment (telephones, facsimile, data terminals, modems, PBXs) account for the greatest proportion of revenue in this segment, 38.4 percent.

Table 3.0-3

Estimated 1988 European Communications Semiconductor Consumption by Subsegment

Subsegment	Millions of Dollars	Percent
Communications		
Customer Premises	$ 628	38.4%
Public Telecommunications	496	30.4
Radio	261	16.0
Broadcast and Studio	137	8.4
Other	112	6.8
Total	$1,634	100.0%

Source: Dataquest
August 1989

Although overall growth for communications—17.7 percent CAGR—ranks behind the consumer and transportation sectors, it contains the highest growth applications for the next five years.

With ISDN services recently announced in France and West Germany, Dataquest expects ISDN semiconductor revenue to show a sharp increase, reflecting an average 90 percent CAGR. By 1992 the market for dedicated ISDN ICs is estimated to be worth $137 million.

The new digital cordless telephone technologies, CT2 and DECT (Digital European Cordless Telephone), also are poised to make a strong impact in the next five years—growing at an estimated 54 percent during this period. Dataquest estimates that the market for CT2 semiconductors in Europe alone will be worth between $90 million and $170 million by 1994.

For the most part, facsimile machines are imported and in the past have not accounted for significant component sales in Europe. Dataquest estimates that in 1988 only 15 percent of this high-growth market was satisfied by production in Europe.

However, the trend here is toward rising local production with both Japanese and European companies expected to expand production in Europe, driving an average 45 percent CAGR in semiconductor consumption during the next five years.

Industrial

The industrial segment covers a diverse range of applications. Table 3.0-4 shows a breakdown for industrial consumption in Europe by subsegment for 1988.

Table 3.0-4

Estimated 1988 European Industrial Semiconductor Consumption by Subsegment

Subsegment	Millions of Dollars	Percent
Industrial		
Energy Management	$ 125	8.9%
Manufacturing Systems	795	57.1
Robot Systems	26	1.9
Medical Systems	217	15.6
Commercial Aviation	75	5.5
Other	153	11.0
Total	$1,392	100.0%

Source: Dataquest
August 1989

Manufacturing systems (production systems, instrumentation) accounted for 59.1 percent of this market, with medical systems accounting for much of the remainder (15.6 percent). However, the energy management systems sector is the one in which Dataquest predicts the main growth (38 percent CAGR) in this segment during the next five years. In this time period, smart electronic metering systems are forecast to gradually replace existing electromechanical meters for electricity, gas, and water.

Consumer

Table 3.0-5 shows the consumer semiconductor consumption in Europe for 1988 broken down by subsegment. Video equipment (television and video recorders) represent the greatest share, with 68 percent of the market, followed by white goods appliances (microwave ovens, washing machines, dishwashers) with 16 percent and audio equipment (hifi, radios) with 12 percent.

3.0 Semiconductor End-User Markets

Dataquest expects the consumer segment to show the strongest growth in semiconductor consumption, with a 26.3 percent CAGR during the next five years. A key factor behind this growth is the European Commission (EC)'s rules on local content and antidumping, which are especially strong on products in this segment—particularly regarding televisions and video recorders.

Table 3.0-5

Estimated 1988 European Consumer Semiconductor Consumption by Subsegment

Subsegment	Millions of Dollars	Percent
Consumer		
Audio	$117	12.0%
Video	666	68.2
Personal Electronics	29	2.9
Appliances	158	16.2
Other	6	0.7
Total	$976	100.0%

Source: Dataquest
August 1989

Where there are new markets presently dominated by imports, Dataquest expects the EC to move to encourage local production. One proposal before the commission is to raise tariffs on imported camcorders from 4.9 percent to 14 percent. In Europe, camcorders represent a $2 billion market, of which almost all are imported.

The semiconductor content per unit in this segment also is steadily increasing, as chips will continue to replace electromechanical controllers in washing machines, dishwashers, and microwave ovens during the coming years. Except for microwave ovens, these items will continue to be produced mainly in Europe by strong, locally owned manufacturers such as Electrolux, Philips, and Bosch-Siemens.

Transportation

The trends in semiconductor consumption for transportation are similar to those for the consumer market. The most prominent of these trends is a market that is shifting toward greater semiconductor content in a legislative environment in which local production is increasingly favored.

Features like antilock braking and fuel injection were at one time luxuries that distinguished top-range performance cars from low-end ones, but this is changing and these items increasingly are being offered as standard equipment on all models.

The EC's target of tightening of regulations regarding car pollution by 1993 is another major factor. These rules will require a much higher proportion of cars to use microprocessor-controlled engine management systems.

Table 3.0-6 shows Dataquest's estimation of transportation semiconductor consumption for Europe broken down by subsegment for 1988. Power train systems (electronic fuel injection and engine management) account for the greatest (41 percent) share of this market, followed by safety and convenience systems (mainly antilock braking) with 22.2 percent and entertainment systems with 19.1 percent.

Table 3.0-6

Estimated 1988 European Transportation Semiconductor Consumption by Subsegment

Subsegment	Millions of Dollars	Percent
Transportation		
Entertainment	$117	19.1%
Body Controls	72	11.8
Safety and Convenience	136	22.2
Power Train	251	41.0
Driver Information	36	5.9
Total	$612	100.0%

Source: Dataquest
August 1989

Military

Semiconductor consumption for the military segment will remain static in real terms during the next five years.

The current political climate between the West and east bloc countries is such that further cuts in defense budgets in Europe are probable, which will result in declining orders for military systems. However, Dataquest predicts that electronic content will continue to increase and, as procurement budgets shrink, military electronic systems will go through successive phases of modernization rather than replacement.

Consolidation through horizontal integration and joint consortia is likely in a European military market that is deeply fragmented along national lines. The main impetus for consolidation in this market comes from the fact that R&D costs are escalating rapidly. Examples include Ferranti's venture with Teledyne to manufacture acoustic sensors, Plessey's 49 percent stake in Electtronic and GEC's 5 percent holding in Matra. Further consolidation is likely.

3.7 Semiconductor Distribution Markets

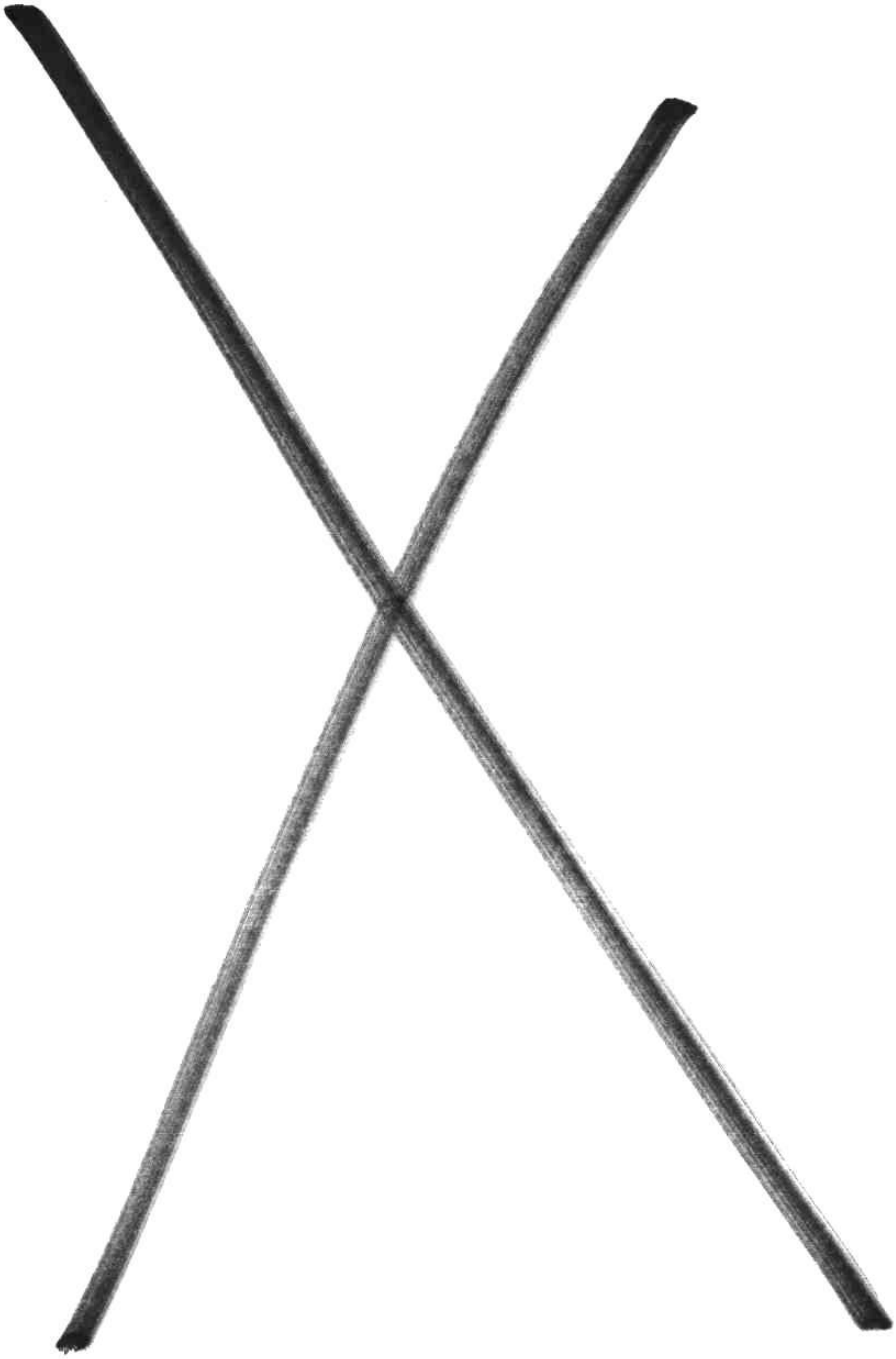
INTRODUCTION

This service section will discuss the European semiconductor distribution markets. Included will be the following topics:

- Major distribution by region
- Market data by region
- Profiles on the major European distributors

A description of the European semiconductor distribution markets, their history, development, and future outlook, is contained in Section 1.5 of this volume, Channels of Distribution.

The formal service section is currently in preparation. Clients who wish advance information should use their inquiry privileges to address their specific topics of interest.



4.0 Major Users

INTRODUCTION

This service section gives Dataquest's estimates of the semiconductor spends of the main equipment companies in Europe in 1990. Two sets of estimates are given: European equipment companies' worldwide purchases, and worldwide companies' European purchases. For the first time these estimates include a breakdown by the major product categories of bipolar digital, MOS memory, MOS micro, MOS logic, analog, discrete, and optoelectronic.

Changes in company structures are constantly taking place due to mergers, acquisitions, divestitures, and so on. In these estimates, company structures are taken to be as at the end of 1989. Detailed company notes explaining the assumptions we have made are given at the end of this section after the tables.

RESEARCH METHODOLOGY

In estimating the semiconductor spend of major equipment companies Dataquest employs two main methodologies:

- **Procurement surveys.** These gather actual inputs from the companies themselves on their spends. The surveys also yield a breakdown of types of semiconductor purchased (microprocessor, memory, and so on).
- **Dataquest's application markets research.** Analysts in Dataquest's European Semiconductor Applications Markets (ESAM) research group use their knowledge of equipment production and semiconductor content of equipment to estimate the semiconductor spends of the major equipment companies.

Other sources of information include:

- Other Dataquest service groups, particularly our European telecommunications, computer, personal computer, printer, and copier and duplicating industry groups
- Publically available sources such as press clippings
- Our own market intelligence

Finally, in completing our 1990 estimates we sent a draft of the final estimates to each of the top 10 semiconductor vendors in Europe. Their comments and corrections have been included, and we gratefully acknowledge their assistance.

THE TABLES

The following tables show Dataquest's estimates of the semiconductor consumption of electronic equipment manufacturers.

- **Table 1** estimates European companies' worldwide semiconductor consumption by major product category in 1990.
- **Table 2** estimates worldwide companies' European semiconductor consumption by major product category in 1990.
- **Table 3** ranks worldwide companies' European semiconductor consumption in 1990 by size in descending order.

Table 1
European Companies' Worldwide Semiconductor Consumption in 1990
(Millions of Dollars)

	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro	MOS Logic	Linear	Discrete	Opto.
AEG	46	34	2	21	6	7	8	11	10	2
Aerospatiale	37	23	2	15	4	6	5	7	11	3
Alcatel	379	289	25	193	64	38	91	71	69	21
Amstrad	83	72	6	49	25	13	12	16	9	1
ASCOM	88	67	6	45	15	9	21	16	16	5
Asea Brown Boveri	83	51	4	32	10	12	10	15	26	7
Bang & Olufsen	15	11	0	6	1	2	3	6	3	0
Bayer	26	24	3	19	12	5	3	2	1	0
Bosch	486	376	14	263	46	105	111	100	91	19
British Aerospace	28	19	1	12	3	5	4	5	7	2
Bull	193	180	22	141	83	36	22	16	11	2
Electrolux	19	15	0	7	1	2	4	7	4	1
Ericsson	321	244	20	163	53	35	75	60	59	18
GEC	143	92	7	57	16	22	19	28	40	11
GPT	153	117	10	78	26	16	37	29	28	9
Grundig	213	161	2	81	16	25	40	78	46	7
Italtel	56	45	4	31	13	7	12	9	9	3
Lucas	54	41	1	31	3	16	11	9	11	2
Mannesmann	62	50	5	37	19	11	7	8	10	2
Matra Communication	41	31	3	21	7	4	10	8	7	2
Nixdorf	117	110	14	87	52	22	13	9	6	1
Nokia	288	230	13	141	52	37	52	75	49	9
Norsk Data	10	10	1	8	5	2	1	1	0	0
Olivetti	304	284	35	224	132	56	35	26	17	4
Philips	799	596	29	344	108	100	136	223	170	33
Racal Electronics	46	33	3	22	7	6	9	9	10	3
Rank Xerox	39	37	5	29	17	7	4	3	2	0
Sagem	50	40	4	28	11	7	10	8	8	2
Schlumberger	112	83	9	58	26	17	15	17	23	6
Semelco	140	111	3	85	12	39	34	22	25	5
Siemens	589	449	41	316	125	91	99	92	111	29
STC (incl. ICL)	97	86	10	65	35	16	14	11	9	2
Thomson	493	363	9	191	39	64	87	163	111	20
Tulip	35	33	4	26	16	7	4	3	2	0
Total Above Companies	$5,646	$4,404	$316	$2,926	$1,059	$848	$1,019	$1,161	$1,010	$232

Note: Totals may not add due to rounding
Source: Dataquest (October 1990)

Table 2
Worldwide Companies' European Semiconductor Consumption in 1990
(Millions of Dollars)

	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro	MOS Logic	Linear	Discrete	Opto.
AEG	31	23	1	14	4	5	6	7	7	1
Aerospatiale	37	23	2	15	4	6	5	7	11	3
Alcatel	318	242	21	162	53	32	76	60	58	18
Amstrad	83	72	6	49	25	13	12	16	9	1
Apple	62	59	7	46	28	12	7	5	3	1
ASCOM	87	66	6	44	15	9	21	16	16	5
Asea Brown Boveri	83	51	4	32	10	12	10	15	26	7
Bang & Olufsen	15	11	0	6	1	2	3	6	3	0
Bayer	23	22	3	17	10	4	3	2	1	0
Bosch	356	276	10	192	34	77	81	73	67	14
British Aerospace	28	19	1	12	3	5	4	5	7	2
Bull	156	146	18	115	68	29	18	13	9	2
Commodore	54	51	6	40	24	10	6	4	3	1
Compaq	0	0	0	0	0	0	0	0	0	0
Digital	116	107	13	84	48	21	14	11	7	2
Electrolux	11	8	0	4	1	1	2	4	2	0
Ericsson	287	218	18	146	47	31	67	54	53	16
GEC	124	80	6	50	14	19	17	24	35	9
GPT	153	117	10	78	26	16	37	29	28	9
Grundig	202	153	2	77	15	24	38	74	43	6
Hewlett-Packard	121	110	13	86	50	22	13	11	9	2
IBM	984	927	115	734	440	187	107	78	48	10
Italtel	56	45	4	31	13	7	12	9	9	3
Lucas	36	27	1	21	2	11	8	6	7	1
Mannesmann	46	37	4	28	14	8	5	6	7	2
Matra Communication	41	31	3	21	7	4	10	8	7	2
NCR	34	32	4	25	15	6	4	3	2	0
Nixdorf	109	103	13	82	49	21	12	9	5	1
Nokia	279	223	13	138	51	36	51	72	47	9
Norsk Data	10	10	1	8	5	2	1	1	0	0
Olivetti	247	230	28	181	107	46	28	21	13	3
Philips	441	327	14	185	53	53	79	128	95	19
Racal Electronics	31	22	2	15	5	4	6	6	7	2
Rank Xerox	39	37	5	29	17	7	4	3	2	0
Sagem	50	40	4	28	11	7	10	8	8	2
Schlumberger	89	67	7	47	21	13	12	13	18	5
Semelco	129	102	3	78	11	36	31	21	23	4

(Continued)

Table 2 (Continued)
Worldwide Companies' European Semiconductor Consumption in 1990
(Millions of Dollars)

	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro	MOS Logic	Linear	Discrete	Opto.
Siemens	409	313	29	220	88	64	69	63	76	20
Sony	61	46	0	23	4	7	11	23	13	2
STC (incl. ICL)	90	79	9	60	32	15	13	10	9	2
Thomson	299	220	5	116	24	39	53	100	67	12
Toshiba	30	23	0	11	2	3	6	11	6	1
Tulip	35	33	4	26	16	7	4	3	2	0
Total Above Companies	$5,894	$4,827	$415	$3,376	$1,466	$934	$976	$1,036	$868	$199
Total European Semiconductor Markets	$10,682	$8,455	$696	$5,809	$2,383	$1,704	$1,722	$1,950	$1,812	$415
Above Companies Percentage of Total European Market	55.2%	57.1%	59.7%	58.1%	61.5%	54.8%	56.7%	53.1%	47.9%	48.0%

Note: Totals may not add due to rounding
Source: (Dataquest) October 1990

Table 3
Ranked Worldwide Companies' European-Based Semiconductor Consumption in 1990
(Millions of Dollars)

	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro	MOS Logic	Linear	Discrete	Opto.
IBM	984	927	115	734	440	187	107	78	48	10
Philips	441	327	14	185	53	53	79	128	95	19
Siemens	409	313	29	220	88	64	69	63	76	20
Bosch	356	276	10	192	34	77	81	73	67	14
Alcatel	318	242	21	162	53	32	76	60	58	18
Thomson	299	220	5	116	24	39	53	100	67	12
Ericsson	287	218	18	146	47	31	67	54	53	16
Nokia	279	223	13	138	51	36	51	72	47	9
Olivetti	247	230	28	181	107	46	28	21	13	3
Grundig	202	153	2	77	15	24	38	74	43	6
Bull	156	146	18	115	68	29	18	13	9	2
GPT	153	117	10	78	26	16	37	29	28	9
Semelco	129	102	3	78	11	36	31	21	23	4
GEC	124	80	6	50	14	19	17	24	35	9
Hewlett-Packard	121	110	13	86	50	22	13	11	9	2
Digital	116	107	13	84	48	21	14	11	7	2
Nixdorf	109	103	13	82	49	21	12	9	5	1
STC (incl. ICL)	90	79	9	60	32	15	13	10	9	2
Schlumberger	89	67	7	47	21	13	12	13	18	5
ASCOM	87	66	6	44	15	9	21	16	16	5
Asea Brown Boveri	83	51	4	32	10	12	10	15	26	7
Amstrad	83	72	6	49	25	13	12	16	9	1
Apple	62	59	7	46	28	12	7	5	3	1
Sony	61	46	0	23	4	7	11	23	13	2
Italtel	56	45	4	31	13	7	12	9	9	3
Commodore	54	51	6	40	24	10	6	4	3	1
Sagem	50	40	4	28	11	7	10	8	8	2
Mannesmann	46	37	4	28	14	8	5	6	7	2
Matra Communication	41	31	3	21	7	4	10	8	7	2
Rank Xerox	39	37	5	29	17	7	4	3	2	0
Aerospatiale	37	23	2	15	4	6	5	7	11	3
Lucas	36	27	1	21	2	11	8	6	7	1
Tulip	35	33	4	26	16	7	4	3	2	0
NCR	34	32	4	25	15	6	4	3	2	0
Racal Electronics	31	22	2	15	5	4	6	6	7	2
AEG	31	23	1	14	4	5	6	7	7	1

(Continued)

Table 3 (Continued)
Ranked Worldwide Companies' European-Based Semiconductor Consumption in 1990
(Millions of Dollars)

	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro	MOS Logic	Linear	Discrete	Opto.
Toshiba	30	23	0	11	2	3	6	11	6	1
British Aerospace	28	19	1	12	3	5	4	5	7	2
Bayer	23	22	3	17	10	4	3	2	1	0
Bang & Olufsen	15	11	0	6	1	2	3	6	3	0
Electrolux	11	8	0	4	1	1	2	4	2	0
Norsk Data	10	10	1	8	5	2	1	1	0	0
Compaq	0	0	0	0	0	0	0	0	0	0
Total Above Companies	$5,894	$4,827	$415	$3,376	$1,466	$934	$976	$1,036	$868	$199

Note: Totals may not add due to rounding
Source: Dataquest (October 1990)

COMPANY NOTES

AEG Group

On 1 July 1989, AEG's aviation, space technology and defense operations were transferred to Deutsche Aerospace AG. AEG and Deutsche Aerospace are subsidiaries of Daimler-Benz. A substantial portion of AEG's office and communications systems division revenue is derived from sales of badged systems.

Aerospatiale

In 1989, Aerospatiale and Thomson-CSF merged their avionics interests to form Sextant Avionics. This new company has not been shown seperately. Sextant's production and semiconductor consumption are included in the original companies.

Alcatel

All equipment production for the Alcatel group is shown, although the eight major companies within the group each procure separately.

Amstrad

Although Amstrad only manufactures a limited amount of equipment in Europe, it is believed to procure for the bulk of its semiconductor needs through its European office.

ASCOM

ASCOM was founded in mid-1987 by the merger of Autophon AG and Hasler Holdings.

Bang & Olufsen

Bang and Olufsen is now majority-owned by Philips, but because the company still has control of its own procurement and equipment production, it is shown separately.

Bayer

The Imaging Technology division of Bayer is Agfa-Gevaert Group. We believe that a major portion of Agfa-Gevaert's sales are derived from badged products.

Robert Bosch

We estimate that the 80 percent of Bosch's semiconductor consumption in transportation is from captive supply while, in other areas, the consumption is predominantly merchant. Our estimates include Bosch's majority stakes in 19 German and 68 foreign subsidiaries. This includes Blaupunkt-Werke GmbH, Bosch-Siemens Hausgeräte, ANT Nachrichtentechnik GmbH and Telenorma. These estimates do not include the Bosch–Matsushita joint venture, MB Video GmbH.

Bull

These figures include Bull's recent acquisition of Zenith Data Systems.

Compaq

Compaq manufactures PCs in Scotland but is believed not to procure semiconductors locally, instead importing PCBs from outside Europe. Consequently we have left its semiconductor consumption at zero.

Deutsche Aerospace

Deutsche Aerospace has not been included in this year's breakdown.

GEC

The estimates for GEC exclude GPT, but include the aerospace and engineering divisions of Plessey.

GPT Telecommunications

GPT is owned 60–40 by GEC and Siemens respectively. It is shown separately because it still has independent purchasing power. Each GPT manufacturing location has its own procurement office, controlled by a steering committee to determine common sources.

Grundig

The estimates cover Grundig AG Group. These consist predominantly of its home consumer/home electronics operations.

IBM

We estimate that there is a 50–50 split between captive and merchant semiconductor consumption in IBM. In PC production, its demand from the merchant market is stronger, with captive supply accounting for only 15 percent of its total PC consumption.

Italtel

Italtel is owned by IRI-STET; the Italtel numbers include Italtel Telematica, Italtel Tecnomeccanica, Italtel Tecnoelettronica and Italtel Telesis.

Magneti Marelli

This is the automotive components arm of the Fiat Group. All of Fiat's semiconductor procurement is through Semelco.

Mannesmann

These estimates include all companies within the Mannesmann group, including Mannesmann Kienzle and Hartmann & Braun.

Matra Communication

The Matra Communication estimates do not include its subsidiaries: MET, LCT, and Matra Communication Systèmes de Sécurité.

Matra SA

Matra SA has not been included in this year's breakdown.

Nixdorf (latterly Siemens–Nixdorf Information Systems)

Nixdorf is now controlled by Siemens. For this analysis, estimates for these companies are shown separately.

Nokia

Nokia estimates include the companies Luxor Oy, Salora Oy, and Oceanic SA.

Olivetti

Olivetti's joint venture in photocopiers with Canon is not included in this estimate.

Philips

At the beginning of 1990, Philips disposed of a major portion of its defense business in Europe to Thomson-CSF, selling an 80 percent interest in Philips' Dutch subsidiary Hollandse Signaalaparaten BV, a 49 percent interest in Philips' Belgian company MBLE, and 99 percent of the defense business of Philips' French company TRT. In the first quarter of 1990 Philips sold its German defense activities.

Since early 1989 Philips' major domestic appliances divisions have been in a joint venture with Whirlpool. Estimates for this venture are not included and semiconductor procurement for this company is not shown.

In mid-1990 Philips took control of Bang & Olufsen. Bang & Olufsen's equipment production is not included because it still has control of its own semiconductor procurement.

Plessey

Plessey was split up between GEC and Siemens. Siemens took the defense electronics division of Plessey, and GEC took the aerospace and engineering divisions. GPT is now owned on a 60–40 split between GEC and Siemens respectively.

Rank Xerox

A large portion of Rank Xerox's revenue comes from its reprographic businesses, which account for about 70 percent of its revenue. Within this, a large portion (45 percent) is made up from service agreements.

Sagem

The Sagem equipment production represents the consolidated sales of Sagem, and not just that of the parent company.

Schneider

The data include only PC production (excluding laptops).

Semelco

Semelco is the semiconductor procurement arm of the Fiat group. These figures include consumption for Magneti Marelli and Telettra.

Sextant Avionics

Sextant Avionics has not been included in this year's breakdown. The joint venture was set up by Aerospatiale and Thomson-CSF by the merger of their civil and fighter electronics businesses. Aerospatiale transferred Crouzet, Sfena and ESA, while Thomson-CSF transferred its general avionics division.

Siemens

These estimates include captive sales to Siemens from Siemens Components (believed to account for 30 percent of Siemens' total demand). After the takeover of Plessey, Siemens took control of the defense electronics division of Plessey. Siemens' 40 percent stake in GPT is not shown, as the company retains its own purchasing locations. Siemens' has recently acquired control of Nixdorf. For the moment, estimates for these companies are shown separately.

STC (including ICL)

STC's equipment production includes ICL (whose controlling interest is being sold to Fujitsu).

Telettra

This is the telecommunications arm of the Fiat Group, and is now merged with Alcatel NV. All of Fiat's semiconductor procurement is through Semelco.

Thomson

Thomson includes equipment production for Thomson Consumer Electronics SA and Thomson-CSF. At the beginning of 1990 Thomson acquired a major portion of Philips' defense business in Europe; this has been included in the estimates. From 1989, Aerospatiale and Thomson-CSF merged their avionics interests to form Sextant Avionics. This has not been included.

Whirlpool International

Whirlpool International was formed by the merger of the European appliance division of Philips and Whirlpool. It has not been included in this year's breakdown.

4.0 Major Users

INTRODUCTION

This service section gives Dataquest's estimates of semiconductor spends for the main equipment companies in Europe in 1991. Two sets of estimates are given—European equipment companies' purchases worldwide, and worldwide companies' purchases in Europe. These estimates include a breakdown by the major product categories of bipolar digital, MOS memory, MOS microcomponent, MOS logic, analog, discrete, and optoelectronic devices.

Changes are taking place in company structures all the time due to mergers, acquisitions, divestitures, and so on. In these estimates company structures are taken to be as they were at the end of 1991. Detailed company notes explaining the assumptions we have made are given at the end, after the tables.

RESEARCH METHODOLOGY

In estimating major equipment companies' semiconductor spend, Dataquest employs two main methodologies:

- **Procurement surveys.** These gather actual inputs from the companies themselves on their spends. The surveys also yield a breakdown of types of semiconductor purchased (microprocessor, memory, and so on).
- **Dataquest's application markets research.** Analysts in Dataquest's European Semiconductor Application Markets (ESAM) research group use their knowledge of equipment production, and semiconductor content of equipment to estimate the semiconductor spends of the major equipment companies.

Other sources of information include:

- Other Dataquest service groups, particularly our European telecoms, computer, personal computer, printer and peripherals service groups.
- Publicly available sources such as press clippings.
- Our own market intelligence.

Finally, in completing our 1991 estimates we sent a draft of our final estimates to each of the top 10 semiconductor vendors in Europe. Their comments and corrections have been included, and we gratefully acknowledge their assistance.

THE TABLES

The following tables show Dataquest's estimates of the semiconductor consumption of electronic equipment manufacturers.

- **Table 1** estimates European companies worldwide semiconductor consumption by major product category in 1991.
- **Table 2** estimates worldwide companies European semiconductor consumption by major product category in 1991.
- **Table 3** ranks worldwide companies European semiconductor consumption in 1991 by size in descending order.

Note: Figures may not always add to totals shown due to rounding.

CHANGES TO 1990 ESTIMATES

Since the last estimates in this section were published (September 1990), the Commercial Aviation segment has been deleted from from the Industrial segment and added to the Military and Aerospace segment, and is reflected in the accompanying estimates.

In addition, more representative nominal margins assumptions have been used this year to translate ex-factory revenue (derived from the company reports) to give the end-user revenues printed in this section. Compared with last year, the following changes have been made:

- Last year's uniform 12.5 percent markup for data processing equipment has been replaced by 25 percent in cases where channels exist between the OEM and the end user. In many cases, this has significantly raised the estimates for manufacturers of personal computers and related peripherals.
- Last year's uniform 12.5 percent markup on communications equipment has been replaced by a 25 percent markup in the Customer Premise subsegment, and a zero markup for the Public Telecommunications segment.
- Last year's uniform 25 percent markup on consumer equipment has been replaced by a 50 percent markup.
- The zero markups for industrial and military equipment remain unchanged.

COMPANY NOTES

Acorn

A subsidiary of the Olivetti Group which currently subcontracts all of its PC motherboard manufacturing in the United Kingdom.

AEG Group

A subsidiary of Daimler-Benz. A substantial portion of AEG's Office and Communications Systems division is derived from sales of badge systems. AEG's estimates include its Telefunken subsidiary.

Aerospatial

Estimates do not include Aerospatiale Crouzet, Sfena and ESA divisions which were transferred to Sextant Avionique in 1989. Sextant Avionique estimates have been shown separately.

Last year's estimates showed Aerospatiale with production in Industrial, due to changes in the way ESAM defines equipment this production of commercial aircraft is now included in Military.

Alcatel

Estimates include the whole of the Alcatel group including Alcatel FACE, Alacatel Bell Telephone, Alcatel Business Systems, Alcatel Standard Eléctrica, Alcatel SEL, Alcatel CIT, Alcatel Cable, and Telettra.

Amstrad

Subcontracts all of its manufacturing, the majority of which is done outside Europe, but is believed to specify and procure the bulk of its semiconductor needs through its European office. Consequently, procurement for its non-European activities is included in the European estimate.

Apple

Currently expanding its current PC factory in Cork, Eire.

Apricot

Included for the first time this year. Apricot was acquired by Mitsubishi in May 1990.

ASCOM

Created in mid-1987 by the merger of Autophon AG and Hasler Holdings.

ASEA AB

Not shown in this year's breakdown, although its two main subsidiaries, Asea Brown Boveri and Electrolux remain listed.

Asea Brown Boveri (ABB)

A joint-venture company between ASEA AB of Sweden and BBC Brown Boveri of Switzerland. The ABB Group owns 1,300 companies worldwide.

Bang & Olufsen (B&O)

Now 25 percent owned by Philips with the remaining 75 percent owned by Bang & Olufsen Holding. The company still procures semiconductors independently and, consequently, its equipment production is shown separately. During B&O's 1990 financial year it sold 50 percent of Dikon, now Diax Telecommunications A/S, to Ericsson A/S for $6.5 million (not included in the equipment estimates).

Bayer

The imaging Technologies sector of Bayer is the Agfa-Gevaert group. Bayer is active in the printer, copier and scanner markets. Dataquest estimates that the majority of Agfa-Gevaert's sales are derived from badged products, midrange to high-end printers and copiers and mainly from Minolta.

Robert Bosch

We estimate that 80 percent of Bosch's semiconductor consumption in transportation is from captive supply while, in other areas, the consumption is predominantly merchant. The estimates include Blaupunkt-Werke, ANT Nachrichtentechnik and Telenorma. This year Bosch-Siemens Hausgerate is broken out and shown separately.

Bosch-Siemens Hausgerate

This year we have split out the equipment estimates of Bosch-Siemens Hausgerate. This is a 50–50 joint venture between Bosch and Siemens, and manufactures electric household appliances and entertainment electronics.

Groupe Bull

Acquired Zenith Data Systems (ZDS) in December 1989, it has since rationalized production to plants in France and closed down the ZDS facility in Eire.

Commodore

Currently expanding it PC facility in Braunschweig, Germany.

Deutsche Aerospace

Founded in 1989 and embraces the activities of Dornier, Messerschmitt-Bölkow-Blohm, Motoren-und Turbinen-Union and Telefunken Systemtechnik. The companies' production estimates have not been shown this year.

Electrolux

Markup for consumer is 50 percent instead of last year's 25 percent.

GEC

Estimates exclude GPT (shown separately) but include Ferranti Defence Systems, which GEC acquired during this year.

Goldstar

Currently manufacturing consumer goods in Germany (VCRs) and in the United Kingdom (microwave ovens). For the consumer electronics–related business, Goldstar is procuring semiconductors locally, its PC operation in the United Kingdom is currently using imported boards so this equipment production is not shown.

GPT

Owned 60–40 by GEC and Siemens respectively. It is shown separately because it still retains independent purchasing power.

IBM

Has a 50–50 split between captive and merchant semiconductor consumption. In PC production, IBM's demand from the merchant market is stronger, with captive supply accounting for only 15 percent of its total PC consumption.

ICL

STC, the previous owner, sold its controlling stake in ICL to Fujitsu this year. ICL's equipment estimates are shown separately. In May 1991, ICL acquired Nokia's computer division, Nokia Data, and Nokia Data's production is also included.

Italtel

Equipment estimates include Italtel's subsidiaries, Italtel Telematica, Italtel Sistemi, Italtel Tecnoelettronica, Italtel Tecnomeccanica and Italtel Telesis.

Mannesmann

Recently entered into two cooperation agreements in the electronic equipment area of its operations. Firstly the printer operations of Mannesmann Tally and Siemens were merged and, secondly, Mannesmann has transferred control of its computer division, Mannesmann Kienzle, to a joint-venture company with Digital. Therefore, an independent estimate for Mannesmann has not been made this year.

Matra Communication

Estimates only include the parent company, and not those of its subsidiaries.

Nokia Corporation

Sold its computer division, Nokia Data Systems, to ICL in May 1991, estimates for this division have therefore been excluded. Nokia Consumer Electronics include production for Luxor, Salora and Oceanic.

Northern Telecom

Took over STC this year. Previously STC sold its stake in ICL to Fujitsu (Northern Telecom estimates are not shown this year).

Olivetti Group

Estimates include Olivetti's PC subsidiary, Triumph-Adler, which it acquired in 1986. The estimates do not include its subsidiary Acorn which is shown separately.

Matsushita

Equipment estimates include Matsushita's subsidiaries, Panasonic and JVC, which manufacture equipment in Europe. It does not include the equipment manufactured by the joint-venture company MB Video.

Philips

Disposed of a major portion of its defense business in Europe to Thomson-CSF at the beginning of 1990. In July 1991, Philips sold the majority of its Information Systems Division (excluding its PC operations) to Digital. These operations have been deducted from our estimates. The estimates include all companies in which Philips has a controlling interest and, therefore, they exclude Bang & Olufsen and Whirlpool International.

Philips estimates have been strongly influenced by a large exchange fluctuation in US dollars to gulden for 1991 over 1990.

Sagem

Equipment estimates represent the consolidated sales of Sagem, and not just those of the parent company.

Sextant Avionique

A joint venture formed between Aerospatiale and Thompson-CSF in 1989. Aerospatiale transferred Crouzet, Sfena and ESA to the new company, while Thomson-CSF transferred its general avionics division. Its revenue was made up of the following: civil aviation (27 percent), military aviation (20 percent), helicopter and space (20 percent) components (33 percent).

Siemens

Estimates include the activities of Siemens-Nixdorf Information Systems (SNI) which was founded by the merger of Siemens' and Nixdorf's computer divisions in January 1990. Siemens also acquired the defense activities of Plessey which are included in the estimates, but excluded from the estimates is Bosch-Siemens Hausgerate's estimates (shown separately). The estimates include captive sales to Siemens from Siemens Components (believed to account for 30 percent of Siemens' total demand.

STC

Sold its controlling interest in ICL to Fujitsu. Later, STC was taken over and incorporated into Northern Telecom.

Sony

Estimates are derived from its TV and VCR production in the United Kingdom, Germany, and Spain.

Thomson Consumer Electronics (TCE)

A subsidiary of Thomson SA, split out for the first time this year. TCE's products are mainly marketed under the brands Thomson, Telefunken, RCA, Nordmende, General Electric, SABA and Ferguson.

Over one-third of TCE's workforce is located in Asia with production facilities in Singapore, Malaysia, Thailand, Indonesia, Hong Kong, Taiwan and China. Most of TCE's Audio and Communication Group's products are manufactured in Asia. For this reason a large part of TCE's production and consumption is outside Europe.

Thomson-CSF

A subsidiary of Thomson SA, split out for the first time this year. Thomson-CSF general avionics division is not included in these estimates as it was transferred to Sextant Avionique in 1989. Sextant Avionique has been shown separately.

Tulip Computers

Manufactures PCs in the Netherlands and has recently announced plans to expand its production facility there. At the moment, Tulip subcontracts its manufacture of motherboards.

Table 1

European Companies' Semiconductor Consumption Worldwide in 1991 (Millions of Dollars)

Company	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro.	MOS Logic	Linear	Discrete	Opto.
AB Electronics	18	14	1	10	3	4	4	4	3	3
Acorn	18	17	2	14	7	4	3	1	1	0
AEG	66	46	3	28	6	11	11	16	16	4
Aerospatiale	22	18	4	10	3	2	4	5	3	1
Alcatel	444	346	19	231	58	94	79	96	64	34
Amstrad	98	81	6	56	24	18	14	19	13	4
Apricot	12	11	1	9	5	3	2	1	0	0
ASCOM	104	77	5	50	12	20	18	22	19	8
Asea Brown Boveri	77	47	5	28	4	12	12	14	24	6
Bang & Olufsen	18	13	0	5	2	2	1	7	5	1
Bayer	31	30	3	25	12	7	6	2	1	1
Bosch	669	493	18	345	49	126	171	130	134	42
Bosch-Siemens	133	91	3	37	12	17	8	52	36	6
British Aerospace	33	27	5	14	5	3	6	7	5	1
Bull	211	198	20	163	78	45	39	15	7	6
Electrolux	46	31	1	13	4	6	3	18	12	2
Ericsson	222	173	10	115	29	46	40	48	32	17
GEC	231	153	23	85	19	31	35	45	61	16
GPT	152	119	6	79	20	32	27	33	22	12
Grundig	319	220	7	97	28	42	27	116	84	15
ICL	206	193	19	160	77	44	39	15	6	6
Italtel	88	68	4	46	11	18	16	19	13	7
Lucas	68	49	4	33	5	11	17	12	15	4
Matra Communication	36	28	2	19	5	8	6	8	5	3
Nokia Group	243	172	8	86	24	37	25	77	58	14
Olivetti	403	377	37	309	147	87	75	31	14	12
Philips	963	661	34	317	92	135	90	310	251	52
Racal Electronics	46	34	4	21	5	8	8	10	8	3
Rank Xerox	48	45	5	37	18	10	9	3	1	1
Sagem	52	43	3	30	10	11	10	10	6	3
Schlumberger	139	101	11	68	22	24	22	21	29	9
Sextant Avionique	11	9	2	5	2	1	2	2	2	0
Siemens	1,025	810	68	576	186	199	192	166	153	62
Thomson Consumer	272	187	6	78	25	35	18	103	72	12
Thomson-CSF	96	78	15	42	14	10	18	20	15	3
Tulip	20	19	2	15	7	4	4	1	1	1
Total	$6,639	$5,079	$365	$3,256	$1,029	$1,167	$1,059	$1,460	$1,190	$372

Source: Dataquest (November 1991)

Table 2

Worldwide Companies' Semiconductor Consumption in Europe 1991
(Millions of Dollars)

Company	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro.	MOS Logic	Linear	Discrete	Opto.
AB Electronics	18	14	1	10	3	4	4	3	3	1
Acorn	18	17	2	14	7	4	3	1	1	0
AEG	47	32	2	17	5	7	6	12	12	3
Aerospatiale	22	18	4	10	3	2	4	5	3	1
Alcatel	373	291	16	194	48	79	67	81	53	29
Amstrad	93	77	6	52	22	17	13	19	13	4
Apple	96	90	9	75	36	21	18	6	3	3
Apricot	12	11	1	9	5	3	2	1	0	0
ASCOM	96	72	5	47	11	19	17	20	16	7
Asea Brown Boveri	61	37	4	22	3	9	9	11	18	5
Bang & Olufsen	18	13	0	5	2	2	1	7	5	1
Bayer	25	24	2	20	9	5	5	2	1	1
Bosch	500	369	13	259	36	94	128	97	100	31
Bosch-Siemens	133	91	3	37	12	17	8	52	36	6
British Aerospace	33	27	5	14	5	3	6	7	5	1
Bull	105	98	10	81	39	22	20	8	3	3
Commodore	78	74	7	61	30	17	15	5	2	2
Compaq	20	20	0	20	20	0	0	0	0	0
Digital	47	43	4	34	15	10	9	5	2	2
Electrolux	31	21	1	9	3	4	2	12	9	1
Ericsson	198	155	9	103	26	41	36	42	29	15
GEC	181	120	18	67	15	24	27	35	48	13
Goldstar	33	22	1	9	3	4	2	13	9	1
GPT	120	93	5	62	16	25	21	26	17	9
Grundig	302	208	7	92	26	40	25	109	80	14
Hewlett-Packard	151	138	14	112	53	32	28	12	8	5
Hitachi	55	38	1	15	5	7	3	21	15	2
IBM	938	886	90	733	355	201	176	63	27	25
ICL	187	175	18	145	70	40	35	13	6	5
Italtel	88	68	4	46	11	18	16	19	13	7
Lucas	50	36	2	25	3	8	13	9	11	3
Matra Communication	36	28	2	19	5	8	6	8	5	3
Mitsubishi	42	29	1	12	4	5	3	16	11	2
NCR	66	62	6	52	25	14	12	4	2	2
Nokia Group	216	152	7	77	21	33	22	69	51	12
Olivetti	358	335	33	275	131	77	67	27	12	11
Matsushita	205	143	5	62	21	27	14	75	53	9
Philips	583	394	19	181	49	80	52	194	157	32
Racal Electronics	38	29	3	18	5	7	7	8	7	3

(Continued)

Table 2 (Continued)

Worldwide Companies' Semiconductor Consumption in Europe 1991
(Millions of Dollars)

Company	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro.	MOS Logic	Linear	Discrete	Opto.
Rank Xerox	48	45	5	37	18	10	9	3	1	1
Sagem	52	43	3	30	10	11	10	10	6	3
Schlumberger	95	69	8	47	16	16	15	14	20	6
Sextant Avionique	11	9	2	5	2	1	2	2	2	0
Siemens	786	637	55	463	163	154	146	118	105	45
Sony	94	64	2	26	8	12	6	36	25	4
Thomson Consumer	167	115	4	48	15	22	11	63	44	8
Thomson-CSF	96	78	15	42	14	10	18	20	15	3
Toshiba	47	33	1	15	5	6	3	17	12	2
Tulip	20	19	2	15	7	4	4	1	1	1
Total	$7,087	$5,662	$436	$3,821	$1,417	$1,279	$1,125	$1,405	$1,077	$348
Total European Semi. Consumption	$10,828	$8,683	$489	$5,776	$2,094	$2,219	$1,463	$2,418	$1,750	$395
Percentage of Total European Market	65.5%	65.2%	89.2%	66.1%	67.7%	57.6%	76.9%	58.1%	61.6%	88.1%

Source: Dataquest (November 1991)

Table 3

Worldwide Companies' Semiconductor Consumption in Europe 1991 (Millions of Dollars)

Company	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro.	MOS Logic	Linear	Discrete	Opto.
IBM	938	886	90	733	355	201	176	63	27	25
Siemens	786	637	55	463	163	154	146	118	105	45
Philips	583	394	19	181	49	80	52	194	157	32
Bosch	500	369	13	259	36	94	128	97	100	31
Alcatel	373	291	16	194	48	79	67	81	53	29
Olivetti	358	335	33	275	131	77	67	27	12	11
Grundig	302	208	7	92	26	40	25	109	80	14
Nokia Group	216	152	7	77	21	33	22	69	51	12
Matsushita	205	143	5	62	21	27	14	75	53	9
Ericsson	198	155	9	103	26	41	36	42	29	15
ICL	187	175	18	145	70	40	35	13	6	5
GEC	181	120	18	67	15	24	27	35	48	13
Thomson Consumer	167	115	4	48	15	22	11	63	44	8
Hewlett-Packard	151	138	14	112	53	32	28	12	8	5
Bosch-Siemens	133	91	3	37	12	17	8	52	36	6
GPT	120	93	5	62	16	25	21	26	17	9
Bull	105	98	10	81	39	22	20	8	3	3
ASCOM	96	72	5	47	11	19	17	20	16	7
Thomson-CSF	96	78	15	42	14	10	18	20	15	3
Apple	96	90	9	75	36	21	18	6	3	3
Schlumberger	95	69	8	47	16	16	15	14	20	6
Sony	94	64	2	26	8	12	6	36	25	4
Amstrad	93	77	6	52	22	17	13	19	13	4
Italtel	88	68	4	46	11	18	16	19	13	7
Commodore	78	74	7	61	30	17	15	5	2	2
NCR	66	62	6	52	25	14	12	4	2	2
Asea Brown Boveri	61	37	4	22	3	9	9	11	18	5
Hitachi	55	38	1	15	5	7	3	21	15	2
Sagem	52	43	3	30	10	11	10	10	6	3
Lucas	50	36	2	25	3	8	13	9	11	3
Rank Xerox	48	45	5	37	18	10	9	3	1	1
Toshiba	47	33	1	15	5	6	3	17	12	2
Digital	47	43	4	34	15	10	9	5	2	2
AEG	47	32	2	17	5	7	6	12	12	3
Mitsubishi	42	29	1	12	4	5	3	16	11	2
Racal Electronics	38	29	3	18	5	7	7	8	7	3
Matra Communication	36	28	2	19	5	8	6	8	5	3
British Aerospace	33	27	5	14	5	3	6	7	5	1
Goldstar	33	22	1	9	3	4	2	13	9	1

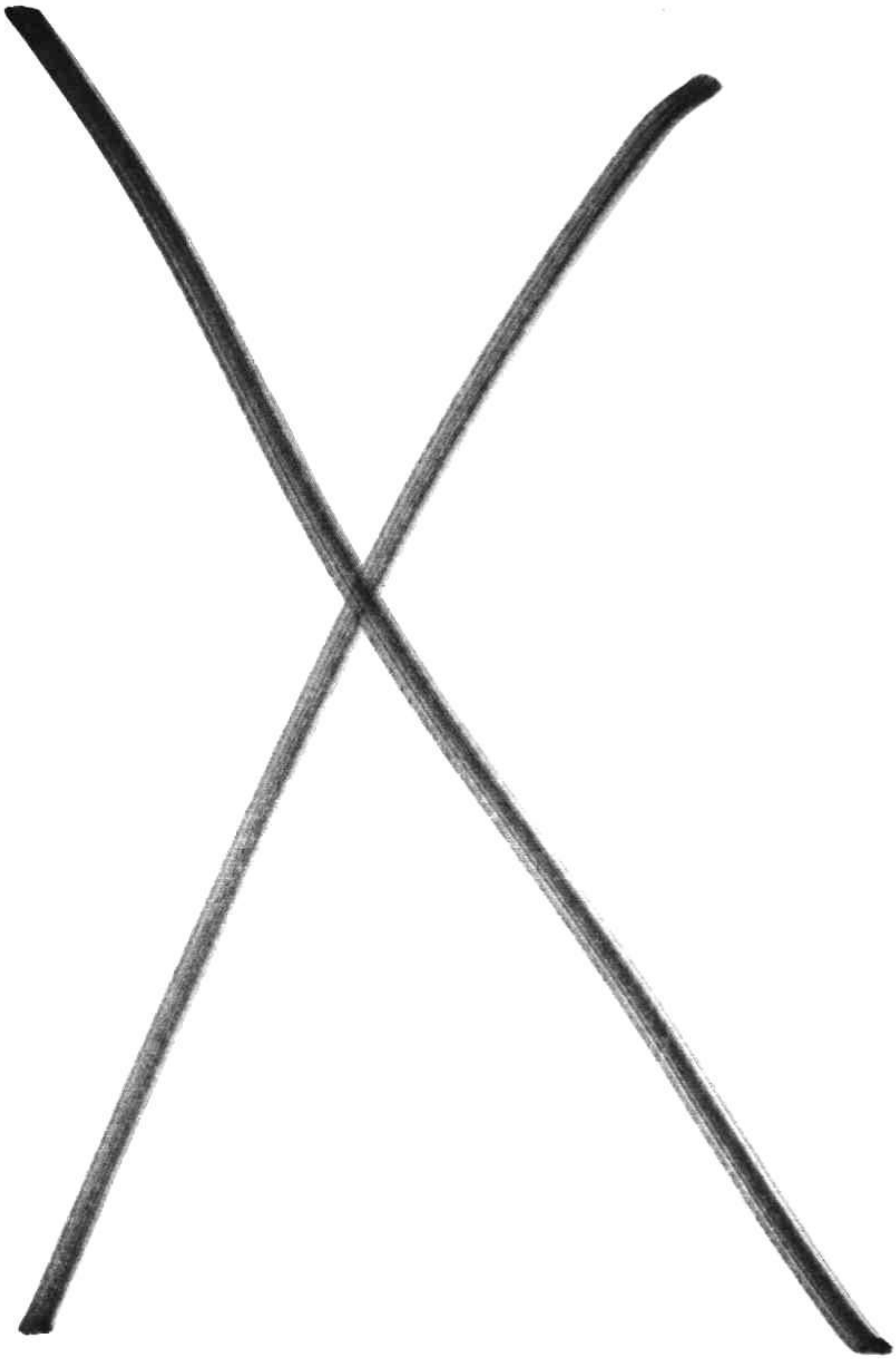
(Continued)

Table 3 (Continued)

Worldwide Companies' Semiconductor Consumption in Europe 1991
(Millions of Dollars)

Company	Total Semi.	Total IC	Digital Bipolar	Total MOS	MOS Memory	MOS Micro.	MOS Logic	Linear	Discrete	Opto.
Electrolux	31	21	1	9	3	4	2	12	9	1
Bayer	25	24	2	20	9	5	5	2	1	1
Aerospatiale	22	18	4	10	3	2	4	5	3	1
Compaq	20	20	0	20	20	0	0	0	0	0
Tulip	20	19	2	15	7	4	4	1	1	1
Bang & Olufsen	18	13	0	5	2	2	1	7	5	1
Acorn	18	17	2	14	7	4	3	1	1	0
AB Electronics	18	14	1	10	3	4	4	3	3	1
Apricot	12	11	1	9	5	3	2	1	0	0
Sextant Avionique	11	9	2	5	2	1	2	2	2	0
Total	$7,087	$5,662	$436	$3,821	$1,417	$1,279	$1,125	$1,405	$1,077	$348

Source: Dataquest (November 1991)



5. Services and Suppliers to the Semiconductor Industry

INTRODUCTION

This service section specifically deals with the European aspects of services and suppliers of the semiconductor industry. For the purposes of specific discussion on individual areas, this document is divided into five main segments:

- Equipment
- Materials
- Wafer Fabrication Services
- Assembly Services
- Test Services

EQUIPMENT

Until the early 1980s, the equipment market in Europe was dominated primarily by United States-owned companies, and to a lesser extent, by the Japanese. Much of this was the result of two factors: the relatively small European-owned semiconductor manufacturing base and the fact that the United States- and Japanese-owned semiconductor companies with manufacturing facilities in Europe have tended to use the same equipment there as in their U.S. or Japanese counterparts.

During the mid-1980s, three forces had a dramatic global impact on the semiconductor equipment industry. The first was the downturn in worldwide IC demand. The second was the shift toward megabit and submicron memory technology. The third was the ASIC revolution. As a result of the downturn in IC demand, a parallel downturn occurred in semiconductor equipment demand. The same rationalization and merger phenomena that affected the semiconductor manufacturers also affected semiconductor equipment manufacturers. Previous market leaders emerged with smaller market share, and Japanese, U.S., and European equipment manufacturers were forced to explore markets far beyond local boundaries. Antiprotectionist measures and trade agreements are forcing the opening of local markets. European wafer fabrication, assembly, and test equipment manufacturers stand poised to take advantage of opportunities associated with free market conditions.

Traditionally, European engineering and innovation are second to none. With the push in memory fabrication toward smaller and smaller critical dimensions, European equipment manufacturers in the areas of lithography, plasma, implant, and inspection have been launching state-of-the-art products to capitalize on these areas of manufacture. Examples are companies such as AET, Electrotech, Heidelberg Instruments, Helmut Seier, High Voltage Engineering, Oxford Instruments, and Plasma Technology. See Table 1 for further listings of European equipment manufacturers.

5. Services and Suppliers to the Semiconductor Industry

Table 1

Equipment and Materials Companies of Europe—by Company

Company	Location	Product Area
AET	France	Plasma etch equipment, RTP
Advanced Semiconductor Materials (ASM)	Netherlands	Furnaces, plasma-enhanced CVD, assembly equipment
Alcatel	France	Plasma etch, sputtering equipment, pumps, vertical furnaces
Align-rite	United Kingdom	Maskmaking
Alphasem	Switzerland	Wafer saws, assembly equipment
Applied Materials	United Kingdom	Implanters
Balzers Aktiengesellschaft	Liechtenstein	Etch equipment, implanters, CVD
BOC	United Kingdom	Gases
COSY Microtec	Germany	SOR ring for X-ray lithography
CSEM	Switzerland	Maskmaking
Cambridge Instruments	United Kingdom	E-beam, inspection systems
Centrotherm	Germany	Diffusion, CVD systems
Compugraphics	United Kingdom	Maskmaking
Convac	Germany	Track equipment, microscope loaders
Cryophysics	Switzerland	Cryopumps
DNS	Italy	Silicon wafers
Deltest	United Kingdom	Engineering test equipment

(Continued)

Table 1 (Continued)

Equipment and Materials Companies of Europe—by Company

Company	Location	Product Area
ESEC	Switzerland	Assembly equipment
Edwards High Vacuum International	United Kingdom	CVD, vacuum pumps
Electrotech	United Kingdom	Etch, CVD, sputter systems
Ernst Leitz	Germany	Inspection equipment, mask comparators, optics
Eurotherm	United Kingdom	Controllers
Farco	Switzerland	Assembly equipment
G. Wirz	Switzerland	Assembly equipment
GE Solid State	Belgium	Maskmaking
Heidelberg Instruments	Germany	Measurement and inspection systems
Helmut Seier	Germany	Furnaces, laminar flow, CVD systems
High Voltage Engineering	Netherlands	Implanters
Hoechst	Germany	Chemicals, resists, gases
Holec	Netherlands	Furnaces
ICI	United Kingdom	III-V semiconductor materials
Karl Suss	Germany	Proximity aligners, X-ray systems
L'Air Liquide	France	Gases
La Porte Industries	United Kingdom	Chemicals, clean room equipment

(Continued)

Table 1 (Continued)

Equipment and Materials Companies of Europe—by Company

Company	Location	Product Area
Laufer	Germany	Molding presses
Leibold-Heraeus	Germany	Quartz, wafer-handling equipment, pumps, sputtering equipment, plasma etchers
Loadpoint	United Kingdom	Wafer saws
MEM	Switzerland	Maskmaking
MTL ATE Systems	United Kingdom	High-pin-count testers
Merck	Germany	Chemicals, chemical systems, resists
Micro-Image Technology	United Kingdom	Resists
Monsanto	United Kingdom	Silicon wafers
Nanomask	France	Maskmaking
Nordiko	United Kingdom	Plasma etchers, sputtering equipment
Okmetic	Finland	Silicon wafers
Oxford Instruments	United Kingdom	X-ray, ion-beam lithography
Philips Semiconductor Product Equipment	Netherlands	Photolithography equipment, E-beam equipment
Plasma Technology	United Kingdom	Plasma etch equipment
Plasmos	Germany	CVD equipment
Rhône-Poulenc	France	Chemicals, gases
Robert Bosch	Germany	Assembly equipment
SEH	United Kingdom	Silicon wafers

(Continued)

5. Services and Suppliers to the Semiconductor Industry

Table 1 (Continued)

Equipment and Materials Companies of Europe—by Company

Company	Location	Product Area
SEMY Engineering	France	CVD systems
Semas	Switzerland	Assembly equipment, photolithography systems
Sitesa	Switzerland	CVD systems
Society Electrothermique de la Tour de France	Switzerland	Quartz
Sofiltra	France	HEPA (high-efficiency particle arresting) filters
Topsil	Denmark	Silicon wafers
VG Semicon	United Kingdom	Chemical-beam epitaxy, etch systems
Vickers Instruments	United Kingdom	Measurement and inspection systems
Wacker Chemitronic	Germany	Silicon wafers
Wellman Furnaces	United Kingdom	Diffusion equipment
Western Equipment Developments Ltd.	United Kingdom	Wafer-handling robots
Wild Leitz	Switzerland	Optics
Zeiss	Germany	Optics, inspection equipment

Source: Dataquest
April 1988

5. Services and Suppliers to the Semiconductor Industry

The ASIC explosion puts other pressures on semiconductor equipment manufacturers. In wafer fab, assembly, and test, equipment must prove flexible and able to handle many different types of product in short time spans. These demands are far different from the high-volume, one-product lines of old. Just-in-time supply also applies pressures for less rework, quick cycle times, and diminished processing queues (which decreases line inventory). All these factors push equipment suppliers to produce light, flexible, small-footprint machinery. Advanced Semiconductor Materials (ASM) and Philips, long-time European suppliers of a range of fab, assembly, and test equipment, have increased their presence worldwide in all three areas over the recent past.

In the European region, Japanese equipment suppliers are increasing their local presence in sales, marketing, and support, but no product development takes place in Europe at the present. The areas in which Japanese companies are aggressively pursuing market share are lithography and assembly equipment. Nikon is actively competing with ASM of Europe and GCA of the United States for European stepper market share. The push of Shinkawa in bonding equipment and Disco in wafer saws probably reflects the large number of Japanese IC assembly/test facilities in Europe. As the Japanese build more wafer fabrication facilities in Europe, Dataquest expects to see the amount of Japanese equipment installed rise in the region.

U.S. equipment companies historically have had a strong commercial and product development base in Europe. Examples are Applied Materials, who do their worldwide implant development in the United Kingdom, and Perkin-Elmer, who purchased Censor, the Liechtenstein-based wafer stepper company.

Another recent trend appears to be the reverse of this, with European ownership of U.S. companies. Examples are Ion Beam Technology (IBT) of Massachusetts (majority-owned by Dubilier PLC, United Kingdom and Robert Flemming, United Kingdom), and Branson/IPC of California (owned by Emerson Electronics, United Kingdom). Branson/IPC makes plasma etch equipment, and IBT, a focused ion-beam system. Though presently used for the repair of photomasks (by depositing or etching out defects), ultimately the IBT system, which offers write, etch, and deposit capabilities, has great potential for a completely maskless wafer fabrication process.

Table 2 shows the major European equipment companies by country.

5. Services and Suppliers to the Semiconductor Industry

Table 2

Equipment and Materials Companies of Europe—by Country

Country	Company	Product Area
Belgium	GE Solid State	Maskmaking
Denmark	Topsil	Silicon wafers
Finland	Okmetic	Silicon wafers
France	AET	Plasma etch equipment, RTP
	Alcatel	Plasma etch, sputtering equipment, pumps, vertical furnaces
	L'Air Liquide	Gases
	Nanomask	Maskmaking
	Rhône-Poulenc	Chemicals, gases
	SEMY Engineering	CVD systems
	Sofiltra	HEPA (high-efficiency particle arresting) filters
Germany	COSY Microtec	SOR ring for X-ray lithography
	Centrotherm	Diffusion, CVD systems
	Convac	Track equipment, microscope loaders
	Ernst Leitz	Inspection equipment, mask comparators, optics
	Heidelberg Instruments	Measurement and inspection systems
	Helmut Seier	Furnaces, laminar flow, CVD systems

(Continued)

Table 2 (Continued)

Equipment and Materials Companies of Europe—by Country

Country	Company	Product Area
Germany	Hoechst	Chemicals, resists, gases
	Karl Suss	Proximity aligners, X-ray systems
	Laufer	Molding presses
	Leibold-Heraeus	Quartz, wafer handling equipment, pumps, sputtering equipment, plasma etchers
	Merck	Chemicals, chemical systems, resists
	Plasmos	CVD equipment
	Robert Bosch	Assembly equipment
	Wacker Chemitronic	Silicon wafers
	Zeiss	Optics, inspection equipment
Italy	DNS	Silicon wafers
Liechtenstein	Balzers Aktiengesellschaft	Etch equipment, implanters, CVD
Netherlands	Advanced Semiconductor Materials (ASM)	Furnaces, plasma-enhanced CVD, assembly equipment
	High Voltage Engineering	Implanters
	Holec	Furnaces
	Philips Semiconductor Product Equipment	Photolithography equipment, E-beam equipment
Switzerland	Alphasem	Wafer saws, assembly equipment

(Continued)

Table 2 (Continued)

Equipment and Materials Companies of Europe—by Country

Country	Company	Product Area
Switzerland	CSEM	Maskmaking
	Cryophysics	Cryopumps
	ESEC	Assembly equipment
	Farco	Assembly equipment
	G. Wirz	Assembly equipment
	MEM	Maskmaking
	Semas	Assembly equipment, photolithography systems
	Sitesa	CVD systems
	Society Electrothermique de la tour de France	Quartz
	Wild Leitz	Optics
United Kingdom	Align-rite	Maskmaking
	Applied Materials	Implanters
	BOC	Gases
	Cambridge Instruments	E-beam, inspection systems
	Compugraphics	Mask maker
	Deltest	Engineering test equipment
	Edwards High Vacuum International	CVD, vacuum pumps
	Electrotech	Etch, CVD, sputter systems
	Eurotherm	Controllers

(Continued)

Table 2 (Continued)

Equipment and Materials Companies of Europe—by Country

Country	Company	Product Area
United Kingdom	ICI	III-V semiconductor materials
	La Porte Industries	Chemicals, clean room equipment
	Loadpoint	Wafer saws
	MTL ATE Systems	High-pin-count testers
	Micro-Image Technology	Resists
	Monsanto	Silicon wafers
	Nordiko	Plasma etchers, sputtering equipment
	Oxford Instruments	X-ray, ion-beam lithography
	Plasma Technology	Plasma etch equipment
	SEH	Silicon wafers
	VG Semicon	Chemical-beam epitaxy, etch systems
	Vickers Instruments	Measurement and inspection systems
	Wellman Furnaces	Diffusion equipment
	Western Equipment Developments Ltd.	Wafer-handling robots

Source: Dataquest
April 1988

5. Services and Suppliers to the Semiconductor Industry

MATERIALS

Key supply areas of semiconductor materials in Europe are the following:

- Gases (bulk and specialty)
- Wet process chemicals
- Photoresists and related chemicals
- Silicon and III-V substrates
- Masks and reticles

(Tables 1 and 2 list key European suppliers in the above categories).

The materials situation in Europe has evolved significantly in the recent past. Large European industrial chemical and gas supply firms have begun to develop products of suitable purity for semiconductor use and are joining the traditionally strong European suppliers in a search for market share in the region. Due to shipment and supply problems related to chemicals and gases, the manufacturers often dominate in market share, and this is true in Europe. Historically, BOC, Hoechst, L'Air Liquide, and Merck, have supplied large quantities of chemicals, photoresists, and gases to local semiconductor manufacturers. Aggressively competing with them are Du Pont, ICI, La Porte, Olin-Hunt, and Rhône-Poulenc.

Silicon production in Europe is dominated primarily by Monsanto of the United States and Wacker of Germany, although local suppliers such as DNS (Italy), Okmetic (Finland), and Topsil (Denmark) are striving for market share. Shin-Etsu-Handotai (SEH) is the only Japanese manufacturer of silicon to have a production facility in Europe. SEH and Monsanto have facilities that produce silicon wafers in the United Kingdom

The ASIC revolution has stimulated the local requirement for masks and reticles in Europe. Several European and U.S. suppliers of masks exist in the region, and semiconductor manufacturers that have in-house maskmaking facilities are offering spare capacity as a service (see Tables 1 and 2 for lists of maskmaking facilities).

WAFER FABRICATION SERVICES

No significant independent wafer fabrication companies, the so-called silicon foundries, exist in Europe today. On a limited scale, some merchant manufacturers will make their capabilities available to third parties, usually on a customer-owned tooling (COT) basis. But the conditions for large foundry-only facilities, such as Taiwan Semiconductor Manufacturing Company, will probably not exist in Europe in the near future. A number of smaller companies are making foundry facilities available, such as Elmos in Germany and MEM in Switzerland. The high costs involved in setting up even a pilot line for modern wafer fabrication are such that a relatively high throughput of material is required for viability. Labor costs in Europe may make major foundry exercises prohibitive.

Nearly all semiconductor component users would ideally like an ASIC facility. However, few are prepared to pay the associated overhead costs brought by the low-volume throughput and the costs for equipping and running a state-of-the-art capability (1.5- to 2-micron, double-layer metal CMOS). We do not believe that anything other than a state-of-the-art facility would be worth the capital investment, and many semiconductor users do not have sophisticated enough knowledge or experience of ASIC manufacture to make this a viable option.

ASSEMBLY SERVICES

Two companies offer subcontract assembly services in the European region: Eurasem in the Netherlands and Indy in Scotland. The Indy European management team just purchased the facility in Scotland from Indy/Olin Hunt in the United States. Indy specializes in high-pin-count, high-reliability, quick-turnaround packaging for the ASIC market. Eurasem pursues the more traditional high-volume assembly scenario.

The reason that more high-volume assembly services are not in Europe is that high volume assembly is best carried out in low-labor-cost areas, such as the Far East. Manufacturing automation can lower labor costs, and, as assembly automation has increased, there are some incentives to perform assembly in the European Economic Community (EEC). Another incentive is a substantial saving in import duty. For a non-European-manufactured wafer, the present import duty on a semiconductor device assembled outside the EEC is approximately 14 percent. For a wafer imported into the EEC, the duty rate is approximately only 4 percent. An incremental 10 percent duty can therefore be saved by assembly within the EEC. Dataquest believes that this differential is actually harmful to Europe in that it effectively encourages low-technology assembly operations to be set up and discourages investment in the high-technology areas of wafer fabrication.

TEST SERVICES

Currently, no market exists in Europe for large independent semiconductor testing houses. Dataquest believes that this is a direct result of the lack of independent assembly houses and the need for manufacturers to carry out their own testing for both cost and engineering reasons.

In the area of component evaluation or qualification, some independent houses exist, such as Elektronik Centralen (Denmark), and MTL Microtesting Limited (United Kingdom), but these are geared more to the user community than to the merchant component suppliers. In the testing area, testing costs and engineering information are the two key issues. The former demands high-volume throughputs; the latter demands easy and direct interface by the relevant design and product engineers. This virtually demands that test equipment be located either at the point of assembly (high-volume force) or near the relevant engineering establishments (technical force).

There are, however, some advantages to outside testing. These include:

- Testing and evaluation by an unbiased source
- Access to wider range of test experience
- Software availability
- Supplementary capacity (particularly in a capacity crunch or for incremental shipment opportunity)
- Access to more up-to-date equipment
- Access to equipment not currently in-house

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Air Products and Chemicals, Inc.

BACKGROUND AND OVERVIEW

Air Products and Chemicals, Inc., (Air Products) was founded in 1940 in the United States (Detroit, Michigan). Initially, the Company was involved in constructing small industrial gas plants on or adjacent to a consumer's plant, delivering products by pipeline.

Since its inception, Air Products has become a large international company with annual worldwide sales exceeding $2.4 billion, employing approximately 13,000 persons in 21 countries. The Company operates more than 100 plants, and has 5 research centers.

Air Products operates in the following three business segments:

- Industrial Gases
- Chemicals
- Equipment and Technology

In 1989, the Company reported worldwide sales of $2.4 billion, of which 76 percent was generated in the United States and 21 percent in Europe. Worldwide sales of the Industrial Gases segment reached $1.4 billion, representing 58 percent of total sales. The Chemicals segment accounted for 34 percent of sales, with revenue of $834 million; the Equipment and Technology segment accounted for 8 percent of sales, at $195 million. These record sales for 1988, which showed an increase of 14 percent over 1987, were accompanied by a record operating income of $376 million, an increase of 15 percent over 1987.

Worldwide capital expenditure in 1988 amounted to $542 million, and of this sum, approximately $300 million was capital spending in the Industrial Gases segment. In Europe, nearly $150 million was invested, surpassing the record of the past several years. The acquisition of a 65 percent interest in L'Oxygene Liquide, an important regional supplier in France, was included in this European total for the year. This acquisition bolsters Air Products' coverage of the French market and complements the operations of Prodair, the Company's French subsidiary and the country's second-largest producer of industrial gases.

In 1988, the Company began construction of a large-scale air-separation plant in Strasbourg, France. This plant is being built in partnership with a German industrial gas producer and will supply gaseous oxygen via a pipeline across the Rhine to a steel mill in West Germany. It will supply liquid products for customers in northeastern France and the southern part of West Germany also. This plant is scheduled to begin operations in 1990.

Air Products also completed the successful start-up of Europe's first commercial-scale liquid hydrogen plant in Rozenburg, The Netherlands; substantial additional capacity was added for liquid oxygen, nitrogen, and argon. In the United Kingdom, construction was completed on an air-separation facility that will supply gaseous oxygen and nitrogen to British Petroleum and liquid products to the merchant market including ultrahigh-purity gases for electronic applications.

Air Products and Chemicals, Inc.

Air Products has continued to expand strategically in the Pacific Rim through increased investments. The Company entered the Malaysian market through the purchase of a 30 percent interest in an existing supplier. Expansion of this joint venture is already under way, with the construction of an 80-ton-per-day merchant plant, which is expected to be on-stream in 1990. In Thailand, Air Products is building an air-separation plant for the country's National Petroleum Company, Ltd., as well as liquid products for the merchant market. The expansions in Malaysia and Thailand both use cryogenic equipment supplied by Air Products.

During 1988, the Company expanded opportunities in chemicals by completing a number of strategic acquisitions. The largest was Anchor Chemical Group plc, a British company that is a leading worldwide supplier of epoxy curatives. This $47 million acquisition significantly accelerated the Company's penetration of the epoxy additives market, where the strategy is to extend commercial and technical strengths in amines and polyurethane catalysts.

The Company also acquired the Valchem Division of United Merchants and Manufacturers Inc., thus providing the Company with a new line of water-based acrylic products and positioning itself to take advantage of the trend toward water-based polymer systems.

Operations

Air Products is located in the United States in Allentown, Pennsylvania. This location also houses the headquarters. The three operating divisions are described briefly in the following paragraphs.

Industrial Gases

This segment produces and sells a variety of industrial, medical, and specialty gases for the microelectronics industry and other industries. Worldwide, the division operates more than 100 plants.

Chemicals

The Chemicals division has numerous plants throughout the United States. It has three principal product lines—polymers, polyurethane intermediates and additives, and amines and specialty additives, including epoxy curatives.

Equipment and Technology

The equipment side of the segment designs and manufactures various lines of cryogenic and gas-processing equipment, builds components for cogeneration facilities, and markets proprietary wastewater treatment technologies and systems. The technology side of this segment includes the Company's initiatives in ceramic-coated products and other advanced materials.

Air Products and Chemicals, Inc.

International Operations

The European and U.K. headquarters, Air Products plc, is located at Hersham, Walton–on–Thames, England. This subsidiary was established in Britain in 1957; it employs approximately 2,000 persons and operates in more than 30 locations.

The principal manufacturing base in the United Kingdom for specialty gases serving the microelectronics industry is at Crewe, with storage depots and sales offices sited strategically throughout the country. An engineering facility for high–quality piping for clean rooms to Class 10,000 specification and Class 100 workbenches is located at Acrefair in Wales. A specific feature of this facility is two mobile clean rooms.

In Europe, there are numerous production plants for the manufacture of nitrogen, oxygen, and hydrogen. The specialty gases facility is located at Keumiee in Belgium. The Company manufactures gas cabinets at Woluwe, near Brussels in Belgium, at the Company's dedicated clean–room facility, constructed to the same high standard as the facility in Wales.

Air Products has regional headquarters at the following locations in Western Europe:

- Belgium—Air Products SA, Brussels
- France—Prodair, Paris
- Netherlands—Air Products Nederland BV, AG, Waddinxveen
- West Germany—Air Products GmbH, Dusseldorf

European operations also include companies in Austria and Italy. In Norway and Spain, the Company has local agents acting on its behalf.

In Korea, Air Products has joined forces with Korea Industrial Gases Ltd. to supply the growing market for industrial gases in that dynamic economy. In addition, a joint venture has been formed with Kinhill Pty in Australia.

Financial

Table 1 gives a worldwide segment sales analysis for the fiscal years 1986 through 1988, ending December 31.

In its 1988 annual report, the Company notes that sales of industrial gases at $1,403 million reached a new record and were 12 percent above those of the previous year. The Company attributes this increase to higher shipments of merchant and on–site gases in all geographic locations in addition to the favorable effect of European currency translation. Using the Company's estimate that the worldwide market for gases is approximately $14 billion, Dataquest estimates Air Products' share to be about 10 percent.

Table 1

Air Products and Chemicals, Inc.
Worldwide Sales Revenue by Business Segment
(Millions of Dollars)

Segment	1986	1987	1988
Industrial Gases	$1,166	$1,255	$1,403
Chemicals	632	664	834
Equipment and Technology	144	213	195
Total	$1,942	$2,132	$2,432

Source: Air Products and Chemicals, Inc.
Annual Report 1988
Dataquest
June 1989

Sales of chemicals increased 26 percent to $834 million. The Company notes that volume rose 4 percent in 1988, as records were attained in most product lines. The increase also reflects higher pricing for most products and sales of Anchor Chemical, which was acquired in January 1988. Anchor accounted for 8 percent of the increase.

Equipment and technology sales declined $18 million to $195 million. This was primarily a result of the high level of activity in fiscal year 1987 associated with the construction of an industrial cogeneration facility sold to an unconsolidated affiliate. If this item is excluded, sales in this segment were higher than the previous year.

Table 2 summarizes Air Products' worldwide operating income by business segment. The figures in Table 2 show that the operating income for the Industrial Gases segment in 1988 increased $18 million over the previous year. This was a record and reflects higher worldwide shipments, stronger European currencies, and lower pension expenses.

The Chemicals segment showed an operating income at an all-time high of $103 million, an increase of 22 percent over 1987. Better pricing in commodity chemicals was the major factor in these improved results. Other factors included higher shipments in most product lines and a first-time profit contribution from Anchor Chemical.

The Equipment and Technology segment showed an operating income of $3 million, a very considerable improvement on the previous loss of $18 million.

Table 2

Air Products and Chemicals, Inc.
Worldwide Operating Income by Business Segment
(Millions of Dollars)

Segment	1986	1987	1988
Industrial Gases	$257	$288	$306
Chemicals	41	85	103
Equipment and Technology	(18)	(18)	3
Corporate and Other	(39)	(27)	(36)
Total	$241	$328	$376

Source: Air Products and Chemicals, Inc.
Annual Report 1988
Dataquest
June 1989

Table 3 summarizes sales and operating income by geographic area. It shows that in 1988, sales in the United States improved by 11 percent and operating income by 15 percent. The gains were very dramatic in Europe, with sales showing an increase of nearly 28 percent over those of 1987 and operating income increasing by 27 percent.

Table 3

Air Products and Chemicals, Inc.
Sales and Operating Income by Geographic Region
(Millions of Dollars)

	1986		1987		1988	
Region	Sales	Income	Sales	Income	Sales	Income
United States	$1,561	$185	$1,662	$242	$1,849	$279
Europe	322	43	394	66	504	84
Canada and Latin America	59	13	76	14	79	15
Other	-	-	-	6	-	(2)
Total	$1,942	$241	$2,132	$328	$2,432	$376

Source: Air Products and Chemicals, Inc.
Annual Report 1988
Dataquest
June 1989

Research and Development

In 1988, research and development (R&D) expenses were increased 27 percent to a total of $72 million. New chemistry advances were made in polymer, polyurethane, and catalytic systems. In gases, the Company strengthened its program in noncryogenic gas separation technologies and in new market uses and applications for gas products.

PRODUCTS

Air Products offers a comprehensive range of high-quality industrial and specialty gases for use in the manufacture of silicon memory devices. These latter products have greater than 99.9 percent purity. Also, the Company is able to blend gases according to the customer's individual stoichiometric and mass requirements for doping purposes.

For plasma etching, Air Products is able to supply a comprehensive range of gases including sulfur hexafluoride, silicon tetrafluoride, and a number of halocarbons. These can be supplied as pure gases or diluted with small amounts of high-purity oxygen.

Recently, the Company introduced a new line of high-purity organometallics for MOCVD processing. These compounds, all of which are guaranteed to greater than 99.9995 percent, are used primarily in the epitaxial growth of compound semiconductors. A full range of high purity gallium, indium, zinc, and aluminium compounds is available, as well as a comprehensive line of phosphorous adducts for semiconductors.

In addition to gases for the electronics industry, Air Products supplies a range of gas-handling and control equipment. In the area of cryogenics, the Company offers a wide range of laboratory cryogenic systems.

In the area of chemicals, two new adhesives have recently been introduced. These adhesives are Airflex 465 emulsion and Flexcryl acrylic-based emulsions for high-speed packaging and pressure-sensitive adhesive applications. (Airflex and Flexcryl are registered trademarks of Air Products.)

OUTLOOK

An essential element of Air Products' growth strategy, particularly in chemicals, is to add new products through internal development, technology licensing, and acquisitions. Thus, an increasing flow of new products is expected as development programs initiated during the past five years come to fruition and reach the commercial stage.

Significant expansion of the Company's traditional water-based markets for polyvinyl alcohol is expected from thermoplastic polyvinyl grades now being introduced to the market. Air Products sees these products as having potential in water-soluble, biodegradable films, containers, and personal care items.

In electronics, the Company is adopting a strategy directed toward becoming a fully integrated supplier of gases, chemicals, and related systems.

Thus, while industrial gases will no doubt remain central to the Company's business, Air Products is now actively developing a strategy of diversification into other business areas. Those targeted include urethanes, adhesives, coatings, and high-performance polymer systems. The Company views these products with optimism, expecting them to provide exciting growth prospects as Air Products enters the 1990s.

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Austria Mikro Systeme International GmbH

BACKGROUND AND OVERVIEW

Austria Mikro Systeme International GmbH (AMS), formerly Austria Microsystems International (AMI), was set up in 1981 as a joint venture between the company that was then called Gould-American Microsystems, Inc., (51 percent ownership) and Voest-Alpine, the Austrian industrial conglomerate (49 percent ownership). A $60 million 11,700-square-meter facility was built near Graz, Austria, to manufacture integrated circuits. It comprises design engineering, maskmaking, wafer fabrication, assembly, and test areas. Lead times offered are competitive—4 weeks for gate arrays, 8 weeks for standard cells, 20 weeks for full custom circuits, and 4 weeks for ROMs, from specification or code approval until delivery of first samples.

In autumn 1986, the name Gould-American Microsystems was changed to Gould Semiconductor Division (supplier of AMI products). Gould Semiconductor Division does not operate in Europe.

In 1982, AMS pioneered SCEPTRE (Standard Cell Placement and Routing Environment) at its Swindon, United Kingdom, design center. SCEPTRE is a system intended to offer small to medium-size electronic equipment manufacturers a chip design capability at low cost. At present, this system supports designs using AMS's CMOS and NMOS 3-, 4-, and 5-micron standard cell families.

In 1985, AMS completed a major investment program and increased its production by 40 percent over 1984. However, because of the depressed market condition, a loss in revenue was reported in 1985. The joint owners, Gould-American Microsystems and Voest Alpine, then injected a further $33 million into the company to enable it to finance future investments with equity.

In 1986, AMS launched Super Sceptre, a standalone PC-based semicustom IC design workstation for gate array and standard cell. The product provides a full range of semicustom IC design software capabilities running on the IBM PC AT. It is the culmination of four years of user experience with the Sceptre and its enhanced version, Sceptre II.

Also in 1986, AMS launched a commercial MOS multiproduct wafer service through which customers can cut their development costs. To accomplish this, customers can share a batch of wafers with other clients or can place several of their chip designs on a fast turnaround, dedicated wafer batch.

In February 1987, AMS announced expansion of its mask processing capability. At the same time, the Company announced the S2570 combined loop disconnect/multi-frequency (LD/MF) dialer IC for push-button telephones.

In March 1987, AMS announced the S2573, a new pulse dialer IC in CMOS for push-button telephones.

In April 1987, AMS announced the S2571 pulse dialer device in CMOS for push-button telephones. At the same time, the Company added high-performance analog, digital, and peripheral cells to its IC design library.

As shown in Table 1, Dataquest estimates that AMS's European revenue in 1986 was US$21 million.

Table 1

Austria Mikro Systeme International GmbH
Estimated European Semiconductor Revenue by Product Line
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986
Total Semiconductor	$26	$13	$20	$18	$21
Total Integrated Circuit	$26	$13	$20	$18	$21
Bipolar Digital	0	0	0	0	0
MOS	26	13	20	18	21
Linear	0	0	0	0	0
Total Discrete	0	0	0	0	0
Transistor	0	0	0	0	0
Diode	0	0	0	0	0
Thyristor	0	0	0	0	0
Other	0	0	0	0	0
Total Optoelectronic	0	0	0	0	0

Source: Dataquest
April 1988

PRODUCTS AND MARKETS SERVED

AMS offers a complete range of custom and semicustom MOS/VLSI capabilities, including gate arrays, standard cell, and full custom circuits, as well as silicon foundry facilities for customer-designed circuits. CAD/CAE tools and IC design training are also available.

AMS's telecommunications and data communications circuits, ROMs, microcomputers, and peripheral devices provide standard solutions for specific applications.

AMS serves the telecommunications, automotive, industrial, instrumentation, EDP, and consumer markets.

In addition to the Graz facility, AMS has design centers in Swindon (United Kingdom), Stockholm (Sweden), Munich and Hamburg (West Germany), Paris (France), and Milan (Italy). The Company has a network of representatives in Denmark, Israel, Spain, Switzerland, and Yugoslavia.

OUTLOOK

In July 1987, Gould sold its 51 percent stake in AMI to Voest-Alpine. The takeover means that AMS, now called Austria Mikro Systeme, is now entirely Austrian owned. Gould stated that it will return to the European marketplace with custom and semicustom chip sets from its U.S. base.

Balzers

BACKGROUND AND OVERVIEW

Balzers, which operates as the Balzers Division of Oerlikon-Bührle Holding Limited of Switzerland, is a leading supplier of high-vacuum equipment and thin-film products for the optics, optoelectronics, and electronics industries.

The origin of the Balzers Division can be traced back to two companies—Arthur Pfeiffer and Balzers AG. The former company was established in Frankfurt in 1890 to produce vacuum pumps; it was taken over by Balzers AG in 1969. Balzers AG was founded in Liechtenstein in 1946 by Prof. Dr. Auwarter to produce thin-film products and was incorporated into the parent company, Oerlikon-Bührle, in 1973.

Today, Balzers coating systems are used by the principal electronics manufacturers worldwide. The main applications for these systems are as follows:

- Metallization of integrated, bipolar, and MOS circuits
- Deposition of resistor and contact films
- Production of highly stable metal film resistors
- Coating of solar cells

Oerlikon-Bührle's 1988 annual report stated that the Balzers Division employed 3,653 persons as of December 31, 1988. It also said that consolidated sales amounted to SFr 471.5 million (U.S. $323 million) for fiscal 1988.

Operations

The principal manufacturing companies in the Balzers Division are as follows:

- Europe
  - Balzers Limited—Liechtenstein
  - Arthur Pfeiffer—Asslar, West Germany
  - Balzers Hochvakuum GmbH—Wiesbaden, West Germany
- United States
  - Balzers—Hudson, New Hampshire

In addition to manufacturing and research and development (R&D), which is also carried out in Liechenstein, Balzers has the following sales and servicing companies:

- Austria--Vienna, Austria
- NV Balzers--Zaventem, Belgium/Luxembourg
- Bakzers SA--Meudon, France
- Balzers SpA--Milan, Italy
- Balzers--Utrecht, Netherlands
- Nordiska Balzers--Kungsbacka, Sweden/Denmark
- Balzers AG--Zurich, Switzerland
- Balzers High Vacuum--Berkhamsted, Herts, U.K.

Worldwide, Balzers has additional representation in 20 countries.

Research and Development

As in previous years, Balzers has concentrated its R&D efforts on thin films and high-vacuum systems associated with those key sectors that are characterized by rapid technological progress. In these areas, the Company reports having increased investment significantly.

The Company reports that after reaching a peak of US$55 million in 1987 because of large volumes of new construction, plant and equipment expenditures in 1988 receded to US$33 million. Apart from the worldwide expansion of manufacturing, sales, and research facilities, large amounts of capital were invested in improving and rationalizing production and development equipment.

PRODUCTS

The range of products offered by Pfeiffer High-Vacuum Department of the Balzers Division include the following:

- Components for the production, measurement, and control of vacuum gas-analysis instruments for use in research and manufacturing
- Vacuum process systems for the production of thin films for optical, electronic, memory technology, and display applications as well as for solar cells

Balzers

The products offered by the Thin-Film Department of the Balzers Division include the following:

- Thin-film products and coating services for the fields of optics, ophthalmic, optoelectronics, and microelectronics, specifically laser, infrared and antireflection applications; office equipment; lighting technology; LCD displays; and chrome masks

Products included in the range of high-vacuum systems that Balzers offers are as follows:

- BAE 250--This sputtering/evaporation system accommodates 205mm diameter metal or glass recipients. It is useful in the preparation of substrate for scanning electron microscopy.
- BAS 450--This is a compact sputterer for development purposes and small production runs. It features up to four 5- to 10-inch planar magnetron or heating stations, as susceptor for 24 3-inch or 6 125mm substrates.
- LLS 900--This load-lock sputtering system is very flexible with regard to substrate size and will process substrates with diameters of up to 200mm or rectangular substrates of up to 200mm x 400mm in a fully automatic cassette-to-cassette mode.
- VIS 750--This is a vertical inline system for plasma-enhanced chemical vapor deposition (CVD). It is particularly suitable for plasma-enhanced CVD (PECVD) of large substrates. To coat 720mm x 720mm on both sides, the throughput per hour is 6 square meters with a cycle time of 10 minutes. Loading time can be reduced to less than 2 minutes by using a suitable vacuum pump system.

Other equipment offered by Balzer are:

- GAM 400--The GAM 400 gas analysis module is an integrated, compact mass spectrometer unit for qualitative and quantitative gas analysis. Its modular design makes it ideal for a wide variety of applications. It incorporates a Balzers state-of-the-art QMG 420 quadruple mass spectrometer, a turbomolecular pump, and application-specific software.
- HLT 150--This is a helium leak tester with the ability to detect leaks in UHV components and cryopumped systems without any need for LN2. This device also is ideal for use as a helium sniffer. Operating convenience is provided by a microprocessor control system that features range selection and autocalibration for a wide variety of applications.

- GIA 707--This is a gas inclusion analysis system. It is important to technical glasses and ceramics where gas inclusions very often have a negative influence on the product and lower its quality to an unacceptabe level. In semiconductor production, gas inclusion analysis is important in the quality control of hermetically sealed, encapsulated components such as IC housings, Reed relays, and other gas-filled components. This system features fast, dynamic measurement of very small gas inclusions in various materials. Sample size can vary from 10^{-3} to approximately 10^{-12} bar 1 and detection limits are approximately 10 to 100 ppm, depending on the components.

In addition to these systems, Balzers offers evaporation and sputter coating materials, evaporation sources, and auxiliary materials.

For EB evaporation, a variety of high-purity materials are available in disk forms. Balzers' range of planar magnetron sputtering targets includes metals, metal alloys, and dielectrics.

Balzers' range of coating materials for optics and electronics contains more than 90 metals and alloys as well as dielectrics in a variety of shapes and degrees of purity.

Financial

The Oerlikon-Bührle Group statement of income is shown in Table 1 for the two fiscal years that ended on December 31, 1987 and 1988.

In its annual report, the parent company notes that organizational and structural changes in the group initiated in previous years were completed in 1988. Gross sales in 1988 increased 5 percent over the previous year.

Table 2 shows gross sales for the Balzers Division for the fiscal years that ended on December 31, 1987 and 1988.

The Oerlikon-Bührle Group notes that after a brief drop in incoming orders at the end of 1987, which caused a slight downturn in sales in 1988, the Balzers Division reported a sharp recovery. This resulted in an order backlog at the end of 1988. During that year, Balzers was able to maintain its leading position both in coating machines for various applications and in numerous sectors of coating operations.

Table 1 and Table 2 show that during the past two years, gross sales of the Balzers Division remained at approximately 11 percent of the parent company's total gross sales.

Balzers

Table 1

Oerlikon-Bührle Group
Statement of Income
Worldwide Revenue
(Millions of U.S. Dollars)

	1987	1988
Gross Sales	$2,757	$2,897
Net Sales	2,536	2,686
Other Income	378	318
Total	$2,914	$3,004
Less Operating Expenses	(2,992)	(3,029)
Consolidated Net Result	$ (78)	$ (25)
Exchange Rate (SFr to US$1)	1.49	1.46

Source: Oerlikon-Bührle
1988 Annual Report
Dataquest
November 1989

Table 2

Balzers Division
Worldwide Revenue
(Millions of U.S. Dollars)

	1987	1988
Gross sales	$324	$323
Exchange Rate (SFr to US$1)	1.49	1.46

Source: Oerlikon-Bührle
1988 Annual Report
Dataquest
November 1989

OUTLOOK

Balzers Division plays an important role in the parent company's operations, which takes the view that Balzers Division has a great future working in the high-vacuum industry in general and in thin-film technology in particular. Today, Balzers ranks as a high-tech company that occupies a significant market position and recognizes that the pursuit of new technologies requires substantial sums of capital made available for R&D.

Balzers therefore faces the future with confidence and is in the forefront with certain technology strengths. One such strengh lies in the arena of special systems for coating compact discs, where the Company claims it is the leader in this rapidly growing market. Another particular strength of Balzers is its claim to be the only company that combines the production of evaporation and sputter coating materials with its own industrial-scale thin-film production and the manufacture of the deposition systems in which those materials are used to make the films.

The BOC Group PLC

BACKGROUND AND OVERVIEW

The BOC Group PLC is one of the United Kingdom's major industrial companies, with worldwide operations in approximately 50 countries. Its business is segmented as follows:

- Gases and Related Products—This segment includes gases for the electronics and food industries and for environmental applications.
- Health Care--This segment embraces anesthetic pharmaceuticals, home health care, intravascular devices, and patient monitoring systems.
- Special Products and Services—This segment includes high-vacuum technology and incorporates Edwards High Vacuum International, a world leader in the technology and manufacture of vacuum systems and components.

In 1988, the Company reported record vacuum turnover of US$4,495 million and profit of US$620 million. In its 1988 Annual Report, the Company noted that the demand for industrial gases showed healthy growth in most markets, and that the health care and special products and services businesses also enjoyed generally strong demand.

Over the past decade, the Company made some notable acquisitions that enabled it to build up an important presence in the area of bulk and special gases for the semiconductor industry. Some of the more important developments are as follows:

- 1978—The Company acquired Airco of the United States, a large supplier of industrial and special gases. In the United Kingdom, the Company acquired Edwards High Vacuum Incorporated, the leading European company in vacuum technology.
- 1984—The Microelectronics Center of North Carolina was opened. This facility is supported by a number of companies, including Airco Inc. and Specialty Gases (members of the BOC Group), with full-time BOC/Airco staff members located on site.
- 1988—BOC purchased the tungsten hexafluoride activities of Genus, Inc., located in California. This valuable gas is used to make low-resistance pathways on megabit chips, which are the building blocks of today's high-speed computers.

  Also in 1988, the Company signed an agreement with Eagle-Picher Research Laboratory in the United States for joint marketing of ultrahigh-purity trimethyl gallium and for future product development. Trimethyl gallium is a critical source material in the manufacture of gallium arsenide semiconductor devices.

The BOC Group PLC

During 1988, BOC announced that construction of a new special gases facility also is under way in order to meet Taiwan's fast-growing semiconductor industry needs. This plant will be adjacent to the newly developed Science-Based Industrial Park in Taiwan, where the semiconductor industry is concentrated.

OPERATIONS

The BOC Group's corporate headquarters is located at Windlesham, Surrey, England. As of September 30, 1988, the Company employed 38,810 persons worldwide. Of these, approximately 30 percent were employed in Europe, 32 percent in the Americas, and the remaining 38 percent divided about evenly among Africa and Asia/Pacific region.

Principal Companies

To meet the worldwide demands of the semiconductor industry for bulk and special gases, BOC has strategically located manufacturing facilities serving a network of localized warehousing and distribution centers in each of these four major geographical areas--Africa, the Americas, Asia/Pacific, and Western Europe. In each of these areas, BOC has many subsidiaries and affiliated companies that either are wholly owned or in which it has a major interest. Worldwide, there are approximately 100 such companies. The four principal companies covering the worldwide operation are as follows:

- In Western Europe, the production and marketing of commodity and special gases is provided by BOC Limited, with headquarters in London, England. On the European continent, these activities are provided by BOC Special Gases GmbH, situated in Marburg, West Germany.
- In the United States, the Company manufactures and markets bulk and special gases across the country through the BOC Group Inc., a 100 percent owned subsidiary. This important subsidiary includes Airco, with headquarters in Murray Hill, New Jersey.
- The Company's South African interests are covered by African Oxygen Ltd.
- Asia/Pacific is covered by The Commonwealth Industrial Gases Ltd., an Australian company that supplies bulk gases.

Other Companies and Joint Ventures

In Japan, where the Group has a 49 percent interest in Osaka Sanso Kogyo KK, it has gained access to new technology. In this joint enterprise, the Company operates a new special gases plant in Osaka and employs state-of-the-art technology in the filling, purification, and manufacture of gases for the Asia/Pacific region.

The BOC Group PLC

The BOC Group has a 50 percent interest in Shanghai BOC Industrial Gases Co., Ltd., in the People's Republic of China. Currently, a new liquid gases plant is being built in Shanghai; this plant is expected to be on-line by the end of 1989. During 1988, a 120-ton-per-day air-separation plant was commissioned in Jamshedpur, India, and a second 70-ton-per-day plant was commissioned in Tarapur. The Company has a 50 percent interest in a joint venture in Turkey, where a 120-ton-per-day gas plant is being built near Istanbul, and is due to be commissioned in early 1990.

FINANCIAL

The Company's 1988 accounts revealed that 26 percent of worldwide revenue and 33 percent of operating profit were derived from its European operations. A summary of the most recent financial information covering the fiscal years ending September 30, 1986 through 1988 for the BOC Group is given in Tables 1 through 3.

Table 1 shows that worldwide revenue increased by 14.5 percent in 1988 over 1987 to reach a record $4,495 million in U.S. dollars. The largest increase in revenue was recorded by Special Products and Services (29 percent), followed by Health Care (22 percent) and Gases and Related Products (14 percent).

Table 1

The BOC Group and Subsidiaries
Worldwide Revenue by Business Segment
(Millions of Dollars)

Business Segment	1986	1987	1988
Gases and Related Products	$2,052	$2,344	$2,665
Health Care	760	844	1,028
Special Products & Services	531	448	588
Discontinued Products	143	289	214
Total	$3,486	$3,925	$4,495
Exchange Rate (£ per US$1)	0.68	0.60	0.57

Source: BOC Annual Accounts 1988
Dataquest
August 1989

The BOC Group PLC

The largest business segment is Gases and Related Products, with 1988 worldwide revenue of $2.665 billion. This represents 59 percent of all revenue. Table 2 shows that of 1988's total operating profit of $620 million, the Gases and Related Products segment contributed $395 million, or 64 percent.

Table 2

The BOC Group and Subsidiaries
Worldwide Operating Profit by Business Segment
(Millions of Dollars)

Business Segment	1986	1987	1988
Gases and Related Products	$261	$327	$395
Health Care	117	136	158
Special Products & Services	24	55	79
Corporate	(19)	(28)	(31)
Discontinued Business	20*	33	19
Total	$403	$523	$620
Exchange Rate (£ per US$1)	0.68	0.60	0.57

*Relates to currency gains

Source: BOC Annual Accounts 1988
Dataquest
August 1989

Worldwide 1988 revenue growth for the Gases and Related Products segment was 13.7 percent. Table 3 shows that revenue in Europe increased by 9.7 percent, Africa had a 10 percent decrease, the Americas had a 20.6 percent increase, and the Asia/Pacific region had a 16.7 percent increase. Table 3 further shows that the Asia/Pacific region is the largest market for Gases and Related Products. In 1988, it accounted for 42 percent of revenue, up from 40 percent in 1987.

Table 3

The BOC Group and Subsidiaries
Revenue of Gases and Related Products by Geographic Area
(Millions of Dollars)

	1987		1988	
Geographic Area	Revenue	Percent	Revenue	Percent
Europe	$ 504	22%	$ 553	21%
Africa	230	10	207	8
Americas	655	28	790	29
Asia/Pacific	955	40	1,115	42
Total	$2,344	100%	$2,665	100%
Exchange Rate (£ per US$1)	0.60		0.57	

Source: BOC Annual Accounts 1988
Dataquest
August 1989

RESEARCH AND DEVELOPMENT

The strong emphasis placed on research and development (R&D) is underlined by the $82 million expenditure in 1988, an increase of 30 percent over 1987. Because of the diverse nature of the Company's activities regarding products, manufacturing processes, and geographical spread of its markets, R&D is organized both centrally and locally.

Local R&D groups are maintained and managed by the operating business units, usually near the Company's plants. They perform advanced technical work close to the point of application. In the United Kingdom, process and product development is carried out at the Morden headquarters in London.

Long-term technical developments requiring significant expenditure are carried out at the BOC Group's technical center in Murray Hill, New Jersey, in the United States. The technical center covers approximately 168,000 square feet and comprises research laboratories and support facilities such as computer, information, and drafting services.

In addition to the Company's own R&D, it has set up a number of strategic alliances with research organizations and universities that have produced some very positive results. Work at the Company's microelectronics center in North Carolina is very much involved in developing new gas applications, and the Company now has strong links with the semiconductor research establishment at Tokohu University in Japan.

In the United Kingdom, BOC is taking part in a major industrial research program on plasma-etching techniques for use in VLSI circuits. The program has been launched under the government's Alvey scheme for the development of advanced information technology.

Another area of research currently being investigated is with silane/diborane mixtures used in passivation to give low-temperature processing. The company also supports the London Computer and Electronics School. In 1988, BOC donated approximately $800,000 to this organization for its studies.

PRODUCTS

Through its Special Gases Division, BOC supplies electronics gases and equipment to the European electronics industry.

Under the Electra II trademark, BOC offers a range of doping, etching, epitaxial, passive structure, and ion-implantation gases to meet the exacting requirements of the European semiconductor industry. In addition to these special gases, a number of diluent gases are offered, including argon, helium, hydrogen, nitrogen, and oxygen.

BOC's Special Gases Division also has a range of gases and gas mixtures in its Electra III-V range for use in the metal-organic chemical vapor decomposition (MOCVD) technique for growing high-quality multilayers for semiconductors. A selection of these gases includes the following:

- Dimethyl zinc in hydrogen
- Diethyl zinc in hydrogen
- Diethyl telluride in hydrogen
- Dimethyl cadmium in hydrogen

In addition to special gases, BOC also offers a complete service for the design, supply, installation, and commission of total gas feed and control systems for industrial gases. These include acetylene, hydrogen, propane, oxygen, nitrogen, and carbon dioxide.

Under its Spectra-matic trademark, BOC recently launched a new generation of microprocessor-controlled gas delivery systems. These systems are used to automate the purging cycle necessary for high-purity and hazardous gases, and also to monitor process and purge conditions, taking corrective action when necessary.

Recently, the Company produced a range of gases that can be certified as less than 10 particles per cubic foot greater than 0.3 micron. This range of gases is called Spectra-Clean and includes silane, arsine, and phosphine as well as the inert gases nitrogen, argon, and helium. These gases are supplied in Spectra-Clean aluminum cylinders.

Edwards High Vacuum International, also a member of the BOC Group, makes vacuum systems and instrumentation and has recently introduced a new version of its Drystar pumping system for harsh semiconductor processes. This system is particularly suitable for plasma etch, film deposition, photoresist stripping, and crystal/epitaxial growth.

Edwards High Vacuum International also has recently introduced new product lines manufactured by its Datametrics Division. These are gas flow transducers that cover the scale range of 5 sscm up to 20 slpm and two new products covering the ranges up to 200 slpm.

FUTURE PROSPECTS

In the long term, the Company takes an optimistic view of the prospects. It recognizes that some important problems must be resolved in the short term, particularly regarding the United States' trade imbalances, which will require changes in policy that will produce a temporary restraint on growth. However, because the Company's revenue is diverse, it is well positioned to weather any downturn in the world economy.

Gas is BOC's biggest business, and it is at the leading edge of new technologies in production, distribution, and applications. The diversity of customers and geography gives the gases business its resilience, stability, and potential for growth.

Compugraphics International

OVERVIEW

Compugraphics International is a wholly owned subsidiary of the British company Laporte Industries plc, one of the world's leading manufacturers of specialty chemicals. In 1988, Laporte reported worldwide sales of $921 million.

Compugraphics International can trace its origins back some 21 years, when in 1968 it was set up as a small software bureau employing CAD techniques for cartography. Between 1971 and 1981, it was part of the Furness Withy Group and underwent an extensive expansion of its operations. In 1982, the Company was sold to a private company—Caledonian Applied Technology Limited, which at that time owned IC Masks. Subsequently, both IC Masks and Compugraphics International were acquired by Laporte. Through these two acquisitions, Laporte has a very major interest in not only the U.K. market for photomasks, but also in the Western European market.

Compugraphics' manufacturing capability fully utilizes its electron beam system and optical equipment, thus providing the flexibility to produce any mask type from simple, large geometry devices to the most complex IC and SAW devices now coming out of design.

The Company, which is located in Scotland's Silicon Glen, offers the most technologically advanced semiconductor photomasking service in Europe. Full electron beam and optical services are available. These are backed by the most advanced inspection equipment available, including die-to-data base and through-pellicle inspection, thus ensuring a fast and reliable quality product.

The Company prides itself on the speed of the service offered. Its Gold Service is a maximum three-day cycle time with data input via package switch system (PSS) where appropriate. Its normal cycle time is 4 days for the first 3 layers and 10 days for the remainder.

OPERATIONS

The headquarters of the Company is housed at Glenrothes, Fife, Scotland. The site consists of some 43,000 square feet and includes a new extension of some 10,000 square feet, which opened in July 1988.

This new extension contains the stores, shipping and receiving areas, and a new supplementary deionized water supply.

In addition, new clean rooms were constructed that include customer viewing corridors. These rooms provide a base for dedicated functional departments such as final plate cleaning, pelliclizations, inspection, and measurement. One area houses the newly installed Mebes III e-beam equipment in a Class 10 vertical laminar flow room with full HEPA filter ceiling and computer floor.

On the technical front, the Company recently added a Quantronix DSR2 pinhole repair station, a KLA 228 data base inspection station, and new metrology equipment to further the goal toward zero defects. The total of new investment is some £5 million ($8.5 million).

FINANCIAL

Table 1 gives revenue and profit for Laporte for the fiscal years ended December 31, 1986, through December 31, 1988.

The figures in Table 1 reveal that turnover in 1988 increased by 21 percent over that of 1987 and that pretax profit increased by 38 percent.

In 1986, the last year before the Company became a wholly owned subsidiary of Laporte, it reported a turnover of $6 million, about 1 percent of the parent company's turnover.

Table 2 shows worldwide revenue for 1987 and 1988 split by business segment.

The figures show very satisfactory increases in all the business segments. The electronic segment, which also includes Micro-Image Technology's contribution, shows a very healthy increase of 41 percent over 1987, reflecting the strong growth in the semiconductor business during the year.

Table 1

Laporte Industries
Worldwide Revenue and Profit
(Millions of Dollars)

	1986	1987	1988
Turnover	$620	$759	$921
Profit before tax	$ 94	$123	$170
Rate of Exchange £ Sterling per U.S. Dollar	0.68	0.61	0.56

Source: Laporte Industries plc
Annual Accounts 1988
Dataquest
June 1989

Table 2

Laporte Industries
Worldwide Revenue by Business Segments
(Millions of Dollars)

Business Segment	1987	1988
Peroxygen products	$256	$272
Building and timber products	108	152
Inorganic and organic specialties	127	137
Absorbents	63	83
Paper and water treatment	66	85
Electronic	29	41
Trading and other activities	110	151
Total	$759	$921

Source: Laporte Industries plc
Annual Accounts 1988
Dataquest
June 1989

RESEARCH AND DEVELOPMENT

The Company is involved in the Alvey project. It is contributing to the study of VLSI photomasks at the 1-micron level.

THE COMPANY'S PHOTOMASK SERVICE

This service covers the following five areas:

- Reticle pattern generation
- Mask/reticle inspection
- Optical projection masters
- Electron beam masking
- Data processing

Compugraphics International

Reticle Pattern Generation

Compugraphics International has three electromask pattern generators. These machines are able to accept pattern generated (PD) data on magnetic tape in Electromask 2000 or D.W. Mann 3000/3600 formats. The data units can be either metric or imperial.

In the interests of speed, reticles are normally pattern generated using a high-intensity xenon flash exposure onto high-resolution halide emulsion plates. The equipment can produce hard-surface reticles directly using UV exposure, but this nearly doubles the PG time with a commensurate increase in cost.

The equipment is housed in individual Class 100 environmental chambers that also provide temperature and humidity control as well as minimizing particulates within the chamber. Access to the chamber is via a sliding safelight window panel for the purpose of plate loading and unloading only.

Mask/Reticle Inspection

The Company has installed and commissioned two new inspection systems, both of which incorporate submicron defect-detection capability. This addition to its service makes Compugraphics International one of the few mask houses offering this capability.

The two systems, Chipcheck and KLA 208, offer 0.5-micron defect detection on DSW reticles and full projection master arrays. In addition, the Chipcheck will inspect against the original data base, thereby ensuring device integrity of all geometries within the device, and identify and classify all defects to submicron levels. The system also can inspect 1X structures; critical level reticles for optical stepping; 1X, 5X, and 1OX DSW reticles and SAW devices. An important feature of this all-embracing facility is the through-pellicle inspection capability.

To complement the Chipcheck and KLA 208, two other KLA systems , the 100 and 211, are operated. These systems have been used by the Company for many years and have high thresholds of defect detection. The KLA 211 also has through-pellicle inspection capability.

For layer-to-layer registration, the Company has two optical mask comparators, a Nikon MC-7 (up to 7-inch by 7-inch masks) and a Leitz (up to 5-inch by 5-inch masks). The Nikon gives 0.25-micron registration accuracy. Critical dimension measurements are made using Vickers M41 microscopes with intensity profile attachments, accurate to 0.03 micron. The Company also uses a NECY 452C Laser repair system.

Compugraphics International

Optical Projection Masters

The Company manufactures optical projection masters of the highest quality. The maximum size is 7-inch by 7-inch, with registration accuracy of ±0.5 micron, CD control of ±0.25 micron, and defectivity of less than 1 per square inch. The equipment used is GCA 3696 Stepper and Electromask 2500 Combo.

Electron Beam Masking

A Mebes III 80-MHz electron beam system, primarily designed for mask manufacture, was commissioned and became operational in May 1988; it also is capable of direct exposure on wafers.

The Mebes III has the capability to write line widths down to about 0.5 micron and can analyze its own performance to a resolution of 0.015 micron. Layer-to-layer overlay registration accuracy is better than 0.12 micron.

This machine complements the Varian VLS40 system, which was installed earlier and provides duplication of critical path equipment in addition to doubling production capacity for electron beam mask generation.

This facility is housed in a 400-square-foot clean area built specifically for it, and environmental conditions are maintained to tightly controlled temperature and humidity tolerances.

Data Processing

Compugraphics offers complete data processing capability for a wide variety of inputs.

Utilizing the Shapesmith software suite from Lattice Logic with a VAX 11/750, it is possible to perform any type of manipulation necessary for generating optical and electron beam photomasks. This manipulation includes oversizing and undersizing (+ve and -ve biasing), data sealing, data base-PG format, -E beam format conversions, and full fracturing ability.

A complementary, though separate, digitizing services also is available. From supplied scaled drawings, dimensional sketches or coordinated listings, the Company can produce data output suitable for optical and e-beam masks. Conversion from punched paper tape is carried out using a DEC PNP 11/40 computer.

Future Prospects

Compugraphics International, with its state-of-the-art facilities and sound commercial and technical backing, is well placed to meet the future demands of the semiconductor industry.

The Company is dedicated to a continuous program of technical improvements, as evidenced by the recent installation of a Balzers BMC 701 Ultrasonic photomask cleaning system. This machine represents the best equipment that is currently offered that can tackle the vital final cleaning stage of mask manufacture. This and other technical improvements will enable the Company to maintain its position as a leading European mask maker.

Dynamit Nobel Silicon

OVERVIEW

Dynamit Nobel Silicon S.p.A. (DNS) is a subsidiary of Dynamit Nobel AG, one of West Germany's largest chemical and plastics producers. Dynamit Nobel AG was established by the Swedish engineer Alfred Nobel, who is also known as the inventor of dynamite and founder of the Nobel Foundation.

Prior to DNS becoming a wholly owned subsidiary of Dynamit Nobel AG in October 1980, it had been known as Smiel, situated at Merano in the Dolomite Alps and owned by Montedison. Today the Company is completely dedicated to the manufacture of silicon for the semiconductor industry, with manufacturing facilities at Merano and Novara in northern Italy.

In 1983 DNS established a technology center in Sunnyvale, California, United States, to support its worldwide customers in the semiconductor industry and its silicon manufacturing plants in Italy and North Carolina, also in the United States.

OPERATIONS

The corporate headquarters of Dynamit Nobel Silicon S.p.A. are located at Novara, Italy.

In addition to administration, this site houses marketing departments, R&D laboratories, and a wafer processing plant. The latter occupies some 150,000 square feet and employs 500 persons.

The Company has another plant at Merano, employing also about 500 persons, which supplies the Novara plant with monocrystalline silicon.

Manufacturing Process

The Merano plant receives rail cars of trichlorosilane (TCS), the basic raw material for the production of ultrapure silicon, from the Dynamit Nobel plant at Rheinfeld. This installation is one of the world's largest production units for silicon tetrachloride.

On arrival at Merano, the liquid TCS is checked for quality and further purified to semiconductor grade (i.e., impurities reduced to less than one part per billion). Polycrystalline silicon of extremely high resistivity is produced by reaction of TCS with very pure hydrogen. The polycrystalline silicon is then transformed into monocrystalline, or single-crystal, silicon rods by either state-of-the-art computer-controlled crystal pullers to give Czochralski (CZ) silicon or Float-Zone (Fz) silicon.

The monocrystalline silicon is dispatched to both the Novara plant in Italy and to the DNS plant in North Carolina, for the actual wafer fabrication process.

At these facilities the rods of silicon undergo sawing into wafers, followed by lapping and polishing. The wafers are now ready for sale or may undergo epitaxial deposition, depending on customer requirements.

Sales Outlets

To serve the European market, the Company has, in addition to its sales office in Novara, offices at Munich, Bavaria, in West Germany and at Slough, Berkshire, in the United Kingdom.

In the United States DNS has sales offices at Sunnyvale, California; Salem, Massachussetts; and Austin, Texas.

FINANCIAL

A summary of the most recent financial statements for the Dynamit Nobel Group for the fiscal years ended 31 December 1983, 1984, and 1985 is shown in Table 1.

In the 1985 Annual Report, the parent company noted that worldwide investment in fixed and financial assets amounted to US$49 million. These were predominantly related to the continued expansion of its activities in high-purity silicon for the semiconductor industry.

DNS expanded production of its Novara and Merano facilities, and work commenced on the erection of a new plant for high-purity silicon wafers in Durham, North Carolina, United States. The first stage in the expansion program involved an investment of about $35 million, with initial production scheduled for early 1986.

Dynamit Nobel Silicon

Table 1

Dynamit Nobel Group
CONSOLIDATED STATEMENT OF INCOME
(Millions of U.S. Dollars)

	1983	1984	1985
Sales (net)	$1,126	$1,102	$1,094
Investments in fixed and financial assets	$ 41	$ 53	$ 49
Depreciation on fixed and financial assets	$ 50	$ 53	$ 49
Balance Sheet Total	$ 630	$ 563	$ 544
Expenditure on Research	$ 31	$ 29	$ 30
Expenditure for Environment Protection	$ 18	$ 22	$ 23
Personnel Expenditure	$ 290	$ 267	$ 273
Exchange Rate DM per U.S. Dollar	2.55	2.85	2.94

Source: Dynamit Nobel Annual Report 1985

RESEARCH AND DEVELOPMENT

Fundamental research and development are carried out in the United States at the Company's technology center in Sunnyvale, California, which was established in 1984. The objectives of the R&D work done at this center are:

- To investigate the relationships between silicon and device performance yield
- To provide comprehensive, prompt quality-assurance services
- To anticipate future requirements for silicon products

Dynamit Nobel Silicon

Recent R&D projects being carried on in Novara include:

- Comprehensive modelling of the behavior of interstitial oxygen in silicon (As a result of these studies, it has been shown that tight control of oxygen can be a very useful tool in itself to improve device yields.)

- Research to optimize gettering techniques and their application to specific processing procedures (This has led to custom-designed gettering and, in particular, to extrinsic gettering, which involves generating crystal damage on the back surface of the polished wafer; this acts as a trap for metallic impurities.)

- Purity studies and the development of techniques for the detection of impurities using Neutron Activation Analysis

- Studies into the deposition of silicon nitride and polysilicon on the back of the wafer

- Development of epitaxy technology to achieve the advanced properties required in the next generation of VLSI circuits

Under an exchange of technical information with Sony in Japan, the Company is studying the effect on impurities of growing silicon crystals under the influence of a magnetic field.

With growing interest in electro-optical devices, another area to which the Company is giving attention is that of multilayered structures using III/V semiconductor alloys.

Another area of interest is the design of epitaxial wafers for complementary metal oxide semiconductors (CMOS), avoiding particle radiation damage.

PRODUCTS

Dynamit Nobel Silicon's principal products include:

- Silicon poly nuggets
- Silicon CZ monocrystals
- Silicon as cut/lapped wafers--CZ
- Polished silicon wafers
- Test wafers

Silicon Poly Nuggets

The Company's silicon poly nuggets have the following specifications:

- Dimensions
  - Size--6 to 70mm typical
  - Weight--15 to 20 grams/piece
- Purity
  - Donor level-- $\geq$300 ohm.cm
  - Acceptor level-- $\geq$3000 ohm.cm
  - Carbon content-- $\geq 2.5 \times 10^{16}$ At/cm^3

Silicon CZ Monocrystals

These are available doped with phosphorous, boron, or antimony in (111) and (100)$\pm$ 1° orientations in standard diameters from 76.2mm (3") to 150mm.

Table 2 gives typical electrical resistivity ranges and tolerance for silicon doped with different agents.

Table 3 gives typical resistivity ranges, tolerances, and radial resistivity variation for FZ monocrystals doped with phosphorous and boron.

Table 2

Dynamit Nobel Silicon
TYPICAL RESISTIVITIES FOR DOPED SILICON CZ* MONOCRYSTALS

Dopant	Resistivity Range	Resistivity Tolerance
Phosphorous	0.1 - 25 ohm.cm	± 30% std. ± 20% min.
Antimony	0.005-0.015 ohm.cm 0.005-0.020 ohm.cm	N/A N/A
Boron	0.1 - 100 ohm.cm	± 25% std. ± 15% min.
Boron P^+	0.005 - 0.020 ohm.cm	N/A N/A

*CZ = Czochralski crucible pulled

Table 3

Dynamit Nobel Silicon
TYPICAL RESISTIVITIES FOR DOPED SILICON FZ* MONOCRYSTALS

Dopant	Resistivity Range	Resistivity Tolerance	Radial Resistivity Variation	
Phosporous	0.1 - 150 ohm.cm	± 25% std. ± 12% min.	≤18% typ.	≤16% typ.
	100 - 150 ohm.cm	± 30% std. ± 20% min.	20% max.	18% max.
Boron	0.1 - 500 ohm.cm	± 25% std. ± 15% min.	≤8% typ. 10% max.	≤8% typ. 10% max.

*FZ = Float Zone

Source: Dynamit Nobel Silicon
Standard Product Specification

Silicon as Cut/Lapped Wafers--CZ

Wafers are available from 76.2mm (3") up to 150mm diameter in resistivity ranges already given in Tables 2 and 3.

Table 4 gives minimum thickness tolerances for various diameters of wafer as a function of surface finish for CZ cut/lapped wafers.

Table 4

Dynamit Nobel Silicon
THICKNESS CHARACTERISTICS FOR CZ AS CUT/LAPPED WAFERS

Surface Finish	Diameter	Minimum Thickness	Thickness Tolerance Std.	Thickness Tolerance Min.
AS CUT	76.2mm (3")	300um	± 25um	± 15um
	100mm	400um	± 25um	± 15um
	125mm	450um	± 25um	± 15um
	150mm	500um	± 25um	± 2um
LAPPED	76.2mm (3")	300um	± 8um	
	100mm	380um	± 8um	
	125mm	420um	± 8um	
	150mm	450um	± 8um	

Source: Dynamit Nobel Silicon
Standard Product Specifications

Polished Silicon Wafers

The range of CZ polished silicon wafers comprises the following eight products:

- (111)P--boron polished
- (111)P^+--boron polished
- (100)P--boron polished
- (100)P^+--boron polished

- $(111)N$--phosphorous polished
- $(100)N$--phosphorous polished
- $(111)N^{+}$--antimony polished
- $(100)N^{+}$--antimony polished

These wafers are manufactured to a very high standard. On the polished side, 98 percent of wafers are free of scratches; the utmost care is taken to ensure that the wafers are free of haze, dimples, chips, and cracks and that all edges are fully contoured, including flats.

Text Wafers

Polished test wafers are available in standard diameters but tailor-made to customer specifications (i.e. in terms of type, dopant, and resistivity). In addition to silicon substrate material, DNS offers the following two electronic grade chemicals:

- Silicon Trichloride
- Silicon Tetrachloride

FUTURE PROSPECTS

As one of the world's leading suppliers of silicon substrates, the Company continues to view its long-term growth prospects with optimism. To this end, the Company is well placed, with its current expansion plans, to take advantage of the increased demand for its products that it expects over the next decade.

DNS is very alert to the effect that changing IC technology will have on the properties demanded of the substrate material, particularly as line widths on devices challenge the 1-um barrier. This is illustrated by the emphasis of the R&D program of study being carried out by the Company on purity and epitaxy.

The Company believes that as a supplier of substrate material, it must have an intimate knowledge not only of the behavioral characteristics of the raw materials but also of the device market being supplied. This takes teamwork, innovation, and creativity across the whole spectrum of its activities--all of which DNS takes great pride in pursuing.

General Signal

OVERVIEW

General Signal Corporation is a leader in instrumentation and control technology for semiconductor production, telecommunications, industrial automation, energy management, and rail transportation.

The Company divides its business into the following four sectors:

- Process Controls
- Technology Industries
- Electrical Controls
- Transportation Controls

The Process Controls sector includes products such as general mixing equipment and industrial valves for use in the chemical and chemical-related industries.

The Technology Industries sector covers the Company's sales of semiconductor equipment. Its position in the industry was greatly enhanced in 1988 by the acquisition of GCA Corporation. This purchase not only enabled the Company to broaden its products and services but provided extensive foreign operations in Japan and Europe, thus furthering General Signal's influence in what has become a highly competitive global industry. The products and services previously offered by GCA Europa, S.A., now are handled by General Signal's Semiconductor Equipment Group Europe.

The Electrical Controls sector covers transformers and their repair, utility switching, and heat-trace and firestop product line business.

The Transport Controls sector includes such items as locomotive control systems, braking equipment, and automatic couplers.

In 1988, General Signal reported net sales of $1,760 million, an increase of 9.8 percent over 1987. In its 1988 annual report, the Company noted that on June 7, 1988, the Company acquired all outstanding shares of GCA for approximately $28.0 million in cash and nearly one million shares of the Company's common stock, which were valued at $51.6 million.

OPERATIONS

General Signal's corporate headquarters is located at High Ridge Park, Stamford, Connecticut, in the United States.

In Europe, semiconductor equipment sales are handled through the General Signal Semiconductor Equipment Group Europe, with sales and service offices located as follows:

- France—Ferney-Voltaire
- United Kingdom—Southampton
- West Germany—Munich

Each company has its own manager, service personnel, and spare parts warehouse; West Germany also has a training center. Altogether, the Group has approximately 90 highly trained specialists throughout Western Europe who provide service to the Company's customers. They are involved in installing the Company's systems and working with customers on problems concerning product/process relationships.

The operating units of the Semiconductor Equipment Group Europe in the United States consist of the following:

- Advanced Mechanization Inc., Horsham, Pennsylvania
- Drytek, Wilmington, Massachusetts
- GCA, Andover, Massachusetts
- General Signal Thinfilm Company, Fremont, California
- Kayex, Rochester, New York
- Semiconductor Systems, Fremont, California
- Ultratech Stepper, Santa Clara, California
- Xynetics, Santa Clara, California

FINANCIAL

A summary of the Company's financial operations for the fiscal years ending December 31, 1986 through 1988, is shown in Table 1.

Table 1

General Signal Corporation
Consolidated Statement of Operations
(Millions of Dollars)

	1986	1987	1988
Net Sales	$1,583	$1,603	$1,760
Cost and Expenses:			
Cost of Sales	1,115	1,152	1,267
Sales and Administrative Expenses	348	355	418
Write-Offs	0	0	58
Operating Revenue	$ 120	$ 96	$ 17

Source: General Signal Corporation
Annual Accounts
September 1989

In the 1988 annual report, the Company notes that sales for 1988 totaled $1,760 million, an increase of 9.8 percent over $1,603 million in 1987. Sales from the Company's continuing businesses increased by 7.6 percent, excluding business acquisitions and divestitures. Sales growth was attributable primarily to continuing strength in the Process Controls sector, renewed demand in the Technology Industries sector's semiconductor capital equipment markets, and advances in the Electrical Controls sector's equipment sales. Sales gains were offset partly by declines experienced by the Company's Transportation Controls sector.

Table 1 reveals that operating earnings in 1988 declined 82.4 percent to $17 million compared with $96 million in 1987. This substantial decrease is attributable to $95 million of significant and nonrecurring charges recorded in 1988. These charges include a $58.1 million goodwill write-off, of which $54.9 million is associated with the Technology Industry sector's Karkar Electronics business.

A breakdown of revenue by business sector is shown in Table 2. This table shows that the Technology Industries sector reported a significant advance in 1988 with sales reaching $445 million. This was due to good growth in semiconductor equipment operations coupled with the acquisition of GCA Corporation in June 1988. In 1988, nearly 17 percent of General Signal's sales were generated outside the United States.

Table 2

General Signal Corporation
Revenue by Business Sector
(Millions of Dollars)

Sector	1986	1987	1988
Process Controls	$ 600	$ 590	$ 637
Technology Industries	311	297	445
Electrical Controls	333	351	387
Transportation Controls	281	286	271
Subtotal	$1,525	$1,524	$1,740
Dispositions	58	79	20
Total	$1,583	$1,603	$1,760

Source: General Signal Corporation
Annual Accounts 1988
September 1989

RESEARCH AND DEVELOPMENT (R&D)

The Company has a strong commitment to R&D. In 1988, R&D expenditure was $116 million, approximately 6.6 percent of total sales turnover. With the challenge posed by ASICs, considerable R&D effort is being expended in the area of maskmaking.

PRODUCTS

The Company's principal markets in the Technology Industries sector are the semiconductor, telecommunications, broadcast, and defense industries. This sector provides equipment for most major segments of semiconductor manufacturing, from wafer preparation and processing through environmental test. Products include crystal-growing furnaces, wafer saws and polishers, diffusion/deposition systems, photolithography wafer steppers and lenses, wafer processing equipment, plasma etching/stripping systems, wafer probers, and die bonders.

General Signal

The following are some of the products offered by the Company:

- AMI model 4206 automatic epoxy die attach system and model 5406 fully automatic epoxy die attach system
- Drytek quad system, which features a central rotary pick-and-place transport that feeds four independent single-wafer process etch chambers and is capable of handling wafers to 200mm
- Electroglas +2010X 4-inch by 6-inch robotic wafer handling system and +3001X 8-inch robotic handling system, each with 100/75 wafer capacity
- ALS Waferstep* 200 System—a microlithography exposure system for producing advanced devices; features the Tropel i-line lens and Maximus* illuminator for submicron production
- ALS Laserstep* 200 system—a microlithography system featuring the Tropel 2035 KrF reduction lens and excimer laser exposure source
- GCA/Tropel metrology products include the Flatmaster* automatic cassette-to-cassette wafer flatness measurement and sorting system with 3-inch to 6-inch capacity; Waferstress* film stress analyzer; Multisort* multiple parameter wafer sorting system; Wafersense* fiber-optic wafer detection system; Smartaligner* noncontact wafer prealignment station
- Tempress thermal processing and deposition equipment—a European product and an ideal ASICs system design
- Micro Automation System SIX/75, which incorporates unique transfer and processing modules, film frame mounted substrates, and flexible software. The model 1100 is a new programmable dicing saw
- Ultrastep 1500 and 990 1:1 projection steppers, which feature a new lens system for submicron circuit pattern lines and are capable of handling various size wafers
- ATEQ Core-2000R high-speed laser pattern generator
- Verteq Superclean 1600-5 rinser/dryer system

Note: R denotes a registered trademark and * a trademark of General Signal Corporation.

FUTURE PROSPECTS

The progress of optical lithography to submicron geometries has been made by moving to shorter light wavelengths. GCA, now a wholly owned subsidiary of General Signal, was one of the pioneers of the i-line wavelength for which the Tropel Division has developed special lenses and the ALS Waferstep 2000 uses i-line. Reaching 0.5-micron levels and lower requires even shorter wavelengths that are beyond the optical spectrum; in this area, the Company is leading the way with its excimer laser lithography systems. General Signal believes that systems for submicron work will be a major development in the market in the years ahead, and the Company commands a leading position in this area.

LTX Corporation

OVERVIEW

LTX Corporation is one of the world's leading suppliers of systems used for the testing of linear, digital, and mixed-signal (combined linear/digital) integrated circuits. These systems also are used for the functional test and alignment of high-volume electronic assemblies. Laser-trimming and computer-networking products also are offered by the Company.

The Company designs and manufactures four lines of semiconductor test systems. All of the Company's test systems have the same fundamental characteristic, namely, a set of computer-controlled instruments that send signals to a device under test and measure the response of that device. The four lines of test systems are as follows:

- Ninety--The new Ninety system enhances the Company's original LTX77 linear and mixed-signal tester. This system uses a Data General computer enhanced by LTX to function as a test controller.

- Hi.T--This line of test equipment provides a completely new architecture for high-throughput testing of linear devices.

- Trillium--The Company's line of digital test equipment is used to test a wide variety of digital VLSI circuits.

- Synchromaster--This product was introduced in May 1988 and was specifically developed for mixed-signal testing.

For the fiscal year ending July 31, 1988, the Company reported record worldwide sales of US$174.8 million and income from operations totaling US$15.1 million.

OPERATIONS

The Company maintains its headquarters at LTX Park, Westwood, Massachusetts. This location houses corporate administration, sales and customer support, and manufacturing and engineering for its Linear Division. The Company also has component parts assembly, final assembly, and testing at its manufacturing facility in San Jose, California. This is the Company's Trillium Digital Division.

LTX maintains 8 sales and customer support offices located throughout the United States. The Company's European and Far Eastern headquarters are located in Woking, United Kingdom, and Tokyo, Japan, respectively. Sales and customer support are provided in 10 additional facilities located throughout Europe and the Far East.

LTX Corporation

As of July 31, 1988, LTX employed 1,411 personnel worldwide. This included 601 in engineering and technical support, 543 in manufacturing, and 267 in sales and administration. In the United States, the Company's support center at Westwood consists of 326 employees. The support center's activities include training, field service, and applications assistance.

Financial

A summary of LTX Corporation's most recent financial information for the fiscal years ending July 31, 1986, through July 31, 1988, is given in Table 1. The Company noted in the 1988 annual accounts that it experienced favorable conditions in the semiconductor industry and a continuing strong market reception for its digital VLSI product line.

Table 1

LTX Corporation
Worldwide Consolidated Statement of Income
(Thousands of U.S. Dollars)

	1986	1987	1988
Net Sales	$95,400	$120,622	$174,804
Less Cost of Sales	-58,295	- 66,706	- 86,223
Gross Profit	$37,105	$ 53,916	$ 88,581
Less R&D Expenses	-21,546	- 23,166	- 31,572
	$15,559	$ 30,750	$ 57,009
Less Selling and Admin. Expenses	-31,612	- 33,615	- 41,945
Income from Operations	($16,053)	($ 2,865)	$ 15,064

Source: LTX Corporation
Annual Accounts
Dataquest
February 1989

In 1988, net sales increased 45 percent over the comparable 1987 period, to a record $174.8 million. For the second year in succession, shipments of digital VLSI test systems nearly doubled to approximately $85 million. The Company also noted that in 1988, shipments of linear product equipment improved about 15 percent over fiscal 1987. The Company's linear business was aided by increased sales of its new Hi.T system and broader application of its Ninety systems.

Table 1 also reveals that gross profit in fiscal 1988 increased to 50.7 percent of net sales from 44.7 percent in fiscal 1987. This is attributable to greater use of manufacturing capacity, improved product margins, and increased manufacturing of the Company's digital product line.

Table 2 shows that sales in the United States have risen progressively from 48 percent in 1986 to 51 percent in 1988. Over this same period, exports from the United States have increased from about 13 percent of net sales to 19 percent. Table 2 also shows that sales to European customers increased in 1988 to 18 percent of the total net sales, up from 20 percent in 1987.

Table 2

LTX Corporation
Worldwide Sales by Geographic Area
(Thousands of U.S. Dollars)

	Year Ending July 31		
	1986*	1987*	1988*
Sales to Unaffiliated Customers			
United States	$46,364	$ 59,135	$ 88,856
Europe	21,577	24,674	31,436
Japan	15,360	15,435	21,625
Export from United States	12,099	21,378	32,887
Total	$95,400	$120,622	$174,804

*Fiscal year ending July 31

Source: LTX Corporation
Annual Accounts
Dataquest
February 1989

Research and Development

LTX operates in a field characterized by rapid technological change, and its future success depends on a large and continuing commitment to R&D. The Company's fiscal 1988 R&D expenses increased 36 percent over 1987 to $31.6 million.

LTX Corporation

PRODUCTS

All four of the LTX test systems have the same fundamental design, i.e., a set of computer-controlled instruments that send signals to an integrated circuit under test and measure that circuit's responses.

Test Systems

Ninety

The Ninety's central processing unit is the CP90 and includes a Data General Nova computer enhanced by LTX as test controller. The CP90 also supports a 160Mb disk drive, a magnetic tape unit, and other peripherals. The LTX 90 computer system may be used with a wide array of instruments, all developed by LTX for testing. The instruments can be configured to provide a range of signals appropriate to many types of linear integrated circuits. This system can laser trim thin- or thick-film hybrid circuits and silicon integrated circuits using suitable system extensions.

Trillium

The Trillium systems for testing digital devices use a new architecture, based on the theory of providing a complete set of testing resources at each pin of the circuit being tested.

Recently, three new additions have been introduced to the Trillium product family. These are the following:

- Validmaster Plus is an ideal cost-effective solution for high-volume production testing of 32-bit MPUs, RISC processors, and peripheral controllers.
- Micromaster HPC (High Pin Count) is geared for high-pin-count, high-performance testing. It is designed for complex device characterization as well as high-throughput testing of the more advanced VLSI devices.
- Validmaster HPC is geared for high-pin-count, cost-effective ASIC gate array and complex VLSI device testing. Performance characteristics and resource-per-pin architecture are similar to those of the Validmaster Plus. The 512-pin test head is the smallest high-pin-count test head in the industry.

Hi.T

The Hi.T linear test system uses Apollo DOMAIN network. The system also makes wide use of microprocessors to control signals and measurements to each pin of the device being tested to improve test efficiency. This line of equipment provides new architecture based on producing a complete set of independently controlled linear resources at each pin of the circuit under test, rather than sharing test instrumentation among pins. This "per-pin" architecture, combined with further independent microprocessors throughout the system, permits test signals and measurement to be executed concurrently whenever possible. The per-pin design significantly improves throughput and accuracy of testing for linear devices.

Synchromaster

Synchromaster is LTX's new-generation, mixed-linear digital tester. It incorporates the Trillium digital architecture and the use of a Trillium system test head and test head digital pin cards combined with the Hi.T system. With the elimination of matrix-switching mechanisms, Synchromaster increases test throughput dramatically. This tester has great flexibility in being able to assign test resources to any pin of a device; thus, it is particularly suited to the best requirements of ASIC devices, no matter where the cells are located in the device and regardless of how the device is packaged.

Product Applications

Linear Applications

Linear applications include the following:

- Industrial--Using devices in a wide variety of commercial and military electronic assemblies. They include such applications as amplifiers, comparators, and voltage regulators. For these, the Ninety system or the Hi.T. system can be used.

- Communications--Using both linear and mixed-signal circuits. Linear circuits such as amplifiers can be tested by either the Ninety or Hi.T system. Mixed-signal circuits such as digital filters, ISDN transceivers, and modems can be tested by either the Ninety, with its digital options, or the Synchromaster.

- Consumer--Products such as radios, compact disc players, and cameras incorporating linear and mixed-signal circuits. These devices can be tested by adding radio, chroma, video, or digital modules to the Ninety system.

- Automotive--Using the Company's Ninety system to test and laser trim integrated circuits or electronic assemblies used in ignition, fuel, and braking systems. Various modules are available for the system, which provide the unique waveforms necessary to test these devices.

Digital Applications

The Trillium family of digital test systems has been designed to test efficiently the wide variety of devices designed with MOS and ECL technologies. These include gate arrays, microprocessors and controllers, RISC processors, complex logic, and programmable logic.

LTX Corporation

Customer Support and Warranty

Because of the highly technical nature of its systems, the Company considers customer support to be important to the success of its business. Customer support activities include training, field service, and applications assistance. As of July 31, 1988, the Company's service and support staff consisted of 326 employees. LTX maintains support centers at its Westwood, Massachusetts, headquarters and at 20 other locations around the world.

The Company's policy is to provide customers with unlimited training at LTX support centers without charge, except for basic test system orientation and certain advanced courses. Customers' employees are instructed in system hardware and in the software developed by LTX specifically for preparing the debugging test programs for its systems.

The Company provides a ten-year warranty against defects in its linear and mixed-signal test systems and a limited lifetime warranty against defects in the digital test systems. Computer peripherals, laser-trim equipment, and certain other components purchased from others outside LTX are covered by a one-year warranty.

OUTLOOK

LTX has a major share of the test equipment market and is well set up to continue the successful expansion of the two sides of the business through the Trillium Digital Division and the Hi.T linear system.

The correctness of the Company's decision to emphasize the digital business is demonstrated by the fact that in just three years Trillium shipments have accumulated to more than $150 million, and LTX has become the largest U.S.-owned supplier of digital VLSI test systems.

The Company views the long-term prospects with cautious optimism and sees continued expansion of its markets from the now well-established Trillium and Hi.T bases. This, together with its dedication to customer support and applications, will ensure that LTX will continue to enjoy a place at the forefront of the semiconductor test equipment market.

MEMC Electronic Materials SpA

OVERVIEW

In January 1988, DNS (formerly Dynamit Nobel Silicon) was acquired by Hüls AG, a wholly owned subsidiary of Veba AG, one of West Germany's largest companies. The acquisition was followed in February 1989 by the announcement that President Bush had ratified the transaction between Hüls and Monsanto, whereby the former company would acquire the Electronic Materials Division of Monsanto. Hüls announced the formation of a new company from the merger of these two companies; the new company is MEMC Inc. It is responsible for worldwide production and marketing of electronic grade silicon products. Implementation of MEMC Inc. became effective in April 1989.

MEMC Inc. forecasts that worldwide sales revenue in 1989 will be in the $400 million range, and MEMC Electronic SpA, with sales of approximately $130 million, will be the principal suppliers to MEMC's business in Europe.

With these acquisitions, the Hüls/Veba Group is implementing its strategic decision to play a primary role in the silicon wafer market. MEMC Inc will benefit from a high degree of synergism, with very positive effects on research and innovation capacity, product quality, service, and competitiveness.

In 1988, the Hüls Group reported net worldwide sales of DM 8.23 billion ($4.7 billion), representing approximately 18.5 percent of Veba's sales, which reported DM 44.4 billion ($25.2 billion) in sales in 1988.

OPERATIONS

MEMC Inc.'s corporate headquarters are located in Novara, Italy. The marketing, administration, and research and development (R&D) laboratories for Europe also are housed at this site. MEMC Inc.'s principal wafer fabrication facilities for Europe also are located in Novara. This plant covers approximately 150,000 square feet and employs 500 persons.

The Company has a second Italian plant at Merano. Here, polycrystalline silicon is manufactured and single-crystal ingots prepared by Czochralski crucible pulling. Approximately 500 persons are employed here.

Sales of the Company's products are made through regional sales offices at the following strategic points throughout Europe:

- West Germany—Munich
- France—Paris
- United Kingdom—Milton Keynes and Manchester
- Italy—Novara

The Company also has distributors and sales agents in Japan, Taiwan, Singapore, and India.

MANUFACTURING PROCESS

The basic raw material for ultrapure silicon production is trichlorosilane (TCS). It is supplied by the Hüls Troisdorf plant at Rheinfelden in West Germany; this plant also is one of the world's largest producers of silicon tetrachloride.

At the Merano plant, the liquid TCS undergoes a series of purifications that bring it to semiconductor grade levels (i.e., impurities less than 1 part per billion). The TCS then is reduced—using very high purity hydrogen made on site—to high-resistivity polycrystalline silicon. This in turn is transformed by state-of-the-art computer-controlled pullers into large diameter single-crystal ingots. These ingots then are ground to give tight diameter tolerances, and reference flats or notches are added for crystal orientation referencing. When this process is completed, the ingots are shipped to Novara to be made into wafers.

The wafer-making process is carried out at the Novara plant. It consists of sawing the ingots into slices, lapping for flatness, polishing to produce a precise mirror-like finish, and cleaning in a Class 10 ambient surrounding to remove microscopic particles. Most wafers are sold in polished form, but that depends on customer requirements. Wafers may undergo further processing (e.g., epitaxial layers, back sealing) before shipment.

FINANCIAL

Financial information for MEMC Electronic Materials SpA is not made available, but rather is consolidated into those of the immediate parent company, Hüls AG. A summary of the most recent financial statements for the Hüls Group for the fiscal years that ended December 31, 1987 and 1988 is shown in Table 1.

Table 1 shows that Group sales increased in 1988 by 66 percent over 1987. Pretax profit increased by a record 35 percent; indeed, 1988 was a record year in all regards, coinciding as it did with Hüls' 50th anniversary.

In its 1987/1988 Annual Report, Veba notes that the Hüls Group's domestic sales increased by 55.3 percent to DM 3.6 billion (US$2 billion) in 1988, while Hüls AG's export sales were up by 68.0 percent to DM 4.6 billion (US$2.6 billion). The export ratio was 56.0 percent compared with 54.0 percent in 1987.

Table 2 shows the business divided into operational areas. The "Other Areas of Business" row in Table 2 includes plastics processing, biotechnology, and silicon wafer fabrication.

Table 2 shows satisfactory increases in all business areas. The companies of the Hüls Troisdorf AG subgroup and Svenska Polystyren Fabriken AB are incorporated into the financial statements for the first time: this incorporation is reflected in the sharp increase in the "Other Areas of Business" part of the table. These data also include for the first time, a full year's contribution from MEMC Electronic Materials SpA, estimated by Dataquest to be in the $100 million to $120 million range, i.e., approximately 11 percent of sales in this area and 2.4 percent of the Group's overall sales.

Table 1

Hüls Group Profit and Loss Account
(Millions of Dollars)

	1987	1988
Net Sales	2,821	4,678
Cost of Sales	2,022	3,412
Gross Profit on Sales	799	1,266
Selling Expenses	(325)	(525)
Research Expenses	(120)	(173)
General Administrative Expenses	(50)	(132)
Other Operating Expenses	(140)	(273)
Other Operating Income	65	(168)
Income from Participations	61	88
Net Interest	18	(3)
Profit before Tax	308	416
Profit after Tax	152	215
Exchange Rate (DM/$)	1.8	1.76

Source: Hüls AG Annual Report 1988
Dataquest
February 1990

Table 2

Hüls Group Worldwide Sales by Business Area
(Millions of Dollars)

	1987	1988
Basic Chemicals	260	645
Organics	944	1,341
Thermoplastics	964	1,157
Elastomers, Coatings	506	543
Other Areas of Business	147	992
Total	2,821	4,678
Exchange Rate (DM/$)	1.80	1.76

Source: Hüls AG Annual Report 1988
Dataquest
February 1990

RESEARCH AND DEVELOPMENT

Great importance is attached to R&D work that is aimed at providing customers with solutions to their problems. In 1988, the Hüls Group expended $173 million on R&D, a 44 percent increase over 1987.

Hüls spends a large amount on R&D. Because of the wide range of the MEMC Inc. interests, the field of research is extensive, particularly recent research into the toxicological and safety aspects of the company's products.

Research on silicon products by MEMC Electronic Materials SpA is carried out at both the Novara and Merano sites. Some of the projects include the following:

- Comprehensive behavior modeling of interstitial oxygen in silicon
- Research to optimize gettering techniques and their application to specific processing procedures
- Studies on the properties of silicon nitride and polysilicon on the back of wafers
- Development of advanced epitaxy technology to achieve the properties required in the next generation of VLSI circuits
- Study of multilayered structures using III/V semiconductor alloys because of growing interest in electro-optical devices

PRODUCTS

MEMC Electronic Materials SpA's products include the following:

- Silicon poly nuggets
- Silicon monocrystals
- Silicon as cut/lapped wafers
- Test wafers
- Polished silicon wafers
- Epitaxial silicon wafers

The monocrystals are available doped with phosphorus, boron, or antimony in 111 and 100 ±1° orientations in diameters that range from 76.2mm, or 3 inches, to 200mm.

Silicon-CZ as cut/lapped wafers are available from 76.2mm (3 inches) up to 150mm diameter in various resistivities.

The range of Czochralski crucible pulled (CZ) polished wafers comprises the following eight products:

- (111)P—boron polished
- (111)P+ —boron polished
- (100)P—boron polished
- (100)P+ —boron polished
- (111)N—phosphorus polished
- (100)N—phosphorus polished
- (111)N+ —antimony polished
- (100)N+ —antimony polished

These wafers are manufactured to a very high standard. On the polished side, all wafers are free from scratches, haze, dimples, chips, and cracks, and all edges are fully contoured, including flats.

Test wafers are available in standard diameters and can be tailor-made to customer specifications, i.e., type, dopant, and resistivity. In addition to silicon substrate material, the Company offers the following two electronic grade chemicals:

- Silicon trichloride
- Silicon tetrachloride

OUTLOOK

With its integration into the Hüls/Veba Group, MEMC Electronic Materials SpA has an assured future in a market that offers good growth prospects. As a result of its new affiliation with MEMC Inc. in the United States, where complementary R&D is carried out, the Company is well placed to study the effect that changing IC technology will have on the properties demanded of the substrate material, particularly as linewidths on devices challenge the 1-micron barrier.

The Company believes that, as one of the world's leading suppliers of substrate material, it must have an intimate knowledge not only of the behavioral characteristics of the raw materials but also of the device market that is being supplied. This knowledge requires teamwork, innovation, and creativity across the whole spectrum of its activities.

Merck Group

OVERVIEW

Merck's history reaches back to 1668 when Jacob Merck took over Engel Apotheke, a pharmacy in what is now Darmstadt, West Germany. In 1827, Heinrich Emanuel Merck, who at that time was the proprietor of Engel, made the important decision to produce certain products on a large scale. Thus was born the industrial enterprise that now is one of West Germany's largest companies.

Merck now is a modern enterprise in the chemical-pharmaceutical industry. It manufactures a broad spectrum of products. It is still owned by the founding family, and its legal form still is that of a general partnership. In 1988, Merck reported worldwide sales of US$1.9 billion.

The Company's activities are grouped into the following two business areas:

- Pharmaceutical
- Chemical

The Pharmaceutical Group covers the production and marketing of formulated medical products, including preparations for the treatment of cardiovascular and central and peripheral nervous system disorders.

The Chemical Group consists of five divisions—Fine Chemicals, Industrial Chemicals, and Pigments, which make up the Chemicals Subgroup; and Reagents and Diagnostics, which form the Laboratory Preparations Subgroup.

The Industrial Chemicals Division is mainly engaged in producing and distributing products and equipment for technically demanding applications. It is a research-intensive operation; a large part of its product portfolio is the result of its own research and development and, accordingly, is protected by patents. Its most important products are liquid crystals and process chemicals with related supply systems for the semiconductor industry. Other major product groups include vapor deposition chemicals for the optical industry, monocrystals, UV initiators for the coatings and printing industry, and printing chemicals.

In order to concentrate more strongly on the two key sectors of liquid crystals and process chemicals, the Company sold its photoresistant business to Ciba-Geigy late in 1988, thus releasing manpower and plant capacity.

OPERATIONS

Merck's corporate headquarters are located in Darmstadt, West Germany. In 1988, companies of the Merck Group were active in 40 countries. Plants at 45 locations in 27 countries manufacture products for Merck's worldwide business, which encompasses approximately 15,000 different chemical and pharmaceutical items.

At the end of 1988, the Merck Group employed 21,017 persons worldwide, up slightly from the previous year. Of this total, employees in West Germany account for 45.1 percent (9,489 persons).

Outside of West Germany, the Industrial Chemicals Division has several plants, including the following:

- United Kingdom
  - BDH Chemicals Ltd., Poole, Dorset
- United States
  - EM Industries Inc., Hawthorne, New York. Also, various companies in New Jersey, Ohio, Georgia, Maine, and California
- Rio de Janeiro
  - Merck S.A. and four other manufacturing plants in the country
- Japan
  - Merck Japan Ltd.
  - Kanto Kagaku K.K., Tokyo

Plants also are located in Australia, New Zealand, the Philippines, and South Africa.

FINANCIAL

Merck Group revenue is given in Table 1 for the fiscal years that ended December 31, 1986 through 1988.

In terms of deutsche marks, the Group's sales increased 9.4 percent in 1988 over 1987. Converted into U.S. dollars, this equals an 11.8 percent increase and reflects real growth far more accurately than in the previous two years because the distortions caused by foreign exchange rates are much less pronounced.

Table 1

Merck Group Worldwide Revenue by Business Sector (Millions of U.S. Dollars)

	1986	1987	1988
Pharmaceuticals	520	652	735
Chemicals	790	941	1,042
Others	51	62	74
Total	1,361	1,655	1,851
Exchange Rate (DM per US$1)	2.17	1.80	1.76

Source: Merck Annual Accounts 1988
Dataquest
February 1990

Table 2 shows that in 1988, pharmaceutical product sales and chemical sales accounted for 39.7 percent and 56.3 percent of total revenue, respectively. Table 2 also shows that sales of pharmaceuticals increased by 12.7 percent in 1988 over 1987, and sales of chemicals increased by 10.7 percent.

The figures in Table 2 show that, in terms of U.S. dollars, 64 percent of the Company's sales were derived in Europe. This sum compares with nearly 67 percent in 1987. The table also makes it clear that important new growth areas lie in new industrial areas such as Asia and Comecon countries.

Table 2

Worldwide Revenue by Geographic Area
(Millions of U.S. Dollars)

	1986	1987	1988
West Germany	366	450	478
Other EEC countries	411	545	581
Other European countries	86	107	126
Total—Europe	863	1,102	1,185
United States	110	119	164
Latin America	150	162	161
Africa	12	8	18
Asia	73	82	103
Other Industrial Countries	132	155	184
Comecon and People's Republic of China	21	27	36
Total	1,361	1,655	1,851
Exchange Rate (DM per US$1)	2.17	1.80	1.76

Source: Merck Annual Accounts 1988
Dataquest
February 1990

RESEARCH AND DEVELOPMENT

For Merck, which is principally concerned with producing and selling chemical and pharmaceutical specialties, research and development (R&D) plays a very vital role. Its importance is reflected both in relatively high expenditure for R&D and the large number of employees (about 11 percent) engaged in these activities. Product lines are being renewed constantly and approximately 40 percent of the sales made by the Merck Group in West Germany is attributable to products that were either introduced or improved within the last two years.

The marked intensification of R&D activities that started in the early 1980s has continued into 1988. Current R&D expenditure amounted to DM 254 million (US$144.00 million), an 8.0 percent increase over 1987. An additional DM 33 million (US$18.75 million) was spent on capital investments. This total outlay of DM 287 million (US$163 million) represents 8.8 percent of sales.

The research center that is of primary importance for the Merck Group is located at Merck's Darmstadt plant. This plant accounts for 80 percent of total R&D expense, but the entire Merck Group benefits from its product and process innovations. Also, the research facilities at BDH Chemicals in the United Kingdom and at Merck Japan Ltd., as well as those in the United States and Spain, are being expanded.

Research is being intensified to meet the increased demands of the electrical and electronics industry. Also, efforts are being concentrated in the area of monocrystals for high-powered laser optics in the IR and UV ranges; liquid cystals, where R&D in Darmstadt, Japan, and Great Britain now has been adapted to the more stringent demands now being imposed by industry.

In the area of pharmaceutical research, Merck has continued to focus on agents for the control of cardiovascular diseases, the central nervous system, and biomaterials. In particular, Bracco Industria SpA, an associated company in Italy, is working on X-ray contrast media and contrast media for in vivo diagnostics with magnetic resonance equipment.

PRODUCTS

In the area of industrial chemicals, Merck offers a comprehensive range of electronic chemicals that serve the semiconductor industry. This range covers general process chemicals, dopants, developers, strippers, rinses, chemical supply systems, evaporation chemicals, and sputtering targets.

The product range for electronic applications includes the following:

- Process Chemicals
  - VLSI Selectipur[R]—These are high purity, low-particulate chemicals for VLSI-semiconductor technology. Particle content has been reduced, and the guarantee values for dissolved critical heavy metals such as Cu, Fe, Ni, Cr, Na, and K all have been reduced to the ppb range.
  - MOS Selectipur[R]—These chemicals have particle class specifications for the manufacture of ICs and cover a range of acids and etchants. In these products, the guarantee limits for impurities have been reduced to the 0.001 ppm region.
  - Selectipur[R]—This covers a broad range of solvents and etchants for semiconductor production, as well as chemicals for the manufacture of variable resistors.

- Mega Electipur®—This covers a range of state-of-the-art high-purity acids and solvents with exceptionally low particle levels for the manufacture of megabit memories and equivalent devices.

- Dopants
  - IC Selectipur®—Under this trademark, Merck supplies a range of very pure products for application in diffusion and epitaxial growth. This product includes:
    - Boron tribromide
    - Phosphorous tribromide
    - Phosphorous oxychloride
    - 1,1,1-Trichloroethane
  - Diodop/Sioge®—These products are high-purity silicate solutions for application by spin-on and other techniques. They are available as undoped liquid or doped with either arsenic, phosphorous, boron, or boron/aluminum. They are suitable for power-device production and for all cases where high doping gradients or planarization are required.

- Developers
  - Selectiplast—These chemicals are used for developing positive and negative photoresists and adhesion promotors. The positive developers are either metal ion free or metal based. Formulations are available for both immersion and in-line development. The negative developer N2 is designed to achieve optimum processing of negative photoresists with spray development. In addition, the HIR range of adhesion promotors and developers is available with polyimides.

- Strippers
  - Losolin chemicals—These chemicals are used for stripping photoresists. Losolin HIR is used with polyimides and does not contain toxic hydrazine compounds, and Losolin IV is a nonphenolic and nonchlorinated stripper that is used with either positive or negative photoresists.

- Rinse
  - Liusin—Liusin is an aqueous alkaline solution of organic surfactants for use in rinsing.

- Chemical Supply Systems
  - Selectimat—Selectimat is a turnkey system designed to give high-purity electronic chemicals as an entire package together with an extended guarantee of chemical quality at the point of use. As an alternative, customers may first select those parts of the package they require to an agreed quality guarantee.

- Evaporation Chemicals and Sputtering Targets
  - Patinal—This trademark covers a range of chemicals used in evaporation and sputtering. They are metals, alloys, and simple inorganic compounds supplied as powders, granules, tablets, or disks.

In the optical products area, Merck manufactures a range of chemicals under the Optipur trademark for the production of low-mass optical fibers. These chemicals cover halides, oxides, carbonates, nitrates, and fluorides. In addition, the Company offers a range of chemicals used for crystal growing.

Other products include single-crystal optical components for IR and UV including windows and prisms, scintillator crystals, and products for use in X-ray fluorescent spectroscopy.

OUTLOOK

The Company expects the trend established in 1988 to continue into 1989. International business should continue to grow at an above-average rate, while domestic business is expected to show only modest expansion, primarily because the West German pharmaceutical industry is passing through a difficult time. Capital expenditure for 1989 is expected to remain at approximately the same level as 1988. The Company notes that steadily rising costs for environmental protection, especially in West Germany, also are expected to have an increasing impact on profitability.

Merck will continue to attach the greatest importance to innovation. Therefore, strong R&D is being maintained not only to keep pace with the fast progress of new technologies with which the Company interfaces, but also to help shape these technologies in key areas.

Short-term business cycles notwithstanding, the Company maintains an optimistic outlook for the longer term. It is confident that it has adopted the correct strategy to meet future demand for leading-edge products, not only in the development of new pharmaceutical products, but also for special chemicals for the electronics industry.

(Products marked ® are registered trademarks of the Merck Group.)

Micro-Image Technology Ltd.

OVERVIEW

Micro-Image Technology Limited (MIT) is a wholly owned subsidiary of Laporte Industries plc, Britain's second largest independent chemicals company. It reported 1988 worldwide sales of $921 million.

The Company was established in 1972 by semiconductor engineers, and it has pioneered the production of high-purity, low-particulate chemicals. During the past 17 years, MIT has gained a reputation for quality and service and is recognized as second to none throughout the United Kingdom and other major European semiconductor centers. MIT now holds at least 70 percent of the U.K. semiconductor market for high-purity, low-particulate acids, etch mixtures, and solvents and is a major supplier to virtually all the leading semiconductor companies operating in the United Kingdom and the Republic of Ireland.

Strategically located service depots located in Livingston, Scotland, and Rousset and Grenoble, France, enable the Company to provide "just in time" (JIT) services to the major companies in those areas whose tightly coordinated production schedules require absolute reliability of chemical supply on a day-to-day basis.

The Company's reputation has enabled it to introduce its own and other manufacturers' state-of-the-art products to the U.K. market, including those manufactured by leading overseas producers of semiconductor chemicals and equipment.

OPERATIONS

The operations of MIT and its associated companies come within the Electronic Chemicals and Services Division of Laporte Industries plc, which has headquarters at Laporte House, Luton, Bedfordshire, United Kingdom.

MIT is headquartered at Greenhill Industrial Estate, Riddings, Derbyshire, in the center of England. The site comprises four main manufacturing facilities of up to 25,000 square feet each and also includes administration, sales, and warehousing facilities.

The Company employs more than 150 persons. The Greenhill site manufactures and distributes the following products:

- Low-particulate chemicals and photoresists
- Flanders filtration products
- Wafer-handling products
- Reclaimed silicon wafers, using Exsil technology
- Antireflective coatings

Micro-Image Technology Ltd.

Countdown Clean Systems Limited, part of the Laporte Electronic Chemicals and Services Division, which opened new facilities in both Riddings and Swindon, Wiltshire in 1988, provides the following products:

- Clean-room garments
- High-efficiency particulate air filters
- Specialized cleaning service
- Contamination control products

Also coming within the control of The Laporte Electronic Chemicals and Services Division are the following companies, all of which are considered leaders in products and services in the electronics industry:

- Compugraphics International—Photomask service
- Cyantek Corporation—Specialty chemicals for photomasks
- Exsil—Wafer reclamation services
- Soprelec SA and UCE of France—High-purity chemicals
- Winchester Disc Inc.—Reclamation of computer memory disks

In West Germany, MIT operates through MIT Halbleiterchemie GmbH.

FINANCIAL

Table 1 gives revenue and profit data for Laporte for the fiscal years ended 31 December, 1986 through 1988. As Table 1 shows, turnover in 1988 increased by 21 percent over that of 1987, and the 1988 pretax profit increased by 38 percent.

Table 1

Laporte Industries
Worldwide Revenue and Profit
(Millions of Dollars)

	1986	1987	1988
Turnover	$620	$759	$921
Pretax Profit	$ 94	$123	$170

Source: Laporte Industries
Annual Accounts 1988
September 1989

Table 2 shows worldwide revenue for 1987 and 1988 split by business segment.

Table 2

Laporte Industries
Worldwide Revenue by Business Segment
(Millions of Dollars)

Business Segment	1987	1988
Peroxide products	$256	$272
Building and timber products	108	152
Inorganic and organic specialties	127	137
Absorbents	63	83
Paper and water treatment	66	85
Electronic	29	41
Trading and other activities	110	151
Total	$759	$921

Source: Laporte Industries
Annual Accounts 1988
September 1989

All the business segments have shown very satisfactory revenue increases. The electronic segment, which includes MIT's contribution, shows a very healthy increase of 41 percent over 1987, reflecting overall strong growth in the semiconductor business during the year.

In its Annual Report, the Company states that both MIT in the United Kingdom and Soprelec in France had outstanding years, with both sales and profits reaching record levels.

Countdown Clean Systems performed well in 1988, with sales ahead of those in 1987. Profit, however, changed little as the opening costs of the new Swindon facility were absorbed.

Compugraphics is reported as having had an exceptional year as did the American company, Exsil. Exsil's new operations in the United Kingdom showed substantial growth, as sales expanded into Europe.

RESEARCH AND DEVELOPMENT

The improvement of existing products and processes and the identification and the development of new products and technologies are key aspects of the R&D Division's strategy and an integral part of the operations of each core business. Research and development make a vital contribution to the organic growth of the Division and facilities are now established at all of the Company's major manufacturing sites. In addition, the Division maintains centralized research and development laboratories and engineering facilities.

Research and development for MIT is carried out principally at the Riddings site, with backup facilities provided by central research at Widnes, United Kingdom. In total, up to 20 people can be involved on any single R&D project. R&D facilities include modern laboratories capable of simulating wafer-processing techniques used by the Company's customers.

The Company has several licensing arrangements, including an exclusive European manufacturing licensing and distribution agreement with Flanders Filters in North Carolina, United States.

MIT is also a U.K. distributor for the range of state-of-the-art products manufactured by Brewer Science of Missouri, United States. Marketing arrangements include one with Eastman Kodak that covers photoresists, and one with other companies that cover vacuum wands and other wafer-handling equipment.

PRODUCTS

Low-Particulate Chemicals

The Company produces a wide range of low-particulate chemicals, photoresists, and related products for large-scale integrated circuit processing. These products are sold under the trade names of Spectrum, Isopoly, Isofine, Nanoclean, Isoform Mixelec, Cleanalec, and Puralec.

MIT markets a number of negative and positive photoresists under the names of Isopoly and Isofine. These are manufactured by Kodak and further refined and quality tested by the Company. Other products include developers, thinners, and rinses.

In conjunction with these high-purity products, the Company also offers chemical dispensing and distribution systems. This includes the new Microguard Solvent Dispense System designed for the automatic filling of baths and process equipment. These systems enable chemicals to be supplied directly to the point of use from drums situated outside the clean room. Thus, etch baths and automated wafer processing equipment can now be replenished with high-purity, low-particulate chemicals from control consoles in the clean room itself.

Micro-Image Technology Ltd.

Photoresists

The photoresist range comprises positive resists, metal ion and metal-ion-free developers, negative resists, developers, and rinses. Protective coatings are available in either negative or positive chemistry, e-beam resists and developers, and associated photolithography products.

The positive range of photoresists, labeled the MEGA series, is characterized by its resolution, cd control, process latitude, thermal stability, and plasma resistance. Viscosities and formulations to suit the majority of processing requirements are available.

The negative range of photoresists, labeled the SNR series, is characterized by its excellent resolution, low-exposed film loss after development, and high adhesion factor.

Complementing the Company's range of photoresists is the new range of high-purity process chemicals. The most important of these products are antireflective coatings (ARCs) that enhance the performance of photoresists. ARCs are currently in use in the manufacture of DRAMs, SRAMs, 32-bit microprocessors, and other integrated circuits; hybrid circuits; diffraction gratings; and holographic images, which result in dramatic yield increases on reflective substrates.

Air Filtration Products

These products are manufactured by MIT under license in the United Kingdom from Flanders Filters Inc., the U.S. leader in this activity. The Company offers a complete service in Flanders, VLSI Filters for VLSI production clean rooms to give Class 10 (0.12 micron, Federal Spec 209d) clean room ceiling.

Accessories

The Company manufactures and distributes the following accessories:

- Vacuum wands and wafer-handling equipment
- Coated and uncoated Tau Pellicles (adhesive type and frame type)
- U.V. actinic spectra lamps
- MIT resolution mask
- Tweezers

Clean Room Products

The Company manufactures and distributes the following clean room products:

- Gloves and wipes
- Entry mats and lockers
- Headwear and footwear
- Coveralls
- Paper products
- Static control system

WAFER RECLAMATION

The Company offers a wafer reclamation service that uses the Exsil process. All traces of foreign materials and process dopants are removed from all wafer surfaces regardless of wafer thickness or orientation.

The Company is capable of processing silicon wafers with diameters of 76mm, 100mm, 125mm, and 150mm. Detailed specifications for individual customers' recycled wafers from Exsil are usually prenegotiated to ensure the maximum possible yield.

OUTLOOK

The semiconductor industry has a continual requirement for processing chemicals that are capable of maintaining and improving yields under the increasingly stringent requirements of line width and pattern reduction. This demand has necessitated an ongoing program of trace element and particle reduction on critical acids, solvents, and other process chemicals. It is in this area that MIT occupies a strong position in Europe and this position is expected to be maintained.

The development of MIT's range of photoresists and UV-sensitive resists, together with its related resists processing chemicals, has fulfilled, and is expected to continue to fulfill, the need for European production of a top-quality range of resists materials that are capable of meeting the most exacting industry requirements for submicron pattern definition. Thus, steady expansion of the Company's activities is expected.

Monsanto Company

BACKGROUND AND OVERVIEW

Monsanto Company was founded in 1901 in the United States (Saint Louis, Missouri). Since then, it has developed into a major multinational company with interests in a wide range of agricultural products, chemicals, pharmaceuticals, and electronic materials. The Company's main business segments are as follows:

- Agricultural Products
- Chemicals
- Electronic Materials
- Pharmaceuticals
- NutraSweet

In 1988 Monsanto turned in its best financial performance ever with net income reaching $591 million, one-third more than in any other year in the Company's history.

During the past year, the Company has continued the restructuring program it started in 1987. Monsanto broadened the base it secured in pharmaceuticals through its G.D. Searle subsidiary. Sales of Calan, an antihypertensive drug, and Cytotec, an antiulcer drug, continue to grow satisfactorily.

As part of the Company's restructuring program, underperforming assets were further pruned and, as a result, the Company announced late in 1988 that the West German conglomerate Huels AG had made a successful bid to buy Monsanto Electronic Materials (MEMC), based in Palo Alto, California, in the United States. Early in 1989, both companies agreed to the sale, and the U.S. president ratified the sale under the new omnibus trade bill. Therefore, although Monsanto will remain in the United States, no indigenous wafer manufacturers remain in North America, and the deal will have important consequences for the silicon wafer market in Western Europe.

Dataquest believes that as a result of this acquisition, VEBA AG subsidiary Huels AG, one of West Germany's largest industrial groups with a turnover of $2.5 billion, will, with its recent takeover of DNS in Italy, have a very important share of the European silicon wafer market. In the United Kingdom alone, Monsanto recently had invested more than $3 million in dedicated research equipment at its Wafer Research and Technology Facility in Milton Keynes. This plant, together with MEMC's other worldwide facilities, is now part of the Huels group and will be known as MEMC Huels Limited.

Monsanto Company

Operations

The Monsanto Company has its corporate headquarters in Saint Louis, Missouri, in the United States. The Company employs approximately 45,600 persons worldwide, with about 8 percent in Western Europe, where it also has six plants, 28 sales offices, and a major technical center in Belgium.

Monsanto Electronic Materials Company (MEMC) handles the manufacturing and marketing of silicon-wafer products used in the fabrication of integrated circuits and other semiconductor devices. The headquarters of MEMC are in Palo Alto, California, in the United States. Plants are located in the United States, Malaysia, South Korea, the United Kingdom, and Japan.

Financial

Table 1 summarizes the most recent financial information for Monsanto Company for the fiscal years ended December 31, 1986, through 1988. This information is broken out by business segments.

Table 1

Monsanto Company
Worldwide Revenue by Business Segment
(Millions of Dollars)

Segment	1986	1987	1988
Agricultural Products	$1,153	$1,305	$1,546
Chemicals	3,548	3,858	3,989
Electronic Materials	154	185	209*
Fisher Controls	645	749	840
NutraSweet	711	722	736
Pharmaceuticals	665	820	973
Corporate	3	-	-
Total Consolidated	$6,879	$7,639	$8,293

*For 10 months, Jan.-Oct. 1988

Source: Monsanto Company
Annual Report 1988
Dataquest
June 1989

Monsanto Company

In its annual report, the Company stated that the strategies established in prior years had paid off in 1988 with sales worldwide reaching a record $8,293 million. This represents an 8.6 percent increase over 1987.

Sales of electronic materials, although reported for only 10 months, showed a strong performance as a result of growth in worldwide semiconductor demand and penetration in markets outside the United States.

Table 2 gives a breakdown of Monsanto's worldwide operating income by business segment. The Company achieved a record operating income in 1988 of $955 million, an increase of 30 percent over 1987.

Table 2

Monsanto Company
Operating Income (Loss) by Business Segment
(Millions of Dollars)

Segment	1986	1987	1988
Agricultural Products	$283	$316	$424
Chemicals	613	450	486
Electronic Materials	(139)	(5)	11*
Fisher Controls	(66)	26	29
NutraSweet	142	145	154
Pharmaceuticals	(119)	(119)	(62)
Biotechnology Product Discovery	(41)	(43)	(47)
Corporate	(38)	(36)	(40)
Total Consolidated	$635	$734	$955

*For 10 months, Jan.-Oct. 1988

Source: Monsanto Company
Annual Report 1988
Dataquest
June 1989

The Electronic Materials segment has shown a substantial improvement over the past three years, moving from a loss in 1986, which included a $90 million asset impairment write-down, to a modest $11 million surplus in 1988.

Table 3 shows the worldwide revenue reported in Table 1 by geographic region. Sales in all regions showed good growth over 1987, with the exception of the Asia/Pacific region, which remained static. Sales in Europe were particularly strong at $1,801 million, showing an increase of 17 percent over 1987.

Table 3

Monsanto Company
Worldwide Revenue by Geographic Region
(Millions of Dollars)

Region	1986	1987	1988
United States	$4,638	$4,883	$5,219
Europe and Africa	1,231	1,537	1,801
Canada	290	329	377
Latin America	283	293	304
Asia/Pacific	437	597	592
Total Consolidated	$6,879	$7,639	$8,293

Source: Monsanto Company
Annual Report 1988
Dataquest
June 1989

Monsanto's operating income, given in Table 2, is shown in Table 4 by geographic region.

The Company noted in its 1988 annual report that operating income in Europe and Africa set a new record, showing an increase of 35 percent more than the previous year. Both net sales and operating income benefited from increased sales volumes of U.S.-produced chemical products resold in Europe and Africa and from higher pharmaceutical and agricultural product sales.

Table 4

Monsanto Company
Operating Income (Loss) by Geographic Region
(Millions of Dollars)

Region	1986	1987	1988
United States	$506	$501	$638
Europe and Africa	117	181	245
Canada	26	31	37
Latin America	6	2	27
Asia/Pacific	16	49	74
Interarea Eliminations	2	6	(26)
Corporate	(38)	(36)	(40)
Total Consolidated	$635	$734	$955

Source: Monsanto Company
Annual Report 1988
Dataquest
June 1989

Economic growth in the Asia/Pacific region continued apace with operating income, increasing 51 percent in 1988 over the previous year. The higher profit was generated principally from higher sales of agricultural products and electronic materials, where sales particularly benefited from strong semiconductor demand.

Research and Development

Monsanto continues to commit significant resources to research. Technological expenses totaled $648 million in 1988, 5 percent higher than in 1987, representing 7.8 percent of net sales. Significant expenditures were in life sciences—pharmaceuticals and agriculture; two thirds of the current research effort is being directed in these areas.

In the area of electronic materials, MEMC recently made a multimillion-dollar investment in a clean module. It also assists in the funding of European research projects concerned with studies in silicon wafer microdefects.

SEMICONDUCTOR PRODUCTS

MEMC markets a different type of silicon wafer to service each of the following three application series:

- ULSI—Ultralarge Scale Integration
- VLSI—Very Large Scale Integration
- LSI/MSI—Large Scale Integration/Medium-Scale Integration

ULSI Application Series Wafer

The evolution of integrated circuits toward greater circuit density and the smaller design rules of ULSI circuits have required concurrent technological advancements in silicon wafers. MEMC has designed silicon wafers that are multizone systems and focus on specific circuit application requirements. The three product systems in this series are as follows:

- MUS—ULSI polished silicon
- MUG—ULSI enhanced gettering
- MUE—ULSI MOS EPI

VLSI Application Series Wafer

This series consists of circuit-focused wafers for use in VLSI applications and incorporates the specifications best suited to meet the requirements of this level of integration. The series offers the following crystallographic improvements over the former VLSI series:

- OISF is now specified at less than $100/cm^2$.
- Oxygen content may now be specified to a target between 28 and 35 ppma with a tolerance of ± 3.

These crystallographic improvements are the result of a novel technique in crystal-pulling technology that gives maximum fab line yield and enhanced device parametrics to the silicon user.

Monsanto Company

LSI/MSI Application Series Wafer

These are circuit-focused silicon wafer products to service LSI and MSI applications. Specifications are designed to be cost effective and to provide excellent performances for the typically mature processes in which this type of substrate is used.

OUTLOOK

Under its new management, MEMC is well placed to capitalize on its ability to design silicon wafer products possessing functional zones tailored to individual requirements. By virtue of MEMC's new ownership, and thereby its relations with DNS, Dataquest anticipates that the marketing of silicon wafer products, particularly in Europe, will undergo considerable change.

Olin Corporation

BACKGROUND AND OVERVIEW

Olin Corporation's business primarily is in chemicals, metals, and applied physics, with special emphasis on electronic materials and services and the defense/aerospace industry.

The Company reported record sales in 1988 of $2,308 million. Electronic materials accounted for 10 percent of sales or $231 million; this was an increase of 15.0 percent on 1987 sales. Projected sales for the Company are $2,650 million for 1989 and for electronic materials $300 million, accounting for 11.3 percent of total company sales. At the end of the first quarter of 1989, the Company reported sales and income as being on target.

Olin Corporation divides its business into the following three segments:

- Chemicals
- Defense
- Metals and Materials

The Chemicals segment embraces a wide variety of electronic materials, and these are marketed through Olin Hunt Specialty Products.

Currently, the Olin Corporation is going through a period of rationalization with a view toward strengthening its position, particularly in electronics. To this end, it recently increased its investment in Indy Electronics, a leading contract assembler of integrated circuits and microelectronic packages.

The Company also is divesting itself of businesses that do not fit with its marketing strategy. As part of this process, the company announced on May 22, 1989 that it had completed the sale of its Olin Hunt worldwide photographic chemicals business to Fuji Photo Film Company Ltd. of Japan for approximately $75 million. The company pointed out at the time of the sale that this transaction had no connection with a Fuji–Olin Hunt venture that covers photoresist products for the semiconductor industry. In Europe, the St. Niklaas plant in Belgium will be transferred to Fuji.

Although the sale of the photographic chemicals business makes Olin Hunt smaller in this area, the company takes the view that it will now be able to focus more sharply on electronics materials. In addition, Olin Hunt continues to participate as a major supplier of process chemicals to the growing semiconductor and printed wireboard markets, of electrostatic materials such as toner for copiers, and of materials for the computer printer markets.

Also in May 1989, Olin announced that it purchased an interest in Langenberg Kupfer und Messingwerke GmbH & Co. to form a joint venture with Wieland–Werke AG of West Germany. The objectives of the new venture, which will operate as an independent company, include the introduction of Olin's high-performance alloys to the electronic and connector industries in Western Europe.

Olin Corporation

OPERATIONS

The Company's corporate headquarters are located in Stamford, Connecticut, in the United States. Worldwide, the company employs approximately 16,400 persons.

Olin Hunt Specialty Products, Inc., manufactures, distributes, and markets a wide range of products used in semiconductor manufacture. The Company employs approximately 1,200 persons in these operations and 150 chemists in R&D outside Europe. In Europe, another 200 persons are employed.

This company markets approximately 600 chemicals to 20,000 customers through an international operation that includes a complex of manufacturing, warehousing, and distribution centers with 17 plants in the United States, Europe, Singapore, and Japan.

In addition to Olin Hunt Specialty Products, Inc., which embraces printed wireboard (PWB), electrostatics, and microelectronics operations, Olin has three interconnect and packaging companies: Olin Mesa, Indy Electronics, and Aegis Inc., which is a joint venture with Asahi Glass of Japan.

To distribute the company's products in Europe, warehousing and regional sales offices are maintained in all the main European countries.

FINANCIAL

In its 1988 Annual Accounts, Olin Corporation reported record sales of $2,308 million, a 20 percent growth over the previous year. A record $98 million in net income also was achieved in 1988, a 26 percent increase over $78 million in 1987. The Company attributes its increased earnings to the impact of increased volumes and ongoing efforts to reduce costs. Table 1 gives the Company's financial results for the fiscal years that ended December 31, 1986, through 1988. Sales by business segment are shown in Table 2.

Table 1

Olin Corporation and Subsidiaries
Worldwide Revenue
(Millions of Dollars)

	1986	1987	1988
Net Sales	$1,732	$1,930	$2,308
Cost of Goods Sold	$1,318	$1,455	$1,781
Selling and Administration	$ 252	$ 264	$ 289
Research & Development	$ 56	$ 62	$ 58
Operating Income	$ 106	$ 149	$ 180

(Continued)

Olin Corporation

Table 1 (Continued)

Olin Corporation and Subsidiaries
Worldwide Revenue
(Millions of Dollars)

	1986	1987	1988
Interest Expense	$ 32	$ 32	$ 43
Interest & Other Income	$ 41	$ 10	$ 14
Income before Taxes	$ 115	$ 127	$ 151
Income Tax Provision	$ 40	$ 49	$ 53
Net Income	$ 75	$ 78	$ 98

Source: Olin Corporation
Annual Accounts 1988
Dataquest
October 1989

Table 2

Olin Corporation and Subsidiaries
Worldwide Sales by Business Segment
(Millions of Dollars)

Segment	1986	1987	1988
Chemical Sales	$1,127	$1,227	$1,366
Defense & Ammunition Sales	361	394	469
Metals & Materials Sales	244	309	473
Total	$1,732	$1,930	$2,308

Source: Olin Corporation
Annual Accounts 1988
Dataquest
October 1989

Olin Corporation

Olin Corporation noted in the 1988 Annual Accounts that its chemical business achieved record sales and profits. It benefited from strong demand for most products, including chloralkali, urethanes, pool chemicals, and electronics chemicals. Net income for chemicals in 1988 was $75 million, compared with $59 million in 1987. This business sector shows an increase of 27 percent. Chemical sales, shown in Table 2, also contain electronics materials sales. Over the 1986 to 1988 period, sales increased 45 percent. This strong growth is attributed to Olin's gradual buildup of its unique strengths in metallurgy and chemistry, creating an electronic materials and services thrust area.

Note that in 1987, sales outside the United States amounted to 7.25 percent. In 1988, this proportion rose to 10.0 percent, indicating that the Company's global approach strategy is working.

RESEARCH AND DEVELOPMENT

Fundamental research and development (R&D) is carried out in the United States. In 1988, Olin Corporation spent $58 million on R&D.

The Company has a long-term commitment to R&D investment. In 1988, new product development and exploration of new technologies accounted for approximately 60 percent of R&D spending. The balance was dedicated to optimizing existing technologies, including yield improvements, waste minimization, and manufacturing cost reduction efforts.

In the area of electronic materials, the company is responding to the challenge of smaller circuit geometries by developing advanced ultrapure imaging and process chemicals, including a new line of photoresists for application-specific integrated circuits (ASICs), a high-growth market.

The PWB unit's investment in R&D also is paying off. It is now commercializing its innovative Blackhole technology, a proprietary carbon-based process for making the through-holes in printed wireboards conductive.

An important area of research that is being addressed by Olin Corporation researchers is the development and commercialization of two devices—a copper alloy package system and a plastic pin grid array—that can dissipate heat and offer other cost-saving benefits.

Olin Corporation

PRODUCTS

Olin Hunt Specialty Products offers a wide range of products for the microelectronics industry that include the following:

- Positive Photoresist Systems
  - Waycoat HPR 204/206 resists—For striation-free coatings, improved adhesion, and shorter exposures in all projection and contact aligners
  - Waycoat MPR resist—Specifically for manufacture of chrome photomasks
  - Waycoat MIF developer—Metal-ion free
- Negative Photoresist Systems
  - Waycoat HNR 80/120 resists—A high-resolution system that also reduces mask sticking in contact exposure
  - Waycoat Negative HR 100/200 resists—For imaging on highly reflective metallized and oxidized surfaces
  - Waycoat IC Type 3 resists—State-of-the-art resists with reduced oxygen sensitivity
  - Waycoat SC resists—A family of photoresists that produce film thicknesses greater than 2 microns
  - Waycoat negative resist developer—Specifically designed for use with resists exposed in the Perkin-Elmer Micralign
  - Waycoat COP resist—A resist for electron-beam applications
- Temperature controllers—A range of Apache models
- Electronics grade chemicals
  - Trimethylphosphite
  - Tetraethyl(ortho)silicate
  - Trimethyl borate
  - Triethyl borate
  - 1,1,1-Trichlorethane

- Chloroform—Plasmaform
- Carbon tetrachloride—Plasmatet
- Phosphorus oxychloride and tribromide
- Boron tribromide
- Boron trichloride—Plasmabor

All of these products (except chloroform and carbon tetrachloride, which are supplied only in stainless steel ampules) are available in Apache quartz bubble ampules. (Plasmaform, Plasmatet, and Plasmabor are registered trademarks of Olin Corporation.)

TECHNICAL SERVICE—EUROPE

Currently, Olin Corporation's technical service is headquartered in St. Niklaas, Belgium. It has a fully equipped microlithographic laboratory housing the latest state-of-the-art equipment. As a result of progressive additions over the past few years, this facility now represents an investment of more than $5.5 million.

The St. Niklaas site occupies an area of approximately 14,000 square meters and comprises the Technical Center, a modern plant for various electronic chemical products, and large warehousing facilities.

Olin Hunt Specialty Products currently employs some 200 persons in Europe, of whom 75 are in sales and customer service, 60 in manufacturing, and 65 in supporting services such as general administration and distribution. The business is divided into the Printed Circuit Board and Microelectronics divisions. The latter division is headed by a director who has technical services and product managers reporting to him. In addition, sales managers for each European country or region also report to the divisional director. Each sales manager supervises several process engineers.

The Microelectronics Division, which is staffed by highly qualified experts conversant in the major European languages, is designed to offer customers the following services:

- Performance demonstrations of photoresist and related products
- Design of new photoresist processing methods
- Evaluation of new types of process equipment
- Training of special seminar and workshop participants

The laboratory is very well equipped with capabilities covering all principal steps in semiconductor fabrication.

Olin Corporation

FUTURE PROSPECTS

Olin Corporation has set as its objective for the early 1990s a goal to perform consistently at a level that exceeds a 20 percent return on equity. At present, the company is achieving approximately 15 percent return on equity.

The Company believes that such performance goals can be attained only by consistently meeting the needs of the customers. Quality, productivity, and innovation are what customers are seeking, and Olin Corporation is setting out to meet these expectations 100 percent of the time.

In the area of electronic materials, the Company sees itself remaining at the forefront, particularly in photolithographic chemicals, because of the emphasis it places on R&D in this field and because of the Company's adherence to strict product-quality control. The Company also places increasing emphasis on producing chemical systems with minimal environmental effects.

Although the Company has set high goals for itself, it views the future with confidence. It intends to continue working at the leading edge of technology in order to produce new and improved products to meet the increasingly complex needs of customers in the microelectronics industry.

The Perkin-Elmer Corporation

BACKGROUND AND OVERVIEW

The Perkin-Elmer Corporation was founded in 1937 by Richard S. Perkin, an investment banker, and Charles W. Elmer, a retired publisher and court reporter. Both shared an avid interest in astronomy and a conviction that a source for the design and production of ultraprecise optics should be established in the United States; at that time, the field was dominated by a few European companies. Incorporation followed in 1939. In the intervening 52 years, Perkin-Elmer has developed into a diversified high-technology company, with a worldwide presence in more than 100 countries.

In 1988, the Company reported a substantially improved financial performance over the previous year with sales of $1,165.5 million, showing a 5 percent increase, and a net income of $71.8 million compared with a loss of $18.2 million in 1987. About 55 percent of the Company's sales are derived from markets outside the United States.

Perkin-Elmer has manufacturing plants in the United States, the Commonwealth of Puerto Rico, the United Kingdom, and West Germany.

The Company segments its business into the following five groups:

- Instrument Group—Accounts for about 42 percent of sales and covers analytical instruments for use in private industry, educational and research institutions, and governmental entities for fundamental research.

- Semiconductor Equipment Group—Accounts for about 17 percent of sales and includes equipment for photolithography, maskmaking, and etching and sputtering steps in semiconductor manufacture.

- Materials and Surface Technology Group—Accounts for about 15 percent of sales and covers combustion, electric arc, and plasma thermal spray equipment and supplies.

- Bodenseewerk Geraetetechnik (BGT)—A subsidiary company in West Germany that manufactures guidance and control systems for NATO's air-to-air missile defense systems. This company accounts for 14 percent of sales.

- Government Systems Group—Accounts for 12 percent of the Company's sales. This business segment covers the production of tactical systems; the Company has recently been awarded an order for the AN/AVR-2 laser warning receiver, signifying the Company's entry into the tactical electro-optical sensor production business, the fastest growing segment of the tactical market.

In January 1988, Perkin-Elmer announced the acquisition of Nelson Analytical, Inc., a California-based company with expertise in data handling and systems integration.

The Perkin–Elmer Corporation

Late in the fourth quarter of 1988, Perkin–Elmer announced that its Board of Directors had approved tendering 9.4 million shares of Concurrent Computer Corporation stock pursuant to an agreement with Massachusetts Computer Corporation. Under the agreement, Perkin–Elmer sold its shares in Concurrent at $20 per share.

Operations

The headquarters of Perkin–Elmer is in Norwalk, Connecticut. The Company does business in more than 100 countries, and its customers are served by a network of approximately 200 Perkin–Elmer sales and service offices and an extensive number of franchised dealerships.

For efficient, easy access to international markets, the Company operates 15 major manufacturing facilities in the United States, West Germany, the United Kingdom, and Puerto Rico. Through joint ventures and other arrangements, the Company plans to extend its production base to Japan and other nations.

In 1988, Perkin–Elmer employed 10,941 persons worldwide, 6,378 of whom were employed in the United States.

Financial

Table 1 summarizes the Company's financial data by business group for the fiscal years ended July 31, 1986, through July 31, 1988. The figures in Table 1 reveal that net income increased by 5 percent in 1988 to $1,166 million. This was mainly due to the strength of the analytical instrument group, which grew by 16.2 percent as a result of the Company's continued marketing advances in both domestic and foreign markets.

In its annual report, Perkin–Elmer noted that 1988 semiconductor equipment revenue was slightly less than in 1987, as demand for the Company's Micrastep product slowed in anticipation of its offering of an advanced optical lithography machine with improved technical performance and better throughput.

Table 2 summarizes worldwide operating income (before taxes) by business group for the fiscal years 1986 through 1988. It shows that income before taxes recovered sharply in 1988 to $104 million from $3 million in the previous year. All the business groups enjoyed improved income except BGT, where income declined not only as a result of lower revenue, but also as a result of increased research and development expenses. Income from the Semiconductor Equipment Group was modest, as a result of lower demand for Micrastep and higher operating expense but compared favorably with the $78 million loss reported for 1987, which included special charges for restructuring and additional research and development expenses.

Table 1

Perkin-Elmer Corporation
Worldwide Net Revenue by Business Group
(Millions of Dollars)

Business Group	1986	1987	1988
Instrument	$ 363	$ 416	$ 484
Semiconductor Equipment	250	203	200
Materials & Surface Technology	150	168	177
Bodenseewerk Geraetetechnik	127	165	163
Government Systems	184	162	145
Subtotal	$1,074	$1,114	$1,169
Intergroup Transfers	(4)	(4)	(3)
Total	$1,070	$1,110	$1,166

Table 2

Perkin-Elmer Corporation
Worldwide Operating Income by Business Group
(Millions of Dollars)

Business Group	1986	1987	1988
Instruments	$ 34	$41	$ 57
Semiconductor Equipment	19	(78)	3
Materials & Surface Technology	22	27	26
Bodenseewerk Geraetetechnik	24	40	32
Government Systems	25	7	13
Subtotal	124	37	131
Less Intergroup, Interest and Corporate Expenses	(22)	(34)	(27)
Income before Taxes	$102	$ 3	$104

Source: Perkin-Elmer
Annual Report 1988

In the Company's first-quarter report for the period that ended October 31, 1988, it was noted that income, revenue, and orders all increased, continuing the favorable results of fiscal 1988. Total net revenue for the quarter was $273.5 million against $256.9 million for the comparable period in 1987. It was noted that there was growth in all business areas, with particular strength being shown in European avionics, materials and surface technology, and semiconductor equipment. Analytical instruments are showing a strong advance in all geographic areas and in a broad range of markets. In particular, the Company cites the new Model 1600 Fourier Transform Infrared Spectrometer as being a world leader in this analytical technique.

Research and Development

Perkin-Elmer is actively engaged in basic and applied research and development (R&D) and engineering programs designed to develop new products. In fiscal 1988, Perkin-Elmer spent $99 million on R&D (i.e., 8.5 percent of net sales revenue).

Areas of investigation include artificial neural systems for advanced analytical instruments and diamond coatings for optical and military sensors. Joint research programs on the processing, deposition, and characterization of high-temperature superconducting materials are under way with the State University of New York at Stony Brook, the University of Connecticut, and several other major research universities and national laboratories.

Perkin-Elmer's technology effort applies the latest research findings to advanced products and processes. Working closely with marketing and engineering personnel, scientists are exploring advanced applications of emerging technologies for new instruments and systems in analytical chemistry, bioanalytics, and microlithography.

PRODUCTS

The Company markets high-technology products in analytical instrumentation for chemical analysis, semiconductor processing equipment, materials and surface technology systems, avionics, and electro-optical systems for defense and space astronomy.

In the field of semiconductor equipment, Perkin-Elmer is the only company able to offer a complete line of integrated wafer fabrication equipment specifically designed to increase VLSI productivity. This equipment has features such as 6-inch wafer processing, high throughput, and pick-and-place wafer handling to minimize contamination. Perkin-Elmer's main products are described in the following paragraphs.

The Perkin-Elmer Corporation

Micrascan 1 System

This is the Company's latest half-micron resolution, high-throughput lithography system. It possesses a powerful 4x reduction, a step-and-scan-based lithography tool that outperforms excimer steppers in all critical performance areas including resolution, throughput, image field size, overlay, and particulates. This system has been made possible by the use of new design concepts including a catadioptric lens; high speed, servo-locked magnetically driven stages; and highly flexible, robust through-the-lens alignment system.

AEBLE 150

The AEBLE 150 is a direct-write electron beam lithography system that processes as many as 30 4-inch wafers per hour; it is also capable of processing 5- and 6-inch wafers. It writes 0.5-micron features with an overlay accuracy of 0.1 micron and a critical dimension control of 0.05 micron. Both optical and positive e-beam resists can be used. The AEBLE 150 is very accurate and can be used in mix-and-match lithography with existing optical tools and advanced X-ray systems.

MEBES 111

The MEBES system represents the latest state-of-the-art technology for the production of high-quality masks and reticles for VLSI devices.

Micralign Series

This is a projection mask alignment system and consists of three models:

- Micralign Model 300/500, providing machine overlay accuracies to 0.5um, machine stabilities to 0.25um, and resolution capabilities from 0.9um to 1.26um
- Micralign 600 HT Series System, a new generation of clean environment projection mask aligners with a guaranteed specification for low particulates
- Micralign 600 Delta Series, offering semiconductor manufacturers a lower-cost machine to meet current needs while providing a migration path to a higher-performance machine in the future

Micrastep I and II

These are step and repeat alignment systems. Both come with an impressive set of features, including air gauge focusing and leveling at each exposure field, dark field/bright field site-by-site alignment, digital alignment signal processing, and automatic calibration of alignment and focusing systems, as well as overall system magnification.

OMS-1

This overlay measurement system is a key tool for automatically measuring overlay accuracies. It optimizes lithography tool performance through the quick and precise measurement of overlay on production wafers.

1600 Series FT-IR Spectrophotometer

This is a single-beam scanning Michelson interferometer. It uses sealed and desiccated optics with a Ge-coated KBr beamsplitter.

The 250 QA/QC System

This system covers a family of modular liquid chromatography instrumentation. It incorporates a fully upgraded binary pump/diode array detection system that claims to be the most cost-effective gradient diode array system on the market.

Metco Diamond Jet

Metco and Perkin-Elmer have developed, with the Metco Diamond Jet System, a completely new coating system for use in producing high-quality coatings, especially where there is need for superior metal, carbide, and specialty coatings. The system uses a new concept in thermal spraying that incorporates a high-velocity, oxygen-fuel (HVOF) system for producing these high-quality coatings.

FUTURE PROSPECTS

The Perkin-Elmer Corporation has a diverse range of high-technology products that serve broad markets. With its very substantial technological strength and marketing position, the Company views the long-term growth opportunities for its products with confidence.

In particular, the Company believes that the international marketplace offers excellent prospects for growth. In the forefront, the Pacific Rim countries (ranging from Japan, to the People's Republic of China, to Australia) are viewed as being fertile areas for future development.

Plasma Technology, Ltd.

OVERVIEW

Founded in 1981, Plasma Technology is now one of Europe's principal manufacturers of plasma etching and deposition equipment. The Company was privately owned until 1986, when it was acquired by The Oxford Instruments Group, a British company engaged in the research, development, manufacture, and sale of advanced instrumentation for scientific research, semiconductor processing, patient monitoring, industrial analysis, and diagnostic imaging.

Following its success in Europe, where it installed more than 200 plasma systems by 1986, the Company undertook an ambitious expansion program aimed at the U.S. and Japanese domestic markets. This strategy's success is evident in that within two years, the Company delivered 200 systems in the United States, bringing the worldwide total to well more than 700 systems. To celebrate this achievement, Plasma Technology opened new facilities including manufacturing, demonstration, and sales and service activities in Concord, Massachusetts.

In 1988, the Company had sales of approximately $14 million. This amount represents about 10 percent of the parent company's sales and is an increase of more than 25 percent over 1987. Substantial growth occurred in the United States and throughout Europe, with particularly heavy demand for the Company's new production-orientated advanced multirole plasma (AMR) system.

In anticipation of Europe in 1992, Plasma Technology has established new subsidiaries and offices in three strategic areas—one near Frankfurt, West Germany; the second in Paris, France, where facilities are shared with Oxford Instruments; and the third in the Netherlands. These activities, which previously were undertaken by distributors, enable Plasma Technology to establish a local presence and to offer customers firsthand process technology and service.

In Japan, the Company marked the start of 1989 with the opening of a new laboratory in Tokyo. This facility operates in cooperation with Marubun Corporation and offers process support and equipment demonstration to users throughout Japan.

OPERATIONS

Plasma Technology headquarters are located in Yatton, near Bristol, England. This site includes a new conference suite and accommodations for customer process and maintenance training. Adjacent to the headquarters is a modern manufacturing facility and a new laboratory, which opened in 1989. It replaces the previous laboratory, which had been in operation under semiclean conditions for almost three years. The new service and test facilities will enable the new laboratory to meet customer requirements into the 1990s. The complex contains two fully automatic production systems installed in a better than Class 100 clean room, with full inspection and wet-processing facilities in a supporting Class 1,000 area.

During the past few years, Plasma Technology has strengthened its international marketing with the implementation of sales, service, and applications support centers in the following locations:

- Netherlands—Oxford Instruments BV, Gorinchem
- France—Plasma Technology SARL, Paris

- West Germany—Plasma Technology GmbH, Wiesbaden
- United States—Plasma Technology Inc, Cambridge, MA and Sunnyvale, CA

In Japan, the Company distributes its products through Marubun Corporation. To establish new markets in both Turkey and Singapore, Plasma Technology has entered into sales and marketing agreements with Tekser to cover Turkey and Hisco (Malaysia) Pty. to cover Singapore.

FINANCE

The individual results of the Company are consolidated into Oxford Instruments' figures. However, the Company stated that sales in 1988 totaled slightly more than $14 million. Table 1 gives a summary of the financial results of The Oxford Instruments Group Plc for the fiscal years that ended on March 31, 1987 through 1989.

In the Annual Report and Accounts 1989, the Company notes that sales turnover improved by 11.4 percent, and pretax profits were well maintained despite the effects of the strong pound. A very high proportion—89 percent—of 1988 and 1989 sales turnover within The Oxford Instruments Group was generated outside the United Kingdom, as shown in Table 2. Table 2 also shows that the United States is the single-largest market for the Company's products.

Table 1

The Oxford Instruments Group Plc
Worldwide Revenue
(Millions of Dollars)

	1987	1988	1989
Turnover	167	158	176
Operating Profit	32	18	22
Profit before Tax	33	20	20
Exchange Rate (Pounds per U.S.$1)	0.6	0.56	0.57

Source: Annual Report and Accounts 1989
The Oxford Instruments Group Plc
Dataquest
February 1990

Table 2

The Oxford Instruments Group Plc
Sales Turnover by Geographic Area
(Millions of Dollars)

	1988 Sales	1988 % Total Sales	1989 Sales	1989 % Total Sales
United States	72	46%	83	47%
West Germany	21	13	21	12
United Kingdom	12	8	19	11
Switzerland	7	4	9	5
Other Western Europe	18	11	19	11
Japan	14	9	11	6
Others	14	9	14	8
Total	158	100%	176	100%

Source: Annual Report and Accounts 1989
The Oxford Instruments Group Plc
Dataquest
February 1990

RESEARCH AND DEVELOPMENT

The parent company has a strong commitment to research and development (R&D) and increased gross expenditure in this area from $17 million in 1988 (10.8 percent of sales) to $23 million (13.0 percent of sales) in 1989. Plasma Technology works closely with government-sponsored research projects, both national and international, and with universities across Europe.

The work that the Company is carrying out with four other companies at the Rutherford Appleton Laboratories near Oxford in England illustrates its cooperative efforts. This research into submicron e-beam technology for silicon devices is funded by the Department of Trade and Industry as part of its National Electronics Research Initiative scheme. This project has ambitious objectives, such as the development of very fine line e-beam technology for mask manufacture and device fabrication. In particular, research is aimed at developing a complete e-beam and dry etch process for advanced maskmaking for the 1990s. Chrome masks with 0.3-micron minimum feature size and with CD control of better than ±0.05 micron will be required. Plasma Technology will be contributing to the project by refining existing chrome mask dry etching processes and developing novel techniques for etching from fine-line e-beam direct write masks.

COMPANY PRODUCTS

Plasma Technology markets a number of Plasmalab systems that cover reactive ion etch (RIE), photoresist strip (PRS), and plasma deposition.

The Plasmalab series includes the following:

- AMR—AMR is an advanced multirole plasma system with the flexibility to be configured for a host of applications. Downstream microwave, electron cyclotron resonance (ECR), propogation ion etch (PIE), and conventional RF options and combinations make the AMR a unique and highly flexible vehicle for advanced device processes. This system is suitable for either pure research or production. The modular concept allows either manual loading for R&D applications or cassette-to-cassette-autoload where extreme cleanliness is paramount.
- ECR—The 2000R is a new electron cyclotron resonance etch (ECR) system. The 3000R is the latest low-temperature deposition technology system.

Both systems use the ECR principle. In the 2000R, electrical damage to the device that may occur using conventional RF plasma systems is removed using a high-density, low-energy directional ion stream. This method is capable of achieving extremely high etch rates at low-ion energies. With the 3000R, ECR can achieve very high deposition rates at very low temperatures and pressure, ensuring excellent film quality.

Alphaline 300

This product is the result of a joint development with Edwards High Vacuum (a division of BOC) and is Europe's first modular, multichamber amorphous silicon production system. It is an in-line vacuum coating system for producing silicon by plasma-enhanced chemical vapor deposition (CVD) on glass substrate. The Alphaline 300 system is capable of meeting the demand for the high-speed deposition of amorphous silicon on large substrates up to 300x300mm in size.

SE 80

The SE 80 is a high-capacity system for photoresist stripping and general, isotropic fluorine-based etching. This barrel etch/strip system is used in finishing solar cells.

Nitrogen Trifluoride

In addition to Plasma Technology's range of equipment and systems is a new gas, which is called nitrogen trifluoride (NF), offered as part of its Expressgas service. Nitrogen trifluoride is finding increasing use as an alternative to carbon tetrachloride for etching silicon-type materials. It has the advantage of producing only gaseous products when it is decomposed; no polymers are formed. In addition, as NF generates large amounts of atomic fluorine, it allows higher silicon etch rates than are obtainable with fluorocarbon gases.

OUTLOOK

Plasma Technology has experienced remarkable growth since it was founded eight years ago. As part of The Oxford Instruments Group with its large resources, the Company is expected to go from strength to strength, as well as maintaining its leading position in the field of plasma technology.

During the past eight years, the Company has built up a steadily increasing user base, with more than 700 systems installed worldwide—200 of which are in the United States. From this base, the Company is well positioned to develop further the opportunities presented in the U.S. market. In addition, the Japanese market is seen as capable of further development during the next few years.

Plasma Technology continues to view the area of plasma-etching techniques as one that offers above-average growth opportunities. To maintain its leading position, the Company plans to continue its strong involvement in processes and applications by further collaborative R&D programs with major users and universities. An example of this involvement is the work that currently is being carried out at the Rutherford Laboratory using the compact synchrotron for X-ray lithography. The following areas have been identified for future development:

- Deposition and etching of refractory metals and silicides
- Etching processes for gallium arsenide integrated circuits
- Plasma etching of optically and electron beam-generated chrome mask plates
- Enhanced plasma techniques for next-generation RIE systems
- Optical mask repair techniques

The Company recognizes that a key feature in maintaining its progress in what is now a very competitive environment is its continued commitment to R&D. Therefore, despite the continued pressure on the parent company's overall financial performance, expenditure on R&D is not being curtailed.

Oxford Instruments' philosophy is that long-term success in a world of increasing competition in high technology requires a willingness to invest for the future, coupled with a determination to succeed commercially in an increasingly harsh marketplace. Today's innovativeness therefore is a measure of the Company's potential for commercial success in the future. Dataquest believes that because of the Company's excellent reputation and its realistic approach to the likely turn of events in its marketplace, it is well placed to expand its share of the growing worldwide market for plasma systems.

Philip A. Hunt Chemical Corporation

BACKGROUND AND OVERVIEW

The Philip A. Hunt Chemical Corporation (Hunt Chemical) was founded on November 30, 1909, in Brooklyn, New York, U.S.A., as a supplier of chemicals for photography and the graphic arts.

During the intervening 76 years, the Company has made major contributions not only to the development of these industries but also to the electronics industry.

Concurrent with these achievements, Hunt Chemical has expanded its operation worldwide. Today it is one of the foremost international producers of high-quality imaging chemicals, with operations spanning four major marketing areas:

- Microelectronics
- Printed Circuits
- Electrostatic Copiers
- Photo/Graphics for photofinishing and printing

In July 1984, Hunt Chemical became a wholly owned subsidiary of the Olin Corporation (Olin) of Stamford, Connecticut, U.S.A., at a purchase price of approximately US$150 million. By so doing, the well-established and trusted name of Hunt Chemical enhanced Olin's own reputation as a supplier of high-quality materials, particularly high-performance metal alloys, to the electronics industry. This also emphasized Olin's ongoing commitment to serve the electronics industry.

In late 1984, Matrix Integrated Systems (Matrix), which specializes in single-wafer plasma stripping technology, also became a wholly owned subsidiary of Olin. Thus Matrix, which reports through Hunt Chemical, represents Olin's entry into the semiconductor equipment business and complements Hunt Chemical's leading position as a supplier of photoresist products.

The most recent developments by Olin to expand its role as a supplier of electronic materials and services are in the manufacture of semiconductor-grade sulphuric acid at a plant in Shreveport, Louisiana, employing the latest technology. This plant was scheduled to begin production in mid-1985. Other recent developments were the purchase of Hi-Pure Chemicals, Inc., from Allied Corporation and the purchase of Apache Chemicals, a supplier of high-purity dopants and chemical delivery systems to the semiconductor and telecommunications industries.

Philip A. Hunt Chemical Corporation

With the above acquisitions, Olin Corporation has obtained a significant presence in the three major process technologies used in semiconductor manufacture: Etchants (Hi-Pure), Dopants (Apache), and Photoresists (Hunt Chemical).

Operations

The corporate headquarters of Hunt Chemical are located at West Paterson, New Jersey, U.S.A.

In 1984, the Company employed worldwide more than 150 qualified chemists, physicists, and engineers in research and development (R&D) and 1,200 employees in manufacturing, marketing, and distribution.

The Company markets some 600 chemicals to 20,000 customers through an international operation that includes a complex of manufacturing, warehousing, and distribution centers with 17 plants in the U.S.A. and Europe.

European Operations

In Europe, the importance of having a local presence was recognized as early as 1967 when, with the increasing number of customers in the growing EEC markets, Hunt Chemical took occupancy of an office and plant in the Sint-Niklaas Europark Industrial Centre in Belgium. In 1969, NV Hunt Chemical commenced manufacture of electronic and graphic arts etchants to be followed by filming agents in 1971 and alkaline etchants in 1972. Since 1972, the Belgium site has been expanded and become the center of Hunt Chemical's European operation, with other companies being established throughout Europe to provide local sales, customer service, and warehousing.

Hunt Chemical now employs some 175 persons in Europe. The functional structure of the Company is described in the following paragraphs.

Belgium

NV Hunt Chemical, Sint-Niklaas, is the European headquarters. It houses the Microelectronics and Printed Circuit Board Divisions, the European Technical Service Centre, and product marketing. In addition, there are manufacturing and warehousing facilities.

United Kingdom

Hunt Chemicals Ltd., Coventry, England, houses the regional sales office for the United Kingdom (excluding Scotland), customer service, and warehousing.

Philip A. Hunt Chemical Corporation

Hunt Chemicals Ltd. (Scotland), East Kilbride, is a new regional sales office providing customer service to the growing electronics industry in Scotland; additionally, it possesses refrigerated warehousing.

France

Hunt Chemicals, Aubervilliers, houses the area sales office, customer service, and warehousing.

West Germany

Hunt Chemicals GmbH, Bischofsheim, provides customer service, warehousing, and local product marketing.

Italy

Hunt Chemicals SRL, Milan, houses the local product sales office, customer service, and warehousing.

Revenues

Table 1 shows a decline in operating profit for Hunt Chemical's foreign operations from 1982 to 1983, primarily due to the strengthening of the U.S. dollar against European currencies. This resulted in European operations having higher costs for U.S.-purchased materials, which could not be recovered in sales prices.

Table 1

Philip A. Hunt Chemical Corporation and Subsidiaries
WORLDWIDE REVENUES
(Millions of U.S. Dollars)

	1981	1982	1983
Net Sales	$111.9	$114.8	$119.9
Operating Profit (Worldwide)	$ 6.5	$ 9.2	$ 10.6
Operating Profit (Europe)	$ 2.3	$ 4.9	$ 3.7

Source: Hunt Chemical Annual Accounts 1983
DATAQUEST
November 1985

At the local level, the effect on sales revenue of the appreciation of the U.S. dollar over the years from 1981 through 1984 is illustrated in Table 2.

Table 2

NV Hunt Chemical
ESTIMATED SALES REVENUES
(Millions of Belgian Francs and U.S. Dollars)

	1981	1982	1983	1984
Net Sales	BF890	BF1,039	BF1,314	BF1,800
Net Sales	$23.9	$22.7	$25.7	$31.2
Exchange Rate (BF to $1)	37.13	45.69	51.13	57.78

Source: DATAQUEST
November 1985

The figures in Table 2 reveal that while sales in local currency have been increasing at a rate in excess of 26 percent per annum since 1982, the growth rate is almost halved when calculated in U.S. dollars.

The high level of activity experienced in the electronics industry in 1984 is reflected in the sales figures. DATAQUEST's estimates show an increase of 37 percent in Belgian francs and still a very healthy 21 percent increase when translated into U.S. dollars, as compared to 1983.

Major growth in sales has been experienced in the United Kingdom. In 1983/84, the United Kingdom accounted for approximately 35 percent of sales, with West Germany, France, and Italy each at 17 percent and the Rest of Europe at 14 percent.

Philip A. Hunt Chemical Corporation

Intercompany Agreements

Hunt Chemical has a number of product and technology arrangements with other companies. The more important agreements include:

- A working agreement with Philips in Holland and Siemens in West Germany

- A joint venture with Fuji of Japan in forming Fuji-Hunt Electronics Technology Co. Ltd. for the manufacture and marketing of Waycoat photoresists

- An interest in Mead Technologies, a world leader in E-beam resists, for the exclusive worldwide marketing by Hunt Chemical of Mead products

- An interest in Advanced Plasma Systems, which manufactures equipment to process and desmear (clean) multilayer printed circuit boards by means of a plasma environment, whereby Hunt Chemical has exclusive worldwide marketing rights

Research and Development

Fundamental research and development (R&D) is carried out in the United States, and Hunt's commitment to maintain its position in the forefront of imaging and related chemicals used in photolithography is demonstrated by the funds allocated to R&D. In 1982, these funds totaled $5.4 million; they were increased to $5.7 million in 1983.

As geometries of integrated circuits shrink and optimization of photoresist resolution becomes increasingly important, Hunt Chemical is directing a major part of its R&D effort into researching improved positive photoresists and into plasma stripping techniques.

New photoresist products include:

- Waycoat Xanthochrome positive photoresist, which has been specially designed to reduce the combined effects of topography and back-reflected light from the substrate

- Waycoat Aristoline positive photoresist, which provides critical dimension control and more consistency, with a typical photospeed some 40 percent faster than alternative products

- E-beam resists of Mead Technologies/Hunt, producing negative and positive working resists for exposure by electron beam, together with their associated developers and rinses

In plasma stripping, Matrix has recently brought to the market its new Matrix Stripper. This equipment is the latest in photoresist removal technology and addresses itself to the problems associated with resists that have become hardened and polymerized by ion implantation, UV, and plasma etching and hard bake processes. The equipment is helpful also where the capability of wet etch and previously used plasma systems have now been exceeded.

PRODUCTS AND MARKETS SERVED

Hunt Chemical's products for the microelectronics industry include the following:

- Positive Photoresist Systems:
  - Waycoat HPR 204/206 Resists--For striation-free coatings, improved adhesion, and shorter exposures in all projection and contact aligners
  - Waycoat MPR Resist--Specifically for manufacture of chrome photomasks
  - Waycoat MIF Developer--Metal ion free
- Negative Photoresist Systems:
  - Waycoat HNR 80/120 Resists--A new, high-resolution system that also reduces mask sticking in contact exposure
  - Waycoat Negative HR 100/200 Resists--For imaging on highly reflective metallized and oxidized surfaces
  - Waycoat IC Type 3 Resists--State-of-the-art resists with reduced oxygen sensitivity
  - Waycoat SC Resists--A family of photoresists producing film thicknesses greater than two microns
  - Waycoat Negative Resist Developer--Specifically designed for use with resist exposed in the Perkin-Elmer Micralign
  - Waycoat COP Resist--A resist for electron beam applications

Technical Service--Europe

Apart from R&D associated with new product development and new technology for the microelectronics industry, Hunt Chemical continues to give the very highest priority to technical service.

In Europe, this is exemplified at the Technical Service Centre located at Sint-Niklaas (Belgium). Here there is a fully equipped Microlithographic laboratory housing the latest state-of-the-art equipment and which, as a result of progressive additions, now represents an investment of some $4.5 million.

The site at Sint-Niklaas occupies an area of 14,000m^2 and comprises the Technical Service Centre and a modern plant for electronic etchants, liquid and dry toners, graphic arts chemicals, and photofinishing systems.

NV Hunt Chemical and its European affiliates employ 175 persons, of whom 50 are in sales and customer service, 50 are in manufacturing, and 75 are in supporting services such as general administration and distribution.

There are two product divisions:

- Microelectronics Division
- Printed Circuit Board Division

Microelectronics Division

The Microelectronics Division is headed by a director who oversees the director of technical service and the product manager. Also reporting to the division director are sales managers for each European country (or region). Each sales manager supervises a number of process engineers.

The Microelectronics Laboratory, which is staffed by highly qualified experts conversant in most European languages, is designed to offer customers the following services:

- Performance demonstrations of photoresist and related products
- Design of new photoresist processing methods
- Evaluation of new types of process equipment
- Training of special seminar and workshop participants

Philip A. Hunt Chemical Corporation

The following list describes Hunt Chemical's major test equipment, including principal capabilities:

- Coating

  - In-Line Wafer Processing System (Veeco) with separate tracks for positive and negative resists; automated-dispense coating; 100mm wafer processing, computer controlled

  - Manual Photoresist Spinner 1001S (Convac) with continuous spin range--0 : 10,000 rpm; 100mm wafer processing; spin coating of PMMA, polymide, and other products with nonstandard solvents

- Exposure

  - Proximity Mask Aligner PLA-521F (Canon) for 100mm wafer processing; contact and proximity printing; standard and deep UV sources; optical filters available

  - Projections Mask Aligner Micralign 230 (Perkin-Elmer); projection printing with manual alignment; mirror projections system; 10mm wafer processing

  - Mask Sets--Hunt resolution masks: 10- to 1-micron feature size; focus wedge mask, opto-line mask, production mask sets; mask versions on quartz plates

- Development

  - In-Line Wafer Processing System (Veeco); separate tracks for positive and negative resists; spray development of negative resists; spray, flood-puddle, or spray-puddle development of positive resists; computer controlled; 100mm wafers

  - Manual--Immersion development; temperature controlled; cascade vane DI water rinse

- Baking

  - Bottom Bake V-300 (Veeco); modules integrated within the wafer processing system; separate for negative and positive resists; uniform heating; in-line 100mm processing; nitrogen purged

- Hot Plate--Integrated part of PSS-200 DUVC machine; temperature controlled ± 1°C up to 350°C; 100mm wafer processing; cassette-to-cassette operation

- Convection

  - LUT 5050 E (Heraeus) with temperature control from ambient to 250°C--Nitrogen purge; high thermal mass

  - WU 340 (Heraeus) with temperature control from ambient to 500°C

- Measurement

  - Critical Dimensions

    - Automatic Telecomparator System MF-68 All (Hitachi)--CD measuring TV system with microcomputer-TV display monitor, including intensity profile; precise measurement down to one micron

    - Leitz Latimet (Leitz)--CRT display; reproducible CD measurements; reliable resolution down to two microns

  - Thickness

    - Nanospec. AFT (Nanometrics)--Transparent film thickness measurement; nondestructive; microcomputer data handling

    - Dektak II (Sloan)--Surface profile scan; thickness and profile evaluation; CRT display

- Inspection

  - Visual

    - Olympus BHMJL 34 (Olympus)--Magnification up to 500x; photocamera; differential interference contrast attachment

  - SEM

    - 1C-130 (ISI)--High-quality SEM photographs with routine use at magnification up to 50K and a DC Sputter Coater with up to 100mm wafers; low accelerating voltage

- Etching
  - Wet
    - Tank etching of Al. poly, nitride, SiO_2, PSG, etc.; temperature-controlled water bath
  - Dry
    - RIE/PE 80 (plasma technology)--Manual loading of single wafer (100mm, 125mm, 150mm); 14 gas sources
- Stripping/Cleaning
  - Wet
    - Tank, Cascade Vane (TSC)
    - Photomask Cleaner 603
    - Rinser/Drier Neptune 111 (FSI)
  - Dry
    - RIE/PE 80 (plasma technology)--Oxygen-based plasma resist stripping, manual loading, etc.
- Stabilization
  - DUVC PSS-200 (Veeco)--Deep UV curing to withstand ion implantation; RIE and hardbake at up to 250°C (100mm wafer); UV source: 200- to 300- nanometer range
  - PRIST RIE/PE 80 (plasma technology)--Photoresist image stabilization technique (PRIST) using F-based plasma for improved product performance

OUTLOOK

Hunt Chemical looks forward to an exciting future, operating as it does at the leading edge of technology and producing new and better generations of products for the increasingly complex needs of the microelectronics industry.

Philip A. Hunt Chemical Corporation

The Company sees itself remaining at the forefront in photolithographic chemicals because of its:

- Continuing program of research and development
- Adherence to the strictest product-quality standards
- Customer support

The fastest-growing segment of the market over the next few years will be positive photoresists. Electron beam technology may well prove to be the next important area of development. In anticipation of this, Hunt Chemical is working on new photoresists to meet the need.

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Teradyne, Inc.

OVERVIEW

Founded in 1960 to produce electronic test equipment designed for industrial use, Teradyne today is a major supplier of automatic test systems to the electronics industry. These systems are used to test integrated circuits, circuit boards, and various other electronic devices and assemblies.

The Company also sells electronic design automation (EDA) products used in the design and testing of electronic devices. The Telecommunications Division produces automatic test systems and related products used by telephone operating companies. The Company also manufactures backplane connection systems, principally for the military/aerospace, computer, and telecommunications industries.

Teradyne sells its products primarily through direct worldwide sales organizations, and the Company supports its products through an extensive service and applications network, with technical centers throughout the United States, Europe, and the Far East.

For fiscal 1988, the Company reported net sales of $462 million and an income of $95,000. In 1987, the comparable figures were net sales of $378 million and a loss before taxes of $33 million.

In 1988, the Company's EDA business expanded as a result of the 1987 acquisitions of AIDA Corporation and CASE Technology. Also in 1988, Zehntel was completely integrated into Teradyne, a process that led to a fourth-quarter restructuring charge of approximately $16 million.

OPERATIONS

The Company's headquarters are located in Boston, Massachusetts, in the United States. As of December 31, 1988, the Company employed approximately 4,700 persons worldwide, with the United States accounting for about 10 percent. Teradyne maintains a direct presence in 13 countries, principally the United States, Western Europe, and the Far East.

United States

In the United States, plants are concentrated in the following four states:

- Massachusetts is the home of the Company's Manufacturing Systems and Industrial/ Consumer Divisions as well as a large portion of its EDA Group.
- California is home of the Semiconductor Test Division, which produces VLSI logic and memory test systems, and of the Zehntel Division, and EDA West.
- Illinois is home of the Telecommunications Division.
- New Hampshire is home of Teradyne Connection systems.

In addition, large sales and service offices are located in important centers such as the San Francisco Bay Area (California), Route 128 (Massachusetts), and Dallas and Austin, Texas.

Europe

Europe has been an important market for Teradyne for more than two decades, and the Company's activity there has intensified further in recent years. This intensification is largely because of the Telecommunications Division, which oversees a fast-growing customer base from its headquarters and engineering center in Bracknell near London. Europe has 13 offices and approximately 300 employees. Offices are located in Paris, Antwerp, Munich, and Milan as well as in London.

Far East

The focal point of Far East activities is Teradyne K.K., which is located in the Naka Meguro district of Tokyo. In addition, the Company has three other offices in Japan in Osaka, Kokubu, and Shokoku. A sales office is located in Seoul, South Korea, and at the southern end of the Pacific Rim is Teradyne's Singapore office, which serves Singapore, Malaysia, Thailand, Indonesia, the Philippines, and Australia. In all, 200 employees service Far East sales. The Singapore office also houses more than $2.5 million worth of spare parts that are ready for immediate use and provides technical support to customers in China, Hong Kong, and Taiwan.

FINANCIAL

A summary of Teradyne's most recent financial information for the fiscal years that ended December 31, 1986 through 1988 is shown in Table 1.

Table 1

Teradyne, Inc.
Worldwide Consolidated Statement of Income
(Millions of Dollars)

	1986	1987	1988
Net Sales	351	378	462
Expenses			
Cost of Sales	200	222	264
Engineering and Development	60	62	62
Selling and Administration	105	115	116
Restructuring and Merger Costs	2	11	16
Income (Loss) from Operations	(16)	(32)	4
Other Income (Expense)	1	(1)	(4)
Income (Loss) before Taxes	(15)	(33)	0*

*Actual Figure—$95,000.

Source: Teradyne, Inc. Annual Accounts 1988
Dataquest
March 1990

The Company notes in its Annual Report that great strides were made in 1988; market share gains were made in key product lines, the three companies acquired in 1987 were integrated into the organization, and major sales gains were achieved in Japan and South Korea.

Sales in 1988 showed an increase of $84 million over 1987, and the Company was able to bring $33 million, or 39 percent, to its pretax profit line. After taxes, there was a favorable bottom-line swing of almost $18 million. Although these comparisons were made against the rather poor 1987 figures, the Company believes that they do show significant progress. Also, in recent years, Teradyne has encountered two adverse industry trends. The first was the 1985 through 1987 recession in the electronics industry, particularly in the semiconductor sector, and the second was the shift in semiconductor market share from the United States to the Far East, where Japanese test equipment companies enjoy a natural advantage. These factors have left the U.S. ATE industry with excess capacity. The excess capacity has resulted in intense competition, aggressive pricing, and razor-thin margins. Against this backdrop, the Company decided to increase market share, even at some sacrifice in near-term profits. Market share gains came not only in ATE but in backplanes and telecommunications test systems. In particular, the competitive tide turned in the analog and mixed-signal area.

Overall 1988 net sales of $462 million, when split by business segments, showed $391 million (84.6 percent) attributable to Electronic Systems and Software and $71 million (15.4 percent) to Backplane Connection Systems. These figures are similar to the 1987 ratios.

Table 2 shows worldwide sales by geographic area for the years 1986 through 1988. The table shows that domestic sales in the United States have declined from 61.8 percent in 1986 to 54.3 percent in 1988. During this same period, sales to Europe increased modestly, from 20.7 percent to 35.5 percent. In contrast to the growth in Europe, sales expansion in Asia has been quite dramatic, with sales doubling from $45 million in 1986 to $90 million in 1988.

The sales expansion in Asia underlines the growing importance of the Asian (Far East) area and proves that the Company's early recognition of the opportunities in this area are paying off. Table 2 also shows that export sales accounted for nearly one-half of the Company's total sales in 1988.

Table 2

Teradyne, Inc.
Worldwide Sales by Geographic Area
(Millions of Dollars)

	1986	1987	1988
United States	217	230	251
Europe	73	84	109
Asia	45	54	90
Rest of World	16	10	12
Total	351	378	462

Source: Teradyne, Inc. Annual Accounts 1988
Dataquest
March 1990

RESEARCH AND DEVELOPMENT

The highly technical nature of the Company's products requires a large and continuing research and development (R&D) effort; for example, 1988 expenditure of $62 million represented 13.4 percent of sales. This expenditure on new product programs underlines the Company's commitment to R&D and its belief that long-term success depends on its ability to respond to the technological needs of its customers, which may require years of continued investment before additional profit occurs.

PRODUCTS

Electronic systems and software produced by the Company include the following:

- Test systems for a wide variety of semiconductors, including digital and analog ICs and ASICs
- Test systems for circuit boards and other subassemblies
- Test systems for telephone lines and networks
- Laser trimming systems used in the production of semiconductor memories and hybrid circuits
- Computer-aided engineering software used in the design of electronic components and assemblies

The Company also manufactures backplane connection systems for the military, aerospace, telecommunications, and computer industries. These applications translate into the following principal products and services offered by the Company:

- 900 VLSI Test Systems—Four basic systems are offered: the high-end J953, with 256-pin, 100-MHz capability; the 1,992-pin J967; the J983 with high-speed production testing capabilities for the latest, high-performance, high-volume devices such as 16-bit microcontrollers and high-integration ASICs; and the J941, which provides efficient, low-cost, reliable testing for 16-bit microprocessors and microperipherals.
- Memory test and laser trim systems—Memory test systems include the 50-MHz J937, and laser trim systems include the monolithic trim system M218 to repair redundant memories and the W429 passive trim system to adjust film resistors and hybrid circuits.
- A500/520 Analog VLSI Supertester—This system offers single-insertion testing of complex mixed-signal devices. It uses "tester-per-pin" architecture and is capable of delivering low-distortion analog waveforms.
- L200 board test line systems—This board tester was the first to use VLSI device tester architecture and advanced technology to deliver very high fault covering on complex PCBs. The L200 range, now in its third generation, includes the L210vxi, L210vx, L293, and L297 test systems. These systems offer a broad range of board test solutions, from a 1,000-pin in-circuit tester to a 1,000-pin functional system with full 40-MHz clock and data rates.
- The L200 line—This line is enhanced by a factory management software package called Boardwatch* and by LASAR software, which helps users deal with the often difficult task of generating functional test programs.
- 1800 Series of board testers—These testers are used with personal computers and offer excellent fault coverage, high throughput, and configurations with up to 2,048 pins.

- 8000 test system—This test system was recently introduced by Zehntel. It offers a full range of combination test capabilities: analog/digital in-circuit test, analog functional test, stored-pattern digital functional test, and "cluster" testing over 2,048 points, at a 10-MHz data rate. The 8000 features a nonmultiplexed architecture and is compatible with the earlier 800-series testers.
- Computer-aided engineering (CAE) products—These products include the AIDA software package, which enables engineers to simulate and verify complex systems that are created in accordance with design rules, and CASE systems, which specialize in CAE tools used in the design and layout of printed circuit boards and application-specific integrated circuits (ASICs). The CAE toolkit includes simulators of various kinds, accelerators (to speed up simulation runs), schematic entry and physical layout programs and a wide assortment of database programs, interfaces, graphics, and other accessories. These products now form part of the Company's Electronic Design Automation (EDA) business area.
- Telecommunications test equipment—These systems include the 4TEL* line tester and the XLT* system. New products include the TESTNET*2000 Megabit Maintenance System (MMS*), which is a remote-controlled tester for 11 circuits, and the Craft Dispatch System (CDS), which enables telephone companies to automate their service dispatch procedures.
- Backplane Connection System—This system covers the HD-Plus* line of high-density connectors. A recent addition is the HD-Plus2* line. The HD-Plus2* provides 60 signal contacts per linear inch, or three times the density of card-edge connectors.

FUTURE PROSPECTS

The Company believes that the rationalization of the ATE industry finally is occurring at a time when it is positioned to offer its customers assurance that, as a result of implementation of Teradyne's long-term strategy, it will be able to serve them in the upcoming years. After rationalization of the Company's recent acquisitions in the EDA business, Teradyne looks to them to become the technical and market leaders in simulation tools used to design and test electronic components and subassemblies.

The Company sees its Telecommunications Division and Connection Systems Division playing increasingly important roles in the years ahead. The Telecommunications Division is shaping an entire new industry based on the premise that the world's telephone systems have accepted the concept of automated testing. In the area of connectors, the Company has decided that a systems approach to connection problems would be sensible in the area of very large scale integration. This approach now is bearing fruit where the Company has gained important footholds in the European and Far East markets.

Teradyne believes that globalization of the electronics industry will bring with it a globalization of attitudes, and Teradyne intends to be in the forefront of this development. To this end, Teradyne believes that the Far East will unquestionably play an ever-increasing role in the Company's future; indeed, it is the home base of many of Teradyne's largest customers. The Company sees the Far East as a market that richly rewards competence, integrity, and perseverance.

*Boardwatch, High Density Plus, HD-Plus, MMS, TESTNET, XLT, 4TEL all are trademarks of Teradyne, Inc.

VG Instruments Plc.

BACKGROUND AND OVERVIEW

VG Instruments was founded in 1962 by two partners, Mr. Eastwell and Mr. Treasure, to manufacture flanges and pumps. Since its inception, the Company has grown and increased in market share to place among the top 20 in the world league of approximately 300 scientific apparatus manufacturers.

The Company's expertise encompasses instruments that generally, but not exclusively, incorporate clean or ultrahigh vacuum and state-of-the-art electron and/or ion optics.

The techniques offered by the Company range from ultrahigh-vacuum (UHV) components and systems; surface analysis; organic, isotope, and gas analysis spectrometry; electron microscopy; molecular-beam epitaxy; and digital communications to laboratory management systems.

The Company serves a diverse market that includes production and research applications in pharmaceuticals, chemical engineering, bioengineering, semiconductor technology, and material sciences.

The VG Instruments Group has successfully expanded during the last few years by creating new companies and by dividing growing companies. Each company is autonomous and deploys its own resources to develop and exploit new instrumentation techniques. Today, The VG Instruments Group consists of 16 instruments companies in the United Kingdom and 10 overseas marketing companies.

Group sales for fiscal 1988 amounted to $239 million, and profit before tax was $34 million. For the half year ended June 30, 1989, sales were $112.0 million compared with $100.0 million for the same period in 1988, while pretax profit amounted to $11.6 million against $10.9 million for the previous year.

In May 1988, the Company acquired all of the issued share capital of Kevex Corporation, an American manufacturer of X-ray instruments located in California, for $65.5 million.

In its *1988 Annual Report and Accounts*, the Company disclosed that its ultimate holding company is B.A.T. Industries Plc., which is located in Great Britain and owns 69.4 percent of the issued ordinary stock. Currently, B.A.T. Industries is the subject of a bid, which raises questions as to the future ownership of VG Instruments.

OPERATIONS

Group headquarters are located in Crawley, West Sussex, England. In the United Kingdom, the Company has a number of manufacturing and sales subsidiaries. Five marketing companies are located in Europe, and five more are located in Massachusetts, United States; Quebec, Canada; Hong Kong; China; and South Korea.

As of December 31, 1988, the Company employed approximately 2,370 persons worldwide, 446 of which were employed by Kevex in the United States.

FINANCIAL

Table 1 presents a summary of the financial results for the fiscal years ended December 31, 1986 through 1988, with the unaudited interim results for the half year ended June 30, 1988 and 1989.

Table 1 shows that although sales turnover has increased steadily during the past two years and is well above the average for the U.K. scientific instruments sector, profits have largely stagnated. This situation is due to the costs arising from the purchase of Kevex. The Company expects it to take two or three years for the full benefits of the purchase to increase profits. Furthermore, the rapid escalation of interest rates in the United Kingdom, together with some performance problems, affected the pretax profits.

Table 2 gives a breakdown of the Company's sales by principal geographic markets served. Table 2 also shows that the Company is highly export oriented and that 82 to 83 percent of sales have been to export markets during the past two years. In fact, the Queen's Award for Export Achievement was recently presented to VG Analytical, Ltd., a subsidiary company. The figures also show the growing sales in both the United States and Japan for the Company's products.

Table 1

VG Instruments Plc.
Worldwide Revenue
(Millions of Dollars)

	1986	1987	1988	1988*	1989*
Sales	127	172	239	100	112
Trading Profit	28	37	36	11	13
Profit before Taxation	30	37	34	11	12
Profit after Taxation	19	25	21	7	7
Exchange Rate (£ Sterling per U.S.$1)	0.68	0.60	0.56	0.56	0.61

*Six months ended June 30

Source: VG Instruments Plc.
Annual Accounts 1988
Interim Accounts 1989
Dataquest
March 1990

Table 2

VG Instruments Plc.
Sales by Geographic Area
(Percentage)

Geographic Area	1987	1988
United Kingdom	17	16
Europe	33	30
United States	30	33
Canada	2	2
Japan	11	13
Rest of Asia	5	4
Australasia	1	1
Rest of World	1	1
Total	100	100

Source: VG Instruments Plc.
Annual Accounts 1988
Dataquest
March 1990

PRODUCT REVIEW

This subsection gives a brief summary of the activities of the major operating subsidiaries of the Company in terms of the systems and instruments offered. These are grouped as follows:

- Organic mass spectrometry
- Inorganic mass spectrometry
- Surface science
- Vacuum technology
- Information technology
- Microanalysis and X-ray fluorescence

Organic Mass Spectrometry

Stringent environmental monitoring, genetic engineering, and the formulation of new drugs are common in today's world. Within these areas, organic and biomedical mass spectrometry have emerged as powerful analytical tools. The techniques are highly sensitive, thus enabling minute quantities to be detected and recognized even within complicated mixtures. Subsidiaries in this field are as follows:

- VG Analytical produces high-performance magnetic sector mass spectrometers, the most sensitive and powerful organic instruments available. They feature high resolution for separating complex ions with almost identical large molecular masses. The ZAB 4-F is the world's most powerful organic mass spectrometer. The Company also makes the TS-250 system using advanced magnet and microprocessor technology.

- VG Masslab specializes in computer-controlled quadruple-mass spectrometers. Rapid scanning of the field provides very fast identification of the components within a mixture, making quadruples ideal for high-throughput and automatic analysis of more routine samples.

Inorganic Mass Spectrometry

Understanding the elemental and isotopic concentrations within solids, liquids, and gases is a routine requirement for a wide range of research and production applications. Subsidiaries in this field are as follows:

- VG Elemental developed the Plasma Quad™. This versatile tool enables rapid determination of all elemental and isotopic concentrations in a solution to below part-per-billion levels.
- VG Microtrace pioneered a glow discharge mass spectrometer with the ability to analyze major, minor, and trace components in a sample, with parts-per-trillion detection levels.
- VG Gas Analysis Systems produces compact, sophisticated magnetic sector and quadruple mass spectrometers.
- VG Isogas specializes in mass spectrometers for measuring the ratio of stable isotopes in simple gases.
- VG Quadruples is a world leader in the design and supply of quadruple mass spectrometers.
- VG Isotopes makes mass spectrometers using thermal ionization techniques. These spectrometers are ideal for precise isotopic measurements of elements such as lead, uranium, and strontium.

Surface Science

Increasingly, today's materials analysis problems can be solved by understanding the chemical and physical interactions that occur on a surface or at the interface between boundaries. Subsidiaries in this field are as follows:

- VG Scientific manufactures a range of surface analysis instruments that can provide spatial and chemical information using a variety of techniques.
- VG Ionex manufactures instruments and components for secondary ion mass spectrometry.
- VG Microscopes produces scanning electron microscopes with high spatial resolution. Applications include the study of grain boundaries and diffusion in metals, ceramics, and semiconductors.
- VG Microtech produces a complete range of "bolt-on" surface analysis components that allow users to build and add new techniques to their own surface analysis facilities.

Vacuum Technology

The demand for semiconductor devices for advanced applications has focused intensive research into the very methods and materials from which semiconductor devices are made. Devices now are being fabricated by molecular beam epitaxy (MBE), where semiconductor layers are grown, atom by atom, onto a wafer substrate using carefully controlled temperatures in a UHV environment. Subsidiaries in this field are as follows:

- VG Semicon leads the world in the manufacture of MBE systems used to produce these new semiconductor materials.
- VG Special Systems concentrates on the growing applications of UHV technology to industrial processing plants that require continuous operation, reliability, and user friendliness. Examples are space simulation systems and the production of optical components for use in night-vision devices.
- Vacuum Generators has pioneered the technology needed to achieve UHV conditions and offers a vast range of components for building UHV systems.

Information Technology

Computer technology applied to the need for rapid and efficient information exchange is changing the modern laboratory almost beyond recognition. Paperwork has been replaced by a distributed computer system running a Laboratory Information Management System (LIMS). Subsidiaries in this field are as follows:

- VG Laboratory Systems produces LIMSs for both products and research environments.
- VG Electronics produces teletext equipment and supporting systems. Recent innovations include radio data systems (RDSs) for FM radio broadcasting that allow additional data to be transmitted along with existing programs.
- VG Data Systems produces hardware and software products for chromatography data collection.

Microanalysis and X-Ray Fluorescence

For many applications in materials analysis, digital X-ray mapping is widely accepted as one of the most efficient methods for determining the spatial distribution of elements in a sample. Subsidiaries in this field are as follows:

- Kevex Instruments produces the Quantum light element detector, enabling simultaneous light and heavy element analysis. The Company also offers Fast X-ray Mapping, which increases X-ray map acquisition speed by one or two orders of magnitude with no reduction in digital-image quality.
- Kevex X-Ray produces standard and customized X-ray tubes with high-voltage power supplies. The Company has focused development on high-technology products such as a totally portable X-ray source for high-resolution radiographic inspection of cracks in small components.

OUTLOOK

Over the years, VG Instruments has proved its ability to convert new ideas into commercial products. It recognizes that its main resource is allowing people to be innovative.

The Kevex acquisition in the United States is expected to yield long-term benefits to VG Instruments. With the restructuring now complete, this area is expected to make substantial contributions to the Company's overall profitability in the coming years.

Because the Company's customer base operates in diverse markets, its products can be expected to be in constant and increasing demand. Dataquest believes that the Company is therefore well placed to maintain its position as a leading supplier of scientific equipment during the years ahead.

Wacker-Chemitronic GmbH

BACKGROUND AND OVERVIEW

Wacker-Chemitronic GmbH is a wholly owned subsidiary of Wacker-Chemie and has been active in semiconductor materials since 1953 when the Company commenced research into the manufacture of hyperpure silicon. Since then, it has developed into one of the world's leading suppliers of semiconductor wafer substrate materials with sales in 1988 of $270 million.

The parent company, Wacker-Chemi GmbH (Wacker), manufactures and markets a wide variety of plastics, silicones, organic chemicals and, through Wacker-Chemitronic, semiconductor materials. Today, silicon chemistry makes up more than one-half of Wacker-Chemie's total sales, which were reported at $1,282 million for 1988.

Wacker-Chemie was established in 1914 by Dr. Alexander Wacker, a nineteenth-century entrepreneur who recognized the economic significance of calcium carbide. In 1892, calcium carbide was successfully manufactured for the first time, using an electrochemical process. In 1916, the Burghausen plant, built to Dr. Wacker's original plans, became operational. From these beginnings the company quickly expanded and developed a number of new technologies and product lines that embraced polyvinyl chloride (PVC), chlorinated solvents, vinyl acetate derivatives, silicones, silanes, and fumed silica. In 1953, fumed silica led to research in hyperpure silicon and production of monocrystalline silicon.

Important milestones in Wacker's semiconductor history are as follows:

- 1960—First sales of hyperpure silicon were made in the United States.
- 1965—Wacker Chemicals Corporation, New York, U.S.A., was established.
- 1968—Wacker-Chemitronic GmbH, Burghausen, West Germany, was established as a wholly owned subsidiary of Wacker Chemie GmbH.
- 1977—Heliotronic GmbH established for carrying out advanced studies in solar-grade silicon.
- 1978—Wacker Siltronic Corporation, Portland, Oregon, U.S.A., was established for the manufacture of silicon wafers.
- 1983—Wacker Chemicals East Asia Ltd., Tokyo, Japan, was established.
- 1984—Capacity of polycrystalline hyperpure silicon reached 2,000 tons per annum.
- 1987—Wacker Chemicals East Asia established the Yokohama Technical Center in Hakusan-Cho, Yokohama, Japan.
- 1988—The facilities for the manufacture of hyperpure silicon underwent major expansion. A new plant was opened in Wasserburg.
- 1989—The parent company, Wacker-Chemie, started construction of new headquarters in Munich-Neuperlach and celebrated its 75th anniversary in October.

Operations

Headquarters of Wacker-Chemie GmbH are located in Munich, West Germany. Shareholders are the Hoechst AG and the Familiengesellschaft Wacker, which have equal share.

Today, the Wacker-Chemie Group employs approximately 14,000 persons worldwide in 100 countries on five continents. Burghausen alone employs almost 10,000 persons. The Group produces approximately 2,600 chemical products, which are manufactured in plants located at Burghausen, Kempten, Merkenich near Cologne, and Stetten in Wurttemberg, all in West Germany. It also has production facilities in the United States, Mexico, Brazil, Japan, and the Netherlands.

Wacker's activities in the area of semiconductor products and related technologies are administered by the following four operating companies:

- Wacker-Chemitronic GmbH, West Germany—Since the Company's establishment in 1968, Wacker-Chemitronic has grown into one of the world's leading suppliers of silicon wafers. In 1988, the Company acquired facilities in Wasserburg am Inn that provided clean rooms and corresponding auxiliary equipment. By doing this, Wacker-Chemitronic was able to consolidate its epitaxy activities—coating silicon wafers, which requires clean room conditions—in high-performance facilities. This consolidation also enabled additional space to become available at Burghausen, where 200mm diameter polished wafers are produced.
- Wacker Siltronic Corporation, United States—This company is situated in Portland, Oregon. It is 100 percent owned by Wacker-Chemie and is an affiliate of Wacker-Chemitronic. The company handles Wacker-Chemie's semiconductor business in the United States and Canada and manufactures silicon single crystals by Czochralski crucible pulling, and produces silicon as cut, lapped, etched, polished, and epitaxial wafers in its Portland plant.
- Wacker Chemicals East Asia Ltd.—This company is 75 percent owned by Wacker and is a joint venture between Wacker-Chemie and Hoechst Japan Limited. It supplies hyper-pure silicon to the East Asian semiconductor industry and silicone products to the electronic, electrical equipment, transportation, and construction industries. In 1987, the Chemitronic Division of this company established a technical service laboratory to meet its customers' specific needs more efficiently. This center is located in Yokohama.
- Heliotronic GmbH, West Germany—This company is located in Burghausen. It is a wholly owned subsidiary of Wacker-Chemitronic GmbH and is engaged in research and development (R&D) to produce a low-cost silicon material for the mass production of photo-voltaic solar cells and its translation to a manufacturing process. This long-term research program is supported by West German Federal Ministry for Research and Technology.

Financial

A summary of the most recent financial information for the Wacker Group is shown in Table 1. It covers the fiscal years that ended December 31, 1987 and 1988.

Table 1

Wacker-Chemie GmbH
Statement of Income
(Millions of Dollars)

	1987	1988
Sales Income	$1,143	$1,282
Change in Inventories	20	12
Total Operating Performance	$1,163	$1,294
Less Cost of Materials	501	564
Gross Result from Operations	662	730
Other Income	98	110
Total Gross Income	760	840
Less Wages and Other Deductions	670	735
Operating Result	90	105
Profit before Income Tax	64	90
Net Profit	25	34

Source: Wacker-Chemie GmbH
Annual Report & Accounts 1988
Dataquest
April 1990

The Company had a record year in 1988, with sales increasing approximately 11 percent over 1987. Sales of Wacker-Chemitronic were reported to have improved by 12 percent in 1988 over 1987, to DM 475 million ($270 million). Wacker-Chemie GmbH therefore accounted for approximately 20 percent of Group turnover.

Table 2 shows sales revenue for Wacker-Chemie expressed as percentages by geographical region.

Table 2 reveals that 83 percent of the Group's revenue is derived within Western Europe.

Table 2

Wacker-Chemie GmbH
Sales by Geographic Region for 1988
(Percentage)

Geographic Region	
West Germany	50%
Other EC	23
Other West Europe	10
East Europe	4
North America/Latin America/Africa	7
Asia/Australia/Oceania	6
Total	100%

Source: Wacker-Chemie GmbH
Annual Report & Accounts 1988
Dataquest
April 1990

Research and Development

Spending on R&D and application engineering amounted to $120 million in 1988, or approximately 9 percent of sales.

As in previous years, the main emphasis in research was on silicon chemistry. Semiconductor research at Wacker-Chemitronic focused on improving the quality of hyperpure silicon wafers. The miniaturization of circuit elements calls for top-quality wafers, and new techniques for improving surface flatness significantly are being developed. Research also is being conducted into monocrystals made of gallium gadolinium garnet and doped with chrome neodymium, which have been proved in solid-state laser technology.

Research priorities at Heliotronic were redefined in 1988. The Company focuses on increased efficiency of solar cells, reducing production costs, and ribbon casting of solar silicon. Sufficient quantities of suitable hyperpure silicon as basic material are available from the production of silicon for electronics applications.

Other areas of research include the development of engineered ceramics for use primarily in engine technology. Work also continues in organic intermediates for pharmaceutical and agrochemical applications.

Basic research for the future is concentrated in the field of biotechnology. Production processes for certain polysaccharides are being investigated. The suitability of liquid crystal silicon compounds for displays and information storage is being examined, with a view to their possible application in information technology.

Products

Wacker-Chemie's products cover the following fields:

- Plastics—Includes PVC and copolymers, PVA and hot melts, vinyl chloride and vinyl acetate resins, dispersions, pressure-sensitive adhesives, and vinyl acetate monomer
- Plasticizers—Phthalates and sebacates
- Silanes—Chlorosilanes, siloxanes, silazanes, and functional silanes
- Silicones—Rubbers, fluids, pastes, greases, release/antifoam agents
- Highly dispersed silica—Fumed, precipitated, and dispersions
- Solvents—Includes methyl and ethyl acetate and butyl glycolate
- Organic intermediates—Covers a wide variety of chemicals
- Pesticides
- Semiconductor products—These Wacker-Chemitronic products serve the semiconductor industry. They include the following:
  - Hyperpure silicon
  - Silicon monocrystals produced by float zoning and by Czochralski crucible pulling
  - Polished, epitaxial, and diffused silicon wafers
  - High-resistivity float-zone crystals and wafers for detector applications
- Solar-grade silicon
  - SILSO, multicrystalline square slices 100 100mm, monocrystalline slices, round or cut to nearly square shape
- III-V semiconductor compounds
  - Gallium arsenide, monocrystal ingots and wafers, polished or cut and etched.
- Chemicals
  - Chlorosilanes
  - Hyperpure hydrogen chloride
- Laser crystals
  - Gadolinium—Gallium-garnet doped with chromium/neodymium
- New products
  - 200mm polished wafers—Controlled oxygen and precipitation, with superior geometry
  - 200mm epitaxial wafers, specifically designed for CMOS application
  - 150mm diameter float-zone (FZ) material
  - Backdiffused wafers
  - Superflat wafers for submicron technology, tightly controlled bulk properties, double-side polished, outstanding geometry: TTV 2-micron for up to 200mm

OUTLOOK

Wacker-Chemitronic anticipates that products dependent on silicon chemistry will continue to be major growth areas.

In the area of semiconductor materials, Wacker-Chemitronic views the future for its products optimistically. Consequently, a new plant is being commissioned to meet the increasing demand for epitaxial wafers, and as microelectronic structures diminish in size the Company sees an increasing demand for the larger 150mm and 200mm wafers. The Company also foresees an increasing demand for III-V semiconductors.

The confidence with which Wacker-Chemitronic views the future is exemplified by the time and expense the Company is expending on improving employee skills and qualifications. High-quality training programs now are in operation at various locations. As an investment for the future, Wacker-Chemie believes that funds devoted to advanced training are as important as those spent on initial training. Furthermore the establishment of the unified European market in 1992 is likely to increase competition. To meet this situation the Company is creating a pool of highly qualified employees. In 1988, approximately DM 6.2 million ($3.5 million) was spent on in-house training, with particular attention given to the development of potential managers. The Company anticipates that increasing sums will be expended on advanced training in the future.

6 Investment

INTRODUCTION

This service section deals with European aspects of investments in the electronics industry, with emphasis on the semiconductor industry.

The section is divided into four main parts:

6.1 Capital Investment
6.2 Research and Development Investment
6.3 Venture Capital
6.4 Government and Private Investment

The four parts really overlap each other, and should be read together. This is particularly so in the case of 6.2, because the major research and development programs are detailed in section 6.4, Government and Private Investment.

1.1 R&D Investment

R&D EXPENDITURE BY MERCHANT EUROPEAN COMPANIES

Dataquest surveys the European merchant semiconductor manufacturers on an annual basis to track their R&D spending plans. Table 1 supplies a summary of the history of worldwide R&D spending in US dollars by European-owned companies for 1989 and 1990. Table 2 expresses European companies' R&D expenditures as a percentage of their worldwide sales. It also includes an R&D spending forecast for 1991. Table 3 shows R&D expenditure by European-owned merchant companies in European Currency Units (ECUs).

Table 1

Estimated European Companies Woldwide R&D Expenditure
(Millions of US Dollars)

Company	1989 ($M)	1990 ($M)	AGR 1990/1989
ABB-HAFO	4	5	26.0%
ABB-IXYS	5	7	39.2%
Austria Mikro Systeme	7	8	9.6%
Ericsson Components	6	7	12.0%
European Silicon Structures	8	9	12.5%
Eurosil	3	5	56.0%
Fagor Electrónica	2	2	20.0%
GEC Plessey Semiconductors*	25	36	44.0%
Matra-MHS	9	21	133.3%
MEDL	6	0	-100.0%
Mietec	7	13	84.0%
Philips	395	425	7.6%
Semikron International	5	8	51.2%
SGS-Thomson Microelectronics	210	240	14.3%
Siemens	315	335	6.3%
STC Components	1	2	92.0%
TAG Semiconductors	2	2	0.0%
Telefunken	28	26	-5.7%
TMS	7	7	-3.6%
Total	1,045	1,158	
Percent Change		10.7%	

* 1989 expenditure is for Plessey Semiconductors only.
AGR = Annual growth rate
Source: Dataquest (March 1991)

Table 2

Estimated European Companies Woldwide R&D Expenditure As a Percentage of Worldwide Semiconductor Revenue

Company	1989	1990	1991
ABB-HAFO	11%	12%	13%
ABB-IXYS	10%	12%	13%
Austria Mikro Systeme	13%	13%	14%
Ericsson Components	11%	12%	10%
European Silicon Structures	44%	33%	14%
Eurosil	10%	12%	11%
Fagor Electrónica	7%	8%	8%
GEC Plessey Semiconductors	10%	9%	13%
Matra-MHS	11%	21%	20%
MEDL	10%	NA	NA
Mietec	13%	14%	14%
Philips	23%	22%	13%
Semikron International	5%	7%	7%
SGS-Thomson Microelectronics	16%	16%	18%
Siemens	26%	27%	26%
STC Components	5%	8%	8%
TAG Semiconductors	9%	8%	9%
Telefunken	9%	8%	10%
TMS	16%	15%	13%
Total Merchant	19%	19%	

NA = Not Applicable
Source: Dataquest (December 1990)

1.0 Capital Investment

CAPITAL SPENDING BY MERCHANT EUROPEAN COMPANIES

Dataquest surveys the major European merchant semiconductor manufacturers on an annual basis to track their capital spending plans. Table 1 gives a summary of the history of worldwide capital spending in US dollars by European-owned companies for 1989 and 1990. Table 2 expresses European companies' capital expenditure as a percentage of their worldwide sales. It includes a capital spending forecast for 1991. Table 3 shows capital spending by European-owned merchant companies in European Currency Units (ECUs).

Table 1

Estimated European Companies Woldwide Capital Expenditure (Millions of US Dollars)

Company	1989 ($M)	1990 ($M)	AGR 1990/1989
ABB-HAFO	5	5	0.8%
ABB-IXYS	7	7	-0.6%
Austria Mikro Systeme	10	11	12.1%
Ericsson Components	7	8	20.0%
European Silicon Structures	3	6	100.0%
Eurosil	4	5	17.0%
Fagor Electrónica	2	3	50.0%
GEC Plessey Semiconductors*	26	34	30.8%
Matra-MHS	12	13	8.3%
MEDL	8	0	-100.0%
Mietec	8	22	176.0%
Philips	292	290	-0.8%
Semikron International	8	11	35.0%
SGS-Thomson Microelectronics	240	278	15.8%
Siemens	193	175	-9.3%
STC Components	2	3	32.0%
TAG Semiconductors	2	3	50.0%
Telefunken	39	46	18.5%
TMS	20	14	-30.0%
Total	888	934	
Percent Change		5.2%	

* 1989 expenditure is for Plessey Semiconductors only.
AGR = Annual growth rate
Source: Dataquest (March 1991)

Table 2

Estimated European Companies Woldwide Capital Expenditure As a Percentage of Worldwide Semiconductor Revenue

Company	1989	1990	1991
ABB-HAFO	14%	12%	14%
ABB-IXYS	14%	12%	14%
Austria Mikro Systeme	18%	19%	16%
Ericsson Components	13%	15%	15%
European Silicon Structures	17%	22%	15%
Eurosil	13%	12%	14%
Fagor Electrónica	7%	10%	11%
GEC Plessey Semiconductors	11%	9%	9%
Matra-MHS	14%	13%	13%
MEDL	13%	NA	NA
Mietec	15%	24%	25%
Philips	17%	15%	14%
Semikron International	8%	10%	10%
SGS-Thomson Microelectronics	18%	19%	18%
Siemens	16%	14%	13%
STC Components	11%	11%	10%
TAG Semiconductors	9%	12%	12%
Telefunken	13%	14%	16%
TMS	44%	31%	25%
Total Merchant	16%	15%	

NA = Not Applicable
Source: Dataquest (March 1991)

6.1 Capital Investment

In 1986, European companies decreased their worldwide semiconductor-related capital spending by 21 percent, to $978 million.

Tables 1 and 2 show the history and forecast, respectively, of the European companies' worldwide merchant capital expenditures.

Table 1

ESTIMATED EUROPEAN COMPANIES' WORLDWIDE CAPITAL EXPENDITURES
1982 THROUGH 1986
(Millions of U.S. Dollars)

	1982	1983	1984	1985	1986
Worldwide Semiconductor Revenue	$1,946	$2,229	$3,183	$2,850	$3,425
Worldwide Semiconductor Capital Expense	$ 315	$ 350	$ 630	$ 600	$ 670
Worldwide Capital Expense as a Percent of Semiconductor Revenue	0	11.1%	80.0%	(4.8%)	11.7%

Soure: Dataquest
March 1987

Table 2

ESTIMATED EUROPEAN COMPANIES' WORLDWIDE CAPITAL EXPENDITURES
1987 THROUGH 1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Worldwide Semiconductor Revenue	N/A	N/A	N/A	N/A	N/A
Worldwide Semiconductor Capital Expense	$787	$1,062	$1,136	$1,363	$1,636
Worldwide Capital Expense as a Percent of Semiconductor Revenue	N/A	N/A	N/A	N/A	N/A

N/A = Not available

Source: Dataquest
March 1987

6.1.1 Proposed Plant Investments

Some reasons for semiconductor plant investment in Europe, are as follows:

- To avoid EEC tariffs of 17 percent (finished units) and 9 percent (semifinished units) that apply to products imported from non-EEC countries

- To provide local support in cases where close customer coordination is required

- To gain access to certain programs where there are stipulations on products used (e.g., products must be manufactured locally)

- To cut costs through better yields, shorter cycle times, elimination of trade barriers, closer customer support, greater product security (built locally with local resources)

Table 6.1.1 lists press announcements to extend or build new plants from 1985 onward. The data have been entered as they were announced, and the latest developments, if any, are listed under the "Comments" section.

Table 6.1.1-1

EUROPEAN MERCHANT SEMICONDUCTOR PLANT INVESTMENTS

Company	Year Announced	Location	Amount ($M)	Product/ Technology	Comments
European Companies					
Eurasem	1986	Netherlands	$13	Ass. & Pack.	35K sq. ft., class 1000 60 employees in first year
Eurosil	1985	Eching, W.G.	N/A	6-inch 2.5-micron CMOS	Start up in 1987
MEM	1986	Neuchatel, Switzerland	N/A	CMOS	6" wafers, 2-micron double metal capability. Large investment to upgrade plant. Capacity = 1,500 wafers per week. Full production 1988. Source of money = parent company (Societe Suisse de Microelectronique et d'Horlogerie)
Micronas	1985	Espoo, Finland	$15	CMOS	4" wafers; Start up in 1986
Philips	1985	Eindhoven, Netherlands		CMOS	Part of the "Mega project"
	1985	Hamburg, W.G.	N/A	N/A	Plant expansion in 1987
	1985	Caen, France	N/A	N/A	Plant expansion in 1987. $3M spent in 1985 on restructuring.
	1986	Hazel Grove, Cheshire, U.K.	$20	N/A	Revamp of existing power semiconductor plant. It will take 4 years to complete. Will produce "POWERMOS" products.
Plessey	1985	Caswell, U.K.	$13	GaAs	Plant development area of 20K sq. ft. under construction
	1985	U.K. & U.S. (Los Angeles)	$500	Megacell semicustom	Plans to build 2 plants in 1985-90.
Racal Microelectronics	1985	Waltham Grange, U.K.	N/A	CMOS	1.25-micron double-level metal; capacity = 1,000 wafers/week

(Continued)

Table 6.1.1-1 (Continued)

EUROPEAN MERCHANT SEMICONDUCTOR PLANT INVESTMENTS

Company	Year Announced	Location	Amount ($M)	Product/ Technology	Comments
European Companies (Continued)					
SGS	1985	Agrate, Italy	N/A	CMOS VLSI	Custom circuits
	1985	Swindon, U.K.	N/A	CMOS	Custom circuits; start up in 1987/88
Siemens	1985	West Berlin, W.G.	$70	N/A	Mfr. of components for optical fiber technology
	1985	Regensburg, W.G.	$300	MOS, submicron	Start up in 1986
	1985	Munich, W.G.	N/A		Submicron pilot facility with production at Regensburg
	1985	West Berlin, W.G.	$24	N/A	Electronic control systems
	1985	U.S.	N/A	N/A	3 possible sites in the U.S. are being considered.
Sopran & Eltek	1985	Nantes, Yvelines, France			Plant to test, cut, inspect, and stock semiconductors; 37 employees; sales forecast at FFr 20M
Thomson	1985	St. Egreve, France	N/A	MOS VLSI	Start up in 1986
	1985	Moirons, France	N/A	MOS VLSI	Start up in 1986
	1985	Far East or U.S.	N/A	6" 1-micron fab.	Break ground 1986
European Silicon Structures (ES2)	1985	Aix en-Province France	$50	Standard product 3-micron	Plant will be in operation in 1987. Design centers to be opened in 1986/7 in Paris, Munich, London, Milan, Stockholm, Edinburgh. A second plant may be built in a few years time in the U.K. or West Germany. No. of employees = 300 by end of 1986, 1,000 by 1990.

(Continued)

Table 6.1.1-1 (Continued)

EUROPEAN MERCHANT SEMICONDUCTOR PLANT INVESTMENTS

Company	Year Announced	Location	Amount ($M)	Product/ Technology	Comments
U.S. Companies					
AMD	1985	Greystones, Ireland	$241	CMOS, telecom, memory	650 jobs; Greenfield site; area = 2 x 22K sq. ft. wafer fab areas; start-up date is 1987; may consider adding assy. and test later. 1986 plant has been indefinitely postponed.
AMI	1985	Graz, Austria	$20	MOS	Plant expansion
AT&T	1985	U.K.	$134	N/A	May set up semiconductor plant; design center definitely in pipeline for custom circuits
ATT Microelectronica de Espana	1985	Madrid, Spain	$200	CMOS MPU & memory	Start up in 1987; full capacity = 3,000 wafers per week; 700 employees; agreement with CTNE to build a semiconductor plant Full capacity in 1991 = 26 million units a year. 80% AT&T owned 20% Telefonica owned
Burr Brown	1985	Scotland, U.K.	N/A	Bipolar	Unconfirmed; start up in 1987
Cypress	1985	England, U.K.	N/A	MOS LSI	No firm plan
Exel	1985	Eire	N/A	MOS Memory	Unconfirmed
Fairchild	1985	Wasserburg, W.G.	$150	MOS	New fab area next to existing Assy. and test plant. Further expansion is planned.
	1985	U.K.	N/A	N/A	New design center in U.K.; location not known. Montrouge, France, facility will be closed down and relocated.

(Continued)

Table 6.1.1-1 (Continued)

EUROPEAN MERCHANT SEMICONDUCTOR PLANT INVESTMENTS

Company	Year Announced	Location	Amount ($M)	Product/ Technology	Comments
U.S. Companies (Continued)					
Hewlett-Packard	1985	South Queensferry, Scotland	$12	PCB facility	
Holt	1985	Scotland, U.K.	N/A	Custom LSI	Unconfirmed
IDT	1985	Northern Germany	N/A	N/A	
IMP	1985	Livingston, U.K.	N/A	CMOS Std. cell	
Intel	1985	Feldkirchen, W.G.	N/A	2-micron CMOS	Unconfirmed
ITT	1985	Freiburg, W.G.	N/A	MOS LSI	Unconfirmed extension
Lattice	1985	England, U.K.	N/A	N/A	Unconfirmed
Linear Technology	1985	Scotland, U.K.	N/A	N/A	Possible linear facility
LSI Logic	1985	Braunschweig, W.G.	$40	2-micron MOS	70,000 sq. ft. facility
MCM	1985	Irving, Scotland	N/A	N/A	No details known
Micro-Image Technology	1985	Riddings, Derbys, U.K.	$1		Silicon wafer recovery facility; 13 employees initially; capacity = 200,000 wafers/year
Micron Technology	1985	May set up assembly plant in Europe	N/A	N/A	No details known
Motorola	1985	East Kilbride	$60	MOS	6" fab out of mothballs as of summer 1986. More money to be invested.
	1985	Toulouse, France	N/A	N/A	Unconfirmed expansion in 1987

(Continued)

Table 6.1.1-1 (Continued)

EUROPEAN MERCHANT SEMICONDUCTOR PLANT INVESTMENTS

Company	Year Announced	Location	Amount ($M)	Product/ Technology	Comments
U.S. Companies (Continued)					
National Semiconductor	1985	Furstenfeldbruck, W.G.	N/A	Memory	Mfr. of 1- and 4-Mbit DRAMs; start up in 1987. No firm plan currently.
Texas Instruments	1985	Nice, France	N/A	N/A	Extension
	1985	Freising, W.G.	N/A	N/A	Upgrade
TRW	1985	Bordeaux, France	Mfr.	N/A	Maybe in 1988. Initially RF devices. Potential for VLSI.
Japanese Companies					
Fujitsu	1985	Landshut, W.G.	N/A	MOS	Not finalized
Hitachi	1985	Limerick, Ireland	N/A	MOS	Not finalized
Mitsubishi	1985	Site unknown	N/A	Mfr.	Planning stage only.
Oki	1985	Not yet known	N/A fab	Assy/Test	Graz site rejected by local council due to environmental considerations. New site being sought. Whole program subsequently put on hold.

Notes: Mfr. = Manufacture, Assy. = Assembly, Test = Test, N/A = Not Available

Source: Dataquest
March 1987

6.2 R&D Investment

INTRODUCTION

Long-term structural change, i.e., economic growth, or decline, depends to a great extent upon technological innovation. Europe has a history of leading the world with ideas, which are then better exploited elsewhere. Europe has a large resource of talented designers and CAD tools, but they lack proximity to advanced-technology wafer production.

Faced with the possibility of an increasing technology gap in Europe, the EEC has implemented several research programs in information technology (see Section 6.4, "Government and Private Investment"). It is known that Europe has strengths in basic scientific research; however, there are weaknesses in the chain from pure research to commercial exploitation.

The EEC has listed a number of points that must be implemented in order to achieve a leading role in new industrial technologies:

- The education system must be adapted. New technical and managerial skills plus the encouragement of adaptability to change must be emphasized.

- The tax system and capital market institutions must provide a financial environment that is favorable to innovation and investment involving risk.

- Technical standards (norms, testing procedures, certification) need to be set at a level that is valid for Europe, so as to give full access to world market norms.

- The relevant agencies in EEC countries need to collaborate with a view to opening up national markets and assuring consistency in the specification of their future equipment requirements.

- Open trade in fast-growing goods and services that employ new technology should be encouraged.

- The competition policy at the EEC level needs to be directed in a manner that favors the collaborative research and development efforts of European enterprises, and subsequently increases efficiency.

6.2 R&D Investment

EUROPEAN GOVERNMENTS' ROLE

European governments are playing an important role in the recovery of their information industries. They have begun to take aggressive action, helping locally based companies not only to recapture large parts of their home markets, but also to export technology across Europe and outside Europe.

European governments are also funding information-technology-related research and development (R&D). This is to enhance the competitive position of their national information industries. The United Kingdom has only minimal planning at the national level (see Section 6.4, "Government and Private Investment" about the Alvey program), and government support is decentralized and loosely coordinated. In Germany, the program is characterized by well-coordinated, close cooperation between the public and private sectors. The German government is moving away from direct grants for projects, and toward indirect incentives such as tax advantages to encourage research and development. France has a centrally planned program, directed and controlled by the French ministry of research and industry. (See Volume II, Section 6.4, for further details.)

JOINT VENTURES

Joint ventures are another way of developing technologies. Examples include: Bull, Siemens, and ICL created a joint research center in Munich; Olivetti and AT&T in office automation; Philips and AT&T in telephone exchange switches; Ericsson and Honeywell in PBXs; and Siemens and Philips in the joint development of advanced memory products. Some companies are also entering into agreements with U.S. and Japanese companies to penetrate markets outside Europe, or to acquire technological advantages over competitors.

NEED FOR UNIFICATION

The fragmentation of Europe's markets is largely responsible for the poor performance of its manufacturers in fast-growing and fast-changing industry sectors such as computers. The United States has the advantage in that it has one domestic market as opposed to many national ones, enabling it to grow quickly. Even the biggest of Europe's electronics companies tend to grow more slowly because they rely on their home markets for the major portion of their sales. There are a few exceptions, such as Philips and Olivetti.

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At a recent conference on Multinationals and High Technology held in London, the need for a unified European market was emphasized by most companies. Statements made there included the following:

- Unless Europe develops a unified domestic market, multinational companies might be driven to find better conditions outside Europe.

- The European market has been divided at every turn by differences in language, business practices, distribution channels, and government regulations.

- European companies have to become more dynamic and profit oriented.

- Europe's diversity of skills, language, and culture is a major strength that can be capitalized upon to give Europe an advantage over its competitors.

- European companies must play the enemy's own game and not sit complacently on the fence.

Although made in 1985, the above points are still valid today.

Finally, however, several fundamental points remain to be overcome:

- European companies must take more risks.

- No one is thinking on the scale that is needed--in BILLIONS (not millions) of dollars.

- Europe now knows what actions are necessary, but has not yet moved to take them.

- There is a lot of grass-root activity, but little at the highest levels.

- Europe needs to be single-minded and to concentrate on the development of components and technologies that will maximize opportunities.

6.2 R&D Investment

RESEARCH AND DEVELOPMENT IN THE SEMICONDUCTOR INDUSTRY

Research and development (R&D) costs in the semiconductor industry are becoming increasingly prohibitive. In Europe, the cost factor plus the increasing desire of European companies to overcome the go-it-alone policy that was the motto some time ago, are just two reasons that encourage companies to pool their R&D resources.

Perhaps the most widely publicized joint agreement is the semiconductor Megaproject made between Siemens and Philips. Under this agreement, the companies aim to produce 4-Mbit RAMs by 1989 at a cost of more than US$300 million.

In Table 1, we have compiled the worldwide semiconductor-related R&D expenditures of European companies in the period from 1980 through 1986.

Table 6.2-1

ESTIMATED WORLDWIDE SEMICONDUCTOR-RELATED R&D EXPENDITURES BY EUROPEAN COMPANIES (Millions of Dollars)

Year	Worldwide Sales	R&D Expenditure	Percent of Worldwide Sales
1980	$2,145	$120	5.6%
1981	$1,903	$110	5.8%
1982	$1,929	$110	5.7%
1983	$2,215	$155	7.0%
1984	$3,183	$225	7.0%
1985	$2,850	$260	9.1%
1986	$3,446	$315	9.1%

Source: Dataquest
March 1987

The limited amount that European companies spend on R&D can also be seen in value terms. For comparison purposes, in 1986, European companies' R&D expenditure totaled US$315 million, whereas U.S. companies spent US$1,008 million and Japanese companies spent US$1,746 million.

6.3 Venture Capital

OVERVIEW

Ever since 1986, there has been a significant increase in venture capital activity in Europe. Although not all European countries are at the same level of development, most have active programs currently under way. Some countries have recorded slow venture capital fund growth, mainly due to unsympathetic government treatment, while others have shown signs of excessive activity with too many venture capitalists chasing too few deals. However, the sharp decline in the stock market in October 1987 (Black Monday), has helped to correct this excess.

Therefore, Black Monday did not adversely affect the venture capital industry. Its worst effect so far has been to postpone stock market flotations. Although the unlisted security market has become less attractive to both entrepreneurs and venture capitalists as an exit route for investment, and the other (less profitable) route of corporate buy-out has also narrowed since big corporations have less money to spend, things are not all bad.

Raising new venture capital could be even easier. Until Black Monday, the high returns from venture capital projects (40 percent a year) looked unspectacular against listed share prices (45 percent a year). Since the crash, valuations of unquoted companies have fallen in line with those of listed ones, reaching what most venture capitalists say are more realistic levels. Although there is (temporarily) less money around, venture capital-backed firms now have a better chance of getting their equity.

The principal sources of capital for the venture capital industry differ from country to country. In Belgium, Italy, and Spain, government-sponsored institutions and banks have taken a leading role in providing equity capital. In the Netherlands, the government provides venture capital through its majority stake in the MIP Equity Fund and through the National Investment Bank. In France, the state provides funds until the privatization of banks. In the United Kingdom, public sector venture capital is evident at the regional level, for example, the Scottish and Welsh Development Agencies.

In the private sector, sources can be pension funds (prevalent in the United Kingdom, the Netherlands, and the United States), or banks and industrial corporations (prevalent in West Germany, where pension funds are not structured as independent investment entities). Banks provide venture capital in nearly all European countries. Most of the leading banks in France have venture capital subsidiaries as well as investments in independent venture capital funds. In Spain, some of the largest private sector venture capital organizations are bank-owned or affiliated.

SINGLE COMMON MARKET

Why a Common Market?

The European Economic Community (EEC) has set 1992 as the deadline when tax and trade barriers will be abolished. A single European common market was created for several reasons. Perhaps the most important reason is the awareness that the United

6.3 Venture Capital

States and Japan are challenging Europe, particularly in high technology. For years, Europe has been active in economic and technological development, which makes it even more difficult to adjust to this new situation.

One of the ingredients necessary for success in Europe is availability of capital. Japan may be an example to emulate. The Japanese government is aware that ample, low-cost industrial capital is vital to the nation's international competitiveness. One of its goals is to assure this capital to industry and to this end, it encourages consumer savings and channels these savings to industry. Other government policies decrease the banks' risks so that they can safely lend industry large amounts of capital at low rates. Japanese laws encourage banks to be closely involved in the management of their prime clients; this involvement allows the bank to act if a company gets into trouble. The Japanese government also directly controls interest rates. It can keep them low by tightly regulating the financial system and keeping this system close to its international market situation.

Recently, Europeans have become increasingly aware of the need for a single common market in Europe. Isolation policies and go-it-alone tendencies have become a thing of the past. Politics may claim isolationism is a form of patriotism and belief in oneself, but the economic reality has proven that this policy is wrong. Such was the case in France. When the socialist government came to power in 1981, President Mitterand announced that henceforth France would go it alone. In 1983, the experiment having failed, President Mitterand admitted that without international cooperation, France could not progress—in industry, in research and development, or in many other important aspects. He recognized the fact that European countries must work together to achieve a single and united Europe, particularly in the area of high technology, if Europe is to remain as a comparable power to the United States and Japan. This sentiment is echoed by the major European countries, and steps have been taken and continue to be taken in this direction.

The EEC is also working toward this goal. It is making headway in encouraging collaboration in precompetitive research and in adoption of Europe-wide technical standards. It believes that a unified European market is crucial to stimulating innovation, entrepreneurial activities, venture capital, and creation of small and medium-size businesses.

WHAT IS HAPPENING IN EUROPE?

In Europe, the venture capital pool (funds already invested or available for investment) rose by 39 percent in 1986 to approximately ECU 10 billion, according to the European Venture Capital Association (EVCA) yearbook. Italy showed the fastest growth (103 percent) in 1986 over 1985, although its venture capital industry is small. The United Kingdom still dominates the European venture capital market with approximately 120 firms and a total venture capital pool of ECU 5.7 billion. France follows in second place with 90 firms and a venture capital pool of ECU 1.3 billion; the Netherlands is third with 90 firms and a venture capital pool of ECU 0.9 billion.

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In the last year or two, some large corporations have formed their own venture capital areas of business. It has also been a time of internationalization or networking in Europe by the venture capital industry. The results are as follows:

- Venture capital firms working independently
- Venture capital firms working jointly with the European Commission of the EEC
- The European Commission working independently
- Industry working independently

Independent Networking

Independent networking by venture capital firms can mean working as partners with other venture capital firms in different countries, or with branches of the same firm in different countries. The aim is to give the "client" company access to the advice and contacts of venture capitalists in potential export markets; it is not primarily to raise equity finance in more than one country, since national venture capital pools should be able to fund most deals. Anything that can be done to open up other European markets, particularly in high-technology areas, is considered. With the 1992 deadline of a single European common market fast approaching, the venture capital industry is working toward removing its constraints on business.

Joint Venture Capital/European Commission Projects

The venture capital industry is working with the European Commission to put together cross-border deals. In 1985, the EVCA and the European Commission launched the Venture Consort Scheme, a joint venture designed to help new companies expand in Europe and particularly to encourage cooperation across national boundaries. The scheme gives grants to companies backed by international venture capital syndicates. The grants are intended to offset the problems investors have with language and the difficulty of getting around the various legal and financial systems in Europe. The ECU 3.3 million originally earmarked for the scheme sparked off a total equity investment of ECU 38.3 million. Because of such an enthusiastic response, the average grant came to only 10 percent of any one project, not the 30 percent originally planned.

Venture Consort backed 18 projects in its first phase in 1986. In 1987, only ECU 400,000 was allotted by the European Commission, with a further ECU 1.5 million being provided by the community's Task Force for Small and Medium Enterprises. The EVCA has since begun lobbying members of the European Parliament to increase the Venture Consort funding to ECU 4 million in 1988. The first phase was successful because funding was timely. Once the EVCA members had vetted and chosen projects for backing, the European Commission had just three weeks to give its opinion. If it failed to do so, the project was simply considered approved.

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Another area of the EVCA and European Commission cooperation is to back Eureka projects. Eureka now has more than 100 projects in progress, but the large companies get the majority of funding. Venture capitalists believe that the small companies they back deserve a chance to participate. The EVCA wants to encourage this approach by providing venture funds for Eureka projects. In return, it hopes its members' clients will have the advantage of working with big companies throughout Europe.

To date, Eureka projects and their financing needs have been circulated to EVCA members. By examining these projects, the EVCA can sort out where it can help to fund companies resulting from Eureka projects. It can also help small companies on its books to take part in the projects.

The European Commission Working Independently

The European Commission is funding its own projects. Its main project, Eurotech, aims to provide larger sums of money than the Venture Consort Scheme for a much earlier stage of a new company's development. It mainly finances projects coming out of European R&D programs such as ESPRIT.

Initially, the European Commission said it would provide ECU 200 million for Eurotech, with the rest coming from banks. This plan has upset the venture capital industry, which would also like to be involved.

Industry Working Independently

European companies themselves are working more and more closely with one another. In 1983, a 20-company strong Round Table of Industrialists was formed to help strengthen and develop Europe's industrial and technological base by creating less-fragmented markets. The 20 Round Table members are: ASEA, BSN, Ciba Geigy, Eternit, Fiat, Lafarge Coppée, National Coal Board, Nestlé, Olivetti, Philips, Pilkington Brothers, Pirelli, Plessey, Renault, Robert Bosch, Saint Gobain, Siemens, Thyssen, Unilever, and Volvo. The chairman is Mr. Gyllenhammar of Volvo, and the vice chairmen are Mr. Agnelli of Fiat and Mr. Dekker of Philips.

The Round Table has also provided financial backing for Euroventures BV, a trans-European venture capital operation. Seventeen members are involved including ASEA, BSN, Fiat, Lafarge Coppée, Olivetti, Philips, Pirelli, Robert Bosch, Saint Gobain, and Volvo. Euroventures BV started operating in 1985 and invests through several independently managed satellite funds in European countries. There is a central fund of £36 million. It is hoped that the satellite funds will eventually raise the total financing available to £93 million.

The Round Table's other main proposal is to set up a postgraduate European institute of technology. Such an institution, specializing in electronics, physics, and mathematics, would improve the technical education of the best engineers and help them to consider the best interests of Europe rather than of individual countries. The institution would draw on the resources of European industry, universities, and governments. Research would be applied rather than theoretical and would concentrate on semiconductors and informatics. The institute would be financed by a fund of at least $5 million a year, set up by participating companies.

TRADE ASSOCIATIONS

As of July 1987, nine European countries had national trade associations in place—Belgium, France, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. West Germany has a venture capital "club" that brings together entrepreneurs and potential investors of capital, but no trade association as such.

The objectives of these associations are similar:

- To promote and stimulate the growth of venture capital in their countries
- To provide an effective mechanism for lobbying government on issues of concern to the venture capitalist
- To introduce and operate a code of practice covering professionals in the industry

In 1983, the EVCA was established to promote venture capital and ensure a smooth flow of information on developments in the sector. The association also develops international markets for the young companies its members are helping to form. The EVCA now has about 100 members, each of which paid ECU 2,200 to join. This bought them the chance to attend international meetings and exchange information. Furthermore, it gave them a joint voice with which to lobby the European Commission for a more uniform legal and financial environment throughout the EEC. Membership also lends credibility to the members—a company has to be reputable to join.

The EVCA is broadening its scope. It is no longer necessary to be an EEC country to join; other European countries are being considered. At the same time, it is forming tentative links with the United States through meetings with the U.S. National Venture Capital Association. In the long term, it could open up the U.S. market for Europe's young companies.

SEED CAPITAL

Seed capital (the financing of embryonic new ventures, i.e., the preventure capital stage) is just beginning to attract interest in Europe. The venture capital industry can back a small company once it is on the road, but usually avoids funding it until it reaches that stage. It is at the previous stage that seed capital is used.

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Because it is such a risky venture, there are few seed capital firms, and these firms usually subsidize their seed funding with other activities. Some of the larger venture capital firms subcontract the "seed" part of their activities to such small firms. The reason for not doing it themselves is that seed capitalists have to work very closely over a period of time with an entrepreneur to get his idea off the ground and it is not viable for a larger venture capital firm to add a seed capital specialist to its staff to do the job. Why bother at all? By investing at an earlier stage than anyone else, the seed fund can come in more cheaply and obtain a higher return (30 to 50 percent) if the venture prospers.

COUNTRY OVERVIEWS

The venture capital industries in France, the Netherlands, West Germany, and the United Kingdom are briefly described in the following sections.

France

Currently, venture capital is prevalent in French industrial policy. In 1981, when the socialist government first came to power, the main emphasis of industrial policy was on nationalization of the large industrial groups. However, since then, there has been a shift toward helping the small and medium-size business sector. The government is now firmly committed to encouraging the development of new small and medium-size industries, particularly in high-technology areas.

In 1983, the French government announced a series of measures to help promote the concept of venture capital and accelerate the creation of small businesses. These measures included fiscal incentives for new businesses, streamlining and shortening of considerable red tape, new soft loans for potential entrepreneurs, and encouragement of cooperation between academic institutions and the business world. These measures have largely been put into practice, so they are no longer an issue. What is an issue is the lack of liquidity, since most companies offer only the 10 percent minimum to the public. If companies offered 25 to 30 percent, prices would be more representative of true values and would fluctuate less widely.

About half the venture capital pool is provided by banks and insurance companies; the other half is provided by industrial and commercial concerns.

In the past couple of years, the French venture capital industry has continued to develop, encouraged by the government which sees it as a way to create new businesses and jobs. However, some investors feel that the government is not going far enough, and that it should back not only companies with proven track records, but also the more risky start-ups.

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The Netherlands

In the past few years, the venture capital industry in the Netherlands has grown considerably. Although initially there were few institutionally backed venture capital funds, this has now changed. The government put forward a series of initiatives, and subsequently, a large amount of institutional capital was injected into the venture capital market. In 1982, the venture capital industry was given a boost with the formation of a secondary stock market.

The present Dutch government is seeking to stimulate industrial growth through less intervention in industry. It aims to reduce the regulatory burden for companies, to introduce fiscal measures to encourage entrepreneurs, and to increase its use of private enterprise for government contracts.

Two important steps have been taken by the government to encourage venture capital. The first was to set up a guarantee scheme for private venture capital companies. It provides for a public authority guarantee for losses incurred on individual investments made by recognized private venture capital firms.

The second step was to set up an MIP equity fund in 1982. The government holds a majority stake in this fund; however, the fund is independently managed by a group of experienced senior industrialists and has strictly commercial objectives. The goal is to invest relatively large amounts of capital in either new or established innovative businesses that are likely to have a significant impact on the Dutch economy. The MIP equity fund complements the private venture capital firms. In 1984, there were approximately 30 private venture capital companies in the Netherlands. The bulk of all investment activity by Dutch-based groups within the country at the smaller end of the scale is channeled through these 30 companies.

The government has decreased its financing role in the industry from 72 percent of all venture capital in 1982, to 44 percent in 1985 while the private sector has increased its role.

The Dutch venture capital industry has matured into a serious industry that plays a significant role in financing young, growing companies.

West Germany

Venture capital activities have been growing in West Germany, but still account for a relatively small part of Germany's business. However, venture capital is becoming an acceptable form of financing and now is better understood by the German business community.

Currently, there are approximately 30 venture capital firms in West Germany with an estimated DM 1 billion of invested funds available. Although much capital is available and there are many ventures available for that capital, there is a dearth of experience and management skills. This means that most ventures do not come to fruition.

6.3 Venture Capital

Traditionally, venture capital is not part of the German approach to business. Approximately 75 percent of German companies are family-owned, and the idea of going public with a stock market listing, or financing a business mainly with bank loans, is not part of the German personality. However, this is changing. It is now recognized that there is a need for capital rather than credit for both small and medium-size businesses. More people are risking leaving a secure job to strike out on their own. Big companies, too, are becoming more tolerant of spin-offs; for example, Siemens and Nixdorf are engaged in venture capital activities.

The main West German venture capital firms include:

- Techno-Venture Management (TVM)
- International Venture Capital Partners (IVCP)
- Deutsche Gesellschaft fuer Wagniskapital (WFG)
- Citicorp Venture Capital
- Euroventures Deutschland (part of Euroventures BV)

The United Kingdom

The number of venture capital organizations has been increasing steadily in the United Kingdom. There are two basic categories of U.K. venture capital companies:

- Independent firms, which receive venture capital funds from a number of different sources (These firms have grown rapidly over the last few years.)
- Captive firms, which are subsidiaries or sometimes simply divisions of larger financial institutions

The ratio is currently around half and half.

As the U.K. venture capital industry matures, it is becoming segmented—separate funds are being set up for different investor groups. U.K. merchant banks are becoming more and more involved in the venture capital business. Major corporations are showing interest in venture capital organizations, and it is the institutionally backed funds that will ultimately determine the course of the industry's future development. The U.K. government's Business Expansion Scheme (BES) encourages individuals to invest risk capital in the ordinary shares of qualifying companies. This effort has stimulated the growth of large professional funds, many based in London. The scheme offers a way to stimulate the flow of smaller amounts of investment capital into growing small firms.

Regional venture capital funds have grown in the last year. More London-based fund managers are getting out to meet the people behind regional funds, and the regional funds themselves are being taken more seriously.

6.4 Government and Private Investment

INTRODUCTION

Investment in the electronics industry can be broadly divided into government and private investment. We define government investment in the strictest sense, that is, funding provided directly by a government through its relevant departments. The definition does not include government involvement through its nationalized industries. Private investment, on the other hand, is funding by anyone who is not representing national or regional governments or the European Economic Community (EEC). This category includes venture capitalists, corporate and individual investors, and private trusts.

Over the past decade, European governments and the EEC have placed increasing emphasis on an indigenous European electronics industry. The following service section lists major electronics investment programs, by region.

RECENT ELECTRONICS INVESTMENT PROGRAMS

Europe (Total)

EEC and Industry

The project was started in 1982. The EEC was to invest $40 million, together with a similar amount put up by companies chosen for support. The purpose was to encourage development of key equipment for VLSI design, test, and production.

The project was not successfully taken up because the industry was not capable at the time and the project's objectives were too fixed. The project funds were transferred to ESPRIT.

ESPRIT

In February 1984, the EEC announced plans for link-ups across its internal borders between academics and industrialists, as part of the ESPRIT program. Approximately 270 different universities, companies, and research institutes have pledged to work together on information technology projects. There is a planned investment of approximately ECU1.5 billion by 1990. The EEC is meeting 50 percent of the cost, while participating companies will meet the remaining 50 percent.

6.4 Government and Private Investment

In January 1985, the European Commission announced the projects and the successful tenders for the first full year of ESPRIT's 10-year program. Table 1 shows the division of these projects.

ESPRIT will concentrate on producing early results, rather than on long-term research projects, as a result of requests by participating companies.

Table 1

ESPRIT: HOW THE PROJECTS ARE DIVIDED
(National Involvement)

Sector	Number	U.K.	France	W. Germany	Italy
Advanced microelectronics	28	18	18	17	6
Software technology	14	9	9	10	7
Advanced information processing	20	13	12	11	12
Office systems	23	14	15	16	15
Computer integrated manufacturing	19	13	10	13	9
Total	104	67	64	67	49

Source: DATAQUEST
September 1985

Groupe Tallois

This is like a small "club of Rome." It was formed because of the need for Europe to do something in Information Technology.

Action Committee for Europe

Its aim is to create a genuine common market without frontiers, to stimulate European industry and growth, to develop the European Monetary System, and to open up the telecommunications and transport sectors. Members include Mr. Helmut Schmidt, Mr. Agnelli, Mr. Van den Hoven, Mr. Simon May, and two leaders of the French trade unions.

6.4 Government and Private Investment

RACE

In March 1985, the EEC published a proposal to undertake an initiative in the telecommunications sector. The project will be called Research in Advanced Communications in Europe (RACE). There will be three main phases:

- RACE Definition Phase (1985). This will define what the Integrated Broadcast Communications (IBC) network should become over the next decade, thus creating a commonly accepted objective. The cost is estimated at ECU44.2 million paid for 50/50 by the Commission and industry.

- RACE (Main) Phase I (1986 through 1991). This period will cover development of the technology base for IBC, conduct the precompetitive development required, provide for services and equipment, field trials and support CEPT and CCITT standards work.

- RACE Phase II (beyond 1991 through 1996). This will be a period of evolutionary development of the technology base established in Phase I for enhanced IBC equipment and services beyond 1995.

BRITE

This is an EEC initiative in flexible manufacturing to ascertain the condition of, and prospects for, the machine tool industry in Europe.

Kangaroo Group

This group was set up by Mr. Basil de Ferranti, and it was named thus because the Kangaroo is good at leaping over and kicking down barriers. It is a club of European parliamentarians formed to promote a truly common market in Europe.

FAST program

Twenty-one Council of Europe member countries have given support to a European research network to make better use of science and technology resources, and to create greater mobility between countries for scientists.

Three-Year Program

In April 1984, a three-year program was announced to develop more robust and efficient numerical models to simulate the detailed physical behavior of semiconductor devices. Industrialists and academics from the United Kingdom, the Netherlands, and the Republic of Ireland are involved.

6.4 Government and Private Investment

Independent European Programme Group

In June 1985, the Independent European Programme Group, composed of defense ministers from 13 European nations, agreed to launch a cooperative research program in five specific areas of advanced technology with military applications: microelectronics, high-strength lightweight materials, compound materials, image processing, and conventional warhead design. Projects will be funded jointly on a case-by-case basis.

Belgium

In 1982, the Flemish government launched a program to fund approximately half the cost of building a full semiconductor facility for the Bell Telephone Manufacturing Company.

The Netherlands

1. In 1981, the Dutch government launched an ongoing program of FL10 million per year, to set up three microelectronics centers, each concentrating on different aspects and areas. The centers are located in Delft, Enschede, and Eindhoven. The goal of the centers is to recover investment costs through contract work. The centers also house a forum for business contacts, an information center, and exhibition space.

2. The Dutch Ministry of Economic Affairs launched two ongoing programs to encourage Dutch companies to design microelectronic technology projects through subsidies and an advisory scheme for participating companies by external consultants.

France

1. Following the Integrated Circuits Plan (1978 through 1981) and the Components Plan (1982 through 1986), the French government currently has a "Filiere Electronique" Plan. Emphasis is on global rebuilding of the entire electronics industry.

   For microelectronic investment, the government had forecast a budget of FFr12.5 billion for 1983 (of which only FFr9.7 billion was actually spent) and of FFr15 billion for 1984 (of which FFr11 billion was spent).

Of the above budgets, some FFr2.4 billion in 1983 and FFr3 billion in 1984 were spent on company subsidies.

In 1985, the government hopes to reach the planned expenditure level of FFr12 billion for the first time.

2. The PAFE program deals with Computer-Aided Design (CAD) for VLSI 1-micron technology.

3. In February 1985, the French government announced that it will inject FFr2.75 billion into three nationalized companies--Thomson, Bull, and CGCT--in the form of capital grants. Thomson will receive FFr1.3 billion to build up its electronic components business and to improve competitiveness of its consumer products division. Bull will receive FFr1 billion, and CGCT will get FFr450 million.

4. At the beginning of 1985, in response to President Reagan's Strategic Defense Initiative, France's President Mitterand announced a proposal for Europe to go ahead on its own with a European Research Coordination Agency under a program entitled Eureka. The program aims to attain the capacity to build technological hardware involving a research effort that draws on the technological base already achieved.

   Ministers of 17 European countries met in Paris on July 17, 1985, to start the program. They created an advisory group to set up procedures that would be acceptable to at least the major countries wanting to take part. The advisory group will also attempt to better define Eureka. A six-nation steering group will do most of the work.

<u>Italy</u>

1. In 1982, the Italian government announced a five-year program. One-fifth of the amount to be spent is for small and medium-size companies. The remainder includes financing a new VLSI center at a cost of Lire170 billion.

2. The Italian PTT's National Plan for Telecommunications Service, which included charges made by Italtel, was set up for companies in the State Telecommunications Sector.

6.4 Government and Private Investment

Scandinavia

1. In 1982, the Finnish government funded a FIM34 million program for a semiconductor project at the Helsinki Institute of Technology. The project is to develop a CMOS process technology suitable for production in 1985 and is supervised by a special council from Micronas, Lohja Electronics, and Vaisala, to guarantee production adaptability.

2. Sweden has an ongoing grant system to technical universities. The Swedish State Industrial Board (SIND) is the primary funding body for applications and research grants to both the technical universities and the private sector.

United Kingdom and Ireland

1. The Microelectronics Application Project (MAP) was set up by the U.K. government in 1978, at a cost of £85 million, to raise awareness of the microchip. The project was extended to 1985.

2. The CAD/CAM, CAT/MAT program (1981 through 1985) consisted of capital grants for computer equipment.

3. The British Technology Group set up Inmos between 1979 and 1983.

4. In June 1982, the Department of Industry allocated £60 million to encourage engineering companies to automate production lines with electronic techniques.

5. In January 1983, the Science and Engineering Research Council allocated £2.5 million to Edinburgh University for VLSI research and development.

6. The Department of Industry has an ongoing Microelectronics Industry Support Programme (MISP) to provide financial aid for companies with new products.

7. The Flexible Manufacturing Systems Scheme is an ongoing project run by the Department of Industry to aid companies whose products would benefit from installing flexible manufacturing systems.

8. The Department of Industry launched a £40 million Fiber Optics and Optoelectronics Scheme to support the fiber optics and optoelectronics industries through grants of up to a third of eligible costs.

9. In 1983, the Scottish Development Agency (SDA) launched a £10 million incentive package for companies setting up business in Scotland. The area is just starting to get an influx of supporting companies to the electronics industry, thereby creating an effective infrastructure.

10. In 1983, the Alvey program was launched to run for five years. It is intended to keep the United Kingdom in the race to build the fifth-generation of intelligent computers. Currently, the program is half-way through its time span and 85 percent through its £200 million budget. One hundred two joint projects involving 60 companies, 40 universities, and 15 polytechnics have been approved.

West Germany

1. The Research Ministry in Bonn allocated DM 450 million to help small companies use microelectronics in their products, in the period 1981 through 1984.

2. From 1982 through 1985 the West German government spent DM 100 million per year through VDI-Technologiezentrum of Berlin to develop new microelectronic products, up to production stage.

3. In 1983, the Research Ministry in Bonn announced a package of measures to assist the formation of technology-based businesses.

4. In January 1985, the Bundestag, West Germany's parliament, approved a DM 3.8 billion research package to help key sectors of the electronics industry catch up with the competition.

Rest of Europe

1. In 1982, in Spain, the Instituto Nacional de Industria (INI) announced an ongoing investment program to increase R&D effort in INI's electronics group by setting up an R&D center in Madrid.

2. The Spanish PTT--Compania Telefonica Nacional de España (CTNE)--has defined its four-year plan (1985 through 1988), which envisions investments of approximately Pta965 billion. The objective is the modernization of the telecommunications network.

3. In 1983, the Spanish government announced the Plan Electronico y Informatico Nacional (PEIN). There are four basic objectives:

   - To increase demand for and consumption of electronics products

   - To attain larger domestic production levels of electronics products, thus gaining greater domestic market shares

- To achieve very high levels of exports

- To diminish technological dependence of indigenous firms

The amounts invested are expected to be at Pta62.9 billion. Part of this amount is destined for the IC plant to be built by CTNE and AT&T, as well as for IBM España to produce medium-range computers.

4. In April 1985, the electronics and informatics industries in Spain were declared to be of "preferential interest" by a Royal Decree. This enables companies in this category to apply for certain benefits, provided they do so by December 31, 1985.

6.4 Government and Private Investment

INTRODUCTION

Investment in the electronics industry can be broadly divided into government and private investment. We define government investment in the strictest sense, that is, funding provided directly by a government through its relevant departments. Private investment, on the other hand, is funding by anyone who is not representing national or regional governments or the European Economic Community (EEC). This category includes venture capitalists, corporate and individual investors, and private trusts.

Over the past decade, European governments and the EEC have placed increasing emphasis on an indigenous European electronics industry. The following service section lists major electronics investment programs, by region.

Recently it has become apparent that nobody is currently reporting in detail what kind of and how much investment each government is providing for the electronics industry. The EEC has published a set of guidelines on how far and in what way governments will be permitted to subsidize civil R&D programs. However, even these guidelines are not in detailed form. In essence, the guidelines suggest that governments should not finance more than 50 percent of government R&D projects. However, in practice there is no way of knowing if the 50 percent limit is exceeded.

RECENT ELECTRONICS INVESTMENT PROGRAMS

Europe (Total)

ESPRIT

In February 1984, the EEC announced plans for linkups across its internal borders between academics and industrialists, as part of the ESPRIT program. Approximately 270 different universities, companies, and research institutes have pledged to work together on information technology projects. There is a planned investment of approximately ECU1.5 billion by 1990. The EEC is meeting 50 percent of the cost, while participating companies will meet the remaining 50 percent.

As a result of requests by participating companies, ESPRIT will concentrate on projects that produce early results, rather than on long-term research projects.

6.4 Government and Private Investment

Plans for ESPRIT II are currently nearing completion. ESPRIT II will keep to the same system as the previous phase with the possible inclusion of EFTA nations. They will have no say, however, in the ESPRIT decision-making process, and they are not funded for their efforts. Details will be announced in late 1986. The program will start in 1987.

Eureka

The European Research Coordination Agency (Eureka) program aims to attain the capacity to build technological hardware involving a research effort that draws on the technological base already achieved.

In July 1986, 60 more projects (mainly in computers, semiconductors, and telecommunications) were approved to a total value of $2.1 billion. The total value of projects involving U.K. firms is currently at $1.1 billion. The U.K. government announced it would pay $15 million towards the Eureka program, through the Support for Innovation scheme, which apparently compares favorably with inputs from other governments. However, the U.K. government recently announced it would not put in any new money for Eureka. The U.K. government has reservations about whether Eureka will open up Europe to be a truly homogeneous internal market. Mrs. Thatcher thinks it is more an aspiration than a reality. The result is uncertainty as to what the participating governments will contribute. To keep each government's contribution as much in line with other governments as possible, a decision was made for participating governments to talk to each other before allocating funds.

Iceland is the latest country to join the Eureka program, making a total of 19 participating countries.

Countries most involved are:

- France with 40 out of 62 projects--government pays up to 40 percent of total cost of $554 million.

- United Kingdom with 29 out of 62 projects--government pays up to 50 percent of research cost and 25 percent of development costs. Since no figures are published on individual levels of support, there is no way of knowing how much has been given in any particular case.

- West Germany with 19 out of 62 projects--government funding is at DM 485 million over 10 years. Total cost is DM 1.6 billion of which the share falling to West German companies is DM 625 million.

6.4 Government and Private Investment

Group Tallois

This is like a small "club of Rome." It was formed because of the need for Europe to do something in Information Technology.

Action Committee for Europe

Its aim is to create a genuine common market without frontiers, to stimulate European industry and growth, to develop the European Monetary System, and to open up the telecommunications and transport sectors. Members include Mr. Schmidt, Mr. Agnelli, Mr. van den Hoven, Mr. May, and two leaders of the French trade unions.

RACE

In March 1985, the EEC published a proposal to undertake an initiative in the telecommunications sector. The project will be called Research in Advanced Communications in Europe (RACE). There will be three main phases:

- RACE Definition Phase (1985). This defined what the Integrated Broadcast Communications (IBC) network should become over the next decade, thus creating a commonly accepted objective. The cost was approximately ECU40 million paid for 50/50 by the Commission and industry.

- RACE (Main) Phase I (1986 through 1991). This period will cover development of the technology base for IBC, conduct the precompetitive development required, provide for services and equipment, field trials and support CEPT and CCITT standards work.

- RACE Phase II (beyond 1991 through 1996). This will be a period of evolutionary development of the technology base established in Phase I for enhanced IBC equipment.

In March 1986 the EEC approved $19 million in funding 31 component level R&D projects for the initial phase, involving 109 companies. Future RACE grants are expected to total around $500 million (no long-term funding has been formally established). U.S. companies are participating in this program provided that they have R&D facilities in Europe.

In December 1986, the European Parliament will debate whether to fund the project proper--the RACE Main--with ECU800 million. Detailed plans have recently been proposed by the European Commission. If approved, the RACE Main is due to start on January 1, 1987, when companies will be invited to tender for specific projects, as yet undetailed. At the same time a more general framework for EEC-funded R&D will be decided upon (see below).

6.4 Government and Private Investment

EEC-funded R&D

The EEC put forward a ECU7.7 billion program for R&D in the next five years, up from ECU3.7 billion in the past four years. West Germany, the United Kingdom and France vetoed the proposal. The three countries agree that Europe has to meet the technology challenge from Japan and the United States, but are reluctant to channel much national R&D spending to EEC programs. The countries argue that the EEC should complement national R&D work, not replace it; more money in Brussels means each government has less say in how this money is used; each country believes its own industrial base is still broad enough to cover most areas of R&D without EEC programs. The crux of the matter is national interest--the bigger the country the better off it is keeping its research national; a smaller country is better off joining a community program.

BRITE

This is an EEC initiative in flexible manufacturing to ascertain the condition of, and prospects for, the machine tool industry in Europe.

Kangaroo Group

This group was set up by Mr. Basil de Ferranti, and it was so-named because the kangaroo is good at leaping over and kicking down barriers. It is a club of European parliamentarians formed to promote a truly common market in Europe.

FAST program

Twenty-one Council of Europe member countries have given support to a European research network to make better use of science and technology resources, and to create greater mobility between countries for scientists.

Three-Year Program

In April 1984, a three-year program was announced to develop more robust and efficient numerical models to simulate the detailed physical behavior of semiconductor devices. Industrialists and academics from the United Kingdom, the Netherlands, and the Republic of Ireland are involved.

Independent European Programme Group

In June 1985, the Independent European Programme Group, composed of defense ministers from 13 European nations, agreed to launch a cooperative research program in five specific areas of advanced technology with military applications: microelectronics, high-strength lightweight materials, compound materials, image processing, and conventional warhead design. Projects will be funded jointly on a case-by-case basis.

6.4 Government and Private Investment

STAR

Special Telecommunications Actions of Regional Development, is a program with an initial budget of ECU7 million to be used to introduce the latest telecommunications techniques to "disadvantaged areas"--Irish Republic and Ulster, Corsica, the Mezzogiorno part of Italy, and some of Greece. There is a proposal to later help parts of Portugal and Spain, and overseas departments of France.

Philips, Siemens, Thomson

Philips, Siemens, Thomson, may establish a joint research program to develop semiconductor technologies for the 1990s. The aim is to set up a joint research institute, at a cost of $720 million, to come from both company and government sources.

Belgium

In 1982, the Flanders regional investment bank (GIMV) launched a program to fund approximately half the cost of building a full semiconductor facility, jointly with the Bell Telephone Manufacturing Company. The company, Mietéc, was formed in 1983 and is dedicated to ASICs.

The Netherlands

In 1981, the Dutch government launched an ongoing program of FL10 million per year, to set up three microelectronics centers, each concentrating on different aspects of the technology and areas of the marketplace. The centers are located in Delft, Enschede, and Eindhoven. The goal of the centers is to recover investment costs through contract work. The centers also house a forum for business contacts, an information center, and exhibition space.

The Dutch Ministry of Economic Affairs launched two ongoing programs to encourage Dutch companies to design microelectronic technology projects through subsidies and an advisory scheme for participating companies by external consultants.

France

Following the Integrated Circuits Plan (1978 through 1981) and the Components Plan (1982 through 1986), the French government currently has a "Filiere Electronique" Plan. Emphasis is on global rebuilding of the entire electronics industry.

6.4 Government and Private Investment

For microelectronic investment, the government had forecast a budget of FFr12.5 billion for 1983 (of which only FFr9.7 billion was actually spent) and of FFr15 billion for 1984 (of which FFr11 billion was spent).

Of the above budgets, some FFr2.4 billion in 1983 and FFr3 billion in 1984 were spent on company subsidies. The amounts spent by companies themselves on R&D (as distinct from government subsidies) were FFr1.2 billion in 1983 and FFr1.35 billion in 1984.

In 1985, the government hopes to reach the planned expenditure level of FFr12 billion for the first time, of which FFr2.5 billion is earmarked for the electronics sector.

The PAFE program deals with Computer-Aided Design (CAD) for VLSI 1-micron technology.

At the beginning of 1985, in response to President Reagan's Strategic Defense Initiative, France's President Mitterand announced a proposal for Europe to go ahead on its own with a program entitled Eureka.

Italy

The Italian PTT's National Plan for Telecommunications Service, which included charges made by Italtel, was set up for companies in the State Telecommunications Sector.

Scandinavia

In 1982, the Finnish government funded a FIM34 million program for a semiconductor project at the Helsinki Institute of Technology. The project is to develop a CMOS process technology suitable for production in 1985 and is supervised by a special council from Micronas, Lohja Electronics, and Vaisala, to guarantee production adaptability.

Sweden has an ongoing grant system to technical universities. The Swedish State Industrial Board (SIND) is the primary funding body for applications and research grants to both the technical universities and the private sector.

United Kingdom and Ireland

The Department of Industry has an ongoing Microelectronics Industry Support Programme (MISP) to provide financial aid for companies with new products.

6.4 Government and Private Investment

The Flexible Manufacturing Systems Scheme is an ongoing project run by the Department of Industry to aid companies whose products would benefit from installing flexible manufacturing systems.

The Department of Industry launched a £40 million Fiber Optics and Optoelectronics Scheme to support the fiber optics and optoelectronics industries through grants of up to a third of eligible costs. The scheme is called JOERS (Joint Optoelectronics Research Scheme).

JOERS II--second phase of above. Submissions for funding are currently being received. Total funding is estimated to be $16.8 million.

In 1983, the Alvey program was launched. The program will run for five years at a cost of £350 million. It is intended to keep the United Kingdom in the race to build the fifth generation of intelligent computers.

When the Alvey VLSI initiative was announced it was strongly criticized for being unambitious and poorly funded. An independent review in 1985 concluded that its time scales for producing the key 1 micron bulk CMOS process were two to three years behind the world leaders. The review did, however, report that the 1 micron bipolar process target date was on a par with the best of the U.S. and Japanese producers.

Projects are currently running 3 to 18 months late. The program needs two or three times more than the £107 million already committed to complete the VLSI work in progress. Total additional investment to exploit all Alvey projects requires $795 million--$345 million for production and library building, and $450 million for production development.

A total of 110 companies are currently engaged in the Alvey program. GEC is involved in the largest number of projects, 59; followed by ICL, 49; British Telecom, 37; and Plessey, 35. Almost every U.K. university is involved in about 85 percent of projects. The U.K. government contributed £200 million to current Alvey funding.

<u>West Germany</u>

From 1982 through 1985 the West German government spent DM 100 million per year through VDI-Technologiezentrum of Berlin to develop new microelectronic products.

In 1983, the Research Ministry in Bonn announced a package of measures to assist the formation of technology-based businesses.

6.4 Government and Private Investment

In January 1985, the Bundestag, West Germany's parliament, approved a DM 3.8 million research package to help key sectors of the electronics industry catch up with the competition.

Rest of Europe

In 1982, in Spain, the Instituto Nacional de Industria (INI) announced an ongoing investment program to increase R&D effort in INI's electronics group by setting up an R&D center in Madrid.

The Spanish PTT--Compania Telefonica Nacional de Espana (CTNE)--has defined its four-year plan (1985 through 1988), which envisions investments of approximately Pta965 billion. The objective is to modernize the telecommunications network.

In 1983, the Spanish government announced the Plan Electronico y Informatico Nacional (PEIN). The plan was approved in 1984, to run for three years. There are four basic objectives:

- To increase demand for and consumption of electronics products
- To attain larger domestic production levels of electronics products, thus gaining greater domestic market shares
- To achieve very high levels of exports
- To diminish technological dependence of indigenous firms

The amounts invested are expected to total Pta62.9 billion. Part of this amount is destined for the IC plant to be built by CTNE and AT&T, as well as for IBM Espana to produce medium-range computers. The plan is showing results in that high-tech investment is coming to Spain--AT&T is building a semiconductor plant in Madrid in conjunction with Telefonica. Siemens is investing Pta10 billion in a three-year program, including a design center geared to export hard and software products to Europe. Pacific Telesis will build an R&D center in conjunction with Telefonica. Hewlett-Packard is to build a new plant to manufacture graphic plotters.

In April 1985, the electronics and informatics industries in Spain were declared to be of "preferential interest" by a royal decree. This allowed companies in this category to apply for certain benefits, provided they did so by December 31, 1985.

7 Packaging

7.0 Packaging

INTRODUCTION

This section discusses semiconductor packaging trends in Europe. The material contained in this section covers:

- Overview
- Major package technologies
- Packaging trends
- Surface-mounted devices (SMDs)

Overview

A basic market force is driving the trends in component packaging. That force is cost, which, in turn, is directly related to materials. DATAQUEST believes that semiconductor material reductions will be achieved through:

- Improved IC chip functional density (smaller geometries)
- Improved performance through denser geometries
- Improved automation (for improved yield)

Other material reductions will be achieved through:

- Fewer and smaller printed circuit boards (PCBs)
- Less external hardware
- Smaller cabinets
- Smaller, more efficient power elements (VLSI and CMOS)

Wafer Package Technologies

The integrated circuit industry's rapid move toward VLSI complexity and the market's demand for more function in less space have prompted several new packaging alternatives. These major package options are:

- Small-outline (SO) plastic packages, which are primarily limited to 28 pins or less.
- Chip carrier and quad packages grouped in the range of 28 to 84 pins

7.0 Packaging

- Pin grid array (PGA) packages for primarily 64 pins or more
- Dual in-line packages (DIPs)

PACKAGING TRENDS

DATAQUEST expects the following packaging trends:

- Plastic DIPs will continue to be the dominant package throughout the forecast period.
- The plastic chip carrier/quad package will sustain a high growth rate, with the LCCC version becoming the dominant package.
- SO packages will have a high initial growth rate due to their acceptance in very large automotive, telecommunications, and consumer programs.
- Both plastic chip carrier and SO package growth will be through displacement of the plastic DIP.
- Ceramic chip carriers will have modest growth at the expense of the flatpack, CERDIP, and Ceramic DIP.
- The pin grid array (PGA) package is an important package in the over 64-pin VLSI segment. Although it will have a high growth rate, absolute volumes are not expected to be large.
- Chip carrier, SO, and PGA packages represent the fastest growth areas.

SURFACE-MOUNTED DEVICES (SMDs)

Even though leaded components still predominate in units, the future clearly lies with SMDs. There are four major market forces at work:

- Economy
- Miniaturization
- Quality
- Complexity

7.0 Packaging

The benefits of SMDs can be summarized as follows:

- Higher levels of automation possible
- Denser component packaging
- Improved performance (especially high frequency)
- Improved quality (primarily as a result of automation)
- Smallest system size
- Lower system cost

DATAQUEST believes that SMDs will be significant in providing the ultimate in cost-effective solutions, especially in the consumer, government and military, and telecommunications end-user markets.

7.1 Packaging Market Estimates

INTRODUCTION

The DATAQUEST European Semiconductor Industry Service analyzes packaging trends by the following package types:

- Plastic DIP
- CERDIP
- Ceramic DIP
- Flatpack
- Ceramic chip carrier
- Plastic chip carrier and quad
- SO
- PGA
- Header
- Other

Tables 7.1-1 and 7.1-2 give DATAQUEST's estimates of European shipment by package type. Table 7.1-1 covers all package types; Table 7.1-2 summarizes that portion that is surface mounted.

A full list of the tables and figures is presented below:

7.1 Packaging Market Estimates

Table 7.1-1

ESTIMATED EUROPEAN SHIPMENTS BY PACKAGE TYPE
(Millions of Units)

Package	1983	1984	1985	1986	1987	1988
Plastic DIP	3,601	4,300	5,551	6,546	7,237	8,552
CERDIP	392	433	520	580	608	669
Ceramic DIP	23	25	29	32	32	35
Flatpak	6	6	6	5	5	5
Ceramic Chip Carrier	12	28	51	91	145	281
Plastic Chip Carrier and Quad	10	31	80	162	271	654
SO	14	37	78	134	212	520
PGA	2	5	10	19	26	50
Header	23	25	29	32	31	33
Other	125	177	259	344	403	563
Total	4,208	5,067	6,613	7,945	8,970	11,362

Table 7.1-2

ESTIMATED EUROPEAN SMD SHIPMENTS BY PACKAGE TYPE
(Percent)

Package	1983	1984	1985	1986	1987	1988
Plastic DIP	85.6%	84.9%	83.9%	82.4%	80.7%	75.3%
CERDIP	9.3	8.6	7.9	7.3	6.8	5.9
Ceramic DIP	0.6	0.5	0.4	0.4	0.4	0.3
Flatpak	0.2	0.1	0.1	0.1	0.1	0
Ceramic Chip Carrier	0.3	0.6	0.8	1.1	1.6	2.5
Plastic Chip Carrier and Quad	0.2	0.6	1.2	2.0	3.0	5.8
SO	0.3	0.7	1.2	1.7	2.4	4.6
PGA	0.1	0.1	0.2	0.2	0.3	0.4
Header	0.5	0.5	0.4	0.4	0.4	0.3
Other	3.0	3.5	3.9	4.3	4.5	5.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Percentages may not add to 100.0% due to rounding.

Source: DATAQUEST
October 1985

7.1 Packaging Market Estimates

DATAQUEST estimates that by the end of this decade, approximately 50 percent of all PCBs produced in Europe will use SMDs (surface-mounted devices) predominantly. The main inhibiting factor will be the high cost of entry associated with the necessity to tool up for automation.

Figure 7.1-1 illustrates the trend toward increasing board functional density. We believe that this trend away from the present level of around 7 percent to the projected 42 percent level in 1993 is due to:

- The movement from conventional DIPs to SMDs
- Package pitch reductions from 0.1-inch lead spacing
- Increased chip functional density

Figure 7.1-2 illustrates the potential opportunities for system cost reduction through the use of SMD packaging techniques. System cost is a function of size and materials. The lowest system costs can therefore be achieved via:

- The densest chip technology (VLSI)
- Minimum chip encapsulation (SMD)
- The lowest-cost substrates
- Automation

Ultimately, we believe that cost reductions will be achieved by direct chip-on-board techniques. Already commonplace in the low-end, consumer-oriented products, DATAQUEST expects chip-on-board techniques to mature sufficiently with the necessary quality and reliability to be used in other application areas.

Figure 7.1-3 illustrates the trend toward SMDs as a percentage of total IC packages. The trend shows this going from 3 percent in 1984 to almost 15 percent by 1988. DATAQUEST expects, however, that this growth may be even faster due to a number of factors:

- SMDs that are more suitable high-speed, high-performance systems
- Device dissipation becoming less of a problem as CMOS technology is used more extensively
- Increasing availability of improved plastics and handling/ insertion equipment

7.1 Packaging Market Estimates

Figure 7.1-1

ESTIMATED FUNCTIONAL BOARD DENSITY

Preferred Package—Pin Count
Small Outline (SO)—28
Chip Carrier—28-84
Pin/Pad Grid Array (PGA)—84

Trend from DIP Caused by

- Higher Functional Density
- Potential Pitch Reductions

Move to TAB via SO then LCC then PLCC as Assembly Techniques Evolve

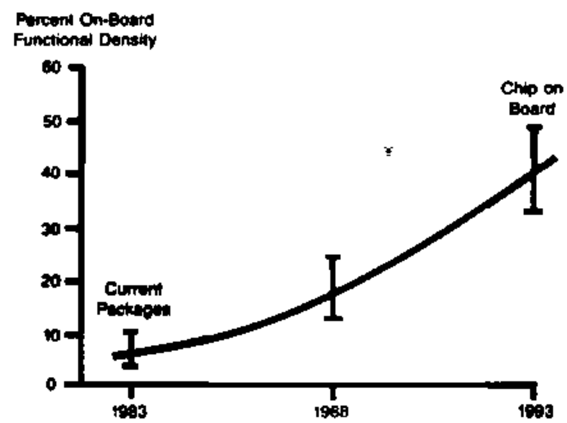


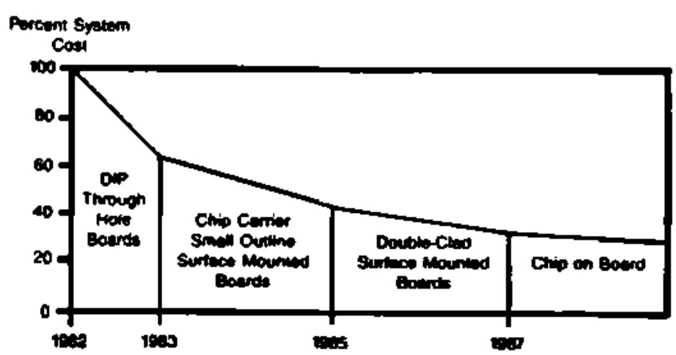
Figure 7.1-2

PROJECTED COST REDUCTION TRENDS

- Cost Proportional to Size
- Cost Proportional to Material

↓

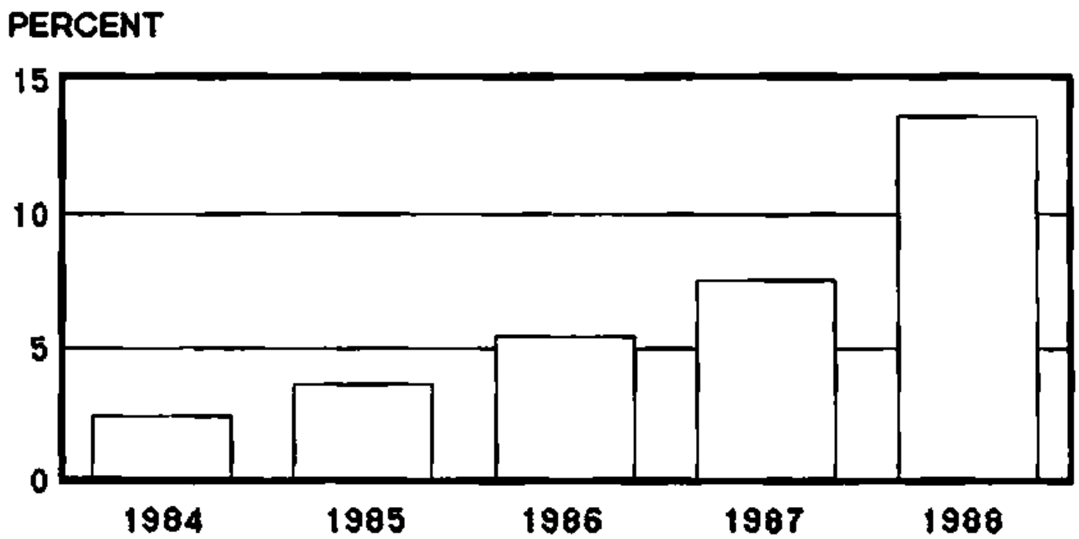
Lowest System Cost through Densest Chip Technology in Minimal Encapsulation Using Low-Cost Substrates



Source: DATAQUEST
October 1985

Figure 7.1-3

SURFACE-MOUNT VS. THROUGH-HOLE PACKAGES
(Percent of SMD Devices)



Source: DATAQUEST
October 1985

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Dataquest

European ASIC Market Consumption Forecast 1987-1995 and Market Share Rankings

European ASIC Market Consumption Forecast 1987-1995 and Market Share Rankings

A European Semiconductor Industry Service Report

Published by Dataquest Europe Limited

January 1991

0008259

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Chapter 1

Introduction and Definitions

Introduction

This booklet gives Dataquest's history and forecast for the European ASIC market. The ASIC market is divided into the following product categories: gate array; programmable logic device (PLD); cell-based integrated circuit (CBIC); and custom. The definition of these categories is given below. Figure 1.1 shows the relationship between the product categories.

The product chapters are divided into sections as follows:

- An introduction containing a summary, trends and Dataquest conclusions about the market
- Forecast and history tables for the product
- The top ten suppliers, where applicable, by technology
- Regional revenues and percentage splits for the product
- Application revenues and percentage splits for the product
- Diagrams illustrating relevant trends

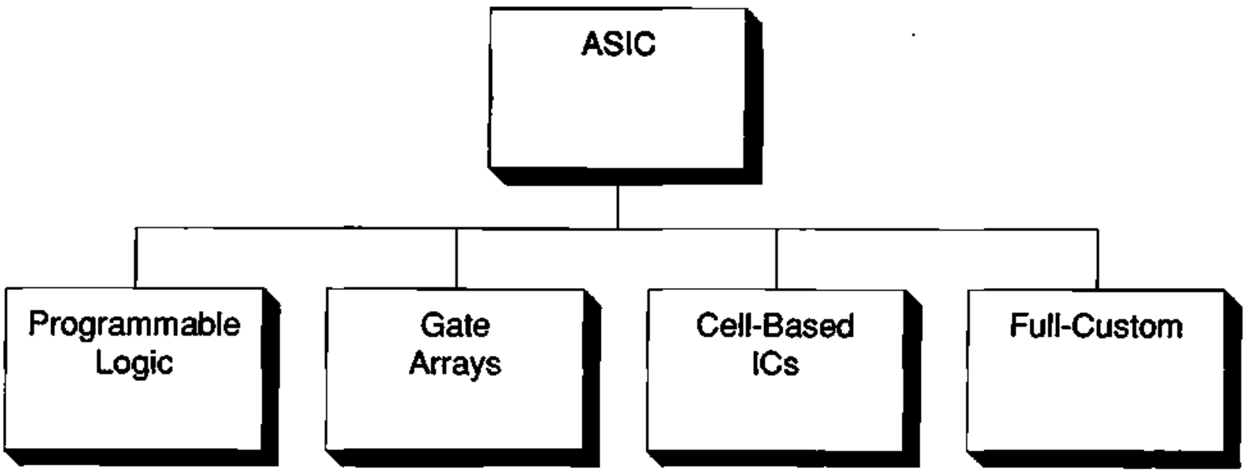
Definitions

The term application-specific integrated circuit (ASIC) can refer to a multitude of product types. However, when Dataquest first coined the term it had a definite meaning, and the product types tracked and forecast conformed to that specific meaning. When comparing company or market data with history, or forecasting potential market share, it is of vital importance that definitions are consistent. For this reason, Dataquest uses the original definition, which is restated as follows:

- **ASIC**. A single-user IC that is manufactured using vendor-supplied tools and/or libraries.
- **Gate Array**. An ASIC device that is customized using the final layers of interconnect. Included

Figure 1.1

ASIC Family Tree



Source: Dataquest (January 1991)

in this category are generic or base wafers that include embedded functions such as static random access memory.

- **PLD.** A logic device that can be customized by the user after assembly.
- **Cell-Based Integrated Circuits.** An ASIC device that is customized using a full set of masks and which uses automatic placement of cells and automatic routing.
- **Custom.** An ASIC device that is customized using a full set of masks and which requires manual placement and routing of the cells.
- **Mixed Signal.** An ASIC device with both digital and analog signal input or output (excluding line driver outputs and single comparator and Schmitt trigger inputs).

  We understand that mixed signal ASICs fall into two categories: simple mixed signal ASICs that use pre-characterized cells that can be tested using a digital tester; and more complex, high-performance mixed signal devices that require analog test. This definition is intended to cover both types of mixed signal ASIC.

It is important to note that ASIC refers to single-user ICs, and not mulitple-user standard products which are targeted at specific applications such as PC chip sets. These multiuser products are more aptly named application-specific standard products (ASSPs). ASSP-type products are currently included in the microperipheral category of both Dataquest and the World Semiconductor Trade Statistics (WSTS) organization.

Data Tables

The tables and figures give Dataquest's ASIC forecast data according to the indexes in each section. In the tables, columns may not add to totals due to rounding.

European ASIC Consumption Forecast 1987–1995

Summary

The European ASIC market will continue to grow faster than the European semiconductor market as a whole, over the next five years. By 1995 Dataquest estimates the European ASIC market to be worth $2,803 million. This represents a compound annual growth rate (CAGR) of 15.8 percent over the five years from 1990 to 1995. The CAGR for the European semiconductor market over the same period is 14.4 percent.

In 1989 the European ASIC market grew by 20 percent compared to a European semiconductor market growth of 14.9 percent. However, in 1990 we expect growth to slow to about 14 percent, followed by 9 percent in 1991. At the end of 1990 there are clear signs of a slowdown in the world economy, and this is expected to worsen as we enter 1991. Inevitably this will impact the European semiconductor market, including ASICs. Dataquest expects the market to begin to recover in the second half of 1991, and climb towards a peak growth rate in 1993.

Gate arrays currently have the largest share of the European ASIC market, representing 34 percent in 1989. This share is expected to remain constant out to 1995, but by then cell-based ICs (CBICs) will have the largest share of the ASIC market, at 37 percent. This is because of the increasing use of mixed signal CBICs, driven by the growth in the telecommunications segment of the semiconductor market. The CAGR for gate arrays for the period 1990 to 1995 is 15.8 percent, compared to a CAGR of 19.0 percent for CBICs. This will give a revenue of $960 million for gate array, and $1,051 million for CBICs.

The ASIC product with the highest CAGR for the period 1990 to 1995 is the programmable logic device (PLD), with a CAGR of 30.2 percent. PLD revenue in 1995 is expected to be $560 million, representing 20 percent of the ASIC market. The high growth for PLD is from a low base of $127 million in 1989, and is due to the expected large growth in usage of CMOS field programmable gate arrays (FPGAs) in telecoms and industrial applications.

The use of full-custom ASIC is expected to decline over the next five years. By 1995 the market is estimated to be worth $232 million, declining at a CAGR of 4.6 percent. In 1995 full-custom is expected to represent only 8 percent of the European ASIC market, declining from 22 percent in 1990.

Trends

The cost per gate of ASICs is expected to decline over the next five years, but the increased complexity of the devices should compensate for this, resulting in a higher average unit price overall. The nonrecurring engineering (NRE) charge for designs is also expected to increase in line with the increase in complexity. In particular, the greater use of analog cells will drive a significant increase in NRE cost for CBICs. The limited number of manufacturers which are capable of supplying mixed signal devices means that in the short term there will be little price competition for mixed signal products. The longer term is less rosy, though, as design tools ease the design of mixed signal devices, and more manufacturers enter the mixed signal arena.

The lifetime of equipment is reducing, as manufacturers fight for market share by introducing new products at a faster rate. As a result, the number of units for any one product will fall, but the number of new designs should rise. This trend is not apparent at the moment, but should become more so in the next few years. The result of this shorter product life means that the design time, and time to market for a product, will be reduced. This will drive equipment manufacturers towards gate arrays for digital applications, as the manufacturing time for gate array is faster than for CBIC. CBIC will therefore be used for designs which cannot be fitted onto a gate array. Typically these are where special cells are required, or where large areas of RAM are needed, or where higher-performance analog cells are required.

The main trend apparent in ASIC applications is the migration through the various implementations of ASIC, as each of these implementations offers additional capabilities as part of the product development. There is a shift through the ASIC implementations from custom to CBIC, from CBIC to gate array, and from gate array to FPGA.

The increased use of FPGAs will attract new ASIC users, who would not have used ASICs before. FPGAs will also take market share from the existing gate array market. The applications where gate arrays will lose share to programmable gate arrays are where the volumes are low, and the NRE represents a large part of the total cost of the ASIC; or where the gate count is low enough to merit the use of the FPGAs. The complexity of FPGAs is gradually increasing, so they will be able to be used for more and more of the applications which were previously only within the capabilities of standard gate array.

Gate arrays will become the preferred choice over CBICs for most digital applications. This will be due to the lower cost of prototyping and manufacturing gate arrays, and the ability to manufacture gate arrays faster. Where time to market and cost are of key consideration, gate arrays will be the first choice. The gate densities of gate arrays are approaching those of CBICs, so the increased cell densities previously achieved for CBICs will not give sufficient advantage to outweigh the increased prototype time or NRE cost.

Cell-based ICs will be used for making devices which cannot be made cost-effectively with gate arrays. Typically, these will be devices which include large areas of RAM, or where specialized cells are required. These cells are most likely to be analog cells, and this will be the biggest growth area for CBICs. The strength of the telecoms market in Europe will give a strong pull to mixed signal ASICs, and cell-based design currently is the most suitable implementation for mixed signal ASICs.

While there is some cannibalization of gate array designs by FPGAs, and CBIC designs by gate arrays, the replacement of full-custom designs by CBIC methodology has been virtually total.

The use of custom is in decline, as cell-based design gives layout densities which are sufficient for most applications. The fast design time offered by CBIC design tools easily compensates for the slightly larger area of the devices. The increasing use of design standards such as VHDL ensure that only cell-based design is used for many projects. These design standards are expensive to implement for custom design, and are not usually cost-effective. Custom design will still be used in some areas, such as some consumer or very high-volume designs, but generally the use of custom ASIC design is in decline.

Conclusions

To achieve success in ASIC a vendor must concentrate in areas of high growth and high profitability. These areas are currently mixed signal CBIC, high gate count gate array, and field programmable gate arrays. However, these areas are likely to become saturated with suppliers and products, forcing prices and profits down. Staying ahead will need continued investment in new products and processes, but this will ultimately result in a situation similar to that of DRAMs, where the development of the next generation of products includes the building of a billion dollar fabrication plant. The real key to success will be the closer coupling of ASIC suppliers and users, to develop the key products that the customer wants, and can use.

In the short term the reduction of design and manufacture time for end equipment will be a requirement by the ASIC user, and so the success of FPGAs should be assured, as these have the shortest manufacture time. Overall, the reduction in design time can only be achieved through the development of better design tools.

Index of Tables and Figures—Chapter 2

Table 2.1

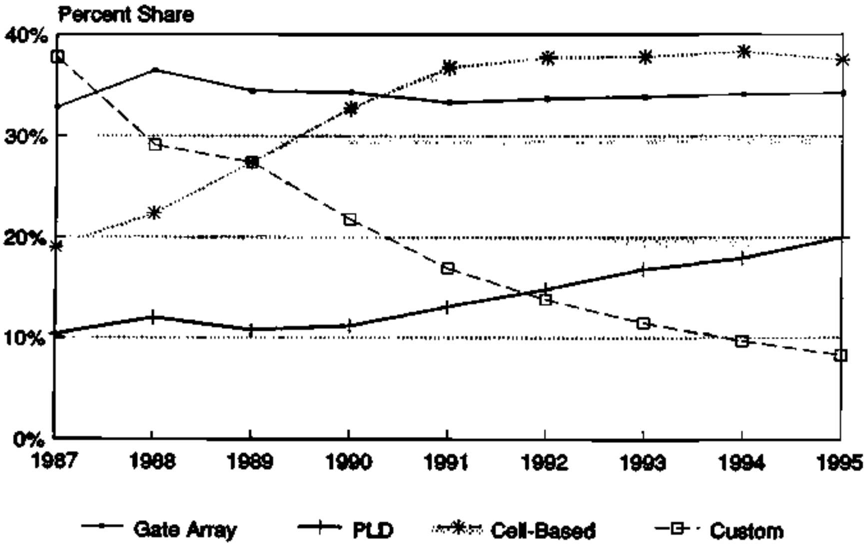
Total ASIC Revenue History and Forecast
(Millions of Dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Total ASIC	792	982	1,182	1,344	1,465	1,779	2,193	2,541	2,803	15.8%
MOS	583	739	918	1,079	1,198	1,473	1,833	2,123	2,345	16.8%
Bipolar	209	232	240	225	202	203	204	202	198	-2.5%
BiCMOS	0	11	24	40	66	103	156	216	260	45.4%
Gate Array	260	358	407	461	488	599	743	867	960	15.8%
MOS	165	257	308	361	393	498	636	748	828	18.1%
Bipolar	95	100	96	95	88	88	84	83	81	-3.1%
BiCMOS	0	1	3	5	7	13	23	36	51	59.1%
PLD	82	118	127	150	191	264	369	455	560	30.2%
MOS	15	27	48	77	126	195	297	382	490	44.8%
Bipolar	67	91	79	73	66	69	72	73	70	-0.7%
CBIC	151	220	324	440	538	671	829	973	1,051	19.0%
MOS	151	210	294	401	481	590	712	814	867	16.7%
Bipolar	0	0	9	8	10	11	14	13	14	11.8%
BiCMOS	0	10	21	31	47	70	103	146	170	40.5%
Custom	299	286	324	293	248	245	252	246	232	-4.6%
MOS	252	245	268	240	198	190	188	179	160	-7.8%
Bipolar	47	41	56	49	38	35	34	33	33	-7.6%
BiCMOS	0	0	0	4	12	20	30	34	39	57.7%

Source: Dataquest (January 1991)

Figure 2.1

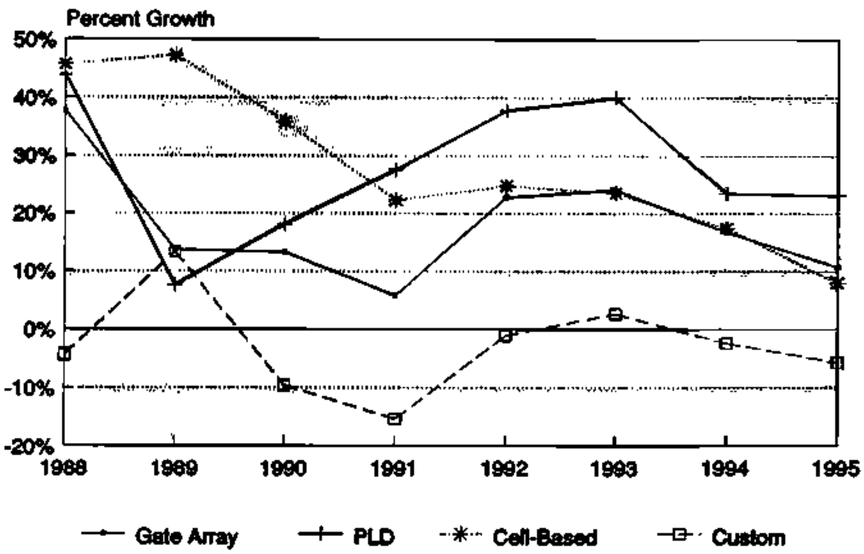
Share of ASIC Market by Product



Source: Dataquest (January 1991)

Figure 2.2

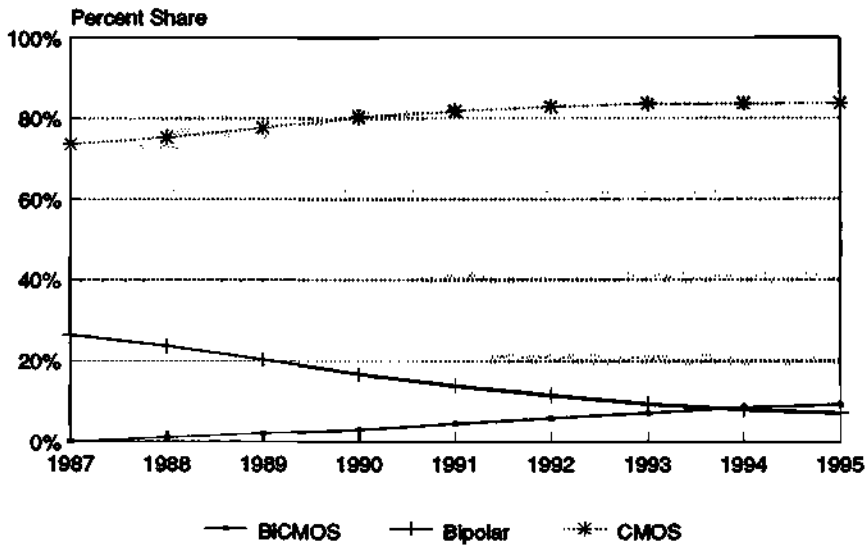
ASIC Product Growth



Source: Dataquest (January 1991)

Figure 2.3

Share of ASIC Market by Technology



Source: Dataquest (January 1991)

Table 2.2

Top 10 Bipolar ASIC Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Plessey	5	43	54	1
Advanced Micro Devices	43	56	49	2
Siemens	51	28	37	3
Texas Instruments	8	28	29	4
Philips	10	15	14	5
National Semiconductor	18	16	11	6
Telefunken	10	10	7	7
Motorola	7	5	6	8
Fujitsu	11	4	5	9
NEC	0	0	5	10

Source: Dataquest (January 1991)

Table 2.3

Top 10 MOS ASIC Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
ITT Intermettal	102	95	91	1
LSI Logic	44	59	69	2
Siemens	39	28	55	3
Mietec	32	42	50	4
Texas Instruments	14	26	50	5
Toshiba	16	41	50	6
SGS-Thomson	23	35	48	7
Plessey	21	39	47	8
Austria Mikro Systeme	29	36	44	9
VLSI Technology	17	25	37	10

Source: Dataquest (January 1991)

Table 2.4

Top 10 Total ASIC Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Plessey	26	82	101	1
Siemens	90	56	92	2
ITT Intermettal	102	95	91	3
Texas Instruments	22	54	79	4
LSI Logic	44	59	69	5
Advanced Micro Devices	45	58	52	6
Toshiba	16	44	52	7
Mietec	32	42	50	8
SGS-Thomson	25	35	50	9
National Semiconductor	35	51	47	10

Source: Dataquest (January 1991)

Table 2.5

Total ASIC Consumption Forecast by Application

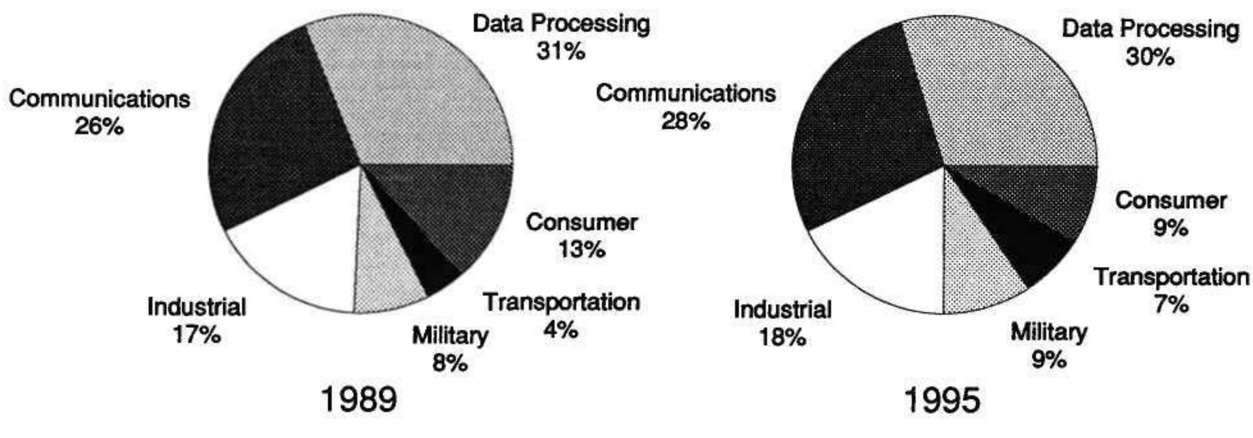
	Millions of Dollars								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	259	316	368	401	432	521	643	743	835
Communication	210	255	312	370	406	499	613	707	774
Industrial	129	171	200	230	252	308	392	455	495
Military	59	76	95	114	129	162	198	230	261
Transportation	22	35	50	63	79	102	138	171	195
Consumer	113	130	158	165	167	187	208	236	243

	Percent of Revenue								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	33%	32%	31%	30%	30%	29%	29%	29%	30%
Communication	27%	26%	26%	28%	28%	28%	28%	28%	28%
Industrial	16%	17%	17%	17%	17%	17%	18%	18%	18%
Military	8%	8%	8%	9%	9%	9%	9%	9%	9%
Transportation	3%	4%	4%	5%	5%	6%	6%	7%	7%
Consumer	14%	13%	13%	12%	11%	11%	9%	9%	9%

Source: Dataquest (January 1991)

Figure 2.4

Total ASIC Consumption by Application



Source: Dataquest (January 1991)

Table 2.6

Total ASIC Consumption Forecast by Region

	Millions of Dollars								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	32	38	55	63	73	93	114	129	142
France	169	203	271	305	322	373	440	496	525
Italy	103	143	157	177	194	225	276	302	334
Scandinavia	63	76	88	94	98	121	150	177	200
UK and Eire	152	179	227	265	301	380	480	567	643
West Germany	245	308	340	388	420	513	628	741	804
Rest of Europe	27	36	45	52	58	75	104	130	155

	Percent of Revenue								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	4%	4%	5%	5%	5%	5%	5%	5%	5%
France	21%	21%	23%	23%	22%	21%	20%	20%	19%
Italy	13%	15%	13%	13%	13%	13%	13%	12%	12%
Scandinavia	8%	8%	7%	7%	7%	7%	7%	7%	7%
UK and Eire	19%	18%	19%	20%	21%	21%	22%	22%	23%
West Germany	31%	31%	29%	29%	29%	29%	29%	29%	29%
Rest of Europe	3%	4%	4%	4%	4%	4%	5%	5%	6%

Source: Dataquest (January 1991)

Chapter 3

European Gate Array Consumption Forecast 1987–1995

Summary

The European gate array market grew by 14 percent in 1989, reaching $407 million. This was a modest growth by comparison with previous years, where annual growth rates were high, characteristic of a market in its infancy. We see this more stable growth continuing into 1990, with the market increasing by 13 percent over 1989. A close inspection of gate arrays reveals that a maturing of CMOS gate array, which represented 76 percent of total gate array in 1989, lies behind this slower growth.

As the semiconductor market continues to slow in 1991, total gate array will show a modest 6 percent growth over 1990. Typical of a maturing market we expect that, while gate array will continue to grow above the semiconductor market average, its growth will track the market average more closely than in the past.

Over the five-year period from 1990 to 1995 Dataquest estimates the European gate array market will grow at a CAGR of 15.8 percent. In 1990 gate array will be the largest portion of the European ASIC market, at 34 percent. By 1992 CBICs will have become the largest product category, overtaking gate array. This is due to the rapid growth of mixed analog/digital CBICs. However, in pure digital ASICs gate arrays will continue to be the major product category for the next five years.

Trends

The average gate count per design for gate arrays is increasing, and the unit cost of the arrays, in terms of cents per gate, is decreasing. The result of this is an increase in unit price, because the gate count is growing faster than the reduction in cents per gate. The maximum number of gates available on a single array is also increasing, and the consequence of this increase in gate density is a reduction in the number of designs required for a particular application. The ability to integrate a large number of gates onto a single chip means the number of chips required to implement complex systems is reduced.

The higher gate density now available in gate arrays is resulting in a lower cost in cents per gate for these arrays. This lower unit cost is therefore giving the user a choice between gate arrays and CBICs in many pure digital applications, as the gate densities for gate array are now approaching those achieved by CBIC designs. Gate arrays are becoming the preferred choice for many digital-only ASICs because they offer faster prototyping and lower nonrecurring engineering charges.

The dominant technology for gate array at the moment is CMOS, but the development and application of BiCMOS technology for gate arrays offers higher performance and drive capability when compared to standard CMOS.

However, the manufacturing technology which these BiCMOS arrays need is expensive, and the cost in terms of cents per gate is currently five to ten times that of existing CMOS designs. This means that the replacement of CMOS arrays by BiCMOS arrays will be low in the short term. The improvement in speed offered by BiCMOS, however, means that the arrays are approaching the speed achieved by ECL arrays, and the cost is still lower than ECL. In addition, the BiCMOS arrays use significantly less power than the ECL arrays. As a result, BiCMOS growth will be achieved in the short term at the expense of ECL.

CMOS gate arrays are also under threat from the recently introduced field programmable gate arrays (FPGAs). The gate density of these FPGAs is reaching 8,000 gates, and will continue to rise as new architectures and processes improve the density and size of the devices. This means FPGAs will be more cost-effective than standard gate arrays for lower-volume, lower gate count applications.

Conclusions

Gate arrays will lose their dominant position in the ASIC market to CBIC within the next two years. The growth in demand for mixed signal ASICs is very strong, and CBICs are the only ASIC implementation which is able to meet the performance requirements of the mixed signal applications. This, when added to the growth in digital CBICs, will topple gate array from its number one position.

Gate arrays are also under attack from FPGA for low-volume, low gate count applications. However, CMOS gate arrays are increasing their maximum achievable gate count by utilizing the increase in gate density to integrate more gates onto a single chip. The price paid for this, though, is a higher cost for the arrays themselves, in a market where the price expectation for these arrays is very low.

The gate array market is low margin business, due to the number of gate array suppliers available. The cost of development of the new products with the bigger profit margins is high, so only the larger manufacturers can afford to compete in the long term. The need to find added value can only be met with specialist development and applications of cells in the array, or the development of unique gate array products. The risk of the development of these cells or products will be that their use may be low, as ASIC users try to standardize on more established arrays, or are unsure of their application.

Index of Tables and Figures—Chapter 3

Table 3.1

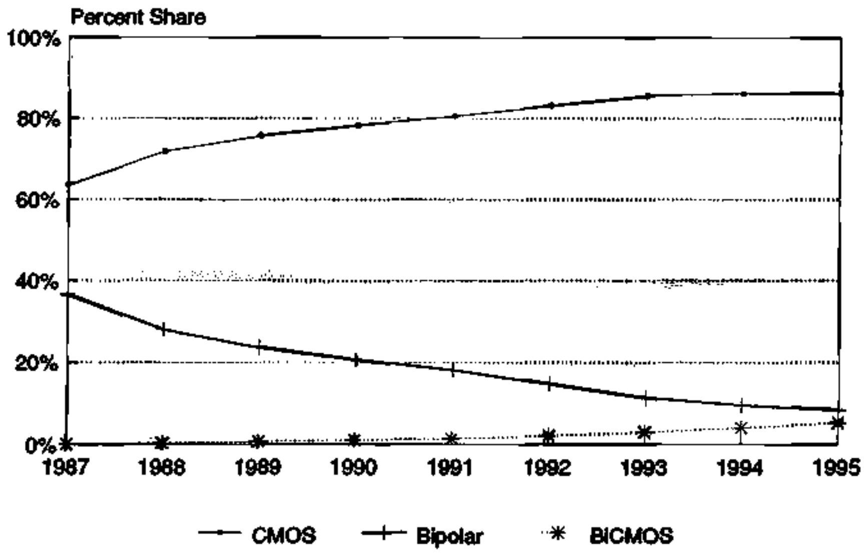
Gate Array Revenue History and Forecast
(Millions of Dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Total ASIC	792	982	1,182	1,344	1,465	1,779	2,193	2,541	2,803	15.8%
MOS	583	739	918	1,079	1,198	1,473	1,833	2,123	2,345	16.8%
Bipolar	209	232	240	225	202	203	204	202	198	-2.5%
BiCMOS	0	11	24	40	66	103	156	216	260	45.4%
Gate Array	260	358	407	461	488	599	743	867	960	15.8%
MOS	165	257	308	361	393	498	636	748	828	18.1%
Bipolar	95	100	96	95	88	88	84	83	81	-3.1%
BiCMOS	0	1	3	5	7	13	23	36	51	59.1%
MOS+BiCMOS	165	258	311	366	400	511	659	784	879	19.2%
Digital	165	257	305	360	393	499	638	754	844	18.6%
Linear	0	1	6	6	7	12	21	30	35	42.3%
Bipolar	95	100	96	95	88	88	84	83	81	-3.1%
Digital	95	100	92	89	82	84	80	80	78	-2.6%
Linear	0	0	4	6	6	4	4	3	3	-12.9%

Source: Dataquest (January 1991)

Figure 3.1

Share of Gate Array Market by Technology



Source: Dataquest (January 1991)

Table 3.2

Top 10 Bipolar Gate Array Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Plessey	4	34	35	1
Siemens	39	26	22	2
Motorola	5	4	6	3
National Semiconductor	6	7	6	4
Fujitsu	11	4	5	5
NEC	0	0	5	6
Philips	2	5	5	7
STC Components	0	7	4	8
Raytheon	0	7	3	9
Applied Micro Circuits	2	1	2	10

Source: Dataquest (January 1991)

Table 3.3

Top 10 MOS Gate Array Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
LSI Logic	40	52	58	1
Toshiba	16	41	50	2
Plessey	17	26	35	3
SGS-Thomson	11	17	28	4
National Semiconductor	14	25	22	5
NEC	8	18	19	6
Fujitsu	10	12	14	7
Texas Instruments	5	9	14	8
Matra-MHS	3	8	12	9
Hitachi	5	7	11	10

Source: Dataquest (January 1991)

Table 3.4

Top 10 Gate Array Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Plessey	21	60	70	1
LSI Logic	40	52	58	2
Toshiba	16	41	50	3
SGS-Thomson	13	17	30	4
National Semiconductor	20	32	28	5
NEC	8	18	24	6
Siemens	42	28	24	7
Fujitsu	21	16	19	8
Texas Instruments	5	9	14	9
Hitachi	5	7	12	10

Source: Dataquest (January 1991)

Table 3.5

Gate Array Consumption Forecast by Application

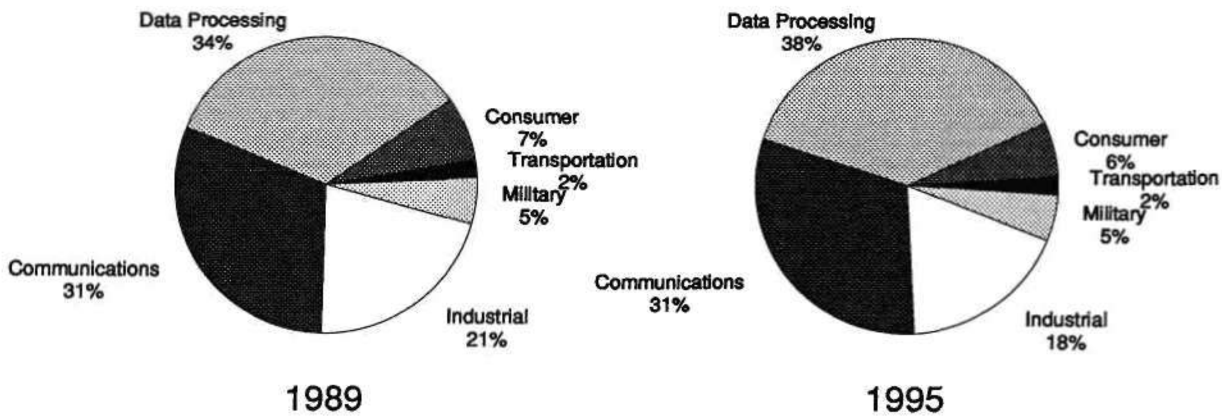
	Millions of Dollars								
Application	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Data Processing	137	175	183	199	209	252	306	350	391
Communication	60	85	114	132	142	177	224	265	294
Industrial	41	65	65	77	80	102	125	149	158
Military	10	15	17	20	22	27	35	41	46
Transportation	2	3	6	7	8	10	13	16	18
Consumer	10	15	22	26	28	31	40	47	53

	Percent of Revenue								
Application	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Data Processing	37%	37%	34%	34%	35%	36%	37%	37%	38%
Communication	26%	26%	31%	31%	31%	31%	31%	31%	31%
Industrial	25%	25%	21%	21%	20%	20%	19%	19%	18%
Military	5%	5%	5%	5%	5%	5%	5%	5%	5%
Transportation	1%	1%	2%	2%	2%	2%	2%	2%	2%
Consumer	6%	6%	7%	7%	7%	6%	6%	6%	6%

Source: Dataquest (January 1991)

Figure 3.2

Gate Array Consumption by Application



Source: Dataquest (January 1991)

Table 3.6

Gate Array Consumption Forecast by Region

Region	Millions of Dollars								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Benelux	10	13	20	25	26	33	40	46	50
France	34	49	67	75	79	94	112	124	130
Italy	43	64	61	63	68	81	103	114	127
Scandinavia	31	39	44	47	48	54	70	78	94
UK and Eire	61	77	89	103	111	142	177	214	246
West Germany	77	107	113	130	138	169	208	250	268
Rest of Europe	5	8	13	17	17	26	34	40	45

Region	Percent of Revenue								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Benelux	3%	3%	5%	5%	5%	5%	5%	5%	5%
France	16%	16%	19%	19%	18%	17%	16%	15%	14%
Italy	23%	23%	18%	16%	16%	15%	15%	14%	14%
Scandinavia	6%	6%	7%	7%	7%	7%	8%	8%	9%
UK and Eire	21%	21%	21%	22%	23%	24%	24%	25%	26%
West Germany	28%	28%	26%	27%	27%	27%	27%	28%	27%
Rest of Europe	3%	3%	4%	5%	4%	5%	5%	5%	5%

Source: Dataquest (January 1991)

European Programmable Logic Devices Consumption Forecast 1987–1995

Summary

The European programmable logic device (PLD) market grew by 8 percent in 1989 to $127 million. The growth of this market is controlled by the size of the bipolar segment, which is suffering severe price erosion. Bipolar PLDs represent 62 percent of the total PLD market for 1989 and this sector of the PLD market declined by 13 percent in 1989, compared with a growth of 78 percent for CMOS PLD over the same period.

Bipolar PLDs are forecast to decline at a CAGR of only 0.7 percent over the period 1990 to 1995, to a total of $70 million. This compares with a CAGR for CMOS PLD of 44.8 percent over the same period, to a value of $490 million. The total PLD market will grow by a CAGR of 30.2 percent to $560 million by 1995. CMOS PLD shipments are forecast to overtake bipolar PLD shipments by 1991.

Trends

The section of the PLD market with the highest growth rate is the field programmable gate array (FPGA), with a CAGR over the period 1990 to 1995 of 61.7 percent. By 1995 these devices will represent 57 percent of the total PLD market. These devices have the capability of integrating up to 8,000 gates at present, which means they are able to implement a large number of designs that were previously only possible with a gate array. As a result, field programmable gate arrays are "stealing" designs from gate arrays, as well as creating a market of their own. Their strength lies in the ability to prototype devices instantly, without undergoing the delay in manufacture that is needed for conventional gate arrays. In addition, the saving of the nonrecurring engineering charge means FPGAs are very cost-effective for low volumes. The trend for shorter production runs and shorter time to market for equipment will ensure the success of these devices.

There is severe price erosion in bipolar PLDs, as competition forces the price down. This is seen in the reduction of bipolar PLD revenue, in spite of an increase in the number of units shipped during 1989. The main battle for share is in the slower 15ns to 25ns parts, and this is where unit prices are at their lowest.

Bipolar PLDs continue in their eternal quest for speed, and the use of ECL cores—and in some cases complete ECL devices—has pushed the propogation delays down as low as 2.5ns. These very high-speed devices fit into narrow niche applications, and command premium prices where they are needed. Bipolar PLDs may have to fight off competition from high-speed gallium arsenide (GaAs) PLDs, though, in their key markets—high-performance supercomputers. These GaAs devices are now becoming more readily available as the manufacturing issues come under more control, and GaAs devices are able to match the performance offered by high-speed bipolar devices.

CMOS standard PLDs are also reducing the propagation delays, and are able to meet the speed requirements of most bipolar PLD applications. CMOS devices are currently able to meet 10ns delays, with some devices offering delays as short as 7.5ns. The mainstream bipolar PLD is therefore under attact by these CMOS devices, which offer lower power, resulting in cooler operation for equipment.

Conclusions

The major area of growth in PLD is with FPGAs—an area which is already experiencing massive growth, although from a low base. Success here depends initially on the ability to establish an installed based of proprietary design tools, tying in customer to a single vendor's product. The short term will see FPGA vendors fighting to achieve a large penetration of these design tools, prior to shipping volume product.

The customer is not ignorant of this strategy, though, having seen it applied with both cell-based ASICs and gate arrays. Some multivendor FPGA programmers are emerging, and customers are likely to latch on to this to ensure safety of supply. Standards are needed to ensure portability of designs between the various implementations of FPGA, and there are already signs of some interchangeability of designs. Success for the FPGA supplier will, then, depend on cost-effectiveness and customer support.

Bipolar PLD will still find niche applications, but the longer-term future will belong to CMOS in all but specialist applications.

Index of Tables and Figures—Chapter 4

Table 4.1

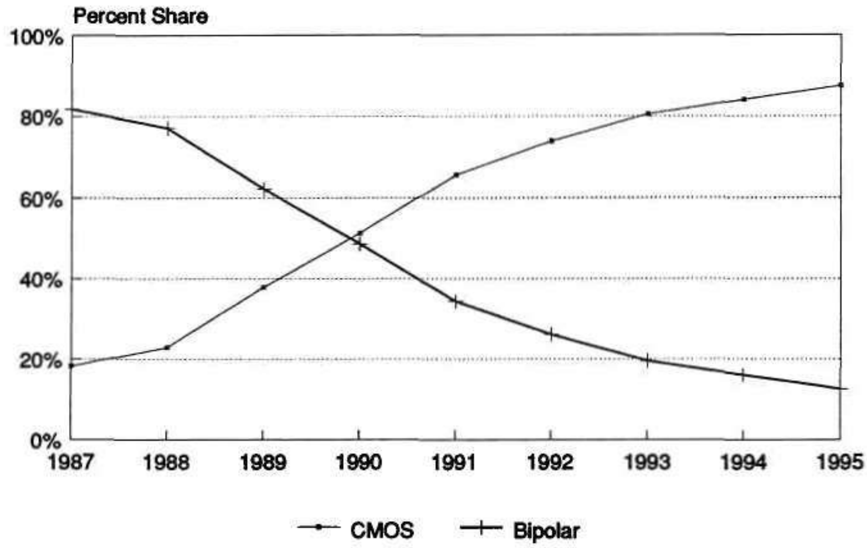
PLD Revenue History and Forecast
(Millions of Dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Total ASIC	792	982	1,182	1,344	1,465	1,779	2,193	2,541	2,803	15.8%
MOS	583	739	918	1,079	1,198	1,473	1,833	2,123	2,345	16.8%
Bipolar	209	232	240	225	202	203	204	202	198	-2.5%
BiCMOS	0	11	24	40	66	103	156	216	260	45.4%
PLD	82	118	127	150	191	264	369	455	560	30.2%
MOS	15	27	48	77	126	195	297	382	490	44.8%
Bipolar	67	91	79	73	66	69	72	73	70	-0.7%
PLA	78	112	114	121	127	148	190	215	240	14.6%
MOS (CMOS)	11	21	35	48	62	79	118	142	169	28.6%
Bipolar	67	91	79	73	66	69	72	73	70	-0.7%
TTL	67	91	78	71	62	64	66	65	62	-2.7%
ECL	0	0	1	2	4	5	6	8	8	33.2%
Field Prog.										
MOS (CMOS)	4	6	13	29	64	116	179	240	321	61.7%

Source: Dataquest (January 1991)

Figure 4.1

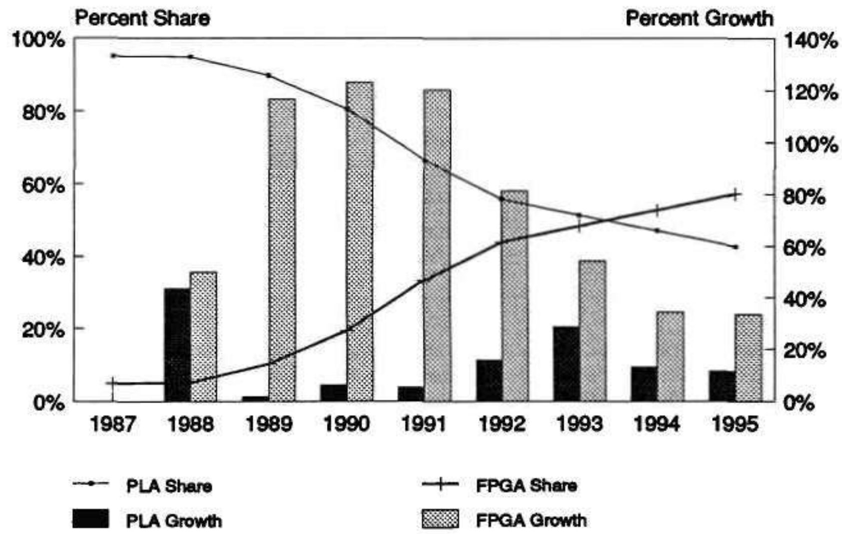
PLD Market Share by Technology



Source: Dataquest (January 1991)

Figure 4.2

PLD Market Trends



Source: Dataquest (January 1991)

Table 4.2

Top 4 Bipolar PLD Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Advanced Micro Devices	43	56	49	1
Texas Instruments	5	18	18	2
Philips	8	10	6	3
National Semiconductor	9	7	5	4

Source: Dataquest (January 1991)

Table 4.3

Top 9 MOS PLD Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Altera	4	7	12	1
Xilinx	4	5	8	2
Cypress	2	4	7	3
Intel	3	4	7	4
Lattice Semiconductor	0	3	4	5
Advanced Micro Devices	2	2	3	6
National Semiconductor	0	1	3	7
Actel	0	0	2	8
SGS-Thomson	0	1	1	9

Source: Dataquest (January 1991)

Table 4.4

Top 10 Total PLD Suppliers (Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Advanced Micro Devices	45	58	52	1
Texas Instruments	5	18	18	2
Altera	4	7	12	3
National Semiconductor	9	8	8	4
Xilinx	4	5	8	5
Cypress	2	4	7	6
Intel	3	4	7	7
Philips	8	10	6	8
Lattice Semiconductor	0	3	4	9
Actel	0	0	2	10

Source: Dataquest (January 1991)

Table 4.5

PLD Consumption Forecast by Application

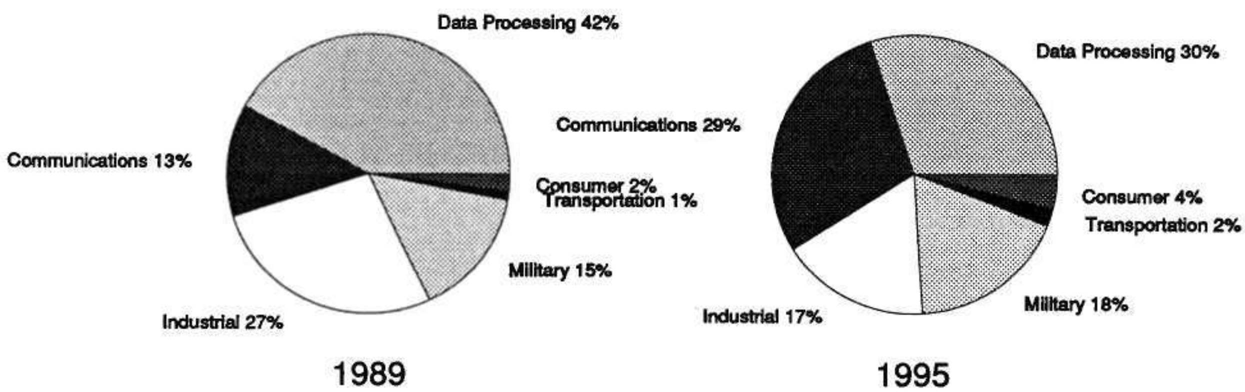
	Millions of Dollars								
Application	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Data Processing	29	47	53	54	65	84	114	141	168
Communication	12	17	17	33	48	74	103	132	162
Industrial	23	31	34	35	38	47	66	77	95
Military	15	18	19	23	31	45	63	82	101
Transportation	1	2	1	2	2	3	7	9	11
Consumer	2	4	3	4	8	11	15	14	22

	Percent of Revenue								
Application	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Data Processing	35%	40%	42%	36%	34%	32%	31%	31%	30%
Communication	15%	14%	13%	22%	25%	28%	28%	29%	29%
Industrial	28%	26%	27%	23%	20%	18%	18%	17%	17%
Military	18%	15%	15%	15%	16%	17%	17%	18%	18%
Transportation	1%	2%	1%	1%	1%	1%	2%	2%	2%
Consumer	3%	3%	2%	3%	4%	4%	4%	3%	4%

Source: Dataquest (January 1991)

Figure 4.3

PLD Consumption by Application



Source: Dataquest (January 1991)

Table 4.6

PLD Consumption Forecast by Region

	Millions of Dollars								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	3	4	4	5	6	8	11	14	17
France	11	14	15	20	25	36	50	64	78
Italy	7	14	15	17	21	28	39	46	56
Scandinavia	8	12	11	14	16	22	30	36	42
UK and Eire	23	30	33	38	48	66	92	114	140
West Germany	25	37	39	48	61	84	118	146	179
Rest of Europe	6	8	9	10	14	20	30	36	48

	Percent of Revenue								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	4%	3%	3%	3%	3%	3%	3%	3%	3%
France	13%	12%	12%	13%	13%	14%	14%	14%	14%
Italy	8%	12%	12%	12%	11%	11%	11%	10%	10%
Scandinavia	10%	10%	9%	9%	9%	9%	8%	8%	8%
UK and Eire	28%	25%	26%	25%	25%	25%	25%	25%	25%
West Germany	30%	31%	31%	32%	32%	32%	32%	32%	32%
Rest of Europe	7%	7%	7%	7%	7%	7%	8%	8%	8%

Source: Dataquest (January 1991)

Chapter 5

European Cell-Based IC Consumption Forecast 1987–1995

Summary

The European cell-based IC (CBIC) market grew by 47 percent in 1989, to $324 million. This was achieved through high growth in both digital CBICs and mixed signal CBICs. Growth for CBIC will fall to 36 percent for 1990, and continue its decline in growth into 1991, with a revenue increase of 22 percent.

Cell-based ICs are forecast to dominate the ASIC market by 1995, with a CAGR of 19.0 percent over the period 1990 to 1995. The CBIC market is forecast to be $1,051 million by 1995. CBICs will overtake gate array as the dominant ASIC technology, mainly through the high growth of mixed signal CBICs in the telecoms and automotive markets.

Trends

The use of CBICs in digital applications will decline from 70 percent of total CBIC revenue in 1989, to 56 percent of all CBIC revenue by 1995. The growth of mixed signal CBIC will be built on telecoms and automotive applications. The European telecoms market is very strong, and the ASIC needs of this market are best met by mixed signal ASIC. The mixed signal capabilities of gate array are not adequate to meet the demands of the telecoms market, so CBIC is the dominant factor here.

The CBIC market will also "steal" designs from custom applications. The increase in the capabilities of CBIC design tools means the benefits offered by custom design become marginal when compared to the cost of these benefits. CBIC designs will have the capability to customize certain cells in a design, giving greater flexibility to the CBIC designs. Several CBIC suppliers are already offering this cell customization service to selected customers.

The cost of prototyping CBICs has always been higher than for prototyping gate arrays, as all the layers used in manufacture need to be defined for a cell-based design. This prototyping cost has normally been a reasonably small percentage of the total cost of prototyping and production for a cell-based design, as the volume orders for CBICs have been high. The newer manufacturing processes such as BiCMOS, however, require many more masks than the older CMOS processes, and this increases significantly the prototyping cost for CBICs. In addition, the volumes needed for the production runs for devices are reducing, meaning a higher prototyping cost will need to be amortized over a lower production run. Therefore, much higher cost will be associated with a cell-based design.

The increase in cost for CBICs means that all of the layers used in manufacture will need to be utilized effectively. This can be achieved through the use of complex or high-performance library cells. The future of CBICs lies with the development of these cells. This development will meet very specialized requirements, which can only be defined and met by close cooperation between the CBIC supplier and the customer.

Conclusions

The greatest strength of CBICs is the flexibility offered by the utilization of all the layers used in manufacture. But, this is also CBIC's greatest weakness, as the cost of using all these layers for manufacture will rise with the increased complexity of the manufacturing processes used. The success for CBIC lies with using this flexibility to its greatest advantage, which is best achieved by offering product functionality that cannot be met by using a gate array. This will be high-density functionality such as memory, or specialized cells such as large microprocessor cores; or with the inclusion of high-performance analog cells.

There are currently few CBIC suppliers which can offer high-performance mixed signal capability, but the development of adequate mixed signal design tools within the next five years will mean other CBIC suppliers will be able to chase this profitable sector of the market. In the meantime, closer cooperation between the CBIC supplier and the customer to define and develop the specialist cells needed by specific applications will ensure success in the short term.

Index of Figures and Tables—Chapter 5

Table 5.1

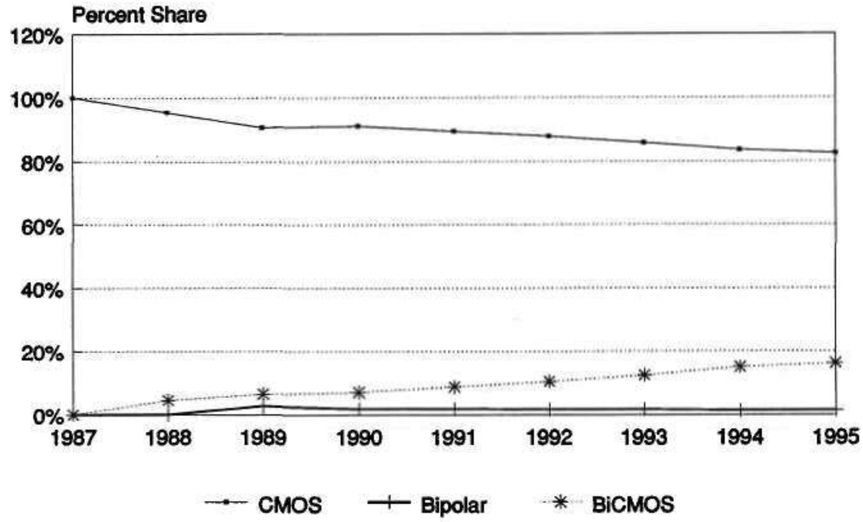
CBIC Revenue History and Forecast (Millions of Dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Total ASIC	792	982	1,182	1,344	1,465	1,779	2,193	2,541	2,803	15.8%
MOS	583	739	918	1,079	1,198	1,473	1,833	2,123	2,345	16.8%
Bipolar	209	232	240	225	202	203	204	202	198	-2.5%
BiCMOS	0	11	24	40	66	103	156	216	260	45.4%
CBIC	151	220	324	440	538	671	829	973	1,051	19.0%
MOS	151	210	294	401	481	590	712	814	867	16.7%
Bipolar	0	0	9	8	10	11	14	13	14	11.8%
BiCMOS	0	10	21	31	47	70	103	146	170	40.5%
Digital	110	155	226	311	344	407	484	551	585	13.5%
MOS	110	155	226	310	341	403	478	544	576	13.2%
Bipolar	0	0	0	0	1	1	2	2	3	
BiCMOS	0	0	0	1	2	3	4	5	6	43.1%
Mixed Signal	41	65	98	129	194	264	345	422	466	29.3%
MOS	41	55	68	91	140	187	234	270	291	26.2%
Bipolar	0	0	9	8	9	10	12	11	11	6.6%
BiCMOS	0	10	21	30	45	67	99	141	164	40.5%

Source: Dataquest (January 1991)

Figure 5.1

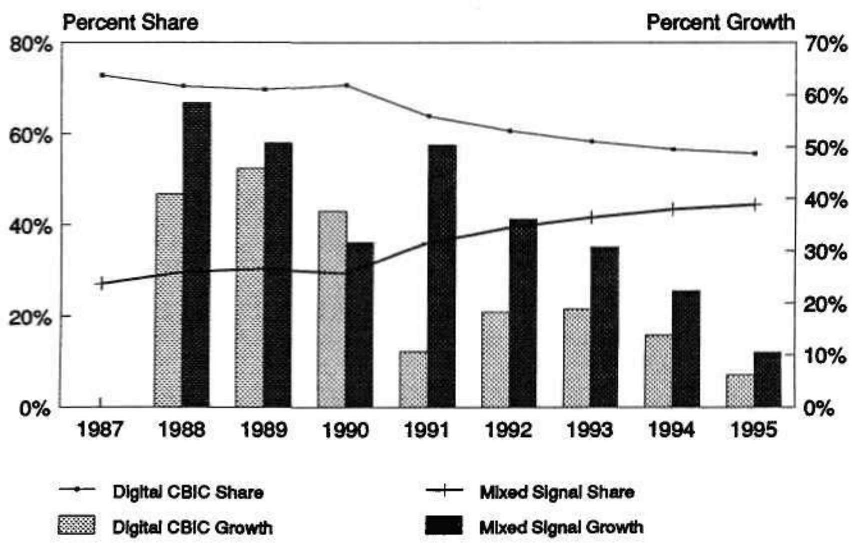
Share of CBIC Market by Technology



Source: Dataquest (January 1991)

Figure 5.2

CBIC Market Trends



Source: Dataquest (January 1991)

Table 5.2

Top 10 Digital MOS CBIC Suppliers (Millions of Dollars)

Company	Revenue 1987	Revenue 1988	Revenue 1989	Ranking 1989
VLSI Technology	15	22	29	1
Austria Mikro Systeme	13	16	24	2
Texas Instruments	5	12	24	3
European Silicon Structures	6	12	17	4
MEDL	5	11	17	5
Siemens	15	15	17	6
SGS-Thomson	2	3	15	7
AT&T	6	9	10	8
Harris Semiconductor	4	8	10	9
Honeywell/Atmel	0	0	10	10

Source: Dataquest (January 1991)

Table 5.4

Top 10 Total MOS CBIC Suppliers (Millions of Dollars)

Company	Revenue 1987	Revenue 1988	Revenue 1989	Ranking 1989
Mietec	27	29	34	1
Texas Instruments	5	12	30	2
VLSI Technology	15	22	29	3
Austria Mikro Systeme	15	19	27	4
MEDL	5	12	19	5
SGS-Thomson	2	3	19	6
European Silicon Structures	6	12	17	7
Siemens	15	15	17	8
IMP Europe	2	7	11	9
LSI Logic	4	7	11	10

Source: Dataquest (January 1991)

Table 5.3

Top 10 Mixed Signal CBIC Suppliers (Millions of Dollars)

Company	Revenue 1987	Revenue 1988	Revenue 1989	Ranking 1989
Mietec	22	20	27	1
IMP Europe	2	7	11	2
Telefunken	10	10	10	3
Plessey Semiconductor	3	7	8	4
National Semiconductor	2	5	6	5
Texas Instruments	0	0	6	6
Philips	0	5	5	7
SGS-Thomson	0	0	4	8
Sierra Semiconductor	0	6	4	9
Austria Mikro Systeme	2	3	3	10

Source: Dataquest (January 1991)

Table 5.5

CBIC Consumption Forecast by Application

	Millions of Dollars								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	27	31	61	83	107	133	173	203	230
Communication	63	81	100	132	157	189	225	254	264
Industrial	29	42	62	83	102	127	165	194	209
Military	20	29	42	57	64	80	91	97	105
Transportation	5	15	26	40	54	74	100	127	147
Consumer	8	22	33	44	54	68	76	99	96

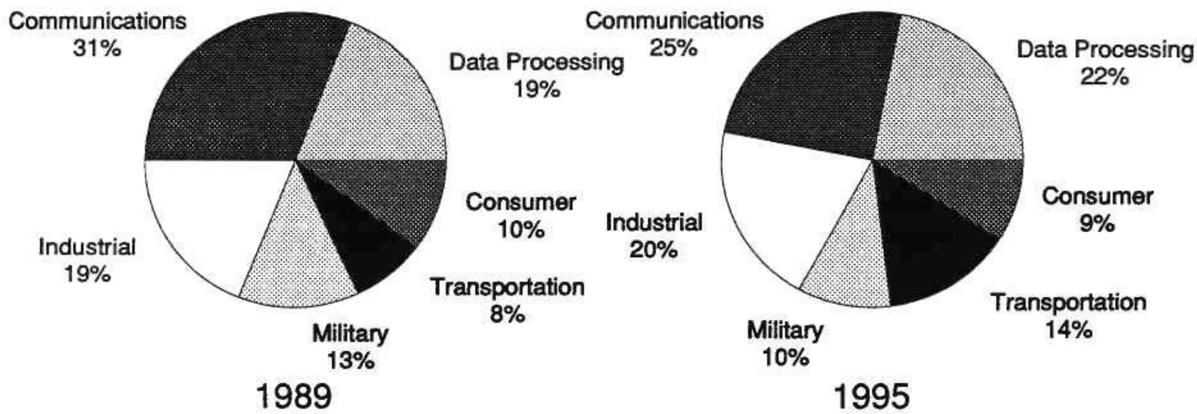
	Percent of Digital Revenue								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	18%	14%	19%	19%	20%	20%	21%	21%	22%
Communication	42%	37%	31%	30%	29%	28%	27%	26%	25%
Industrial	19%	19%	19%	19%	19%	19%	20%	20%	20%
Military	13%	13%	13%	13%	12%	12%	11%	10%	10%
Transportation	3%	7%	8%	9%	10%	11%	12%	13%	14%
Consumer	5%	10%	10%	10%	10%	10%	9%	10%	9%

	Percent of Mixed Signal Revenue								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	14%	13%	12%	11%	10%	10%	10%	10%	10%
Communication	42%	37%	31%	36%	38%	38%	35%	34%	33%
Industrial	19%	19%	19%	16%	15%	14%	14%	14%	14%
Military	13%	13%	13%	12%	11%	10%	9%	8%	8%
Transportation	3%	7%	8%	10%	13%	14%	14%	14%	15%
Consumer	9%	11%	17%	15%	13%	14%	18%	20%	20%

Source: Dataquest (January 1991)

Figure 5.3

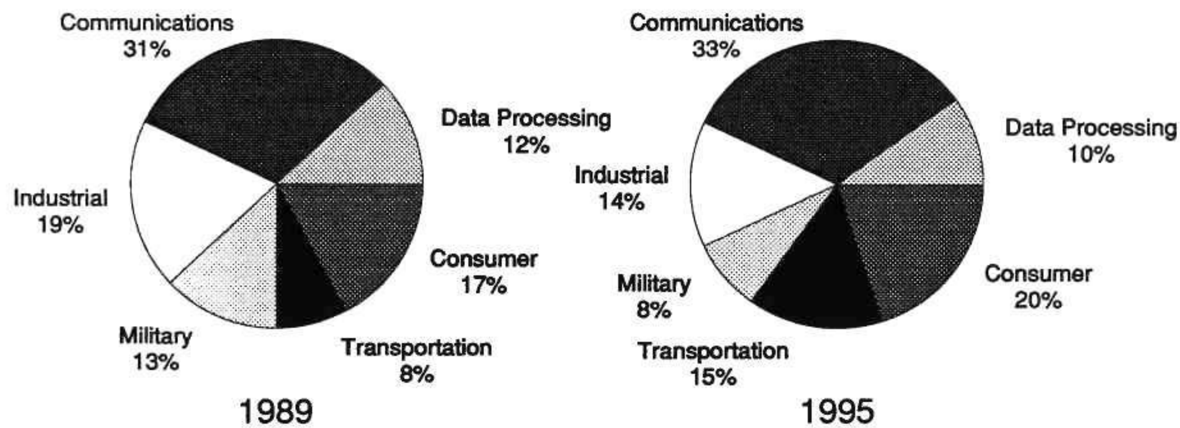
Digital CBIC Consumption by Application



Source: Dataquest (January 1991)

Figure 5.4

Mixed Signal CBIC Consumption by Application



Source: Dataquest (January 1991)

Table 5.6

CBIC Consumption Forecast by Region

Region	1987	1988	1989	1990	1991	1992	1993	1994	1995
				Millions of Dollars—Total MOS CBIC					
Benelux	4	7	14	19	28	40	51	57	63
France	41	60	98	128	149	174	207	239	252
Italy	27	38	52	70	82	94	112	121	130
Scandinavia	3	4	10	13	16	27	33	44	48
UK and Eire	14	20	46	72	97	127	166	195	215
West Germany	54	79	91	122	147	187	227	271	287
Rest of Europe	7	11	13	16	20	22	33	46	56

Region	1987	1988	1989	1990	1991	1992	1993	1994	1995
				Percent of Digital Revenue					
Benelux	1%	1%	2%	2%	2%	2%	2%	2%	2%
France	28%	28%	32%	30%	28%	26%	25%	25%	24%
Italy	18%	18%	17%	17%	17%	16%	16%	15%	15%
Scandinavia	2%	2%	3%	3%	3%	4%	4%	5%	5%
UK and Eire	9%	9%	14%	16%	18%	19%	20%	20%	20%
West Germany	36%	36%	28%	28%	28%	29%	29%	30%	30%
Rest of Europe	6%	6%	4%	4%	4%	4%	4%	3%	4%

Region	1987	1988	1989	1990	1991	1992	1993	1994	1995
				Percent of Mixed Signal Revenue					
Benelux	8%	9%	10%	10%	11%	12%	12%	11%	11%
France	25%	25%	26%	27%	27%	26%	25%	24%	24%
Italy	18%	16%	14%	13%	12%	11%	10%	9%	9%
Scandinavia	2%	2%	3%	3%	3%	4%	4%	4%	4%
UK and Eire	9%	10%	15%	17%	18%	19%	20%	20%	21%
West Germany	36%	36%	28%	27%	26%	26%	25%	25%	24%
Rest of Europe	2%	2%	4%	3%	3%	2%	4%	7%	7%

Source: Dataquest (January 1991)

Chapter 6

European Custom IC Consumption Forecast 1987–1995

Summary

The European custom IC market grew by 13 percent in 1989 to $324 million. This is considerably less than the growth for the ASIC market as a whole, which grew by 20 percent in 1989. Neither is the future for the custom IC market so rosy, as it is forecast to decline by 4.6 percent per year over the period 1990 to 1995. The years 1990 and 1991 show the largest decline, with falls of 10 percent and 15 percent respectively.

Trends

The use of custom design is in decline, as more cost-effective methods are used by designers. The main advantages of custom are a smaller die size, and the ability to achieve higher performance by optimizing either the cells in a design or the design layout. The improvements in speed or layout area are becoming minimal, as new design tools give layout densities comparable with custom layout and are able to perform the layout in a fraction of the time.

The performance improvement achieved by custom design is also being eroded. Again, CBIC design tools are able to optimize layout so that critical paths are as short as possible, giving performance that is difficult to improve upon by customizing the design.

The flexibility given through custom design can also be met with CBIC design methods. It is unusual to have a design composed of cells which all need customizing. Cell-based design methods allow customization of some of the cells in a design, giving the required performance or area improvement. Cell-based design will therefore meet many applications which previously required custom design.

CMOS will be the preferred choice for most of the custom designs, as CMOS offers the best compromise of speed and peformance. BiCMOS is emerging as the newer technology, but the cost of BiCMOS manufacture is high when compared to CMOS. BiCMOS offers a speed advantage over CMOS without the high cost and requirement for power needed by bipolar designs. In addition to this, BiCMOS is particularly suitable for mixed signal applications. BiCMOS will therefore be used where mixed signal is required, or where high speed or high current drive is needed. By 1995, BiCMOS will represent 10 percent of all custom applications, and this is the only segment of custom ASIC which shows a positive CAGR.

Conclusions

The time-to-market requirements for many products will dictate the design style used by ASIC customers. The price paid for using custom design is a long design time, and a need for experienced custom designers. There are few applications where the length of time to develop a product allows for custom design. For some products the product life is long enough to allow CBICs to give the initial product within the time scales required, and then replace the CBIC with a custom device as part of the cost reduction of the product, but this is the exception rather than the rule.

Index of Tables and Figures—Chapter 6

Table 6.1

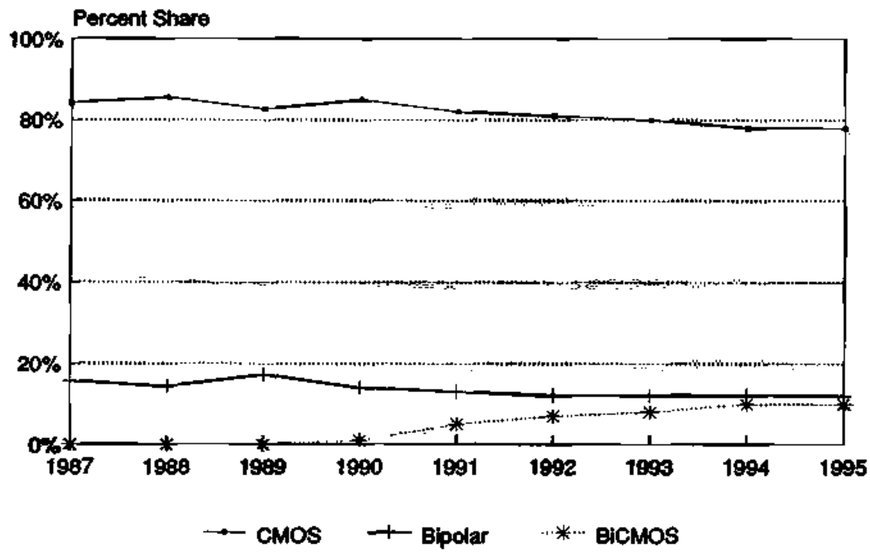
Custom ASIC Revenue History and Forecast
(Millions of Dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Total ASIC	792	982	1,182	1,344	1,465	1,779	2,193	2,541	2,803	15.8%
MOS	583	739	918	1,079	1,198	1,473	1,833	2,123	2,345	16.8%
Bipolar	209	232	240	225	202	203	204	202	198	-2.5%
BiCMOS	0	11	24	40	66	103	156	216	260	45.4%
Custom	299	286	324	293	248	245	252	246	232	-4.6%
MOS	252	245	268	240	198	190	188	179	160	-7.8%
Bipolar	47	41	56	49	38	35	34	33	33	-7.6%
BiCMOS	0	0	0	4	12	20	30	34	39	57.7%

Source: Dataquest (January 1991)

Figure 6.1

Share of Custom ASIC Maket by Technology



Source: Dataquest (January 1991)

Table 6.2

Top 6 Bipolar Custom ASIC Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
Plessey	1	9	15	1
Siemens	12	2	15	2
Texas Instruments	3	10	11	3
Telefunken	10	10	7	4
Mitsubishi	0	0	2	5
Toshiba	0	3	2	6

Source: Dataquest (January 1991)

Table 6.3

Top 10 MOS Custom ASIC Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
ITT Intermettal	102	95	91	1
Siemens	21	11	36	2
Asea Brown Boveri	23	25	21	3
Mietec	5	13	16	4
Telefunken	10	15	15	5
Austria Mikro Systeme	10	12	13	6
TMS	0	0	12	7
Philips	5	5	8	8
Sprague	0	3	8	9
Eurosil	7	7	7	10

Source: Dataquest (January 1991)

Table 6.4

Top 10 Custom ASIC Suppliers
(Millions of Dollars)

	Revenue			Ranking
Company	1987	1988	1989	1989
ITT Intermettal	102	95	91	1
Siemens	33	13	51	2
Telefunken	20	25	22	3
Asea Brown Boveri	23	25	21	4
Plessey	2	15	19	5
Texas Instruments	7	15	17	6
Mietec	5	13	16	7
Austria Mikro Systeme	10	12	13	8
Thomson Military Semi.	0	0	12	9
Philips	5	5	8	10

Source: Dataquest (January 1991)

Table 6.5

Custom ASIC Consumption Forecast by Application

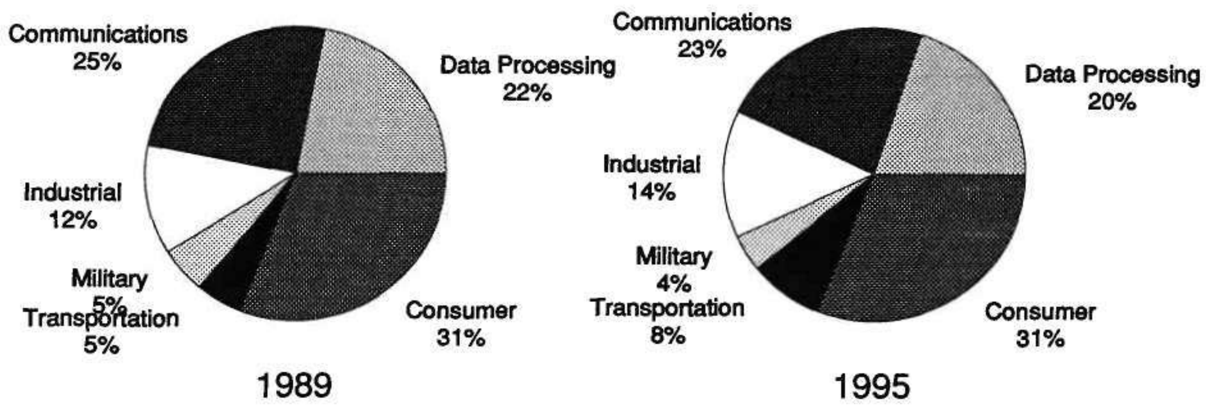
	Millions of Dollars								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	66	63	71	64	52	52	50	49	46
Communication	75	72	81	73	60	59	60	57	53
Industrial	36	34	39	35	32	32	35	34	32
Military	15	14	16	15	12	10	10	10	9
Transportation	15	14	16	15	15	15	18	20	19
Consumer	93	89	100	91	77	79	78	76	72

	Percent of Revenue								
Application	1987	1988	1989	1990	1991	1992	1993	1994	1995
Data Processing	22%	22%	22%	22%	21%	21%	20%	20%	20%
Communication	25%	25%	25%	25%	24%	24%	24%	23%	23%
Industrial	12%	12%	12%	12%	13%	13%	14%	14%	14%
Military	5%	5%	5%	5%	5%	4%	4%	4%	4%
Transportation	5%	5%	5%	5%	6%	6%	7%	8%	8%
Consumer	31%	31%	31%	31%	31%	32%	31%	31%	31%

Source: Dataquest (January 1991)

Figure 6.2

Custom ASIC Consumption by Application



Source: Dataquest (January 1991)

Table 6.6

Custom ASIC Consumption Forecast by Region

	Millions of Dollars								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	15	14	16	15	12	12	13	12	12
France	84	80	91	82	69	69	71	69	65
Italy	27	26	29	26	22	22	23	22	21
Scandinavia	21	20	23	21	17	17	18	17	16
UK and Eire	54	51	58	53	45	44	45	44	42
West Germany	90	86	97	88	74	74	76	74	70
Rest of Europe	9	9	10	9	7	7	8	7	7

	Percent of Revenue								
Region	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Benelux	5%	5%	5%	5%	5%	5%	5%	5%	5%
France	28%	28%	28%	28%	28%	28%	28%	28%	28%
Italy	9%	9%	9%	9%	9%	9%	9%	9%	9%
Scandinavia	7%	7%	7%	7%	7%	7%	7%	7%	7%
UK and Eire	18%	18%	18%	18%	18%	18%	18%	18%	18%
West Germany	30%	30%	30%	30%	30%	30%	30%	30%	30%
Rest of Europe	3%	3%	3%	3%	3%	3%	3%	3%	3%

Source: Dataquest (January 1991)

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European ASIC Market Share Estimates 1987-1989

European ASIC Market Share Estimates 1987-1989

A European Semiconductor Industry Service Report

Published by Dataquest Europe Limited

January 1991

0008263

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Chapter 1

Introduction and Definitions

Introduction

This booklet presents Dataquest's historical market share tables and rankings for the European application-specific integrated circuit (ASIC) market. The historical data for the period 1987 to 1989 is presented in chapters according to the ASIC product groupings as shown in Figure 1.1.

Product Segmentation

Figure 1.1 shows how the ASIC family tree breaks out into the four categories: gate array; programmable logic devices (PLD); cell-based integrated circuits (CBIC); and full-custom integrated circuits. The market share tables are subdivided into bipolar and MOS technology, with separate market share and ranking tables for the two technologies. The only exception to this is for bipolar CBIC, where the size of the bipolar CBIC market in 1989 ($9 million) precludes the detailing of the bipolar CBIC suppliers.

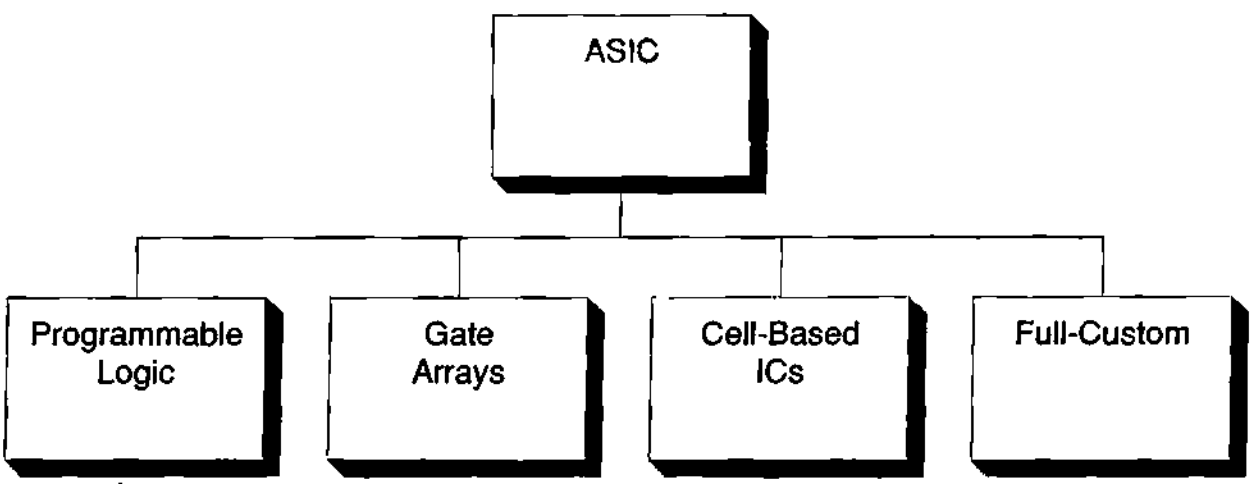
Definitions

The term application-specific integrated circuit (ASIC) can refer to a multitude of product types. However, when Dataquest first coined the term it had a definite meaning, and the product types tracked and forecast conformed to that specific meaning. When comparing company or market data with history, or forecasting potential market share, it is of vital importance that definitions are consistent. For this reason, Dataquest uses the original definition, which is restated as follows:

- **ASIC**. A single-user IC that is manufactured using vendor-supplied tools and/or libraries.

Figure 1.1

ASIC Family Tree



Source: Dataquest (January 1991)

- **Gate Array**. An ASIC device that is customized using the final layers of interconnect. Included in this category are generic or base wafers that include embedded functions such as static random access memory.
- **PLD**. A logic device that can be customized by the user after assembly.
- **Cell-Based Integrated Circuits**. An ASIC device that is customized using a full set of masks and which uses automatic placement of cells and automatic routing.
- **Custom**. An ASIC device that is customized using a full set of masks and which requires manual placement and routing of the cells.
- **Mixed Signal**. An ASIC device with both digital and analog signal input or output (excluding line driver outputs and single comparator and Schmitt trigger inputs).

  We understand that mixed signal ASICs fall into two categories: simple mixed signal ASICs that use pre-characterized cells that can be tested using a digital tester; and more complex, high-performance mixed signal devices that require analog test. This definition is intended to cover both types of mixed signal ASIC.

It is important to note that ASIC refers to single-user ICs, and not mulitple-user standard products which are targeted at specific applications such as PC chip sets. These multiuser products are more aptly named application-specific standard products (ASSPs). ASSP-type products are currently included in the microperipheral category of both Dataquest and the World Semiconductor Trade Statistics (WSTS) organization.

Revenue Classification

ASICs may be fabricated, assembled and sold in several different locations, and because of this Dataquest uses the country of origin as the basis for classifying suppliers. The home office where the balance sheet is consolidated is therefore considered the country of origin for multinational companies. For example, a company such as Texas Instruments selling in Europe is considered a North American company, whereas a company such as Philips selling in North America is considered a European company.

Estimates for each company comprise the following four sources of revenue (where applicable):

- Intracompany revenue
- Sales of EDA software
- Nonrecurring engineering (NRE) charges
- Device production

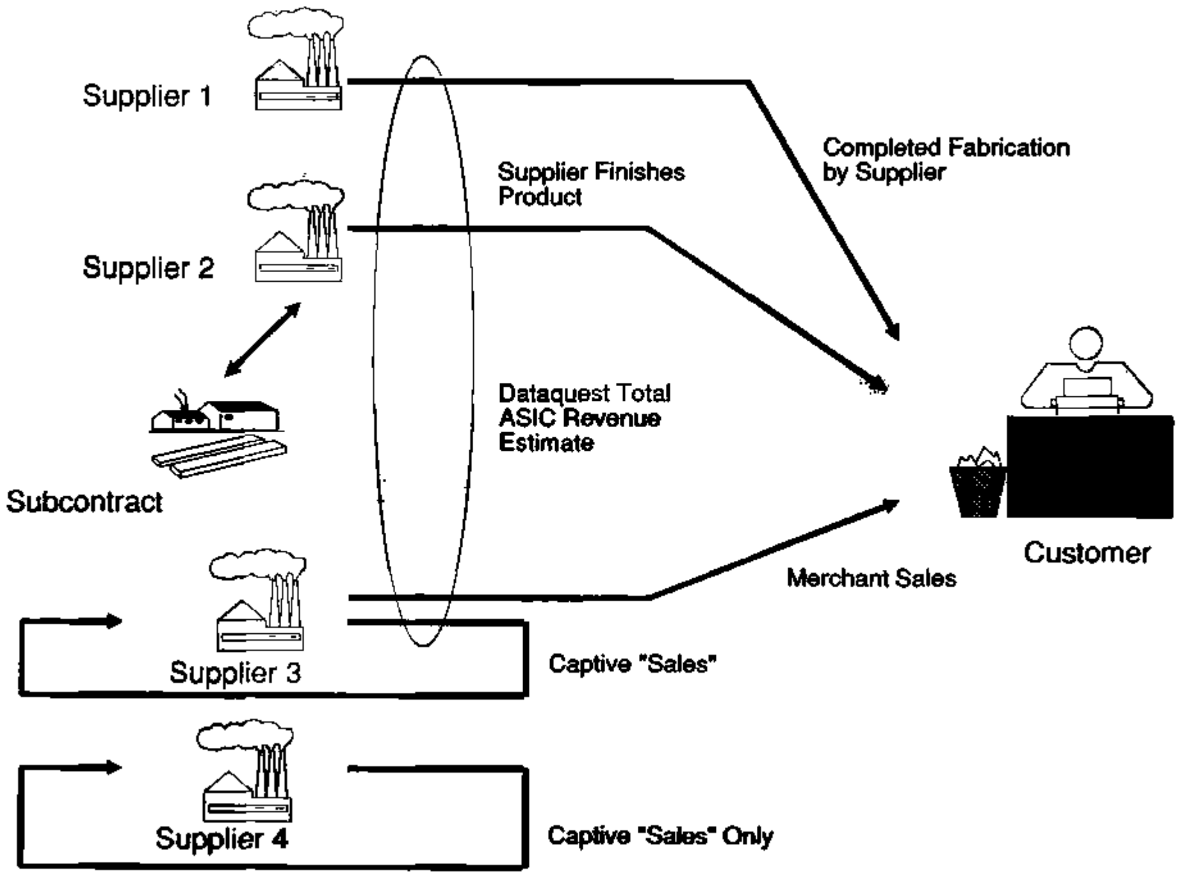
ASIC Shipments Model

Many suppliers make ASICs for internal consumption as well as for merchant customers, so Dataquest uses the ASIC shipments model as shown in Figure 1.2 to accurately reflect the manufacture and sale of ASICs in the marketplace. Figure 1.2 shows four types of ASIC supplier.

- Supplier 1 is a straightforward ASIC manufacturer which manufactures ASICs and sells them on the open market. Dataquest's ASIC revenue estimates include all of the ASIC sales for supplier 1.
- Supplier 2 subcontracts part of the manufacture of the ASIC to another foundry, and then finishes the ASICs with its own facility. Dataquest's ASIC revenue estimates include the ASIC revenue for supplier 2, but the foundry revenue for supplier 2's subcontractor is not included, as this is measured in supplier 2's revenue.
- Supplier 3 is a manufacturing company with an internal ASIC manufacturing capability. Supplier 3 has chosen to sell some of the ASIC manufacturing capability on the merchant market. Dataquest's ASIC revenue estimates include all of the ASIC sales achieved by supplier 3, because the internal ASIC sales are potentially available to outside suppliers, but these sales are in fact filled by internal supply. An example of this would be Philips, which manufactures its own ASICs and sells them both internally and externally, and which also purchases ASICs from external suppliers.
- Supplier 4 has an internal ASIC capability, and has chosen not to sell the ASIC capability onto the open market. Dataquest's ASIC revenue estimates include none of the captive ASIC sales, as this internal market is not normally available to outside suppliers. An example of this would be IBM, or Digital Equipment Corporation, which manufacture their own ASICs, and do not sell these ASICs into the merchant market.

Figure 1.2

ASIC Shipments Model



Source: Dataquest (January 1991)

Chapter 2

Estimated European ASIC Revenue 1987–1989

Index of Tables and Figures—Chapter 2

Note: Some figures may not add to totals due to rounding.

Table 2.1

Estimated European Total ASIC Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$792	$982	$1,182
European Companies	$377	$438	$546
Austria Mikro Systeme	29	36	44
Asea Brown Boveri	23	25	21
Ericsson	16	6	7
ES2*	6	12	17
Eurosil	9	12	13
Ferranti	28	0	0
Matra-MHS	3	14	17
MEDL	8	15	21
Mietec	32	42	50
Philips	21	34	38
Plessey	26	82	101
SGS-Thomson	25	35	50
Siemens	90	56	92
STC	8	13	9
Telefunken	30	35	32
TMS	0	0	12
Others	24	21	22
N. American Companies	$355	$442	$503
Actel	0	0	2
Advanced Micro Devices	45	58	52
Altera	4	7	12
Applied Micro Circuits	2	1	2
AT&T	6	9	12
Cypress	2	4	7
Harris	9	11	19
Honeywell/Atmel	2	5	10
IMP Europe	4	7	11
Intel	4	4	7
ITT Intermettal	102	95	91
Lattice Semiconductor	0	3	4
LSI Logic	44	59	69
Motorola	13	19	10
National Semiconductor	35	51	47
NCR	0	0	2
Raytheon	0	7	3
Sierra Semiconductor	0	6	4
Siliconix	8	0	0

(continued)

Table 2.1 (Continued)

Estimated European Total ASIC Revenue
(Millions of Dollars)

	1987	1988	1989
Sprague	0	3	8
Texas Instruments	22	54	79
VLSI Technology	17	25	37
Xilinx	4	5	8
Others	33	9	7
Japanese Companies	$59	$102	$132
Fujitsu	21	16	23
Hitachi	5	7	12
Mitsubishi	0	0	2
NEC	10	22	31
Oki	1	2	3
Seiko Epson	0	9	9
Toshiba	16	44	52
Others	6	2	0
Rest of World	$0	$0	$1
Goldstar	0	0	1

*ES2 = European Silicon Structures
Source: Dataquest (January 1991)

Table 2.2

Estimated European Bipolar ASIC Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$209	$232	$240
European Companies	$111	$107	$122
Ericsson	5	0	0
Ferranti	24	0	0
Philips	10	15	14
Plessey	5	43	54
SGS-Thomson	2	0	2
Siemens	51	28	37
STC	0	7	4
Telefunken	10	10	7
Others	4	4	4
N. American Companies	$87	$118	$103
Advanced Micro Devices	43	56	49
Applied Micro Circuits	2	1	2
AT&T	0	0	2
Honeywell/Atmel	2	5	0
Motorola	7	5	6
National Semiconductor	18	16	11
Raytheon	0	7	3
Texas Instruments	8	28	29
Others	7	0	1
Japanese Companies	$11	$7	$15
Fujitsu	11	4	5
Hitachi	0	0	1
Mitsubishi	0	0	2
NEC	0	0	5
Toshiba	0	3	2

Source: Dataquest (January 1991)

Table 2.3

Estimated European MOS ASIC Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$583	$750	$942
European Companies	$267	$331	$424
Austria Mikro Systeme	29	36	44
Asea Brown Boveri	23	25	21
Ericsson	11	6	7
ES2*	6	12	17
Eurosil	9	12	13
Ferranti	4	0	0
Matra-MHS	3	14	17
MEDL	8	15	21
Mietec	32	42	50
Philips	11	19	24
Plessey	21	39	47
SGS-Thomson	23	35	48
Siemens	39	28	55
STC	8	6	5
Telefunken	20	25	25
TMS	0	0	12
Others	20	17	18
N. American Companies	$268	$324	$400
Actel	0	0	2
Advanced Micro Devices	2	2	3
Altera	4	7	12
AT&T	6	9	10
Cypress	2	4	7
Harris	9	11	19
Honeywell/Atmel	0	0	10
IMP Europe	4	7	11
Intel	4	4	7
ITT Intermettal	102	95	91
Lattice Semiconductor	0	3	4
LSI Logic	44	59	69
Motorola	6	14	4
National Semiconductor	17	35	36
NCR	0	0	2
Sierra Semiconductor	0	6	4
Siliconix	8	0	0
Sprague	0	3	8
Texas Instruments	14	26	50

(Continued)

Table 2.3 (Continued)

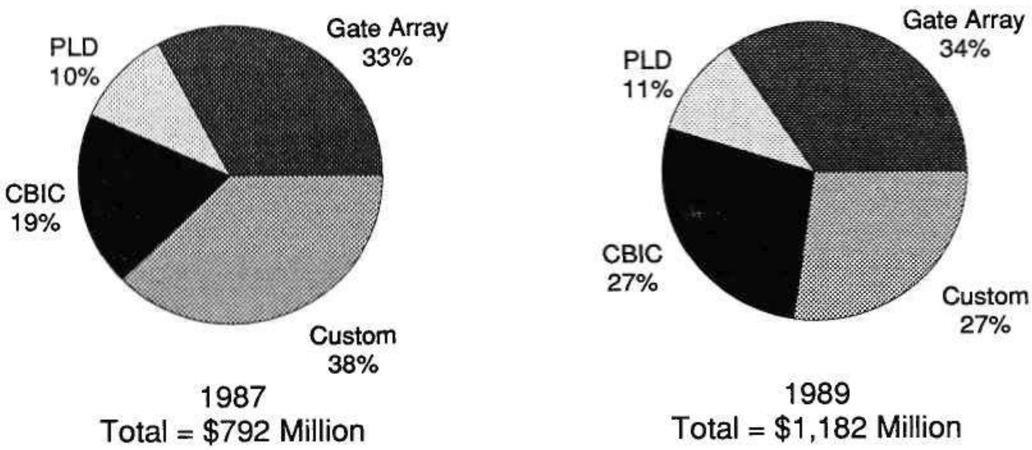
Estimated European MOS ASIC Revenue
(Millions of Dollars)

	1987	1988	1989
VLSI Technology	17	25	37
Xilinx	4	5	8
Others	26	9	6
Japanese Companies	$48	$95	$117
Fujitsu	10	12	18
Hitachi	5	7	11
NEC	10	22	26
Oki	1	2	3
Seiko Epson	0	9	9
Toshiba	16	41	50
Others	6	2	0
Rest of World	$0	$0	$1
Goldstar	0	0	1

*ES2 = European Silicon Structures
Source: Dataquest (January 1991)

Figure 2.1

European ASIC Revenue by Product 1987 and 1989



Source: Dataquest (January 1991)

Table 2.4

Estimated European 1989 Total ASIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	2	1	Plessey	26	82	101	23.2%	101	8.5%	8.5%
2	5	3	Siemens	90	56	92	64.3%	193	7.8%	16.3%
3	1	-2	ITT Intermettal	102	95	91	-4.2%	284	7.7%	24.0%
4	6	2	Texas Instruments	22	54	79	46.3%	363	6.7%	30.7%
5	3	-2	LSI Logic	44	59	69	16.9%	432	5.8%	36.5%
6	4	-2	Advanced Micro Devices	45	58	52	-10.3%	484	4.4%	40.9%
7	8	1	Toshiba	16	44	52	18.2%	536	4.4%	45.3%
8	9	1	Mietec	32	42	50	19.0%	586	4.2%	49.6%
9	11	2	SGS-Thomson	25	35	50	42.9%	636	4.2%	53.8%
10	7	-3	National Semiconductor	35	51	47	-7.8%	683	4.0%	57.8%
11	10	-1	Austria Mikro Systeme	29	36	44	22.2%	727	3.7%	61.5%
12	13	1	Philips	21	34	38	11.8%	765	3.2%	64.7%
13	15	2	VLSI Technology	17	25	37	48.0%	802	3.1%	67.8%
14	12	-2	Telefunken	30	35	32	-8.6%	834	2.7%	70.5%
15	16	1	NEC	10	22	31	40.9%	865	2.6%	73.2%
16	18	2	Fujitsu	21	16	23	43.8%	888	1.9%	75.1%
17	14	-3	Asea Brown Boveri	23	25	21	-16.0%	909	1.8%	76.9%
18	19	1	MEDL	8	15	21	40.0%	930	1.8%	78.7%
19	24	5	Harris	9	11	19	72.7%	949	1.6%	80.3%
20	22	2	European Silicon Structures	6	12	17	41.7%	966	1.4%	81.7%
21	20	-1	Matra-MHS	3	14	17	21.4%	983	1.4%	83.1%
22	23	1	Eurosil	9	12	13	8.3%	996	1.1%	84.2%
23	30	7	Altera	4	7	12	71.4%	1,008	1.0%	85.3%
24	26	2	AT&T	6	9	12	33.3%	1,020	1.0%	86.3%
25	28	3	Hitachi	5	7	12	71.4%	1,032	1.0%	87.3%
26	46	20	TMS	0	0	12	NA	1,044	1.0%	88.3%
27	29	2	IMP Europe	4	7	11	57.1%	1,055	0.9%	89.2%
28	34	6	Honeywell/Atmel	2	5	10	100.0%	1,065	0.8%	90.1%
29	17	-12	Motorola	13	19	10	-47.4%	1,075	0.8%	90.9%
30	25	-5	Seiko Epson	0	9	9	0.0%	1,084	0.8%	91.7%
31	21	-10	STC	8	13	9	-30.8%	1,093	0.8%	92.4%
32	37	5	Sprague	0	3	8	166.7%	1,101	0.7%	93.1%
33	33	0	Xilinx	4	5	8	60.0%	1,109	0.7%	93.8%
34	35	1	Cypress	2	4	7	75.0%	1,116	0.6%	94.4%
35	32	-3	Ericsson	16	6	7	16.7%	1,123	0.6%	95.0%
36	36	0	Intel	4	4	7	75.0%	1,130	0.6%	95.6%
37	38	1	Lattice Semiconductor	0	3	4	33.3%	1,134	0.3%	95.9%
38	31	-7	Sierra Semiconductor	0	6	4	-33.3%	1,138	0.3%	96.2%
39	39	0	Oki	1	2	3	50.0%	1,141	0.3%	96.5%

(Continued)

Table 2.4 (Continued)

Estimated European 1989 Total ASIC Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
40	27	-13	Raytheon	0	7	3	-57.1%	1,144	0.3%	96.8%
41	41	0	Actel	0	0	2	NA	1,146	0.2%	96.9%
42	40	-2	Applied Micro Circuits	2	1	2	100.0%	1,148	0.2%	97.1%
43	42	-1	Mitsubishi	0	0	2	NA	1,150	0.2%	97.3%
44	43	-1	NCR	0	0	2	NA	1,152	0.2%	97.4%
45	44	-1	Goldstar	0	0	1	NA	1,153	0.1%	97.5%
46	45	-1	Ferranti	28	0	0	NA	1,153	0.0%	97.5%
47	47	0	Siliconix	8	0	0	NA	1,153	0.0%	97.5%
			European Others	24	21	22	4.8%	1,175	1.9%	99.4%
			North American Others	33	9	7	-22.2%	1,182	0.6%	100.0%
			Japanese Others	6	2	0	-100.0%	1,182	0.0%	100.0%
			Total All Companies	792	982	1,182	20.4%			
			Total European Companies	377	438	546	24.7%		46.2%	
			Total North American	355	442	503	13.8%		42.5%	
			Total Japanese	59	102	132	29.4%		11.2%	
			Total Rest of World	0	0	1	NA		0.1%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 2.5

Estimated European 1989 Bipolar ASIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	2	1	Plessey	5	43	54	25.6%	54	22.5%	22.5%
2	1	-1	Advanced Micro Devices	43	56	49	-12.5%	103	20.4%	42.9%
3	3	0	Siemens	51	28	37	32.1%	140	15.4%	58.3%
4	4	0	Texas Instruments	8	28	29	3.6%	169	12.1%	70.4%
5	6	1	Philips	10	15	14	-6.7%	183	5.8%	76.3%
6	5	-1	National Semiconductor	18	16	11	-31.3%	194	4.6%	80.8%
7	7	0	Telefunken	10	10	7	-30.0%	201	2.9%	83.8%
8	11	3	Motorola	7	5	6	20.0%	207	2.5%	86.3%
9	12	3	Fujitsu	11	4	5	25.0%	212	2.1%	88.3%
10	-	NA	NEC	0	0	5	NA	217	2.1%	90.4%
11	9	-2	STC	0	7	4	-42.9%	221	1.7%	92.1%
12	8	-4	Raytheon	0	7	3	-57.1%	224	1.3%	93.3%
13	14	1	Applied Micro Circuits	2	1	2	100.0%	226	0.8%	94.2%
14	18	4	AT&T	0	0	2	NA	228	0.8%	95.0%
15	-	NA	Mitsubishi	0	0	2	NA	230	0.8%	95.8%
16	-	NA	SGS-Thomson	2	0	2	NA	232	0.8%	96.7%
17	13	-4	Toshiba	0	3	2	-33.3%	234	0.8%	97.5%
18	-	NA	Hitachi	0	0	1	NA	235	0.4%	97.9%
			European Others	4	4	4	0.0%	239	1.7%	99.6%
			North American Others	7	0	1	NA	240	0.4%	100.0%
			Total All Companies	209	232	240	3.4%		20.3%	
			Total European Companies	111	107	122	14.0%		50.8%	
			Total North American	87	118	103	-12.7%		42.9%	
			Total Japanese	11	7	15	114.3%		6.3%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 2.6

Estimated European 1989 MOS ASIC Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	ITT Intermettal	102	95	91	-4.2%	91	9.7%	9.7%
2	2	0	LSI Logic	44	59	69	16.9%	160	7.3%	17.0%
3	9	6	Siemens	39	28	55	96.4%	215	5.8%	22.8%
4	3	-1	Mietec	32	42	50	19.0%	265	5.3%	28.1%
5	10	5	Texas Instruments	14	26	50	92.3%	315	5.3%	33.4%
6	4	-2	Toshiba	16	41	50	22.0%	365	5.3%	38.7%
7	8	1	SGS-Thomson	23	35	48	37.1%	413	5.1%	43.8%
8	5	-3	Plessey	21	39	47	20.5%	460	5.0%	48.8%
9	6	-3	Austria Mikro Systeme	29	36	44	22.2%	504	4.7%	53.5%
10	13	3	VLSI Technology	17	25	37	48.0%	541	3.9%	57.4%
11	7	-4	National Semiconductor	17	35	36	2.9%	577	3.8%	61.2%
12	14	2	NEC	10	22	26	18.2%	603	2.8%	64.0%
13	12	-1	Telefunken	20	25	25	0.0%	628	2.7%	66.6%
14	15	1	Philips	11	19	24	26.3%	652	2.5%	69.2%
15	11	-4	Asea Brown Boveri	23	25	21	-16.0%	673	2.2%	71.4%
16	16	0	MEDL	8	15	21	40.0%	694	2.2%	73.6%
17	22	5	Harris	9	11	19	72.7%	713	2.0%	75.7%
18	21	3	Fujitsu	10	12	18	50.0%	731	1.9%	77.6%
19	19	0	European Silicon Structures	6	12	17	41.7%	748	1.8%	79.4%
20	17	-3	Matra-MHS	3	14	17	21.4%	765	1.8%	81.2%
21	20	-1	Eurosil	9	12	13	8.3%	778	1.4%	82.6%
22	25	3	Altera	4	7	12	71.4%	790	1.3%	83.8%
23	48	25	TMS	0	0	12	NA	802	1.3%	85.1%
24	26	2	Hitachi	5	7	11	57.1%	813	1.2%	86.3%
25	27	2	IMP Europe	4	7	11	57.1%	824	1.2%	87.4%
26	23	-3	AT&T	6	9	10	11.1%	834	1.1%	88.5%
27	43	16	Honeywell/Atmel	0	0	10	NA	844	1.1%	89.6%
28	24	-4	Seiko Epson	0	9	9	0.0%	853	1.0%	90.5%
29	35	6	Sprague	0	3	8	166.7%	861	0.8%	91.4%
30	31	1	Xilinx	4	5	8	60.0%	869	0.8%	92.2%
31	32	1	Cypress	2	4	7	75.0%	876	0.7%	93.0%
32	28	-4	Ericsson	11	6	7	16.7%	883	0.7%	93.7%
33	33	0	Intel	4	4	7	75.0%	890	0.7%	94.4%
34	30	-4	STC	8	6	5	-16.7%	895	0.5%	95.0%
35	34	-1	Lattice Semiconductor	0	3	4	33.3%	899	0.4%	95.4%
36	18	-18	Motorola	6	14	4	-71.4%	903	0.4%	95.8%
37	29	-8	Sierra Semiconductor	0	6	4	-33.3%	907	0.4%	96.2%
38	36	-2	Advanced Micro Devices	2	2	3	50.0%	910	0.3%	96.6%
39	37	-2	Oki	1	2	3	50.0%	913	0.3%	96.9%

(Continued)

Table 2.6 (Continued)

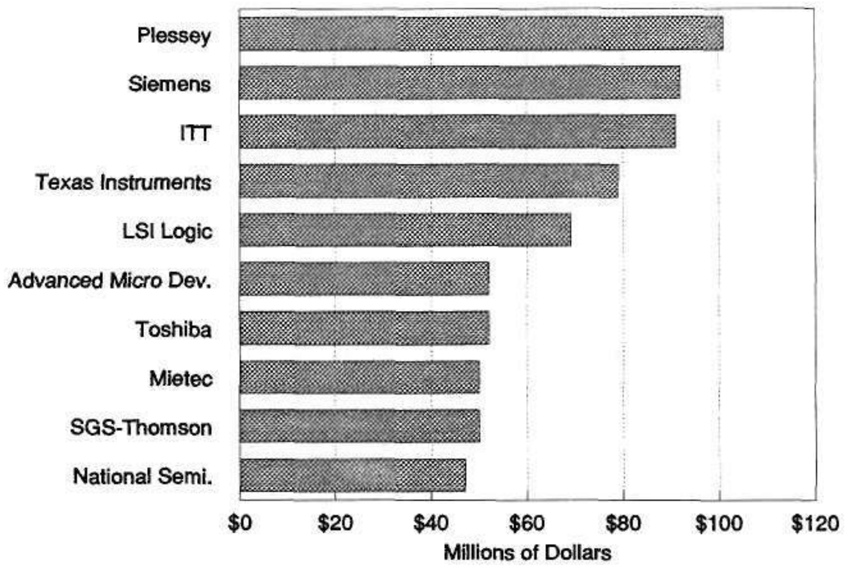
Estimated European 1989 MOS ASIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
40	-	NA	Actel	0	0	2	NA	915	0.2%	97.1%
41	-	NA	NCR	0	0	2	NA	917	0.2%	97.3%
42	-	NA	Goldstar	0	0	1	NA	918	0.1%	97.4%
43	-	NA	Ferranti	4	0	0	NA	918	0.0%	97.4%
44	-	NA	Siliconix	8	0	0	NA	918	0.0%	97.4%
			European Others	20	17	18	5.9%	936	1.9%	99.3%
			North American Others	26	9	6	-33.3%	942	0.6%	100.0%
			Japanese Others	6	2	0	-100.0%	942	0.0%	100.0%
			Total All Companies	583	750	942	25.6%			
			Total European Companies	267	331	424	28.1%		45.0%	
			Total North American	268	324	400	23.5%		42.4%	
			Total Japanese	48	95	117	23.2%		12.4%	
			Total Rest of World	0	0	1	NA		0.1%	

NA = Not Applicable
Source: Dataquest (January 1991)

Figure 2.2

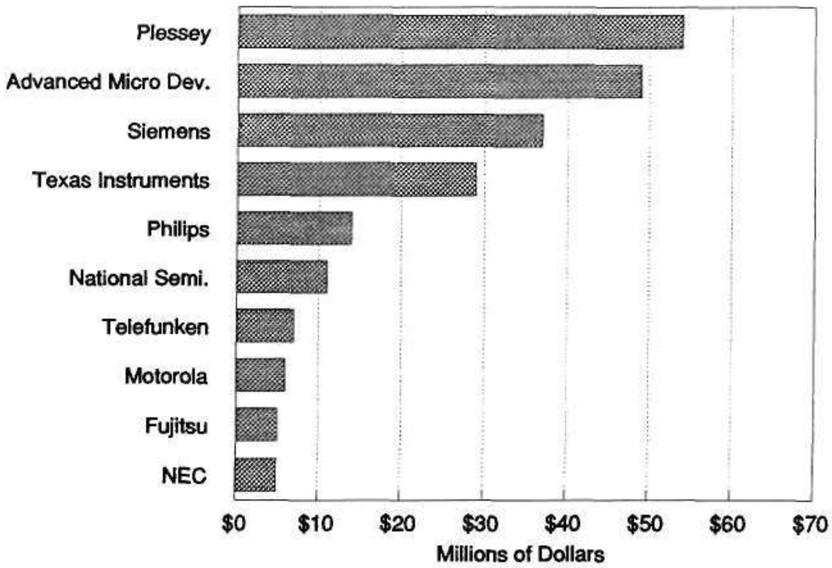
Top 10 Suppliers 1989, Estimated European Total ASIC Revenue



Source: Dataquest (January 1991)

Figure 2.3

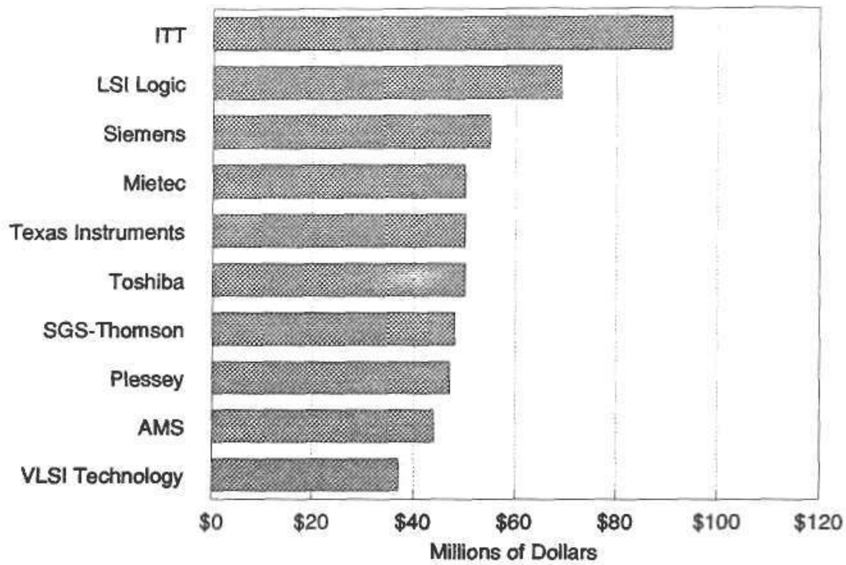
Top 10 Suppliers 1989, Estimated European Bipolar ASIC Revenue



Source: Dataquest (January 1991)

Figure 2.4

Top 10 Suppliers 1989, Estimated European MOS ASIC Revenue



Source: Dataquest (January 1991)

Chapter 3

Estimated European Gate Array Revenue 1987–1989

Index of Tables and Figures—Chapter 3

Table 3.1

Estimated European Total Gate Array Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$260	$358	$407
European Companies	$128	$149	$169
Austria Mikro Systeme	4	5	4
Eurosil	0	1	1
Ferranti	22	0	0
Matra-MHS	3	8	12
MEDL	2	3	2
Philips	5	11	12
Plessey	21	60	70
SGS-Thomson	13	17	30
Siemens	42	28	24
STC	0	7	4
Others	17	9	10
N. American Companies	$81	$120	$126
Applied Micro Circuits	2	1	2
Harris	2	1	2
Honeywell	2	5	0
LSI Logic	40	52	58
Motorola	7	8	10
National Semiconductor	20	32	28
Raytheon	0	7	3
Texas Instruments	5	9	14
VLSI Technology	2	3	8
Others	1	2	1
Japanese Companies	$51	$89	$111
Fujitsu	21	16	19
Hitachi	5	7	12
NEC	8	18	24
Oki	1	2	2
Seiko Epson	0	4	4
Toshiba	16	41	50
Others	0	1	0
Rest of World	$0	$0	$1
Goldstar	0	0	1

Source: Dataquest (January 1991)

Table 3.2

Estimated European Bipolar Gate Array Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$95	$100	$96
European Companies	$69	$72	$68
Ferranti	22	0	0
Philips	2	5	5
Plessey	4	34	35
SGS-Thomson	2	0	2
Siemens	39	26	22
STC	0	7	4
N. American Companies	$15	$24	$17
Applied Micro Circuits	2	1	2
Honeywell	2	5	0
Motorola	5	4	6
National Semiconductor	6	7	6
Raytheon	0	7	3
Japanese Companies	$11	$4	$11
Fujitsu	11	4	5
NEC	0	0	5
Hitachi	0	0	1

Source: Dataquest (January 1991)

Table 3.3

Estimated European MOS Gate Array Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$165	$258	$311
European Companies	$60	$77	$101
Austria Mikro Systeme	4	5	4
Eurosil	0	1	1
Matra-MHS	3	8	12
MEDL	2	3	2
Philips	3	6	7
Plessey	17	26	35
SGS-Thomson	11	17	28
Siemens	3	2	2
Others	17	9	10
N. American Companies	$66	$96	$109
Harris	2	1	2
LSI Logic	40	52	58
Motorola	2	4	4
National Semiconductor	14	25	22
Texas Instruments	5	9	14
VLSI Technology	2	3	8
Others	1	2	1
Japanese Companies	$40	$85	$100
Fujitsu	10	12	14
Hitachi	5	7	11
NEC	8	18	19
Oki	1	2	2
Seiko Epson	0	4	4
Toshiba	16	41	50
Others	0	1	0
Rest of World	$0	$0	$1
Goldstar	0	0	1

Source: Dataquest (January 1991)

Table 3.4

Estimated European 1989 Total Gate Array Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Plessey	21	60	70	16.7%	70	17.2%	17.2%
2	2	0	LSI Logic	40	52	58	11.5%	128	14.3%	31.4%
3	3	0	Toshiba	16	41	50	22.0%	178	12.3%	43.7%
4	7	3	SGS-Thomson	13	17	30	76.5%	208	7.4%	51.1%
5	4	-1	National Semiconductor	20	32	28	-12.5%	236	6.9%	58.0%
6	6	0	NEC	8	18	24	33.3%	260	5.9%	63.9%
7	5	-2	Siemens	42	28	24	-14.3%	284	5.9%	69.8%
8	8	0	Fujitsu	21	16	19	18.8%	303	4.7%	74.4%
9	10	1	Texas Instruments	5	9	14	55.6%	317	3.4%	77.9%
10	13	3	Hitachi	5	7	12	71.4%	329	2.9%	80.8%
11	11	0	Matra-MHS	3	8	12	50.0%	341	2.9%	83.8%
12	9	-3	Philips	5	11	12	9.1%	353	2.9%	86.7%
13	12	-1	Motorola	7	8	10	25.0%	363	2.5%	89.2%
14	20	6	VLSI Technology	2	3	8	166.7%	371	2.0%	91.2%
15	16	1	Austria Mikro Systeme	4	5	4	-20.0%	375	1.0%	92.1%
16	18	2	Seiko Epson	0	4	4	0.0%	379	1.0%	93.1%
17	15	-2	STC	0	7	4	-42.9%	383	1.0%	94.1%
18	14	-4	Raytheon	0	7	3	-57.1%	386	0.7%	94.8%
19	22	3	Applied Micro Circuits	2	1	2	100.0%	388	0.5%	95.3%
20	24	4	Harris	2	1	2	100.0%	390	0.5%	95.8%
21	19	-2	MEDL	2	3	2	-33.3%	392	0.5%	96.3%
22	21	-1	Oki	1	2	2	0.0%	394	0.5%	96.8%
23	23	0	Eurosil	0	1	1	0.0%	395	0.2%	97.1%
24	26	2	Goldstar	0	0	1	NA	396	0.2%	97.3%
25	25	0	Ferranti	22	0	0	NA	396	0.0%	97.3%
26	17	-9	Honeywell	2	5	0	-100.0%	396	0.0%	97.3%
			European Others	17	9	10	11.1%	406	2.5%	99.8%
			North American Others	1	2	1	-50.0%	407	0.2%	100.0%
			Japanese Others	0	1	0	-100.0%	407	0.0%	100.0%
			Total All Companies	260	358	407	13.6%			
			Total European Companies	128	149	169	13.5%		41.6%	
			Total North American	81	120	126	5.0%		31.0%	
			Total Japanese	51	89	111	24.7%		27.3%	
			Total Rest of World	0	0	1	NA		0.2%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 3.5

Estimated European 1989 Bipolar Gate Array Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Plessey	4	34	35	2.9%	35	36.5%	36.5%
2	2	0	Siemens	39	26	22	-15.4%	57	22.9%	59.4%
3	9	6	Motorola	5	4	6	50.0%	63	6.3%	65.6%
4	3	-1	National Semiconductor	6	7	6	-14.3%	69	6.3%	71.9%
5	8	3	Fujitsu	11	4	5	25.0%	74	5.2%	77.1%
6	-	NA	NEC	0	0	5	NA	79	5.2%	82.3%
7	7	0	Philips	2	5	5	0.0%	84	5.2%	87.5%
8	5	-3	STC Components	0	7	4	-42.9%	88	4.2%	91.7%
9	4	-5	Raytheon	0	7	3	-57.1%	91	3.1%	94.8%
10	10	0	Applied Micro Circuits	2	1	2	100.0%	93	2.1%	96.9%
11	-	NA	SGS-Thomson	2	0	2	NA	95	2.1%	99.0%
12	-	NA	Hitachi	0	0	1	NA	96	1.0%	100.0%
13	-	NA	Ferranti	22	0	0	NA	96	0.0%	100.0%
14	6	-8	Honeywell	2	5	0	-100.0%	96	0.0%	100.0%
			Total All Companies	95	100	96	-4.0%			
			Total European Companies	69	72	68	-5.6%		70.8%	
			Total North American	15	24	17	-29.2%		17.7%	
			Total Japanese	11	4	11	175.0%		11.5%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 3.6

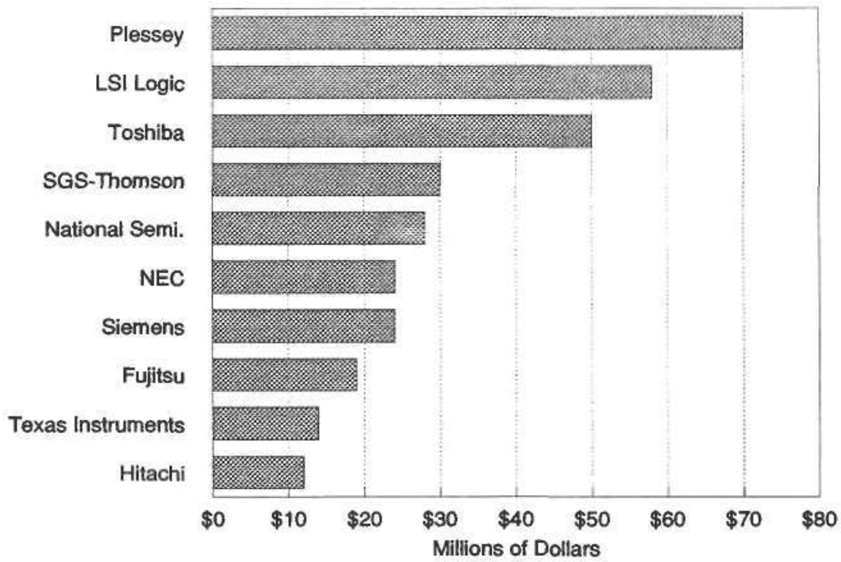
Estimated European MOS Gate Array Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	LSI Logic	40	52	58	11.5%	58	18.6%	18.6%
2	2	0	Toshiba	16	41	50	22.0%	108	16.1%	34.7%
3	3	0	Plessey	17	26	35	34.6%	143	11.3%	46.0%
4	6	2	SGS-Thomson	11	17	28	64.7%	171	9.0%	55.0%
5	4	-1	National Semiconductor	14	25	22	-12.0%	193	7.1%	62.1%
6	5	-1	NEC	8	18	19	5.6%	212	6.1%	68.2%
7	7	0	Fujitsu	10	12	14	16.7%	226	4.5%	72.7%
8	8	0	Texas Instruments	5	9	14	55.6%	240	4.5%	77.2%
9	9	0	Matra-MHS	3	8	12	50.0%	252	3.9%	81.0%
10	10	0	Hitachi	5	7	11	57.1%	263	3.5%	84.6%
11	16	5	VLSI Technology	2	3	8	166.7%	271	2.6%	87.1%
12	11	-1	Philips	3	6	7	16.7%	278	2.3%	89.4%
13	12	-1	Austria Mikro Systeme	4	5	4	-20.0%	282	1.3%	90.7%
14	13	-1	Motorola	2	4	4	0.0%	286	1.3%	92.0%
15	14	-1	Seiko Epson	0	4	4	0.0%	290	1.3%	93.2%
16	20	4	Harris	2	1	2	100.0%	292	0.6%	93.9%
17	15	-2	MEDL	2	3	2	-33.3%	294	0.6%	94.5%
18	17	-1	Oki	1	2	2	0.0%	296	0.6%	95.2%
19	18	-1	Siemens	3	2	2	0.0%	298	0.6%	95.8%
20	19	-1	Eurosil	0	1	1	0.0%	299	0.3%	96.1%
21	-	NA	Goldstar	0	0	1	NA	300	0.3%	96.5%
			European Others	17	9	10	11.1%	310	3.2%	99.7%
			North American Others	1	2	1	-50.0%	311	0.3%	100.0%
			Japanese Others	0	1	0	-100.0%	311	0.0%	100.0%
			Total All Companies	165	258	311	20.4%			
			Total European Companies	60	77	101	31.3%		32.6%	
			Total North American	66	96	109	13.5%		35.0%	
			Total Japanese	40	85	100	17.6%		32.2%	
			Total Rest of World	0	0	1	NA		0.3%	

NA = Not Applicable
Source: Dataquest (January 1991)

Figure 3.1

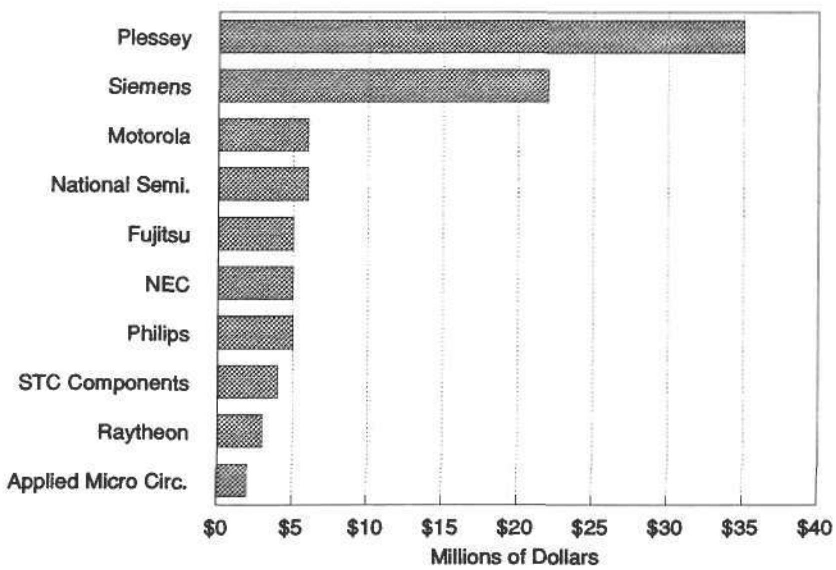
Top 10 Suppliers 1989, Estimated European Total Gate Array Revenue



Source: Dataquest (January 1991)

Figure 3.2

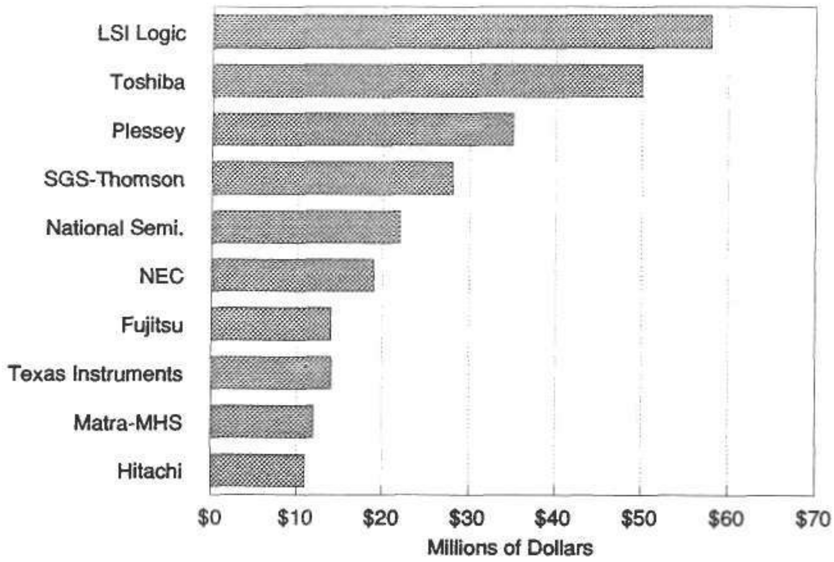
Top 10 Suppliers 1989, Estimated European Bipolar Gate Array Revenue



Source: Dataquest (January 1991)

Figure 3.3

Top 10 Suppliers 1989, Estimated European MOS Gate Array Revenue



Source: Dataquest (January 1991)

Chapter 4

Estimated European PLD Revenue 1987–1989

Table 4.1

Estimated European Total PLD Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$82	$118	$127
European Companies	$8	$11	$7
Philips	8	10	6
SGS-Thomson	0	1	1
N. American Companies	$74	$107	$120
Actel	0	0	2
Altera	4	7	12
Advanced Micro Devices	45	58	52
Cypress	2	4	7
Intel	3	4	7
Lattice Semiconductor	0	3	4
National Semiconductor	9	8	8
Texas Instruments	5	18	18
Xilinx	4	5	8
Others	2	0	2

Source: Dataquest (January 1991)

Table 4.2

Estimated European Bipolar PLD Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$67	$91	$79
European Companies	$8	$10	$6
Philips	8	10	6
N. American Companies	$59	$81	$73
Advanced Micro Devices	43	56	49
National Semiconductor	9	7	5
Texas Instruments	5	18	18
Others	2	0	1

Source: Dataquest (January 1991)

Table 4.3

Estimated European MOS PLD Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$15	$27	$48
European Companies	$0	$1	$1
SGS-Thomson	0	1	1
N. American Companies	$15	$26	$47
Actel	0	0	2
Altera	4	7	12
Advanced Micro Devices	2	2	3
Cypress	2	4	7
Intel	3	4	7
Lattice Semiconductor	0	3	4
National Semiconductor	0	1	3
Xilinx	4	5	8
Others	0	0	1

Source: Dataquest (January 1991)

Table 4.4

Estimated European 1989 Total PLD Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Advanced Micro Devices	45	58	52	-10.3%	52	40.9%	40.9%
2	2	0	Texas Instruments	5	18	18	0.0%	70	14.2%	55.1%
3	5	2	Altera	4	7	12	71.4%	82	9.4%	64.6%
4	4	0	National Semiconductor	9	8	8	0.0%	90	6.3%	70.9%
5	6	1	Xilinx	4	5	8	60.0%	98	6.3%	77.2%
6	7	1	Cypress	2	4	7	75.0%	105	5.5%	82.7%
7	8	1	Intel	3	4	7	75.0%	112	5.5%	88.2%
8	3	-5	Philips	8	10	6	-40.0%	118	4.7%	92.9%
9	9	0	Lattice Semiconductor	0	3	4	33.3%	122	3.1%	96.1%
10	-	NA	Actel	0	0	2	NA	124	1.6%	97.6%
11	10	-1	SGS-Thomson	0	1	1	0.0%	125	0.8%	98.4%
			North American Others	2	0	2	NA	127	1.6%	100.0%
			Total All Companies	82	118	127	7.6%			
			Total European Companies	8	11	7	-36.4%		5.5%	
			Total North American	74	107	120	12.1%		94.5%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 4.5

Estimated European 1989 Bipolar PLD Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change In Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Advanced Micro Devices	43	56	49	-12.5%	49	62.0%	62.0%
2	2	0	Texas Instruments	5	18	18	0.0%	67	22.8%	84.8%
3	3	0	Philips	8	10	6	-40.0%	73	7.6%	92.4%
4	4	0	National Semiconductor	9	7	5	-28.6%	78	6.3%	98.7%
			North American Others	2	0	1	NA	79	1.3%	100.0%
			Total All Companies	67	91	79	-13.2%			
			Total European Companies	8	10	6	-40.0%		7.6%	
			Total North American	59	81	73	-9.9%		92.4%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 4.6

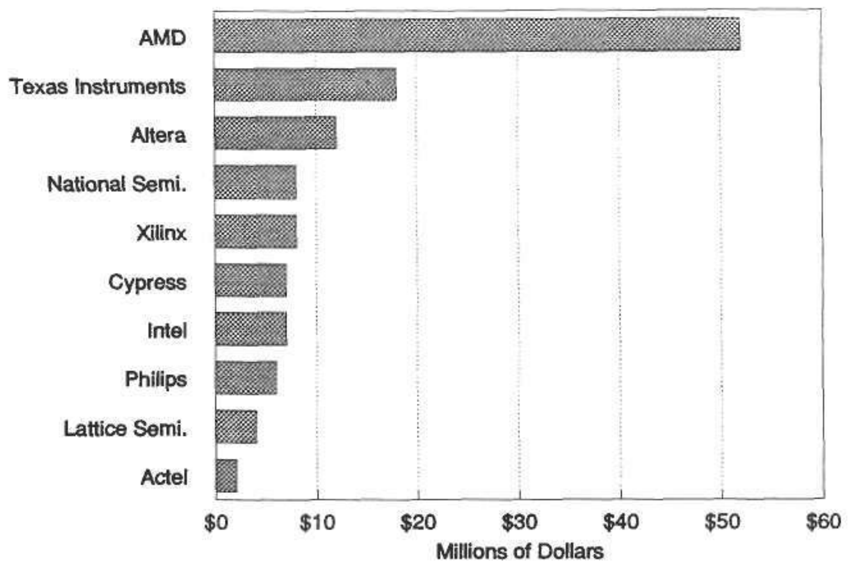
Estimated European 1989 MOS PLD Market Share Rankings (Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Altera	4	7	12	71.4%	12	25.0%	25.0%
2	2	0	Xilinx	4	5	8	60.0%	20	16.7%	41.7%
3	3	0	Cypress	2	4	7	75.0%	27	14.6%	56.3%
4	4	0	Intel	3	4	7	75.0%	34	14.6%	70.8%
5	5	0	Lattice Semiconductor	0	3	4	33.3%	38	8.3%	79.2%
6	6	0	Advanced Micro Devices	2	2	3	50.0%	41	6.3%	85.4%
7	7	0	National Semiconductor	0	1	3	200.0%	44	6.3%	91.7%
8	-	NA	Actel	0	0	2	NA	46	4.2%	95.8%
9	8	-1	SGS-Thomson	0	1	1	0.0%	47	2.1%	97.9%
			North American Others	0	0	1	NA	48	2.1%	100.0%
			Total All Companies	15	27	48	77.8%			
			Total European Companies	0	1	1	0.0%		2.1%	
			Total North American	15	26	47	80.8%		97.9%	

NA = Not Applicable
Source: Dataquest (January 1991)

Figure 4.1

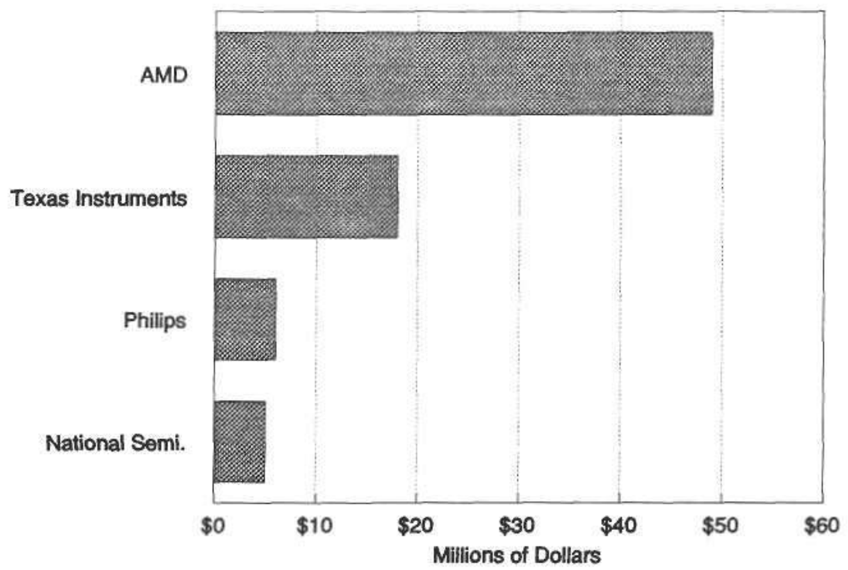
Top 10 Suppliers 1989, Estimated European Total PLD Revenue



Source: Dataquest (January 1991)

Figure 4.2

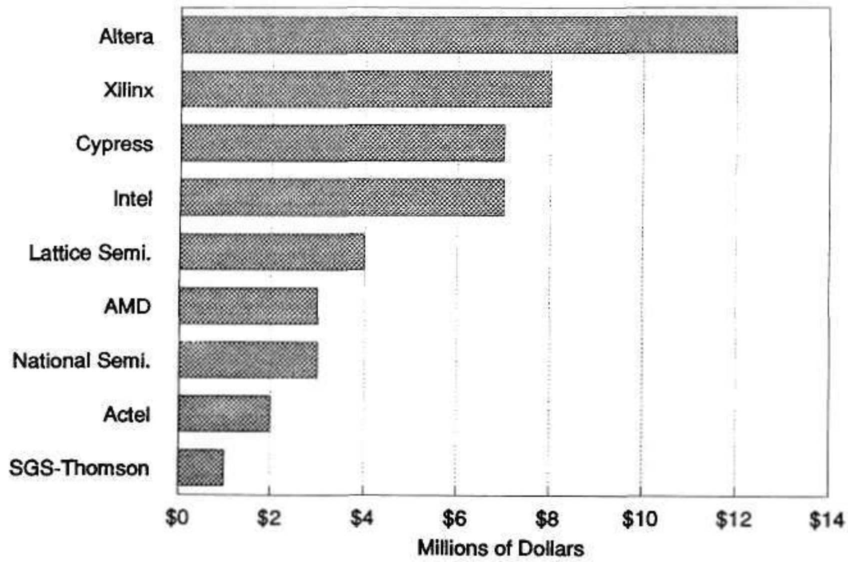
Top 4 Suppliers 1989, Estimated European Bipolar PLD Revenue



Source: Dataquest (January 1991)

Figure 4.3

Top 9 Suppliers 1989, Estimated European MOS PLD Revenue



Source: Dataquest (January 1991)

Chapter 5

Estimated European CBIC Revenue 1987–1989

Table 5.1

Estimated European Total MOS CBIC Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$151	$220	$315
European Companies	$102	$135	$181
Austria Mikro Systeme	15	19	27
Ericsson	9	6	7
ES2*	6	12	17
Eurosil	2	4	5
MEDL	5	12	19
Mietec	27	29	34
Philips	3	8	9
Plessey Semiconductor	3	7	8
SGS-Thomson	2	3	19
Siemens	15	15	17
STC	4	6	5
Telefunken	10	10	10
Others	1	4	4
N. American Companies	$49	$84	$129
AT&T	6	9	10
Harris Semiconductor	4	8	10
Honeywell/Atmel	0	0	10
IMP Europe	2	7	11
LSI Logic	4	7	11
National Semiconductor	3	6	8
NCR	0	0	2
Sierra Semiconductor	0	6	4
Texas Instruments	5	12	30
VLSI Technology	15	22	29
Others	10	7	4
Japanese Companies	$0	$1	$5
Fujitsu	0	0	4
NEC	0	0	1
Others	0	1	0

*ES2 = European Silicon Structures
Source: Dataquest (January 1991)

Table 5.2

Estimated European MOS Digital CBIC Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$110	$155	$226
European Companies	$65	$88	$121
Austria Mikro Systeme	13	16	24
Ericsson	9	6	7
ES2*	6	12	17
Eurosil	2	4	5
MEDL	5	11	17
Mietec	5	9	7
Philips	3	3	4
SGS-Thomson	2	3	15
Siemens	15	15	17
STC	4	6	5
Others	1	3	3
N. American Companies	$45	$66	$100
AT&T	6	9	10
Harris Semiconductor	4	8	10
Honeywell/Atmel	0	0	10
LSI Logic	4	7	9
National Semiconductor	1	1	2
NCR	0	0	2
Texas Instruments	5	12	24
VLSI Technology	15	22	29
Others	10	7	4
Japanese Companies	$0	$1	$5
Fujitsu	0	0	4
NEC	0	0	1
Others	0	1	0

*ES2 = European Silicon Structures
Source: Dataquest (January 1991)

Table 5.3

Estimated European MOS Mixed Signal CBIC Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$41	$65	$89
European Companies	$37	$47	$60
Austria Mikro Systeme	2	3	3
MEDL	0	1	2
Mietec	22	20	27
Philips	0	5	5
Plessey Semiconductor	3	7	8
SGS-Thomson	0	0	4
Telefunken	10	10	10
Others	0	1	1
N. American Companies	$4	$18	$29
IMP Europe	2	7	11
LSI Logic	0	0	2
National Semiconductor	2	5	6
Sierra Semiconductor	0	6	4
Texas Instruments	0	0	6

Source: Dataquest (January 1991)

Table 5.4

Estimated European 1989 Total MOS CBIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Mietec	27	29	34	17.2%	34	10.8%	10.8%
2	7	5	Texas Instruments	5	12	30	150.0%	64	9.5%	20.3%
3	2	-1	VLSI Technology	15	22	29	31.8%	93	9.2%	29.5%
4	3	-1	Austria Mikro Systeme	15	19	27	42.1%	120	8.6%	38.1%
5	6	1	MEDL	5	12	19	58.3%	139	6.0%	44.1%
6	20	14	SGS-Thomson	2	3	19	533.3%	158	6.0%	50.2%
7	5	-2	European Silicon Structures	6	12	17	41.7%	175	5.4%	55.6%
8	4	-4	Siemens	15	15	17	13.3%	192	5.4%	61.0%
9	12	3	IMP Europe	2	7	11	57.1%	203	3.5%	64.4%
10	13	3	LSI Logic	4	7	11	57.1%	214	3.5%	67.9%
11	9	-2	AT&T	6	9	10	11.1%	224	3.2%	71.1%
12	10	-2	Harris Semiconductor	4	8	10	25.0%	234	3.2%	74.3%
13	-	NA	Honeywell/Atmel	0	0	10	NA	244	3.2%	77.5%
14	8	-6	Telefunken	10	10	10	0.0%	254	3.2%	80.6%
15	11	-4	Philips	3	8	9	12.5%	263	2.9%	83.5%
16	16	0	National Semiconductor	3	6	8	33.3%	271	2.5%	86.0%
17	14	-3	Plessey Semiconductor	3	7	8	14.3%	279	2.5%	88.6%
18	15	-3	Ericsson	9	6	7	16.7%	286	2.2%	90.8%
19	19	0	Eurosil	2	4	5	25.0%	291	1.6%	92.4%
20	18	-2	STC	4	6	5	-16.7%	296	1.6%	94.0%
21	-	NA	Fujitsu	0	0	4	NA	300	1.3%	95.2%
22	17	-5	Sierra Semiconductor	0	6	4	-33.3%	304	1.3%	96.5%
23	-	NA	NCR	0	0	2	NA	306	0.6%	97.1%
24	-	NA	NEC	0	0	1	NA	307	0.3%	97.5%
			European Others	1	1	4	300.0%	311	1.3%	98.7%
			North American Others	10	7	4	-42.9%	315	1.3%	100.0%
			Japanese Others	0	1	0	-100.0%	315	0.0%	100.0%
			Total All Companies	151	220	315				
			Total European Companies	102	135	181	34.1%		57.5%	
			Total North American	49	84	129	53.6%		41.0%	
			Total Japanese	0	1	5	400.0%		1.6%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 5.5

Estimated European 1989 MOS Digital CBIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	VLSI Technology	15	22	29	31.8%	29	12.8%	12.8%
2	2	0	Austria Mikro Systeme	13	16	24	50.0%	53	10.6%	23.5%
3	5	2	Texas Instruments	5	12	24	100.0%	77	10.6%	34.1%
4	4	0	European Silicon Structures	6	12	17	41.7%	94	7.5%	41.6%
5	6	1	MEDL	5	11	17	54.5%	111	7.5%	49.1%
6	3	-3	Siemens	15	15	17	13.3%	128	7.5%	56.6%
7	15	8	SGS-Thomson	2	3	15	400.0%	143	6.6%	63.3%
8	7	-1	AT&T	6	9	10	11.1%	153	4.4%	67.7%
9	9	0	Harris Semiconductor	4	8	10	25.0%	163	4.4%	72.1%
10	-	NA	Honeywell/Atmel	0	0	10	NA	173	4.4%	76.5%
11	10	-1	LSI Logic	4	7	9	28.6%	182	4.0%	80.5%
12	11	-1	Ericsson	9	6	7	16.7%	189	3.1%	83.6%
13	8	-5	Mietec	5	9	7	-22.2%	196	3.1%	86.7%
14	13	-1	Eurosil	2	4	5	25.0%	201	2.2%	88.9%
15	12	-3	STC	4	6	5	-16.7%	206	2.2%	91.2%
16	-	NA	Fujitsu	0	0	4	NA	210	1.8%	92.9%
17	14	-3	Philips	3	3	4	33.3%	214	1.8%	94.7%
18	16	-2	National Semiconductor	1	1	2	100.0%	216	0.9%	95.6%
19	-	NA	NCR	0	0	2	NA	218	0.9%	96.5%
20	-	NA	NEC	0	0	1	NA	219	0.4%	96.9%
			European Others	1	3	3	0.0%	222	1.3%	98.2%
			North American Others	10	7	4	-42.9%	226	1.8%	100.0%
			Japanese Others	0	1	0	-100.0%	226	0.0%	100.0%
			Total All Companies	110	155	226	45.8%			
			Total European Companies	65	88	121	37.5%		53.5%	
			Total North American	45	66	100	51.5%		44.2%	
			Total Japanese	0	1	5	400.0%		2.2%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 5.6

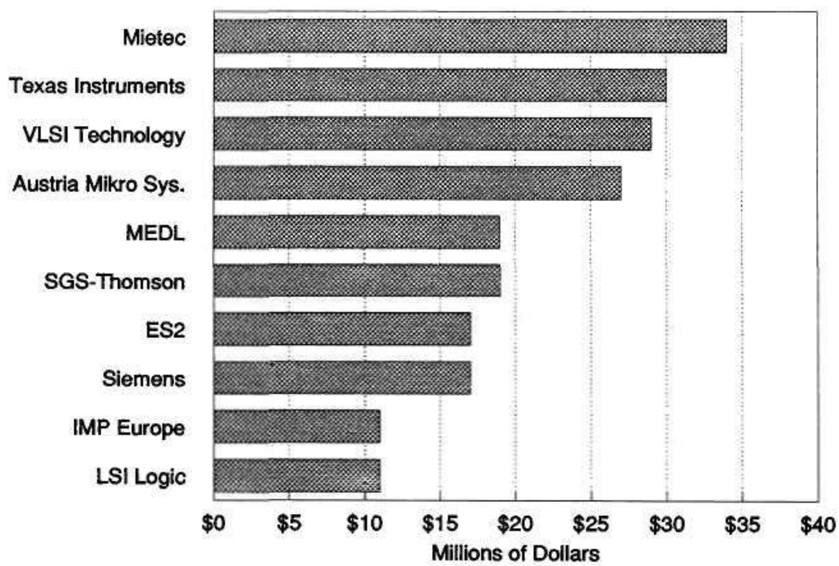
Estimated European 1989 MOS Mixed Signal CBIC Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	Mietec	22	20	27	35.0%	27	30.3%	30.3%
2	3	1	IMP Europe	2	7	11	57.1%	38	12.4%	42.7%
3	2	-1	Telefunken	10	10	10	0.0%	48	11.2%	53.9%
4	4	0	Plessey Semiconductor	3	7	8	14.3%	56	9.0%	62.9%
5	6	1	National Semiconductor	2	5	6	20.0%	62	6.7%	69.7%
6	-	NA	Texas Instruments	0	0	6	NA	68	6.7%	76.4%
7	7	0	Philips	0	5	5	0.0%	73	5.6%	82.0%
8	-	NA	SGS-Thomson	0	0	4	NA	77	4.5%	86.5%
9	5	-4	Sierra Semiconductor	0	6	4	-33.3%	81	4.5%	91.0%
10	8	-2	Austria Mikro Systeme	2	3	3	0.0%	84	3.4%	94.4%
11	-	NA	LSI Logic	0	0	2	NA	86	2.2%	96.6%
12	9	-3	MEDL	0	1	2	100.0%	88	2.2%	98.9%
			European Others	0	1	1	0.0%	89	1.1%	100.0%
			Total All Companies	$41	$65	$89	36.9%			
			Total European Companies	37	47	60	27.7%		67.4%	
			Total North American	4	18	29	61.1%		32.6%	

NA = Not Applicable
Source: Dataquest (January 1991)

Figure 5.1

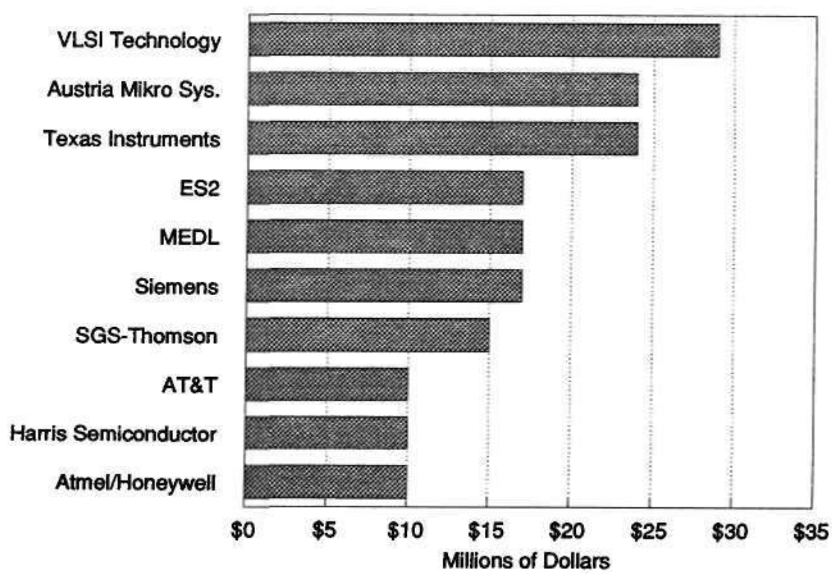
Top 10 Suppliers 1989, Estimated European MOS CBIC Revenue



Source: Dataquest (January 1991)

Figure 5.2

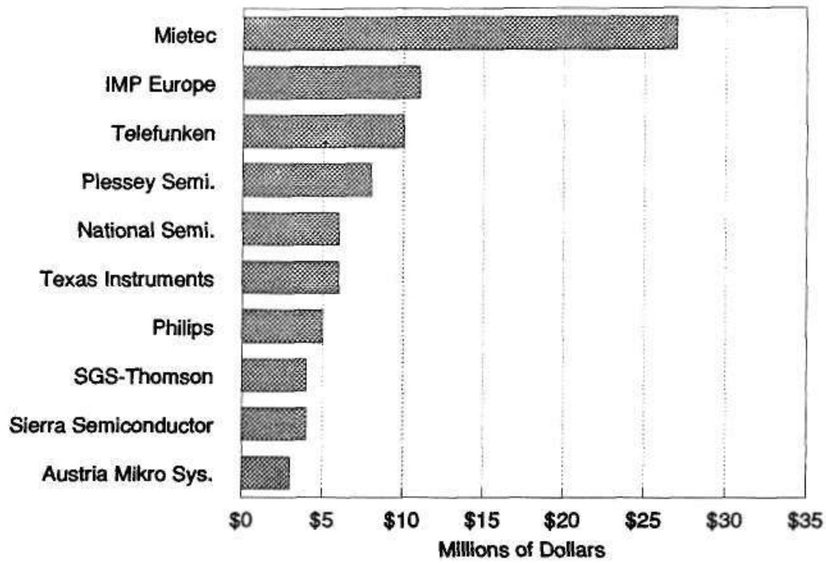
Top 10 Suppliers 1989, Estimated European Digital MOS CBIC Revenue



Source: Dataquest (January 1991)

Figure 5.3

Top 10 Suppliers 1989, Estimated European MOS Mixed Signal CBIC Revenue



Source: Dataquest (January 1991)

Chapter 6

Estimated European Custom Revenue 1987-1989

Table 6.1

Estimated European Total Full-Custom Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$299	$286	$324
European Companies	$139	$143	$182
Austria Mikro Systeme	10	12	13
Asea Brown Boveri	23	25	21
Ericsson	7	0	0
Eurosil	7	7	7
Ferranti	6	0	0
Matra-MHS	0	6	5
MEDL	1	0	0
Mietec	5	13	16
Philips	5	5	8
Plessey	2	15	19
SGS-Thomson	10	14	0
Siemens	33	13	51
STC	4	0	0
Telefunken	20	25	22
TMS	0	0	12
Others	6	8	8
N. American Companies	$152	$131	$126
Harris	3	2	7
IMP Europe	2	0	0
Intel	1	0	0
ITT Intermettal	102	95	91
Motorola	6	11	0
National Semiconductor	3	5	3
Siliconix	8	0	0
Sprague	0	3	8
Texas Instruments	7	15	17
Others	20	0	0
Japanese Companies	$8	$12	$16
Mitsubishi	0	0	2
NEC	2	4	6
Oki	0	0	1
Seiko Epson	0	5	5
Toshiba	0	3	2
Others	6	0	0

Source: Dataquest (January 1991)

Table 6.2

Estimated European Bipolar Full-Custom Revenue (Millions of Dollars)

	1987	1988	1989
Total Shipments	$47	$41	$56
European Companies	$34	$25	$41
Ericsson	5	0	0
Ferranti	2	0	0
Plessey	1	9	15
Siemens	12	2	15
Telefunken	10	10	7
Others	4	4	4
N. American Companies	$13	$13	$11
Motorola	2	1	0
National Semiconductor	3	2	0
Texas Instruments	3	10	11
Others	5	0	0
Japanese Companies	$0	$3	$4
Mitsubishi	0	0	2
Toshiba	0	3	2

Source: Dataquest (January 1991)

Table 6.3

Estimated European MOS Full-Custom Revenue
(Millions of Dollars)

	1987	1988	1989
Total Shipments	$252	$245	$268
European Companies	$105	$118	$141
Austria Mikro Systeme	10	12	13
Asea Brown Boveri	23	25	21
Ericsson	2	0	0
Eurosil	7	7	7
Ferranti	4	0	0
Matra-MHS	0	6	5
MEDL	1	0	0
Mietec	5	13	16
Philips	5	5	8
Plessey	1	6	4
SGS-Thomson	10	14	0
Siemens	21	11	36
STC	4	0	0
Telefunken	10	15	15
TMS	0	0	12
Others	2	4	4
N. American Companies	$139	$118	$115
Harris Semiconductor	3	2	7
IMP Europe	2	0	0
Intel	1	0	0
ITT Intermettal	102	95	91
Motorola	4	10	0
National Semiconductor	0	3	3
Siliconix	8	0	0
Sprague	0	3	8
Texas Instruments	4	5	6
Others	15	0	0
Japanese Companies	$8	$9	$12
NEC	2	4	6
Oki	0	0	1
Seiko Epson	0	5	5
Others	6	0	0

Source: Dataquest (January 1991)

Table 6.4

Estimated European 1989 Total Full-Custom Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	ITT Intermetall	102	95	91	-4.2%	91	28.1%	28.1%
2	8	6	Siemens	33	13	51	292.3%	142	15.7%	43.8%
3	3	0	Telefunken	20	25	22	-12.0%	164	6.8%	50.6%
4	2	-2	Asea Brown Boveri	23	25	21	-16.0%	185	6.5%	57.1%
5	4	-1	Plessey	2	15	19	26.7%	204	5.9%	63.0%
6	5	-1	Texas Instruments	7	15	17	13.3%	221	5.2%	68.2%
7	7	0	Mietec	5	13	16	23.1%	237	4.9%	73.1%
8	9	1	Austria Mikro Systeme	10	12	13	8.3%	250	4.0%	77.2%
9	-	NA	TMS	0	0	12	NA	262	3.7%	80.9%
10	14	4	Philips	5	5	8	60.0%	270	2.5%	83.3%
11	17	6	Sprague	0	3	8	166.7%	278	2.5%	85.8%
12	11	-1	Eurosil	7	7	7	0.0%	285	2.2%	88.0%
13	19	6	Harris	3	2	7	250.0%	292	2.2%	90.1%
14	16	2	NEC	2	4	6	50.0%	298	1.9%	92.0%
15	12	-3	Matra-MHS	0	6	5	-16.7%	303	1.5%	93.5%
16	15	-1	Seiko Epson	0	5	5	0.0%	308	1.5%	95.1%
17	13	-4	National Semiconductor	3	5	3	-40.0%	311	0.9%	96.0%
18	-	NA	Mitsubishi	0	0	2	NA	313	0.6%	96.6%
19	18	-1	Toshiba	0	3	2	-33.3%	315	0.6%	97.2%
20	-	NA	Oki	0	0	1	NA	316	0.3%	97.5%
-	-	NA	Ericsson	7	0	0	NA	316	0.0%	97.5%
-	-	NA	Ferranti	6	0	0	NA	316	0.0%	97.5%
-	-	NA	IMP Europe	2	0	0	NA	316	0.0%	97.5%
-	-	NA	Intel	1	0	0	NA	316	0.0%	97.5%
-	-	NA	MEDL	1	0	0	NA	316	0.0%	97.5%
-	10	NA	Motorola	6	11	0	-100.0%	316	0.0%	97.5%
-	6	NA	SGS-Thomson	10	14	0	-100.0%	316	0.0%	97.5%
-	-	NA	Siliconix	8	0	0	NA	316	0.0%	97.5%
-	-	NA	STC	4	0	0	NA	316	0.0%	97.5%
			European Others	6	8	8	0.0%	324	2.5%	100.0%
			North American Others	20	0	0	NA	324	0.0%	100.0%
			Japanese Others	6	0	0	NA	324	0.0%	100.0%
			Total All Companies	$299	$286	$324	13.3%			
			Total European Companies	139	143	182	27.3%		56.2%	
			Total North American	152	131	126	-3.8%		38.9%	
			Total Japanese	8	12	16	33.3%		4.9%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 6.5

Estimated European 1989 Bipolar Full-Custom Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	3	2	Plessey	1	9	15	66.7%	15	26.8%	26.8%
2	6	4	Siemens	12	2	15	650.0%	30	26.8%	53.6%
3	2	-1	Texas Instruments	3	10	11	10.0%	41	19.6%	73.2%
4	1	-3	Telefunken	10	10	7	-30.0%	48	12.5%	85.7%
5	-	NA	Mitsubishi	0	0	2	NA	50	3.6%	89.3%
6	4	-2	Toshiba	0	3	2	-33.3%	52	3.6%	92.9%
-	-	NA	Ericsson	5	0	0	NA	52	0.0%	92.9%
-	-	NA	Ferranti	2	0	0	NA	52	0.0%	92.9%
-	7	NA	Motorola	2	1	0	NA	52	0.0%	92.9%
-	5	NA	National Semiconductor	3	2	0	NA	52	0.0%	92.9%
			European Others	4	4	4	0.0%	56	7.1%	100.0%
			North American Others	5	0	0	NA	56	0.0%	100.0%
			Total All Companies	47	41	56	36.6%			
			Total European Companies	34	25	41	64.0%		73.2%	
			Total North American	13	13	11	-15.4%		19.6%	
			Total Japanese	0	3	4	33.3%		7.1%	

NA = Not Applicable
Source: Dataquest (January 1991)

Table 6.6

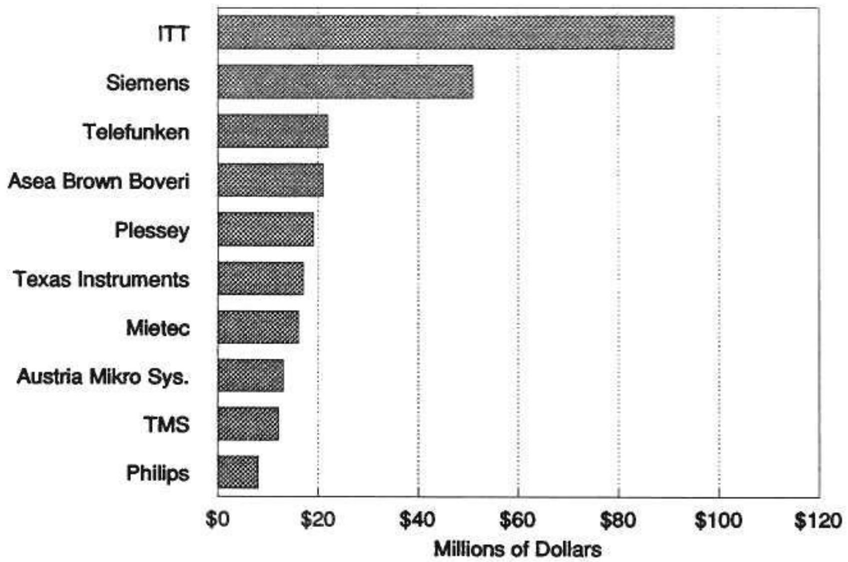
Estimated European 1989 MOS Full-Custom Market Share Rankings
(Millions of Dollars)

1989 Rank	1988 Rank	Change in Rank		1987 Sales ($M)	1988 Sales ($M)	1989 Sales ($M)	1988-89 Growth (%)	1989 Cum. Sum ($M)	1989 Share (%)	1989 Cum. Sum (%)
1	1	0	ITT Intermetall	102	95	91	-4.2%	91	34.0%	34.0%
2	7	5	Siemens	21	11	36	227.3%	127	13.4%	47.4%
3	2	-1	Asea Brown Boveri	23	25	21	-16.0%	148	7.8%	55.2%
4	5	1	Mietec	5	13	16	23.1%	164	6.0%	61.2%
5	3	-2	Telefunken	10	15	15	0.0%	179	5.6%	66.8%
6	6	0	Austria Mikro Systeme	10	12	13	8.3%	192	4.9%	71.6%
7	-	NA	TMS	0	0	12	NA	204	4.5%	76.1%
8	12	4	Philips	5	5	8	60.0%	212	3.0%	79.1%
9	17	8	Sprague	0	3	8	166.7%	220	3.0%	82.1%
10	9	-1	Eurosil	7	7	7	0.0%	227	2.6%	84.7%
11	18	7	Harris Semiconductor	3	2	7	250.0%	234	2.6%	87.3%
12	15	3	NEC	2	4	6	50.0%	240	2.2%	89.6%
13	14	1	Texas Instruments	4	5	6	20.0%	246	2.2%	91.8%
14	10	-4	Matra-MHS	0	6	5	-16.7%	251	1.9%	93.7%
15	13	-2	Seiko Epson	0	5	5	0.0%	256	1.9%	95.5%
16	11	-5	Plessey	1	6	4	-33.3%	260	1.5%	97.0%
17	16	-1	National Semiconductor	0	3	3	0.0%	263	1.1%	98.1%
18	-	NA	Oki	0	0	1	NA	264	0.4%	98.5%
-	-	NA	Ericsson	2	0	0	NA	264	0.0%	98.5%
-	-	NA	Ferranti	4	0	0	NA	264	0.0%	98.5%
-	-	NA	IMP Europe	2	0	0	NA	264	0.0%	98.5%
-	-	NA	Intel	1	0	0	NA	264	0.0%	98.5%
-	-	NA	MEDL	1	0	0	NA	264	0.0%	98.5%
-	8	NA	Motorola	4	10	0	-100.0%	264	0.0%	98.5%
-	4	NA	SGS-Thomson	10	14	0	-100.0%	264	0.0%	98.5%
-	-	NA	Siliconix	8	0	0	NA	264	0.0%	98.5%
-	-	NA	STC	4	0	0	NA	264	0.0%	98.5%
			European Others	2	4	4	0.0%	268	1.5%	100.0%
			North American Others	15	0	0	NA	268	0.0%	100.0%
			Japanese Others	6	0	0	NA	268	0.0%	100.0%
			Total All Companies	252	245	268	9.4%			
			Total European Companies	105	118	141	19.5%		52.6%	
			Total North American	139	118	115	-2.5%		42.9%	
			Total Japanese	8	9	12	33.3%		4.5%	

NA = Not Applicable
Source: Dataquest (January 1991)

Figure 6.1

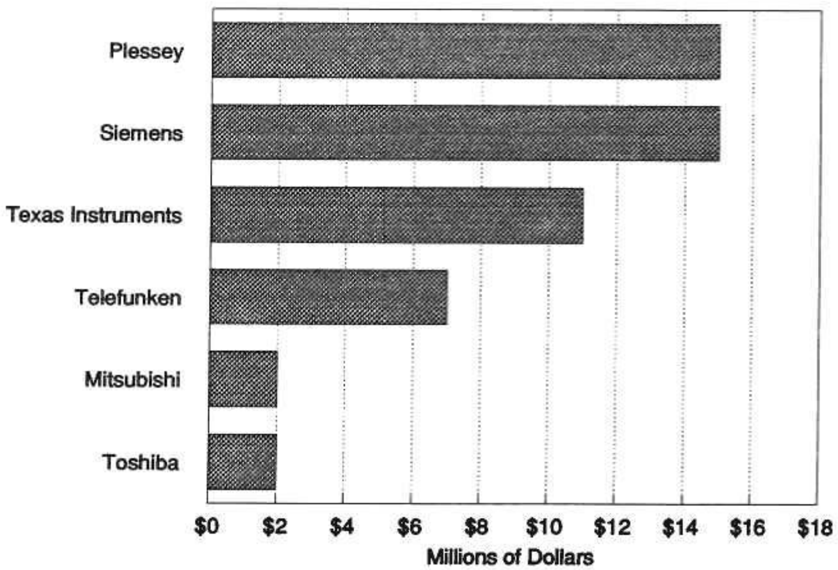
Top 10 Suppliers 1989, Estimated European Total Full-Custom Revenue



Source: Dataquest (January 1991)

Figure 6.2

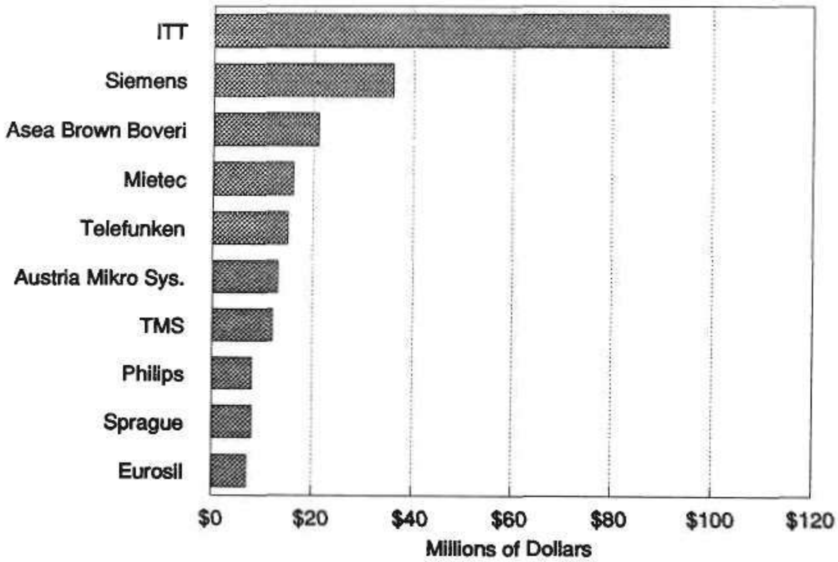
Top 6 Suppliers 1989, Estimated European Bipolar Full-Custom Revenue



Source: Dataquest (January 1991)

Figure 6.3

Top 10 Suppliers 1989, Estimated European MOS Full-Custom Revenue



Source: Dataquest (January 1991)

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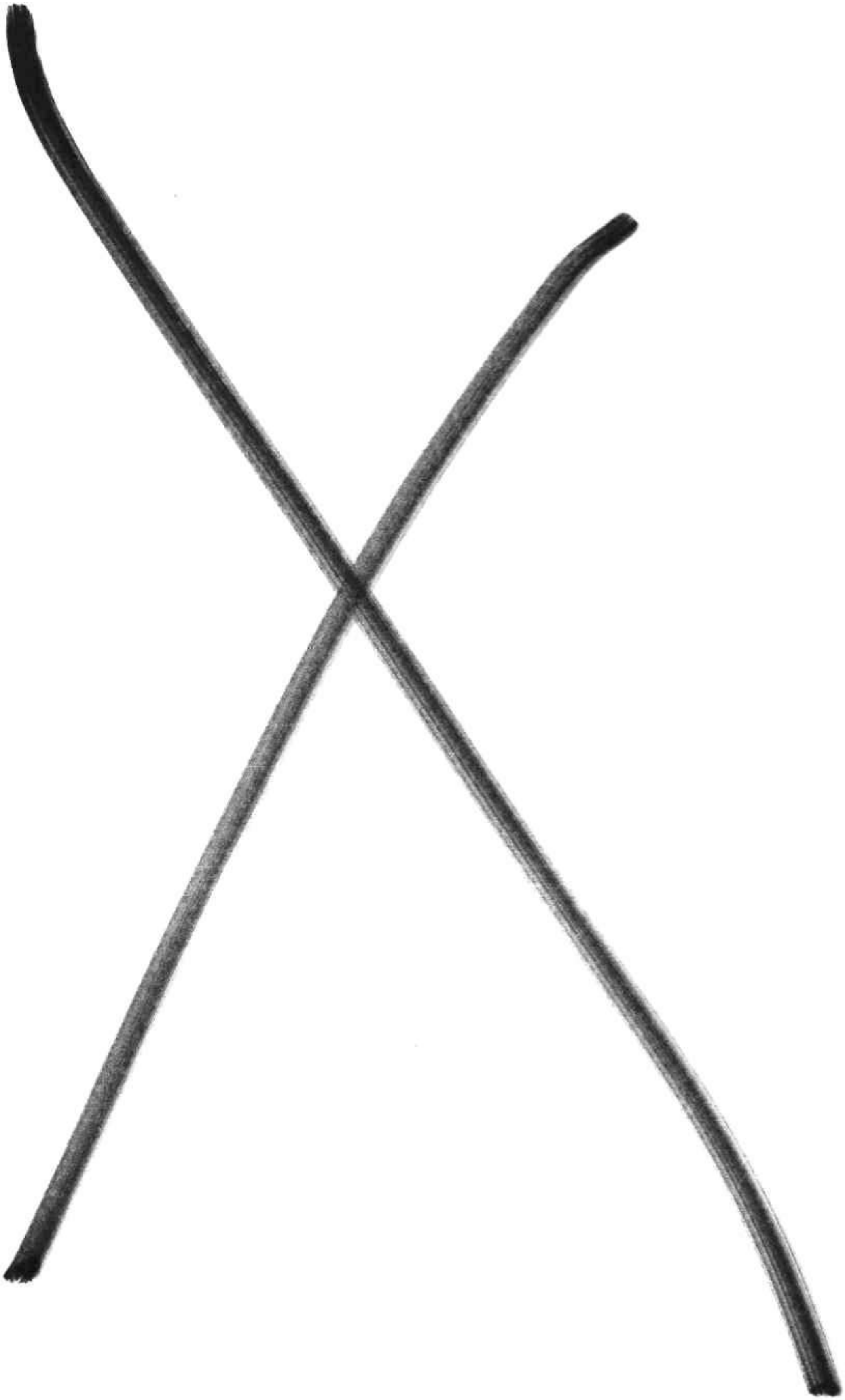

Dataquest

European MOS Memory Market Consumption Forecast 1988-1995 and Market Share Rankings

European MOS Memory Market Consumption Forecast 1988-1995 and Market Share Rankings

A European Semiconductor Industry Service Report

ESIS Volume II, Section 9, Memory.

Published by Dataquest Europe Limited

March 1991

0008320

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Chapter 1

Introduction and Overview

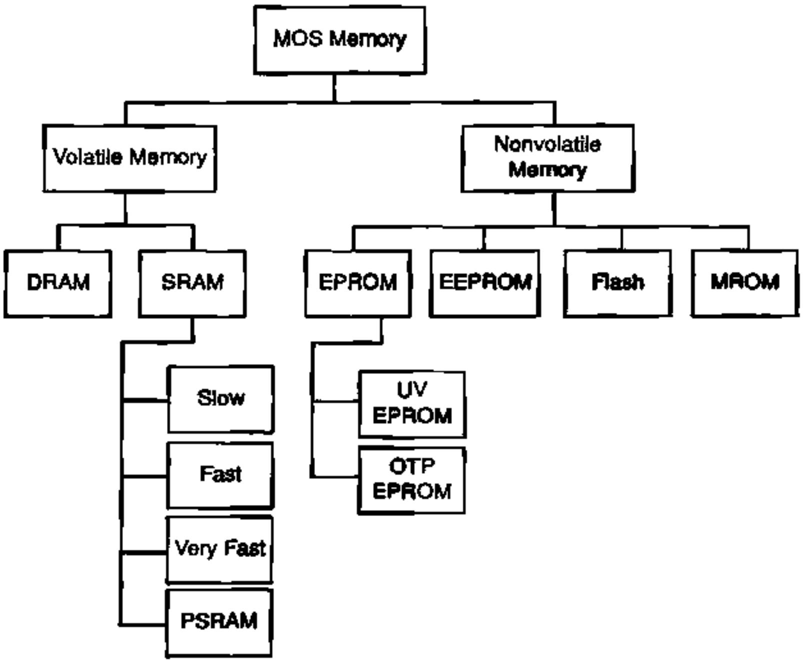
Introduction

This booklet presents Dataquest's analysis of the European MOS memory market. Updates to this analysis are provided every quarter in Research Newsletters. Specific inquiries on this booklet and the European MOS memory market should be directed to Dataquest's UK office.

The MOS memory market has been segmented into device families in order to differentiate between the various types of memory on offer. Our analysis covers DRAM, SRAM, EPROM, EEPROM, flash memory, and mask ROM. The MOS memory family tree is shown in Figure 1.1 with a key to the product acronyms.

Figure 1.1

MOS Memory Family Tree



KEY

DRAM:	Dynamic random access memory
SRAM:	Static random access memory
PSRAM:	Pseudo SRAM
EPROM:	Erasable programmable read-only memory
UV EPROM:	Ultraviolet EPROM
OTP EPROM:	One-time-programmable EPROM
EEPROM:	Electrically erasable programmable read-only memory
Flash:	Flash memory
MROM:	Mask-programmable read-only memory

Source: Dataquest (March 1991)

Overview

The size of the European MOS memory market in 1990 was an estimated $2.3 billion and was served by 43 MOS memory vendors. Finalized estimates for the MOS memory market in 1990 will be provided in a Research Newsletter in the second quarter of 1991.

A measure of relative market size for each product family is included in Table 1. This shows that DRAM accounts for nearly 60 percent of the European MOS memory market. In fact, the DRAM market strongly influences all other MOS memory product markets as it is a key technology driver. On an average cost-per-bit basis, DRAM is one of the cheapest forms of memory available today.

Table 1.1 also compares the functionality that makes each form of MOS memory unique and suited to particular applications. It is important to recognize the higher costs associated with nonvolatility and high functionality. End-user demand for each form of MOS memory is a result of the trade-off between functions and price. Any change in these factors has an immediate effect on demand and is the motivation for constant product development by suppliers.

Table 1.1

Comparison Between MOS Memory Products (Based on 1990 Figures)

Measure	DRAM	SRAM	UV EPROM	OTP EPROM	EEPROM	Flash	Mask ROM	Total MOS Memory
Market Size ($M)	$1,140	$400	$272	$30	$86	$9	$32	$1,995
Relative Market Share (%)	57.1%	20.0%	13.6%	1.5%	4.3%	0.5%	1.6%	100%
Number of Suppliers to Europe	18	27	19	11	14	4	8	43
Average Revenue/Vendor ($M)	$63	$15	$14	$3	$6	$2	$4	$46
Average Cost per Mbit ($)	$6.77	$35.71	$9.00	$8.00	$215.00	$30.00	$1.76	$8.46
Relative Cost per Mbit (DRAM=1)	1.0	5.6	1.4	1.3	39.1	4.4	0.3	1.2
Typical 1M Die Size (mm)	50	90	50	50	100	60	50	NA
No. of Transistors in Memory Cell	1T	4T/6T	1T	1T	2T/4T	1T/2T	1T	NA
Volatile or Nonvolatile	V	V	NV	NV	NV	NV	NV	NA
Device User Programmable	Yes	Yes	Yes	Yes	Yes	Yes	No	NA
Device Reprogrammable	Yes	Yes	Yes	No	Yes	Yes	No	NA
Programming Voltage	5V	5V	12V	12V	5V	12V/5V	NA	NA
Erase and Write Method	Bit	Bit	Chip	NA	Byte/Page	Sector	NA	NA
Write Cycle Endurance	>100T	>100T	100-1K	1	1K-100K	100-100K	NA	NA
Read Access Speed (ns)	25-150	10-120	90-200	90-200	35-200	90-200	90-200	NA
Maximum Density in Production	4M	1M	4M	4M	1M	2M	16M	NA
Plastic Package Option	Yes	Yes	No	Yes	Yes	Yes	Yes	NA

T = Teracycle (i.e. 10^{12})
NA = Not Available/Applicable
Source: Dataquest (March 1991)

Total MOS Memory

Analysis and Forecast

European MOS memory unit consumption grew by 9.0 percent between 1989 and 1990. Yet average selling prices (ASPs) eroded by 28.1 percent during this time, resulting in a 21.7 percent decline in the value of the market. The cause of this price erosion was increased capacity, a result of many new entrants increasing their production volumes in MOS memory throughout 1990 combined with a slowdown in demand for PC memory. Memory capacity consumption in Europe totaled an estimated 235.7 terabits in 1990, which is a 48.5 percent growth over 1989. Dataquest expects a compound annual growth rate (CAGR) of 57.8 percent for the period 1990 to 1995 in the number of terabits shipped to Europe.

Demand for MOS memory in the European market is expected to be driven by continued foreign investment in equipment manufacturing plants. Many of these new plants will be true manufacturing facilities, and not just assembly sites for imported subsystems. The decision to locate a true equipment manufacturing plant in Europe is based on economics. Import duty on equipment and subsystems ranges between 5 and 7 percent. If the volume of imports is large enough, the value of the duty payable can justify the cost of moving manufacture into Europe. Local procurement of semiconductors will be important in order to avoid the 14 percent that is currently imposed on most commodity products. This will boost shipments of semiconductors, especially in MOS memory.

Political issues also affect the European MOS memory market. In 1990, the industry saw the introduction of floor price controls for DRAMs by the European Commission as a protection against dumping. This was followed in early 1991 by similar controls on EPROMs. The industry may also see SRAMs come under floor price control in the medium term. Whether these measures serve to stabilize the market, or destabilize it, is open to debate. What is certain is that governments are finding themselves under pressure to protect local semiconductor manufacturers from external competition, while providing them with funds for strategic R&D. This angers European semiconductor users who see this as raising European memory prices and limiting government funds available to users.

Semiconductor origin has been determined by the European Commission as representing the country of fabrication. This rule has been under consideration for completed printed circuit boards (PCBs) whereby semiconductor source is the main factor in determining PCB origin. This definition is contrary to that applied in North America where assembly mostly determines origin. If the European Commission applies the PCB origin rule, there may be an impact on import tariff structures.

Estimated European unit shipments are shown in Figure 2.1. Note that DRAM remains by far the largest market in terms of units. EPROM and EEPROM units are expected to show some decline leading up to 1995, partly due to the migration of demand to higher densities and partly due to some replacement by flash memory.

Estimated European ASPs are shown in Figure 2.2. Note that DRAM ASPs peaked sharply in 1989 due to a combination of users migrating from the 256K to the 1M and the ASP inflation that resulted from supply shortages. SRAM ASPs follow a similar course. EPROM ASPs suffered from strong market share competition leading up to 1990. Mask-programmable ROM ASPs follow a steady upward trend due to user acceptance of cost-effective new generations and the obsolescence of earlier generations.

Estimated European market sizes by value are shown in Figure 2.3. The DRAM market peaked in 1989 due to inflated ASPs, and then the EPROM and DRAM markets shrank in 1990 due to severe price erosion. Flash memory will see strong growth from a small base, reaching half the size of the EPROM market by 1995.

Estimated consumption of the MOS memory in megabits in Europe is shown in Figure 2.4. DRAM and SRAM follow a similar log gradient. Mask-programmable ROM is expected to grow below average and be overtaken by SRAM in 1995. The slowdown in EPROM and EEPROM growth is balanced against the high growth of flash memory.

Figure 2.5 shows estimated European cost per Mbit. While the cost per bit is declining for all forms of memory, there are interesting details to note. EEPROM remains the most expensive form of memory, followed by SRAM. Flash memory has crossed the SRAM cost-per-bit line and is heading towards the EPROM cost range. Dataquest expects that flash memory will ultimately cross the EPROM line somewhere around 1997. This will be hastened as EPROM is not expected to be developed beyond the 16M generation and will therefore limit any further cost-per-bit erosion.

Applications for MOS memory include data processing as the key end-user segment. Growing investment in European EDP manufacturing will drive higher-than-average growth in this segment. Telecommunications and industrial applications, as the second- and third-largest areas, will lose share as a result. These two application segments consist of equipment with relatively low memory requirement when measured as a percentage of total equipment cost. Consumer and transportation end-user segments will show above-average growth from a small base. Consumer applications include frame store in TVs, scratch pad and user configurations in a wide variety of equipment. Transportation applications include engine management parameter store, scratch pad and buffering for microcontrollers. Military purchasing is expected to grow at around the market average.

The UK and Irish MOS Memory market will continue to grow above average and maintain its position as the largest regional market in Europe. Continuing investment by EDP, telecoms and consumer equipment manufacturers in this region is expected to drive this growth. Germany, the next-largest market is also expected to grow above average, benefiting from strong export markets for its telecoms and computer equipment and the demand that the former East Germany will place on its western counterpart. Italy and the Nordic regions are forecast to grow below average due to the lackluster performance of their equipment industries. France and Benelux are expected to grow close to the European average, while the rest of Europe will see the highest growth, albeit from a small base.

A category which is not broken down into detail is "Other MOS Memory." This consists of speciality MOS memory products which do not fit into our standard categories. These include cache tag memory, cache RAM, dual and multiport RAM, FIFOs, LIFOs, RAMDACs and other existing and emerging MOS memory products not already accounted for elsewhere.

The value of the European MOS memory market is expected to experience a CAGR of 20.7 percent between 1990 and 1995.

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Table 2.1

MOS Memory Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
DRAM	196.8	220.6	237.4	272.3	286.2	308.5	324.0	355.3
Slow SRAM	44.7	46.5	53.3	61.1	73.2	90.0	101.3	113.0
Fast SRAM	9.1	10.9	11.3	12.3	14.0	14.1	12.7	10.8
Very Fast SRAM	1.8	4.0	7.3	10.3	13.4	15.7	18.2	20.9
PSRAM	0.3	0.5	1.4	3.5	5.9	7.6	8.4	10.2
Total SRAM	55.9	61.9	73.3	87.2	106.5	127.4	140.6	154.9
EPROM	70.7	91.2	93.95	88.6	83.0	82.1	84.3	83.9
EEPROM	20.3	26.0	30.9	32.7	32.2	30.4	28.9	27.9
Flash	0.0	0.1	0.6	2.9	8.0	19.0	32.0	42.4
Mask ROM	10.0	7.0	7.1	8.6	9.6	10.1	9.7	9.7
Total NV	101.0	124.3	132.6	132.8	132.8	141.6	154.9	163.9
Other	NA	NA	NA	NA	NA	NA	NA	NA
Total	353.7	406.8	443.2	492.3	525.5	577.5	619.5	674.1
ASP (Dollars)								
DRAM	$5.40	$7.46	$4.80	$4.39	$5.05	$6.41	$7.37	$8.04
Slow SRAM	$3.83	$5.12	$4.65	$5.12	$5.93	$6.77	$6.85	$7.47
Fast SRAM	$6.92	$6.70	$5.42	$5.45	$6.57	$7.90	$8.58	$8.89
Very Fast SRAM	$11.73	$11.50	$9.59	$9.66	$11.04	$11.53	$11.43	$10.24
PSRAM	$3.96	$5.30	$4.92	$5.37	$5.97	$6.94	$7.17	$7.63
Total SRAM	$4.59	$5.81	$5.27	$5.73	$6.70	$7.52	$7.65	$7.98
EPROM	$5.29	$4.61	$3.21	$3.28	$3.76	$4.26	$4.72	$5.45
EEPROM	$2.86	$2.77	$2.78	$3.03	$3.23	$3.65	$3.74	$4.23
Flash	$39.68	$19.14	$16.01	$9.69	$7.83	$7.57	$6.91	$6.34
Mask ROM	$3.00	$4.00	$4.51	$5.12	$5.83	$7.13	$8.56	$8.87
Total NV	$4.47	$4.11	$3.13	$3.32	$3.83	$4.53	$5.00	$5.39
Other	NA	NA	NA	NA	NA	NA	NA	NA
Weighted Average	$5.08	$6.26	$4.50	$4.48	$5.20	$6.36	$7.04	$7.58
TAM (Millions of Dollars)								
DRAM	$1,062	$1,646	$1,140	$1,195	$1,444	$1,976	$2,387	$2,856
Slow SRAM	$171	$238	$248	$313	$434	$609	$694	$844
Fast SRAM	$63	$73	$61	$67	$92	$111	$109	$96
Very Fast SRAM	$21	$46	$70	$99	$148	$181	$208	$214
PSRAM	$7	$11	$21	$34	$38	$68	$93	$96
Total SRAM	$262	$368	$400	$513	$712	$969	$1,104	$1,250
EPROM	$374	$420	$302	$291	$312	$350	$398	$457
EEPROM	$58	$72	$86	$99	$104	$111	$108	$118
Flash	$1	$2	$9	$28	$63	$144	$221	$269
Mask ROM	$30	$28	$32	$44	$56	$72	$83	$86
Total NV	$463	$522	$429	$462	$535	$677	$810	$930
Other	$10	$12	$26	$33	$40	$52	$61	$72
Total	$1,797	$2,548	$1,995	$2,203	$2,731	$3,674	$4,362	$5,108

(Continued)

Table 2.1 (Continued)

MOS Memory Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Mbits (Millions)								
DRAM	63.2	110.5	168.3	277.6	462.1	739.5	1058.9	1715.3
Slow SRAM	3.5	5.6	9.5	16.3	29.2	50.0	79.6	126.0
Fast SRAM	0.4	0.7	1.1	1.8	3.2	5.1	7.5	11.5
Very Fast SRAM	0.1	0.3	0.6	1.2	2.6	4.3	7.3	12.4
PSRAM	NA	NA	NA	NA	NA	NA	NA	NA
Total SRAM	4.0	6.6	11.2	19.3	35.0	59.4	94.4	149.9
EPROM	17.3	30.3	37.3	50.8	76.3	114.0	159.6	213.2
EEPROM	0.1	0.2	0.4	0.5	0.7	0.9	1.2	1.7
Flash	0.0	0.1	0.3	1.6	5.1	18.4	47.6	80.6
Mask ROM	6.7	11.0	18.2	28.3	45.2	68.8	101.2	146.4
Total NV	24.1	41.6	56.2	81.2	127.3	202.1	309.6	441.9
Other	NA	NA	NA	NA	NA	NA	NA	NA
Total	91.3	158.7	235.7	378.1	624.4	1,001.0	1,462.9	2,307.1
Cost per Mbit (Dollars)								
DRAM	$16.80	$14.90	$6.77	$4.30	$3.12	$2.67	$2.25	$1.67
Slow SRAM	$48.86	$42.50	$26.11	$19.20	$14.86	$12.18	$8.72	$6.70
Fast SRAM	$157.50	$104.29	$55.45	$37.22	$28.75	$21.76	$14.53	$8.35
Very Fast SRAM	$210.00	$153.33	$116.67	$82.50	$56.92	$42.09	$28.49	$17.26
PSRAM	NA	NA	NA	NA	NA	NA	NA	NA
Total SRAM	$65.50	$55.76	$35.71	$26.58	$20.34	$16.31	$11.69	$8.34
EPROM	$21.62	$13.86	$8.10	$5.73	$4.09	$3.07	$2.49	$2.14
EEPROM	$580.00	$360.00	$215.00	$198.00	$148.57	$123.33	$90.00	$69.41
Flash	NA	$20.00	$30.00	$17.50	$12.35	$7.83	$4.64	$3.34
Mask ROM	$4.48	$2.55	$1.76	$1.55	$1.24	$1.05	$0.82	$0.59
Total NV	$19.21	$12.55	$7.63	$5.69	$4.20	$3.35	$2.62	$2.10
Other	NA	NA	NA	NA	NA	NA	NA	NA
Weighted Average	$19.68	$16.06	$8.46	$5.83	$4.37	$3.67	$2.98	$2.21

TAM = Total Available Market
NA = Not Available
Source: Dataquest (March 1991)

Table 2.2

1989 MOS Memory Market Shares in Europe
(Millions of Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (%)	1989 Cum. Sum ($M)	1989 Market Share (%)	1989 Cum. Sum (%)
5	1	4	Siemens	130	338	160.0%	338	13.3%	13.3%
3	2	1	Texas Instruments	216	250	15.7%	588	9.8%	23.1%
1	3	-2	Toshiba	228	247	8.3%	835	9.7%	32.8%
2	4	-2	NEC	223	232	4.0%	1,067	9.1%	41.9%
6	5	1	Samsung	128	186	45.3%	1,253	7.3%	49.2%
4	6	-2	Hitachi	138	172	24.6%	1,425	6.8%	55.9%
9	7	2	SGS-Thomson	84	129	53.6%	1,554	5.1%	61.0%
7	8	-1	Fujitsu	102	120	17.6%	1,674	4.7%	65.7%
10	9	1	Mitsubishi	71	104	46.5%	1,778	4.1%	69.8%
8	10	-2	Intel	97	102	5.2%	1,880	4.0%	73.8%
11	11	0	AMD	56	71	26.8%	1,951	2.8%	76.6%
17	12	5	Matsushita (Panasonic)	22	67	204.5%	2,018	2.6%	79.2%
16	13	3	Motorola	25	60	140.0%	2,078	2.4%	81.6%
29	14	15	Micron Technology	2	60	2,900.0%	2,138	2.4%	83.9%
13	15	-2	NMB	30	51	70.0%	2,189	2.0%	85.9%
12	16	-4	Oki Electric	38	48	26.3%	2,237	1.9%	87.8%
14	17	-3	National Semiconductor	30	30	0.0%	2,267	1.2%	89.0%
18	18	0	Matra-MHS	20	28	40.0%	2,295	1.1%	90.1%
25	19	6	Sony	5	26	420.0%	2,321	1.0%	91.1%
15	20	-5	IDT	27	24	-11.1%	2,345	0.9%	92.0%
23	21	2	Sharp	10	22	120.0%	2,367	0.9%	92.9%
20	22	-2	Cypress	16	21	31.3%	2,388	0.8%	93.7%
21	23	-2	Philips	14	20	42.9%	2,408	0.8%	94.5%
-	24	NA	ITT	-	9	NA	2,417	0.4%	94.9%
32	25	7	Goldstar	1	4	300.0%	2,421	0.2%	95.0%
31	26	5	MEDL*	1	3	200.0%	2,424	0.1%	95.1%
-	27	NA	Plessey Semiconductors**	-	2	NA	2,426	0.1%	95.2%
27	28	-1	Harris	4	1	-75.0%	2,427	0.0%	95.3%
26	29	-3	VLSI Technology	4	1	-75.0%	2,428	0.0%	95.3%
-	30	NA	Sanyo	-	1	NA	2,429	0.0%	95.3%
19	-	NA	Inmos	19	-	-100.0%	NA	NA	NA
22	-	NA	Seiko Epson	11	-	-100.0%	NA	NA	NA
24	-	NA	GE Solid State	8	-	-100.0%	NA	NA	NA
28	-	NA	Austria Mikro Systeme	4	-	-100.0%	NA	NA	NA
30	-	NA	STC Components	1	-	-100.0%	NA	NA	NA

(Continued)

Table 2.2 (Continued)

1989 MOS Memory Market Shares In Europe
(Millions of Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (%)	1989 Cum. Sum ($M)	1989 Market Share (%)	1989 Cum. Sum (%)
			European Others	2	-	-100.0%	NA	NA	NA
			North American Others	18	61	238.9%	2,490	2.4%	97.7%
			Japanese Others	1	39	3,800.0%	2,529	1.5%	99.3%
			Rest of World Others	11	19	72.7%	2,548	0.7%	100.0%
			Total All Companies	1,797	2,548	41.8%	NA	100.0%	NA
			Total European	275	520	89.1%	NA	20.4%	NA
			Total North American	503	690	37.2%	NA	27.1%	NA
			Total Japanese	879	1,129	28.4%	NA	44.3%	NA
			Total Rest of World	140	209	49.3%	NA	8.2%	NA

* MEDL = Marconi Electronic Devices
** Plessey and MEDL now merged and known as GEC Plessey Semiconductors (GPS)
NA = Not Applicable
Source: Dataquest (March 1991)

Table 2.3

Estimated MOS Memory Consumption by Application Segment in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
Application	1990	1991	1995	AGR 1990-91	CAGR 1990-95	1990	1991	1995
EDP	$941	$1,035	$2,540	10.0	22.0	47	48	50
Communications	429	468	960	9.1	17.5	22	21	19
Industrial	301	316	637	5.0	16.2	15	14	12
Consumer	142	165	399	16.2	23.0	7	7	8
Military	113	136	287	20.4	20.5	6	6	6
Transport	69	83	285	20.3	32.8	3	4	5
Total	$1,995	$2,203	$5,108	10.4	20.7	100	100	100

AGR = Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Table 2.4

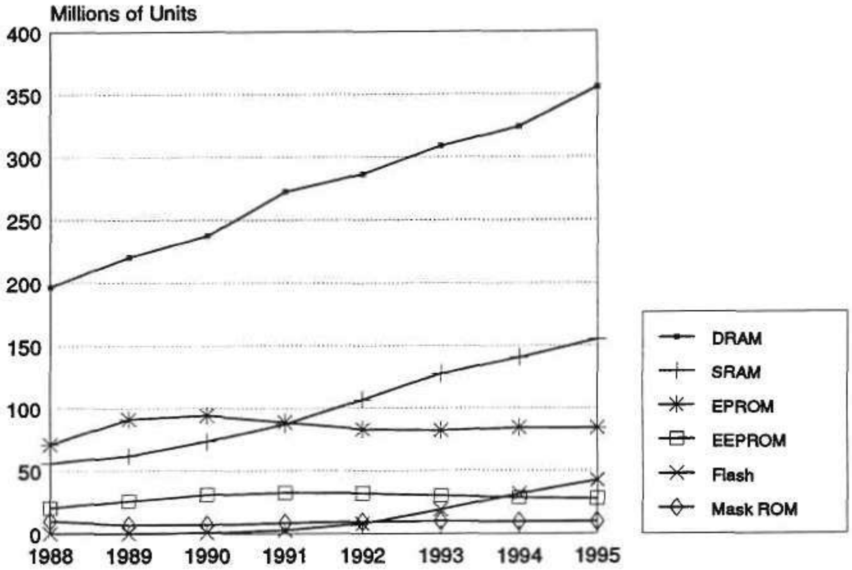
Estimated MOS Memory Consumption by Region in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
Region	1990	1991	1995	AGR 1990-91	CAGR 1990-95	1990	1991	1995
Benelux	$83	$95	$210	14.5	20.4	4	4	4
France	294	292	695	-0.7	18.8	15	13	14
Italy	254	246	524	-3.1	15.6	13	12	10
Nordic	134	136	249	1.5	13.2	7	6	5
UK and Ireland	624	709	1,682	13.6	21.9	31	32	33
Germany	479	568	1,333	18.6	22.7	24	26	26
Rest of Europe	127	157	415	23.6	26.7	6	7	8
Total	$1,995	$2,203	$5,108	10.4	20.7	100	100	100

AGR = Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Figure 2.1

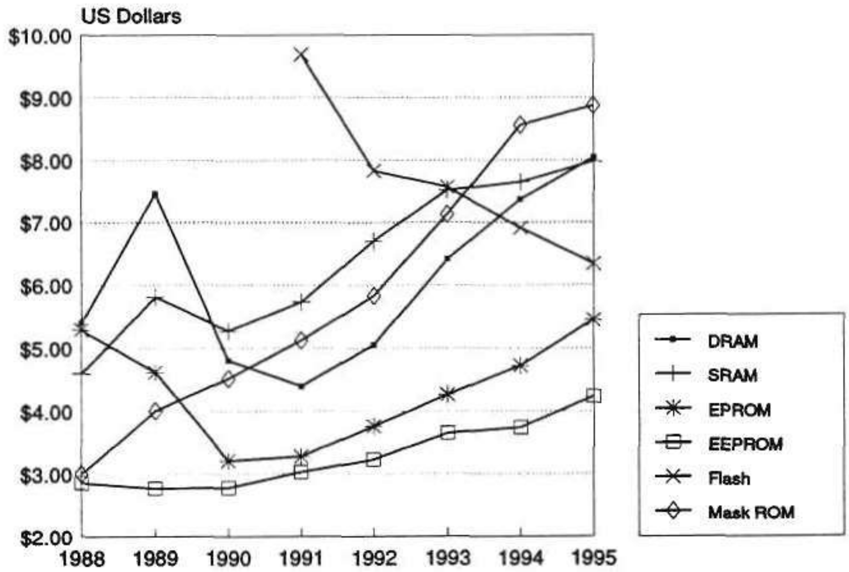
Estimated MOS Memory Unit Consumption in Europe



Source: Dataquest (March 1991)

Figure 2.2

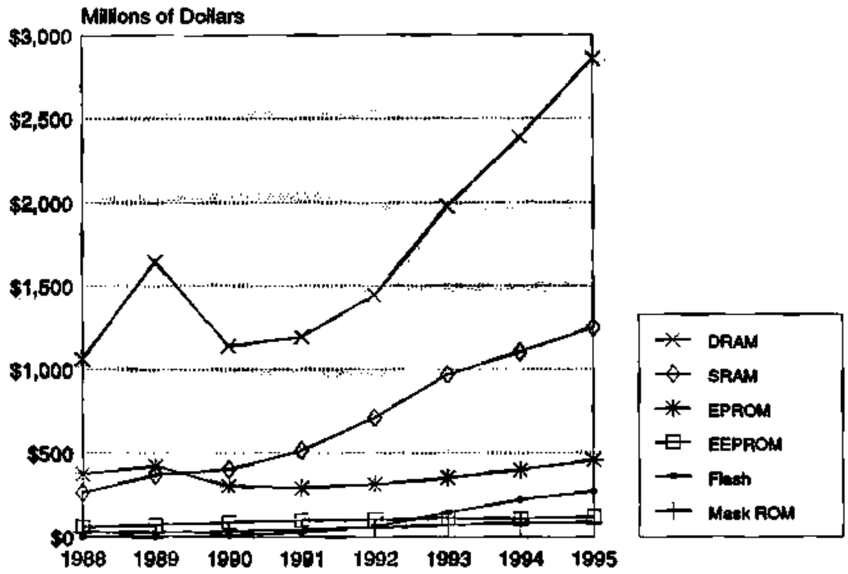
Estimated MOS Memory ASPs in Europe



Source: Dataquest (March 1991)

Figure 2.3

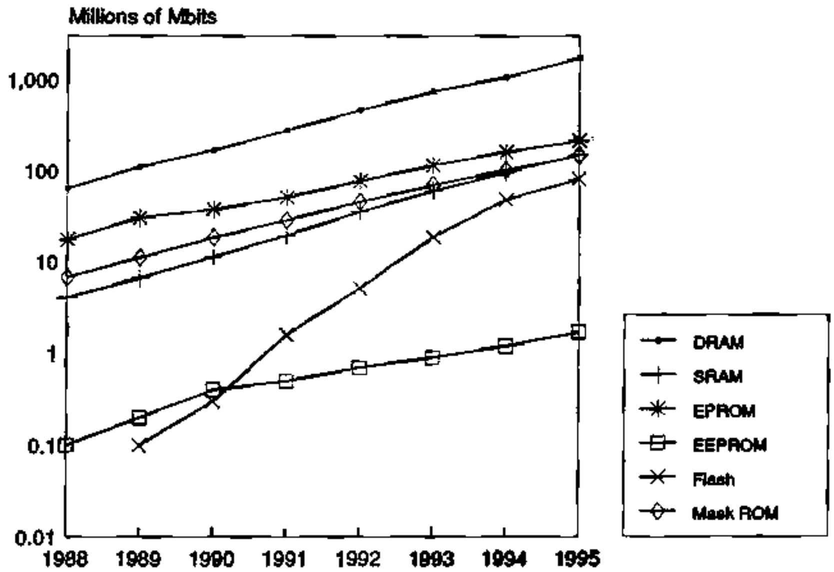
Estimated MOS Memory Market Size in Europe



Source: Dataquest (March 1991)

Figure 2.4

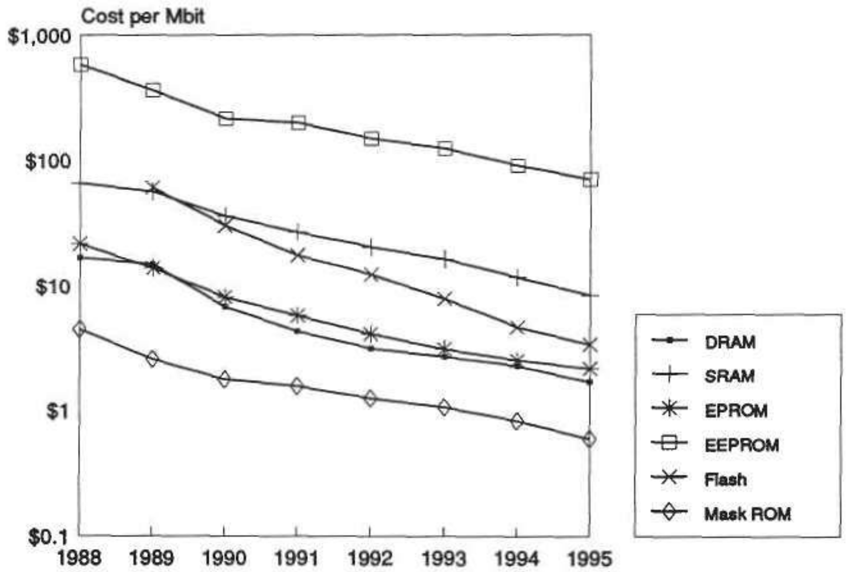
Estimated MOS Memory Mbit Consumption in Europe



Source: Dataquest (March 1991)

Figure 2.5

Estimated MOS Memory Cost per Mbit in Europe



Source: Dataquest (March 1991)

Chapter 3

DRAM

Analysis and Forecast

DRAM unit consumption grew by only 7.6 percent between 1989 and 1990. However, as ASPs declined by 35.7 percent, the value of this market declined by 30.7 percent. This has hurt many DRAM-dependent vendors. A reference price agreement between the European Commission and 11 Japanese DRAM manufacturers was made in the first quarter of 1990. (Reference prices are revised quarterly and cover all densities of DRAM.) Each participant agreed to abide by the same floor price, with the effect that market prices quickly adjusted to reference prices. As a result, Europe became the cheapest market worldwide for 1M DRAMs by the second quarter of 1990. By the first quarter of 1991, market prices increased with the reference price. For Dataquest analysis on the reference price agreement, see ESIS newsletters 1990-4 "European Commission DRAM Reference Price Agreement," 1990-17 "European Commission DRAM Reference Prices Behind the Scenes," and 1991-3 "European DRAM Price Hike."

Demand for the 4M DRAM generation is expected to take off in the second quarter of 1991. Japanese vendors have been slowing down 1M DRAM production since the third quarter of 1990 and increasing 4M DRAM production. The ratio between European market prices for the 4M DRAM and 1M DRAM crossed the 4:0 threshold early in the first quarter of 1991. Current worldwide leaders in 4M shipments are Hitachi and Toshiba.

The die-shrink version (or second generation) of the 4M has an outline the same as the 1M, making it a very attractive replacement for existing 1M users. European users are expected to request wide-organized versions of the 4M (for example, ×4, ×8, ×16) instead of the deep-organized version (i.e. ×1). This is because most popular applications do not require large volumes of memory, and will require instead the 4M to replace existing 1M applications.

North American, South Korean and European manufacturers are expected to take up much of the 1M business left behind by Japanese vendors. This should help drive continued price erosion as these companies are not yet restricted by DRAM reference prices.

Shipments of 256K DRAM are expected to decline as major DRAM vendors shut down production and manufacturers of equipment with long life cycles move to the 1M part. Prices of the 256K are forecast to stabilize early in 1991, followed by price increases as the part reaches obsolescence.

New European fabrication plants are planned by Texas Instruments, Fujitsu, Hitachi and Mitsubishi. These will supplement existing local production from Siemens, NEC and Motorola and will have the effect of reducing imports subject to duty, making floor price controls less effective. Benefits for any latecomers locating DRAM production in Europe are diminishing.

Local procurement of DRAMs for PC production in Europe is believed to account for 30 percent of total European consumption. European PC unit production is forecast to grow at a CAGR of 12.2 percent between 1990 and 1995, while the value of total semiconductor content per PC unit is expected to grow at a CAGR of 5 percent in the same period. Any changes in the European PC industry will have significant repercussions on the DRAM market.

Alliances between vendors have been made for the 16M and 64M generations in order to share the accelerating costs of development and manufacture. It is also becoming very important to get the fabrication technology right first time, as has been proved by the overwhelming success of Toshiba in the 1M market. There is no clear leader in the 4M DRAM market yet.

Application-specific DRAMs, such as video RAM and multiport DRAM, are gaining popularity in the end-user market. Total DRAM shipments represented 10.7 percent of the 1990 European semiconductor market in terms of revenue. This was despite severe price erosion, and is expected to increase to around 15 percent by 1995. The long-term outlook for the DRAM market is a CAGR of 18.9 percent in terms of revenue between 1990 and 1995.

The EDP application segment is estimated to be more than twice as large as communications, the next-largest segment. Strong investment from PC, workstation and printer manufacturers has driven local demand; furthermore, the average memory content of this equipment is increasing. Memory modules generally fall into the EDP segment and are a convenient form of main or optional memory. As much as 50 percent of all DRAMs consumed in the European market in 1990 were as mounted on memory modules. Demand from the communications equipment segment is expected to grow in 1991, but decline in the long term as domestic and export markets mature. Industrial and military applications are expected to see below-average growth as these are not memory-hungry segments.

Demand for DRAM in the UK and Irish market is expected to continue to grow because of its strong PC manufacturing base. Germany, the next-largest market, will also see above-average growth, although in the long term this region is expected to lose out to the UK and Irish market. The Nordic region and Italy are expected to decline due to unfavorable economic conditions and the relative weakness of their equipment industries. The rest of Europe will grow strongly.

European DRAM unit life cycles are shown in Figure 3.1. The 64K part is still experiencing a small and diminishing demand from the telecommunications sector. The 256K generation peaked in 1989 and is now in rapid decline. The 1M generation is expected to peak in units in 1991 and experience a slow decline in 1992 followed by more rapid decline in subsequent years. The 4M part is expected to overtake the 1M around 1993 with a peak in 1995. Production volumes of the 16M are expected in 1994.

Index of Tables and Figures—Chapter 3

Table 3.1

DRAM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
64K	21.0	12.1	10.9	6.6	3.0	2.0	1.0	0.2
256K	153.1	133.3	88.0	56.0	34.0	25.0	19.0	15.0
1M	22.7	75.0	136.3	192.0	182.0	145.0	110.0	85.0
4M	0.0	0.2	2.2	17.7	67.0	133.0	180.0	205.0
16M					0.2	3.5	14.0	50.0
64M								0.1
Total	196.8	220.6	237.4	272.3	286.2	308.5	324.0	355.3
ASP (Dollars)								
64K	$1.52	$1.89	$1.36	$1.41	$1.63	$1.67	$1.70	$1.80
256K	$3.59	$3.76	$2.09	$1.57	$1.77	$1.90	$2.00	$2.20
1M	$21.16	$14.71	$6.36	$4.48	$3.83	$3.45	$3.30	$3.00
4M	$200.00	$120.00	$33.59	$13.45	$9.78	$9.00	$8.30	$7.50
16M					$132.50	$65.00	$35.00	$20.00
64M								$300.00
Weighted Average	$5.40	$7.46	$4.80	$4.39	$5.05	$6.41	$7.37	$8.04
TAM (Millions of Dollars)								
64K	$32	$23	$15	$9	$5	$3	$2	$0
256K	550	501	184	88	60	48	38	33
1M	480	1,103	867	860	697	500	363	255
4M	0	19	74	238	655	1,197	1,494	1,538
16M					27	228	490	1,000
64M								30
Total	$1,062	$1,646	$1,140	$1,195	$1,444	$1,976	$2,387	$2,856
Terabits	63.2	110.5	168.3	277.6	462.1	739.5	1,058.9	1,715.3

TAM = Total Available Market
Source: Dataquest (March 1991)

Table 3.2

Estimated 1989 DRAM Market Shares in Europe (Millions of Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (%)	1989 Cum. Sum ($M)	1989 Market Share (%)	1989 Cum. Sum (%)
5	1	4	Siemens	114	338	196.5%	338	20.5%	20.5%
1	2	-1	Toshiba	170	186	9.4%	524	11.3%	31.8%
2	3	-1	Texas Instruments	160	175	9.4%	699	10.6%	42.5%
4	4	0	Samsung	120	170	41.7%	869	10.3%	52.8%
3	5	-2	NEC	156	165	5.8%	1,034	10.0%	62.8%
6	6	0	Hitachi	105	121	15.2%	1,155	7.4%	70.2%
8	7	1	Mitsubishi	47	91	93.6%	1,246	5.5%	75.7%
7	8	-1	Fujitsu	73	80	9.6%	1,326	4.9%	80.6%
11	9	2	Matsushita (Panasonic)	22	67	204.5%	1,393	4.1%	84.6%
14	10	4	Micron Technology	2	55	2,650.0%	1,448	3.3%	88.0%
10	11	-1	NMB	30	51	70.0%	1,499	3.1%	91.1%
12	12	0	Motorola	17	47	176.5%	1,546	2.9%	93.9%
9	13	-4	Oki Electric	30	39	30.0%	1,585	2.4%	96.3%
-	14	NA	Sharp	-	5	NA	1,590	0.3%	96.6%
-	15	NA	Goldstar	-	4	NA	1,594	0.2%	96.8%
13	16	-3	Intel	8	3	-62.5%	1,597	0.2%	97.0%
15	-	NA	Inmos	2	-	-100.0%	NA	NA	NA
16	-	NA	STC Components	1	-	-100.0%	NA	NA	NA
			European Others	2	-	-100.0%	NA	NA	NA
			North American Others	-	2	NA	1,599	0.1%	97.1%
			Japanese Others	-	38	NA	1,637	2.3%	99.5%
			Rest of World Others	3	9	200.0%	1,646	0.5%	100.0%
			Total All Companies	1,062	1,646	55.0%	NA	100.0%	NA
			Total European	119	338	184.0%	NA	20.5%	NA
			Total North American	187	282	50.8%	NA	17.1%	NA
			Total Japanese	633	843	33.2%	NA	51.2%	NA
			Total Rest of World	123	183	48.8%	NA	11.1%	NA

NA = Not Applicable
Source: Dataquest (March 1991)

Table 3.3

Estimated DRAM Consumption by Application Segment in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Application	1990	1991	1995	1990-91	1990-95	1990	1991	1995
EDP	$604	$621	$1,542	2.8	20.6	53	52	54
Communications	228	251	514	10.1	17.7	20	21	18
Industrial	160	155	343	(3.1)	16.5	14	13	12
Consumer	57	72	200	26.3	28.5	5	6	7
Military	57	60	114	5.3	14.9	5	5	4
Transport	34	36	143	5.9	33.3	3	3	5
Total	$1,140	$1,195	$2,856	4.8	20.2	100	100	100

AGR= Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Table 3.4

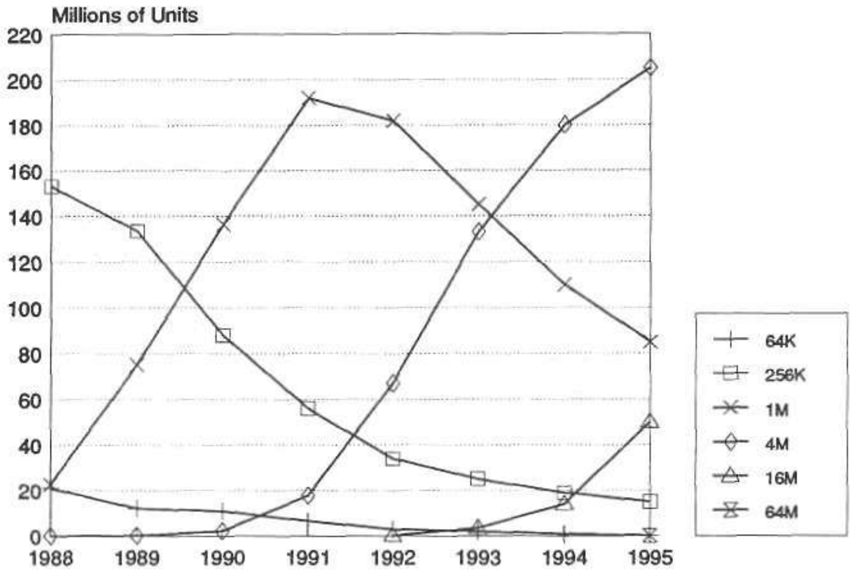
Estimated DRAM Consumption by Region in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Region	1990	1991	1995	1990-91	1990-95	1990	1991	1995
Benelux	$34	$36	$86	5.9	20.4	3	3	3
France	171	143	371	(16.4)	16.8	15	12	13
Italy	148	131	286	(11.5)	14.1	13	11	10
Nordic	80	72	114	(10.0)	7.3	7	6	4
UK and Ireland	388	430	1,057	10.8	22.2	34	36	37
Germany	251	299	685	19.1	22.2	22	25	24
Rest of Europe	68	84	257	23.5	30.5	6	7	9
Total	$1,140	$1,195	$2,856	4.8	20.2	100	100	100

AGR= Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Figure 3.1

DRAM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 4

Total SRAM

Analysis and Forecast

The European SRAM market saw an 18.3 percent growth in units between 1989 and 1990. In contrast to other MOS memory products, ASP erosion was relatively minor at 8.2 percent, leading to a growth of 8.7 percent in the value of the market.

Dataquest divides the SRAM market into three performance categories defined as follows:

- Slow SRAM—access speeds of 70ns and slower
- Fast SRAM—access speeds below 70ns and above 25ns
- Very fast SRAM—access speeds 25ns and faster

In general, cost increases with the speed of the SRAM. Users of SRAMs in these categories have unique requirements for their particular speed, which is determined by the performance of the end equipment. SRAM vendors cater for these groups of users by specializing in one or two SRAM categories only. Consequently, each SRAM speed category has a different base of suppliers and end users, but there is some overlap between adjacent categories.

Slow SRAM accounted for 62.0 percent of the total SRAM market value in 1990. Fast SRAM accounted for 15.2 percent, very fast SRAM accounted for 17.5 percent, and PSRAM accounted for 5.3 percent. One of the key benefits of SRAM over DRAM, apart from access speed, is the availability of low-power operation and standby modes. This is important for portable applications, and is expected to be one of the key drivers behind the growth of this market. SRAM lags behind DRAM in terms of maximum bit density due to its greater cell complexity. Slow SRAM lags behind by one generation, while fast and very fast SRAMs lag by two generations. The long-term outlook for the value of the SRAM market is a strong CAGR of 25.6 percent between 1990 and 1995.

The European SRAM market is dominated by slow SRAM end users. These users perceive low-power operation as a key benefit for use in portable equipment or in areas where the memory refresh required by DRAM presents too much overhead. These types of equipment are primarily EDP- and communications-oriented. EDP is expected to increase with local production and demand for laptop PCs and games machines. The demand for communications will also grow above average in the long term, with demand coming from export markets for cellular telephone base stations and PBX. Military demand is expected to rise as the 256K SRAM achieves military qualification. Transportation applications are also in strong growth, albeit from a small base, with demand for buffering.

The UK and Irish market is the largest for SRAM and DRAM, primarily due to the strong EDP manufacturing base in this region. Above-average growth is expected to increase this region's share of the European SRAM market. Germany, the next-largest market, has a strong industrial and communications sector, but below-average growth is forecast for SRAM. Other regions are expected to experience long-term average growth.

Total European SRAM life cycles are shown in Figure 4.1. This figure is dominated by products from the slow SRAM category due to its large representation. However, higher-speed SRAMs have sustained shipments of the 64K part during its decline and boosted shipments of the 256K during its ramp up.

Index of Tables and Figures—Chapter 4

Table 4.1

SRAM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
1K	0.2							
4K	0.9	0.6	0.4	0.3	0.1			
16K	22.7	17.9	14.8	11.7	8.0	5.4	4.0	3.2
64K	23.5	25.6	26.1	24.8	23.4	19.7	16.0	13.0
256K	8.3	17.0	28.5	39.4	48.9	53.4	51.5	47.9
1M		0.3	2.1	7.5	20.0	40.2	54.2	61.9
4M					0.2	1.1	6.5	18.7
Total	55.6	61.4	71.9	83.7	100.6	119.8	132.2	144.7
PSRAM	0.3	0.5	1.4	3.5	5.9	7.6	8.4	10.2
Total	55.9	61.9	73.3	87.2	106.5	127.4	140.6	154.9
ASP (Dollars)								
1K	$5.00							
4K	$3.33	$3.33	$2.50	$3.33				
16K	$2.73	$2.46	$2.23	$1.97	$2.25	$2.59	$2.75	$2.50
64K	$4.17	$4.65	$3.52	$3.15	$3.08	$3.10	$3.06	$3.00
256K	$10.98	$9.53	$6.21	$5.51	$4.93	$4.27	$3.86	$3.55
1M		$100.00	$37.07	$21.48	$16.25	$13.36	$10.77	$9.60
4M					$90.00	$58.10	$25.85	$18.34
Weighted Average	$4.59	$5.81	$5.27	$5.73	$6.70	$7.52	$7.65	$7.98
PSRAM	$23.33	$22.00	$15.00	$9.71	$6.44	$8.95	$11.07	$9.41
Weighted Average	$4.69	$5.95	$5.46	$5.89	$6.69	$7.61	$7.85	$8.07
TAM (Millions of Dollars)								
1K	$1							
4K	3	$2	$1	$1				
16K	62	44	33	23	$18	$14	$11	$8
64K	98	119	92	78	72	61	49	39
256K	91	162	177	217	241	228	199	170
1M		30	76	160	325	537	584	594
4M					18	61	168	343
Total	$255	$357	$379	$479	$674	$901	$1,011	$1,154
PSRAM	$7	$11	$21	$34	$38	$68	$93	$96
Total	$262	$368	$400	$513	$712	$969	$1,104	$1,250
Terabits	4.0	6.6	11.3	19.3	34.9	59.4	94.5	149.8

TAM = Total Available Market
Source: Dataquest (March 1991)

Table 4.2

Estimated 1989 SRAM Market Shares in Europe (Millions of Dollars)

1988 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (%)	1989 Cum. Sum ($M)	1989 Market Share (%)	1989 Cum. Sum (%)
7	1	6	NEC	15	55	266.7%	55	14.9%	14.9%
11	2	9	SGS-Thomson	10	49	390.0%	104	13.3%	28.3%
1	3	-2	Toshiba	41	39	-4.9%	143	10.6%	38.9%
2	4	-2	Hitachi	21	39	85.7%	182	10.6%	49.5%
3	5	-2	Matra MHS	20	28	40.0%	210	7.6%	57.1%
16	6	10	Sony	5	26	420.0%	236	7.1%	64.1%
12	7	5	Fujitsu	10	20	100.0%	256	5.4%	69.6%
8	8	0	AMD	13	18	38.5%	274	4.9%	74.5%
4	9	-5	IDT	20	14	-30.0%	288	3.8%	78.3%
14	10	4	Cypress	8	12	50.0%	300	3.3%	81.5%
21	11	10	Motorola	3	12	300.0%	312	3.3%	84.8%
13	12	1	Samsung	8	10	25.0%	322	2.7%	87.5%
10	13	-3	Mitsubishi	11	9	-18.2%	331	2.4%	89.9%
-	14	NA	Micron Technology	-	5	NA	336	1.4%	91.3%
15	15	0	Sharp	6	4	-33.3%	340	1.1%	92.4%
20	16	4	Oki Electric	3	4	33.3%	344	1.1%	93.5%
22	17	5	Philips	2	3	50.0%	347	0.8%	94.3%
24	18	6	MEDL*	1	3	200.0%	350	0.8%	95.1%
6	19	-13	National Semiconductor	16	1	-93.8%	351	0.3%	95.4%
19	20	-1	Harris	4	1	-75.0%	352	0.3%	95.7%
23	21	2	VLSI Technology	1	1	0.0%	353	0.3%	95.9%
-	22	NA	Sanyo	-	1	NA	354	0.3%	96.2%
5	-	NA	Inmos	17	-	-100.0%	NA	NA	NA
9	-	NA	Seiko Epson	11	-	-100.0%	NA	NA	NA
17	-	NA	GE Solid State	5	-	-100.0%	NA	NA	NA
18	-	NA	Intel	4	-	-100.0%	NA	NA	NA
25	-	NA	Goldstar	1	-	-100.0%	NA	NA	NA
			European Others						
			North American Others	-	4	NA	358	1.1%	97.3%
			Japanese Others						
			Rest of World Others	6	10	66.7%	368	2.7%	100.0%
			Total All Companies	262	368	40.5%	NA	100.0%	NA
			Total European	50	83	66.0%	NA	22.6%	NA
			Total North American	74	68	-8.1%	NA	18.5%	NA
			Total Japanese	123	197	60.2%	NA	53.5%	NA
			Total Rest of World	15	20	33.3%	NA	5.4%	NA

* MEDL - Marconi Electronic Devices
Source: Dataquest (March 1991)

Table 4.3

Estimated SRAM Consumption by Application Segment in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Application	1990	1991	1995	1990-91	1990-95	1990	1991	1995
EDP	$156	$210	$536	34.6	28.0	39	41	43
Communications	104	123	263	18.3	20.4	26	24	21
Industrial	64	77	150	20.3	18.6	16	15	12
Consumer	36	41	113	13.9	25.7	9	8	9
Military	24	36	100	50.0	33.0	6	7	8
Transport	16	26	88	62.5	40.6	4	5	7
Total	$400	$513	$1,250	28.3	25.6	100	100	100

AGR= Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Table 4.4

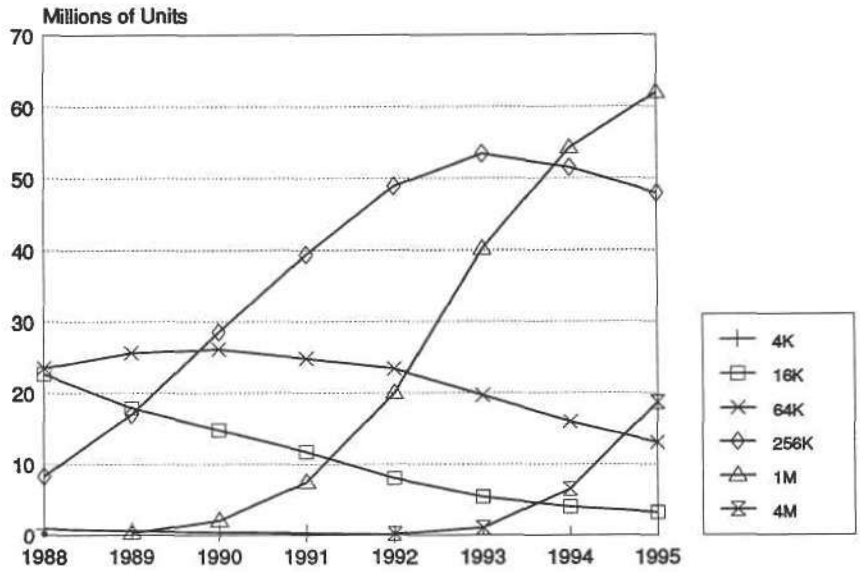
Estimated SRAM Consumption by Region in Europe (Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Region	1990	1991	1995	1990-91	1990-95	1990	1991	1995
Benelux	$20	$26	$75	30.0	30.3	5	5	6
France	64	87	200	35.9	25.6	16	17	16
Italy	48	56	125	16.7	21.1	12	11	10
Nordic	24	31	75	29.2	25.6	6	6	6
UK and Ireland	112	149	375	23.1	23.7	28	29	30
Germany	104	128	312	33.3	28.3	26	25	25
Rest of Europe	28	36	88	28.6	25.7	7	7	7
Total	$400	$513	$1,250	28.3	25.6	100	100	100

AGR= Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Figure 4.1

SRAM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 5

Slow SRAM

(Access Speeds of 70ns and Slower)

Analysis and Forecast

Slow SRAM unit consumption grew by 18.1 percent between 1989 and 1990. ASPs declined by 9.1 percent, resulting in a marginal 8.0 percent increase in the value of this market. But, the slow SRAM market is expected to pick up strongly in the medium term as production of laptop PCs, games machines, and other portable equipment moves into Europe. Low-power operation and standby modes will be important to the successful application of slow SRAM in these segments. The thin, small, outline package (TSOP) is expected to be the preferred option for this device because of its small volume.

Further applications for slow SRAM include telephone handsets, incorporating memories with battery backup, low-end printers with user-configurable settings, and hand-held calculator memories. Memory cards are another important long-term growth application for slow SRAM. Low-power SRAM with battery backup is expected to provide a portable data storage solution in many different segments. The TSOP and the development of even smaller packages are expected to allow memory cards to reach impressive minimum dimensions.

The expected development of slow SRAMs, which operate on a 3-volt supply, will encourage the take-up of this product in all battery-operated enviroments. Once this standard is introduced, it is likely to be adopted for many other semiconductor devices for which portable applications represent a large potential market. It is surprising that power supply standards for batteries and semiconductors have not been reconciled before now.

Military users prefer slow SRAM over DRAM because of its greater inherent stability. Demand from this segment is generally for silicon-on-sapphire (SOS), sub-256K densities, although 256K slow SRAM is believed to be at the qualification stage.

Some large SRAM vendors are running down production below the 1M density, which may cause some shortages in the short term. This is believed to be related to requests by MITI for Japanese vendors to prevent prices falling, although some of these vendors will probably phase out these products. This will create opportunities for new entrants in the commercial slow SRAM market.

Pseudo SRAM remains a niche market. The product is based on a DRAM cell architecture and offers similar access speeds and densities to DRAM, but does not require multiplexed addressing. Its applications are limited to DRAM replacement when non-multiplexed addressing or low standby current is a benefit.

In 1990, 19 vendors were active in the European slow SRAM market. This market was worth an estimated $269 million, which translates into an average revenue per company of $14.2 million, indicating overpopulation in the supply base. Fallout is expected to continue as a result of this, leaving behind only innovative niche players and strong, broadly based commodity suppliers. The European Commission will probably be asked to protect local SRAM suppliers from potential dumping by introducing reference prices. This has already been done for DRAM and EPROM products.

Life cycles for the slow SRAM market in Europe are shown in Figure 5.1. The 16K and 64K densities are in decline, while the 256K and 1M parts are in ramp-up phase. The 256K is expected to peak in 1993, around the time the 4M is introduced. The slow SRAM market is expected to experience a CAGR of 28.4 percent between 1990 and 1995.

Index of Tables and Figures—Chapter 5

Table 5.1

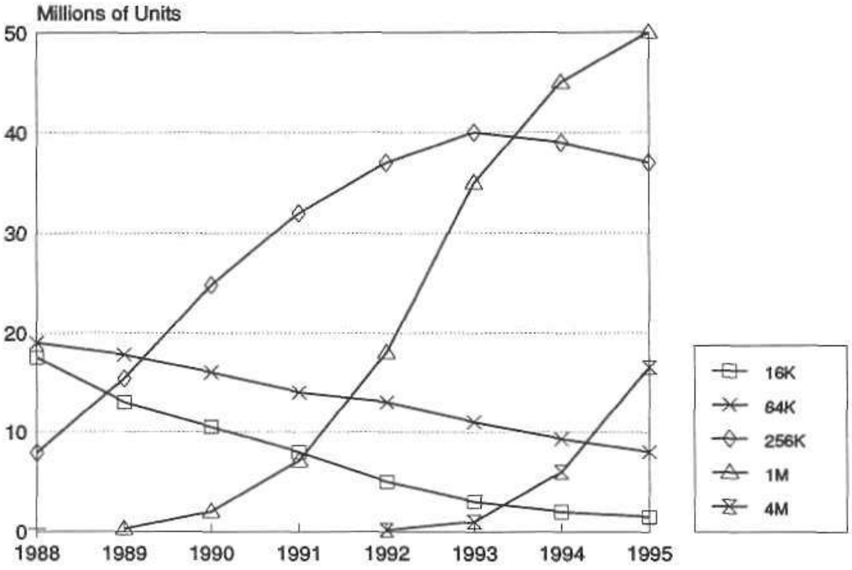
Slow SRAM Consumption Forecast in Europe
(Access Speeds of 70ns and Slower)

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
4K	0.3							
16K	17.5	13.0	10.5	8.0	5.0	3.0	2.0	1.5
64K	19.0	17.8	16.0	14.0	13.0	11.0	9.3	8.0
256K	7.9	15.4	24.8	32.0	37.0	40.0	39.0	37.0
1M		0.3	2.0	7.1	18.0	35.0	45.0	50.0
4M					0.2	1.0	6.0	16.5
Total	44.7	46.5	53.3	61.1	73.2	90.0	101.3	113.0
PSRAM	0.3	0.5	1.4	3.5	5.9	7.6	8.4	10.2
Total	45.0	47.0	54.7	64.6	79.1	97.6	109.7	123.2
ASP (Dollars)								
4K	$2.04							
16K	$2.38	$2.00	$1.80	$1.50	$1.70	$1.90	$2.10	$2.30
64K	$3.03	$3.50	$2.20	$1.80	$1.95	$2.10	$2.35	$2.55
256K	$8.90	$7.80	$5.00	$4.20	$3.50	$3.00	$2.90	$2.80
1M		$100.00	$35.00	$20.00	$14.00	$11.50	$9.00	$8.40
4M				$250.00	$90.00	$57.00	$25.00	$18.00
Weighted Average	$3.83	$5.12	$4.65	$5.12	$5.93	$6.77	$6.85	$7.47
PSRAM	$23.66	$21.47	$14.89	$9.80	$6.52	$8.93	$11.09	$9.40
Weighted Average	$3.96	$5.30	$4.92	$5.37	$5.97	$6.94	$7.17	$7.63
TAM (Millions of Dollars)								
4K	$1							
16K	42	$26	$19	$12	$9	$6	$4	$3
64K	58	62	35	25	25	23	22	20
256K	70	120	124	134	130	120	113	104
1M		30	70	142	252	403	405	420
4M					18	57	150	297
Total	$171	$238	$248	$313	$434	$609	$694	$844
PSRAM	$7	$11	$21	$34	$38	$68	$93	$96
Total	$178	$249	$269	$347	$472	$677	$787	$940
Terabits	3.5	5.6	9.5	16.3	29.2	50.0	79.6	126.0

TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 5.1

Slow SRAM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 6

Fast SRAM

(Access Speeds of Below 70ns and Above 25ns)

Analysis and Forecast

The value of the European fast SRAM market was estimated at $61 million in 1990, declining by 16.4 percent from 1989. This decline was the result of ASP erosion of 19.1 percent and a mediocre unit growth of 3.2 percent. Vendors in this segment are a mixture of broad-based suppliers entering from the commodity slow SRAM sector, and specialized suppliers maintaining leading-edge proprietary fast and very fast SRAM products. These two groups of vendors differ in their fundamental strategies. The former group targets large-volume users with low-cost commodity products, while the latter targets niche markets offering products with high-cost premiums.

Strong competition is expected in the medium term from South Korean and other Far Eastern vendors, carrying on from their success in the slow SRAM market. These vendors are following the Japanese, who have succeeded in entering the market dominated by North American players. In general, users in Europe are less likely to source advanced proprietary SRAMs than their North American counterparts, preferring instead to source lower-performance commodity parts. This has led to a number of specialized suppliers seeking second-source agreements in order to instill confidence in European users.

Applications for fast SRAM include buffering for automotive microcontrollers, cache memory for high-end PCs and RISC workstations, main memory in high-end minicomputers, buffering of data in telecommunications and military equipment, and DSP applications. Low-power versions are also required for high-end laptop PC applications. A proportion of the market is catered for with substandard very fast SRAMs. These are functionally acceptable for fast applications. This means that some niche, very fast SRAM players occasionally compete against fast SRAM players. However, this is not believed to significantly affect the stability of the market.

The long-term market outlook is a reasonable but below-average CAGR of 9.5 percent for the period of 1990 to 1995. This low growth is in part a result of the migration of speed barriers. Improving SRAM access speeds and declining prices will eventually attract users out of one category into another.

The life cycles of European fast SRAMs are shown in Figure 6.1. The market is currently dominated by the 64K density. The 16K part is in decline, and is now being overtaken by the 256K in its ramp-up phase. The 1M part has now been introduced.

Index of Tables and Figures—Chapter 6

Table 6.1

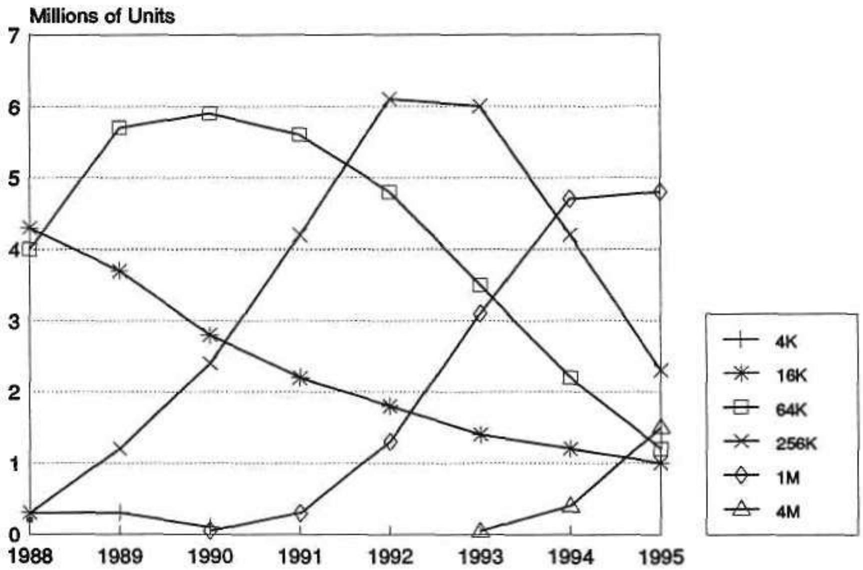
Fast SRAM Consumption Forecast in Europe (Access Speeds of Below 70ns and Above 25ns)

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
1K	0.2							
4K	0.3	0.3	0.1					
16K	4.3	3.7	2.8	2.2	1.8	1.4	1.2	1.0
64K	4.0	5.7	5.9	5.6	4.8	3.5	2.2	1.2
256K	0.3	1.2	2.4	4.2	6.1	6.0	4.2	2.3
1M			0.1	0.3	1.3	3.1	4.7	4.8
4M						0.1	0.4	1.5
Total	9.1	10.9	11.3	12.3	14.0	14.1	12.7	10.8
ASP (Dollars)								
1K	$3.40							
4K	$2.89	$2.91	$2.94	$2.99	$3.04			
16K	$3.55	$3.20	$3.00	$2.50	$2.80	$3.15	$3.50	$3.20
64K	$8.05	$6.00	$3.70	$3.30	$3.10	$3.00	$3.20	$3.40
256K	$45.00	$22.00	$10.50	$7.00	$6.30	$5.00	$4.70	$4.30
1M			$120.00	$45.00	$26.00	$20.00	$14.00	$11.00
4M					$160.00	$75.00	$30.00	$17.00
Weighted Average	$6.92	$6.70	$5.42	$5.45	$6.57	$7.90	$8.58	$8.89
TAM (Millions of Dollars)								
1K	$1							
4K	1	$1	$0					
16K	15	12	8	$6	$5	$4	$4	$3
64K	32	34	22	18	15	11	7	4
256K	14	26	25	29	38	30	20	10
1M			6	14	34	62	66	53
4M						4	12	26
Total	$63	$73	$61	$67	$92	$111	$109	$96
Terabits	0.4	0.7	1.1	1.8	3.2	5.1	7.5	11.5

TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 6.1

Fast SRAM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 7

Very Fast SRAM

(Access Speeds of 25ns and Faster)

Analysis and Forecast

The very fast SRAM market grew by 82.5 percent in terms of units between 1989 and 1990. A decline of 16.6 percent in ASPs led to a very reasonable growth of 52.2 percent in the value of the market, albeit from a small base. Very fast SRAM vendors are typically specialized North American start-ups. Their products employ innovative proprietary technologies and often use external foundries for volume production. This has enabled these companies to minimize their capital investment and maintain high levels of profitability that can be used to fund leading-edge technologies.

Small North American vendors are dominant in the very fast SRAM market and a high proportion of their worldwide sales is in the United States. This means that their presence in Europe is relatively low and consequently, a large amount of their business is performed via distribution. This limits vendor–user relationships, and may explain why European users are less likely to design in very fast SRAM than their North American counterparts. However, as the market growth indicates, this situation is expected to change.

Japanese fast SRAM vendors are expected to target the very fast SRAM market in the near future. This will encourage price erosion and attract new users. The very fast SRAM market has grown quickly from a small base and overtook the fast SRAM market value in 1990. But, due to the higher ASPs of very fast SRAMs, this market is half the size of the fast SRAM market in terms of bit shipments. The very fast SRAM market is expected to overtake the fast SRAM in terms of capacity by 1995.

The main application for very fast SRAMs is cache memory in very high-end, zero-wait-state systems. These include RISC workstations, superminicomputers and dedicated high-performance commercial and military systems. The value of the very fast SRAM market is expected to grow at a CAGR of 25.0 percent between 1990 and 1995.

Life cycles of European very fast SRAM are shown in Figure 7.1. The 64K part dominates the market and is expected to peak in 1992 when it will be overtaken by the 256K part in its ramp-up phase. The 16K part is still popular, although it has now matured. The 1M and 4M parts will be introduced in 1991 and 1994, respectively.

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Table 7.1

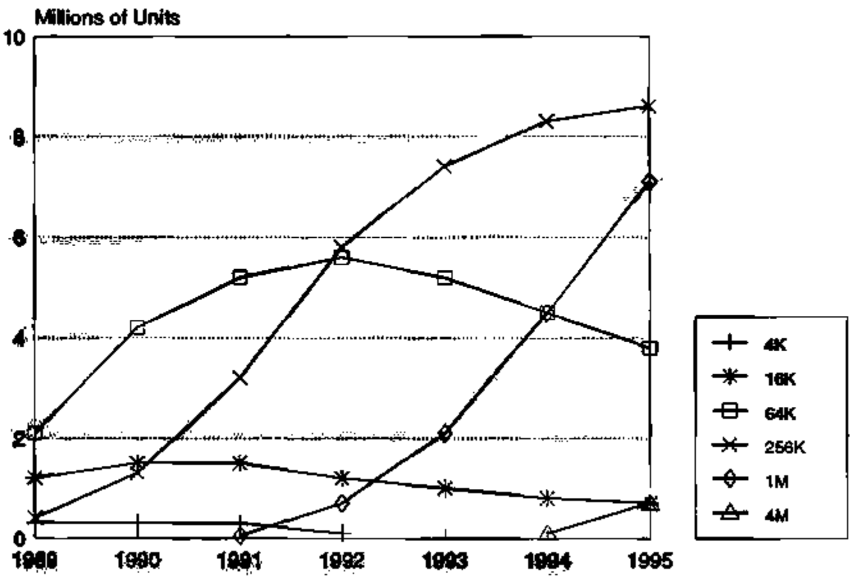
Very Fast SRAM Consumption Forecast in Europe (Access Speeds of 25ns and Faster)

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
4K	0.3	0.3	0.3	0.3	0.1			
16K	0.9	1.2	1.5	1.5	1.2	1.0	0.8	0.7
64K	0.5	2.1	4.2	5.2	5.6	5.2	4.5	3.8
256K	0.1	0.4	1.3	3.2	5.8	7.4	8.3	8.6
1M				0.1	0.7	2.1	4.5	7.1
4M							0.1	0.7
Total	1.8	4.0	7.3	10.3	13.4	15.7	18.2	20.9
ASP (Dollars)								
4K	$3.22	$3.04	$3.01	$3.01	$3.05	$3.15	$3.25	$3.25
16K	$5.14	$4.76	$3.89	$3.52	$3.40	$3.72	$3.49	$3.35
64K	$16.23	$10.74	$8.22	$6.80	$5.80	$5.20	$4.45	$4.00
256K	$82.17	$39.88	$21.50	$16.80	$12.50	$10.60	$8.00	$6.50
1M				$84.82	$55.00	$34.50	$25.00	$17.00
4M						$185.00	$57.00	$28.00
Weighted Average	$11.73	$11.50	$9.59	$9.66	$11.04	$11.53	$11.43	$10.24
TAM (Millions of Dollars)								
4K	$1	$1	$1	$1	$0			
16K	5	6	6	5	4	$4	$3	$2
64K	8	23	35	35	32	27	20	15
256K	7	16	28	54	73	78	66	56
1M				4	39	72	113	121
4M							6	20
Total	$21	$46	$70	$99	$148	$181	$208	$214
Terabits	0.1	0.3	0.6	1.2	2.6	4.3	7.3	12.4

TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 7.1

Very Fast SRAM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 8

Total Nonvolatile

Analysis and Forecast

The nonvolatile MOS memory market saw a 6.6 percent growth in units between 1989 and 1990. This growth was balanced against a 23.8 percent decline in ASPs, resulting in a sharp 18.8 percent decline in the value of the market. This decline is mainly attributable to the ASP erosion of EPROM. EPROM products represented 70 percent of the nonvolatile memory market in 1990, even after severe price erosion and mediocre unit growth.

The market for nonvolatile MOS memory has always been quite different from the market for DRAM and SRAM memory. This is because with the benefit of nonvolatility comes penalties in speed, density, user-programmability, endurance, or cost, when compared with volatile memory. The introduction of the EEPROM in the early 1980s was promoted to end such limitations, but it still failed in several categories. The latest hopeful contender is flash memory. This product is expected to perform well on density and cost, but its performance on speed and endurance is still questionable.

Typical end users for nonvolatile memory are either those who require little or no user-programmability, or those who require nonvolatility together with user-programmability, and who are able to justify the high cost this brings. EDP accounts for the majority of nonvolatile MOS memory consumption; it is expected to increase this share in the long term. Flash memory in particular promises to boost demand from this segment. Communications and industrial, the next-largest application segments, are expected to grow below average. This is only because other application segments, especially EDP, are growing so strongly.

The largest market for nonvolatile MOS memory is the UK and Ireland region, due to its strong EDP and communications manufacturing base, and its increasing share of the European market. Germany, the next-largest market, is also strong in growth. Other regions are expected to experience an average growth rate in the long term. The long-term outlook for nonvolatile MOS memory is a 16.3 percent CAGR between 1990 and 1995.

European nonvolatile MOS memory life cycles are shown in Figure 8.1. The figure is dominated by EPROM products, which represent the majority of nonvolatile unit shipments. However, it is notable that EEPROM products extend the decline phase of each density and flash memory accelerates the ramp-up phase of each new density.

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Table 8.1

Nonvolatile MOS Memory Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
<1K	4.0	3.9	3.4	3.0	2.8	2.5	2.2	2.0
1K	9.9	11.3	12.0	11.0	9.0	7.0	5.5	4.0
2K	1.8	2.8	3.8	4.5	4.7	4.2	3.7	3.2
4K	2.0	4.0	6.0	7.2	7.3	7.1	6.7	6.0
16K	3.1	3.6	4.0	4.0	4.0	3.6	3.1	2.7
32K	3.1	2.9	2.9	2.1	1.6	1.5	1.1	0.9
64K	17.0	15.4	12.9	11.6	10.4	9.2	8.9	8.2
128K	12.5	11.3	10.5	7.6	5.6	4.8	3.7	2.7
256K	29.2	35.0	32.8	30.4	27.9	26.4	22.9	20.9
512K	12.9	20.1	22.3	20.9	17.3	15.0	14.8	13.2
1M	4.8	11.9	17.3	19.2	19.6	21.1	22.0	21.2
2M	0.2	0.5	1.8	4.3	8.4	13.8	20.0	24.7
4M	0.5	1.5	2.3	5.9	11.7	21.2	33.4	41.8
8M		0.1	0.5	1.0	1.9	2.6	3.8	7.1
16M				0.1	0.5	1.2	2.1	3.4
32M					0.1	0.4	0.9	1.5
64M							0.1	0.5
Total	101.0	124.3	132.5	132.8	132.8	141.6	154.9	163.9
ASP (Dollars)								
<1K	$0.75	$0.77	$0.59	$0.67	$0.71	$0.80	$0.45	$0.50
1K	$1.11	$0.97	$1.00	$1.09	$1.11	$1.14	$1.09	$1.25
2K	$2.78	$2.50	$2.11	$2.22	$2.34	$2.38	$2.43	$2.5
4K	$4.50	$4.00	$3.83	$3.33	$3.15	$2.96	$2.99	3.17
16K	$4.49	$3.61	$3.25	$3.00	$3.25	$3.33	$3.23	$3.33
32K	$3.23	$3.10	$2.41	$2.38	$3.13	$3.33	$3.64	$3.33
64K	$4.12	$3.70	$2.79	$3.28	$3.65	$4.13	$4.27	$4.02
128K	$3.92	$3.19	$2.00	$2.24	$2.68	$3.13	$3.24	$3.33
256K	$4.62	$3.37	$2.10	$2.01	$2.29	$2.73	$2.93	$2.83
512K	$6.82	$5.17	$4.04	$3.06	$3.06	$3.99	$4.05	$3.71
1M	$10.83	$9.98	$5.83	$5.20	$5.10	$5.26	$5.04	$4.86
2M	$5.00	$12.00	$7.20	$7.53	$6.41	$6.31	$6.00	$5.38
4M	$10.00	$7.33	$6.67	$8.81	$7.86	$6.84	$6.47	$6.08
8M		$10.00	$10.00	$9.00	$7.37	$8.08	$11.55	$15.18
16M				$30.00	$22.00	$18.33	$15.24	$15.25
32M					$40.00	$30.00	$22.22	$16.67
64M							$40.00	$28.00
Weighted Average	$4.47	$4.11	$3.13	$3.32	$3.83	$4.53	$5.00	$5.39

(Continued)

Table 8.1 (Continued)

Nonvolatile MOS Memory Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
TAM (Millions of Dollars)								
<1K	$3	$3	$2	$2	$2	$2	$1	$1
1K	11	11	12	12	10	8	6	5
2K	5	7	8	10	11	10	9	8
4K	9	16	23	24	23	21	20	19
16K	14	13	13	12	13	12	10	9
32K	10	9	7	5	5	5	4	3
64K	70	57	36	38	38	38	38	33
128K	49	36	21	17	15	15	12	9
256K	135	118	69	61	64	72	67	59
512K	88	104	90	64	53	60	60	49
1M	52	119	101	100	100	111	111	103
2M	1	6	13	32	54	87	120	133
4M	5	11	15	52	92	145	216	254
8M		1	5	9	14	21	44	107
16M				3	11	22	32	52
32M					4	12	20	25
64M							4	14
Total	$452	$511	$415	$441	$509	$641	$774	$883
Terabits	24.1	41.6	56.1	81.3	127.2	202.1	309.5	441.9

Source: Dataquest (March 1991)

Table 8.2

Estimated 1989 Nonvolatile MOS Memory Market Shares in Europe

1988 Rank	1989 Rank	Change In Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1988-89 Annual Growth (%)	1989 Cum. Sum ($M)	1989 Market Share (%)	1989 Cum. Sum (%)
1	1	0	Intel	85	99	16.5%	99	19.1%	19.1%
2	2	0	SGS-Thomson	74	80	8.1%	179	15.4%	34.5%
3	3	0	Texas Instruments	56	75	33.9%	254	14.5%	48.9%
5	4	1	AMD	43	52	20.9%	306	10.0%	59.0%
9	5	4	National Semiconductor	14	29	107.1%	335	5.6%	64.5%
7	6	1	Toshiba	17	22	29.4%	357	4.2%	68.8%
6	7	-1	Fujitsu	19	20	5.3%	377	3.9%	72.6%
11	8	3	Philips	12	17	41.7%	394	3.3%	75.9%
17	9	8	Sharp	4	13	225.0%	407	2.5%	78.4%
4	10	-6	NEC	52	12	-76.9%	419	2.3%	80.7%
12	11	1	Hitachi	12	12	0.0%	431	2.3%	83.0%
-	12	NA	ITT	-	9	NA	440	1.7%	84.8%
13	13	0	Cypress	8	7	-12.5%	447	1.3%	86.1%
-	14	NA	Samsung	-	6	NA	453	1.2%	87.3%
15	15	0	Oki Electric	5	5	0.0%	458	1.0%	88.2%
10	16	-6	Mitsubishi	13	4	-69.2%	462	0.8%	89.0%
-	17	NA	Plessey Semiconductors*	-	2	NA	464	0.4%	89.4%
16	18	-2	Motorola	5	1	-80.0	465	0.2%	89.6%
8	-	NA	Siemens	16	-	-100.0%	NA	NA	NA
14	-	NA	IDT	7	-	-100.0%	NA	NA	NA
18	-	NA	Austria Mikro Systeme	4	-	-100.0%	NA	NA	NA
19	-	NA	VLSI Technology	3	-	-100.0%	NA	NA	NA
20	-	NA	GE Solid State	3	-	-100.0%	NA	NA	NA
			European Others						
			North American Others	18	53	194.4%	518	10.2%	99.8%
			Japanese Others	1	1	0.0%	519	0.2%	100.0%
			Rest of World Others	2	-	-100.0%	NA	NA	NA
			Total All Companies	473	519	9.7%	NA	100.0%	NA
			Total European	106	99	-6.6%	NA	19.1%	NA
			Total North American	242	325	34.3%	NA	62.6%	NA
			Total Japanese	123	89	-27.6%	NA	17.1%	NA
			Total Rest of World	2	6	200.0%	NA	1.2%	NA

* Plessey and MEDL are now merged and known as GEC Plessey Semiconductors (GPS).
Source: Dataquest (March 1991)

Table 8.3

Estimated Nonvolatile MOS Memory Consumption by Application Segment in Europe
(Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Application	1990	1991	1995	1990-91	1990-95	1990	1991	1995
EDP	$160	$177	$402	10.6	20.2	38	38	43
Communications	94	91	177	(3.2)	13.5	22	20	19
Industrial	76	83	142	9.2	13.3	18	18	15
Consumer	49	52	86	6.1	11.9	11	11	9
Military	31	38	69	22.6	17.4	7	8	8
Transport	19	21	54	10.5	23.2	4	5	6
Total	$429	$462	$930	7.7	16.7	100	100	100

AGR = Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Table 8.4

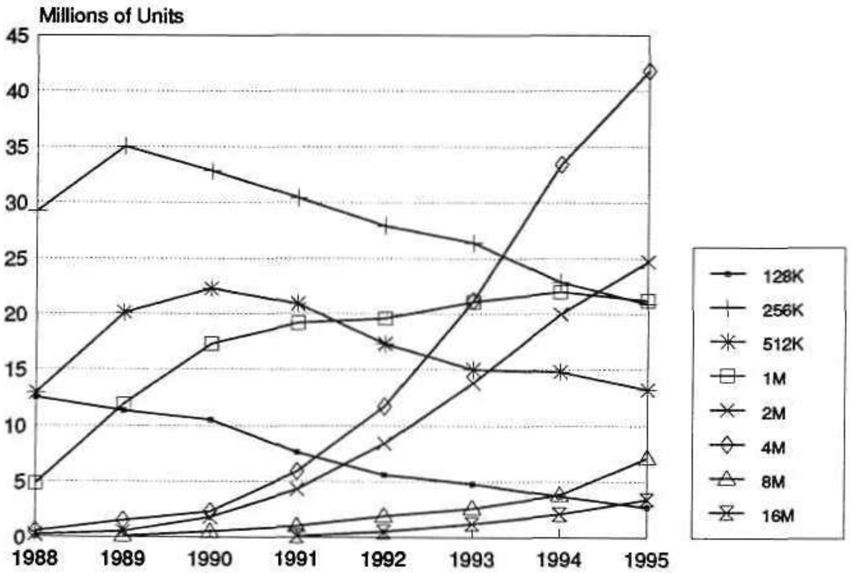
Estimated Nonvolatile MOS Memory Consumption by Region in Europe
(Millions of Dollars)

	Revenue			Percent Growth Rates		Percentages		
				AGR	CAGR			
Region	1990	1991	1995	1990-91	1990-95	1990	1991	1995
Benelux	$27	$31	$45	14.8	10.8	6	7	5
France	55	56	111	1.8	15.1	13	12	12
Italy	57	58	111	1.8	14.3	13	13	12
Nordic	28	30	54	7.1	14.0	7	6	6
UK and Ireland	119	136	286	14.3	19.2	28	29	30
Germany	113	116	257	2.6	17.9	26	25	28
Rest of Europe	30	35	66	16.7	17.1	7	8	7
Total	$429	$462	$930	7.7	16.7	100	100	100

AGR = Annual Growth Rate
CAGR = Compound AGR
Source: Dataquest (March 1991)

Figure 8.1

Nonvolatile MOS Memory Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 9

EPROM

Analysis and Forecast

EPROM unit consumption increased by a mediocre 3.0 percent between 1989 and 1990. Coupled with this, ASPs declined by 30.4 percent during this period, resulting in a severe 28.1 percent decline in the value of the market. Strong competition between North American and European suppliers contributed to this sharp price erosion and the European market became the cheapest in the world for EPROMs. Some vendors have openly complained that dumping was occurring.

The European Commission has introduced reference prices for Japanese-sourced EPROMs, effective from the first quarter of 1991. This is the result of complaints made against seven Japanese vendors for alleged dumping during the period 1986 to 1988. Japanese vendors now account for about 15 percent of the European EPROM market and are no longer regarded as price-competitive. The reference price agreement is not expected to have any effect on European EPROM ASPs or their availability.

Ultraviolet (UV) EPROMs represented an estimated 88 percent of all EPROM units shipped in 1990, while one-time-programmable (OTP) EPROMs accounted for the remaining 12 percent. Prices for OTP EPROMs are typically 10 percent less than UV EPROMs due to the lower cost of their packaging.

Users of UV EPROMs fall into two categories: those who intend to reprogram regularly; and those who would like to use mask-programmable ROM but cannot guarantee the final code until their system is ready for shipment. Applications include program-code storage in PCs, network communication protocols, automotive engine management, and industrial process control. All these applications require a periodic but limited number of reprogramming cycles. Although OTP EPROM applications overlap with the UV EPROM applications, they do include font storage for printers with short life cycles. OTP EPROM is used in other high-volume applications requiring fast turnaround without the need for reprogramming. Vendors of OTP EPROM generally batch program for their customers.

Many vendors of EPROM are phasing out production below the 256K density, resulting in a rise in price from 1992 onwards. The value of the European EPROM market is expected to grow with a below-average CAGR of 8.6 percent between 1990 and 1995.

Figure 9.1 shows the life cycles of European EPROMs. The 256K and 512K densities are now beyond maturity with unit shipments of the 256K peaking in 1989 and the 512K in 1990. The 1M part is expected to peak in unit shipments in 1991 as 2M and 4M parts start to become available in volume. The 8M and 16M parts are expected to be the last generations of EPROM, after which flash memory will serve as a cost-effective replacement.

Index of Tables and Figures—Chapter 9

Table 9.1

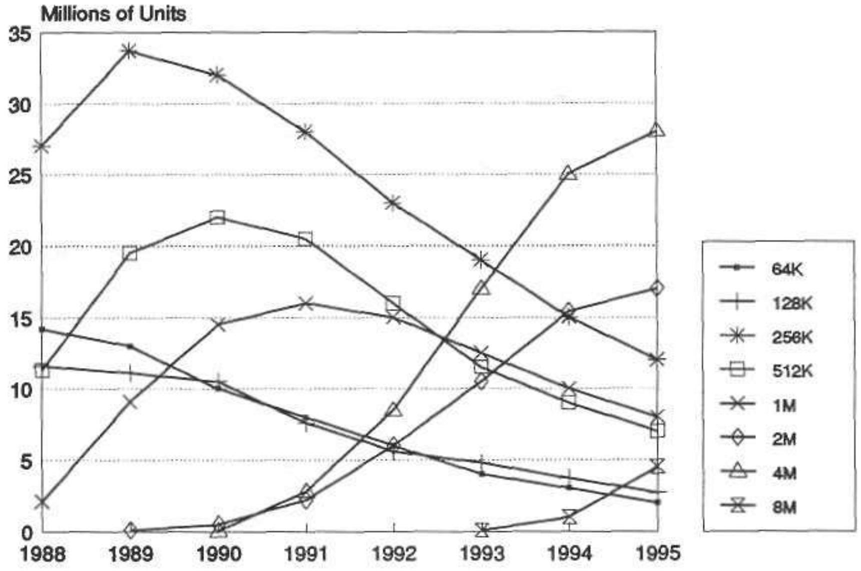
EPROM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
16K	1.7	1.8	1.5	1.4	1.3	1.2	1.0	0.8
32K	2.8	2.9	2.9	2.1	1.6	1.5	1.1	0.9
64K	14.2	13.0	10.0	8.0	6.0	4.0	3.0	2.0
128K	11.6	11.1	10.5	7.6	5.6	4.8	3.7	2.7
256K	27.0	33.7	32.0	28.0	23.0	19.0	15.0	12.0
512K	11.3	19.5	22.0	20.5	16.0	11.5	9.0	7.0
1M	2.1	9.1	14.5	16.0	15.0	12.5	10.0	8.0
2M		0.1	0.5	2.2	6.0	10.5	15.4	17.0
4M			0.1	2.8	8.5	17.0	25.0	28.0
8M						0.1	1.0	4.5
16M							0.1	1.0
Total	70.7	91.2	94.0	88.6	83.0	82.1	84.3	83.9
ASP (Dollars)								
16K	$4.07	$2.78	$2.20	$2.30	$2.80	$3.00	$3.20	$3.40
32K	$3.57	$3.10	$2.30	$2.40	$3.00	$3.30	$3.50	$3.70
64K	$3.87	$3.07	$1.90	$2.10	$2.50	$3.00	$3.30	$3.50
128K	$4.14	$3.24	$2.00	$2.20	$2.60	$3.10	$3.35	$3.50
256K	$4.81	$3.41	$2.10	$1.85	$2.00	$2.40	$2.90	$3.30
512K	$7.35	$5.30	$4.00	$2.90	$2.50	$2.85	$2.75	$2.60
1M	$19.50	$11.88	$6.10	$5.00	$4.50	$4.00	$3.70	$3.50
2M		$38.00	$13.16	$10.00	$7.00	$6.10	$5.40	$4.60
4M			$40.00	$12.86	$9.01	$6.87	$5.96	$5.46
8M						$35.00	$27.00	$20.00
16M							$40.00	$28.00
Weighted Average	$5.29	$4.61	$3.21	$3.28	$3.76	$4.26	$4.72	$5.45
TAM (Millions of Dollars)								
16K	$7	$5	$3	$3	$4	$4	$3	$3
32K	10	9	7	5	5	5	4	3
64K	55	40	19	17	15	12	10	7
128K	48	36	21	17	15	15	12	9
256K	130	115	67	52	46	46	44	40
512K	83	103	88	59	40	33	25	18
1M	41	108	88	80	68	50	37	28
2M		4	7	22	42	64	83	78
4M			2	36	77	117	149	153
8M						4	27	90
16M							4	28
Total	$374	$420	$302	$291	$312	$350	$398	$457
Terabits	17.3	30.3	37.3	50.8	76.3	114.0	159.6	213.2

TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 9.1

EPROM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 10

EEPROM

Analysis and Forecast

EEPROM unit consumption reached an estimated 30.9 million in 1990, growing by 18.8 percent from 1989. Average selling prices increased by just 0.4 percent to produce a market growth of 19.4 percent. The European market was worth an estimated $86 million in 1990, and was served by 14 vendors. This equates to a low average revenue per vendor of $6 million. The market is served by a broad base of manufacturers.

The EEPROM market has two distinct branches: serial EEPROM and parallel EEPROM. Serial EEPROM offers serial data input/output. Consequently, this option has a lower pin count than the parallel option, which means the package can be smaller, cost is lower, and mounting is easier. Typical applications for this option include smart cards, telephone memories, radio tuning presets, domestic appliance feature settings, games machines and other assorted consumer equipment. These applications generally require low-density EEPROM of up to about 16K.

Parallel EEPROM offers parallel data input/output. This option has a relatively high pin count, not only because more pins are required for parallel access, but because users of this option generally require higher capacity. Typical applications for this option include process control, automatic cash dispensers, encryption/decryption, portable instrumentation, and military equipment such as flight recorders, terrain mapping, and electronic fuses.

Approximately 80 percent of all European EEPROM units consumed in Europe in 1990 were accounted for by serial EEPROM. However, in terms of market value, serial EEPROM accounts for less than 60 percent of sales. This is due to the lower average bit density and cost of serial EEPROM compared to parallel EEPROM.

The value of the EEPROM market is expected to see a low CAGR of 6.5 percent for the period from 1990 to 1995. This is partly because of the continuing popularity of low-cost serial EEPROM.

The life cycles of European EEPROM are shown in Figure 10.1. By far the most popular EEPROM category is the 1K density. This low-density serial EEPROM is used in a wide range of equipment for user-programmable information. However, this part is now in decline. The 2K and 4K parts, the next most popular serial densities, are expected to plateau in 1991 and 1992. On the high-density side, 64K and 256K EEPROMs are in ramp-up phase, and small volumes of the 1M will become available in 1992.

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Table 10.1

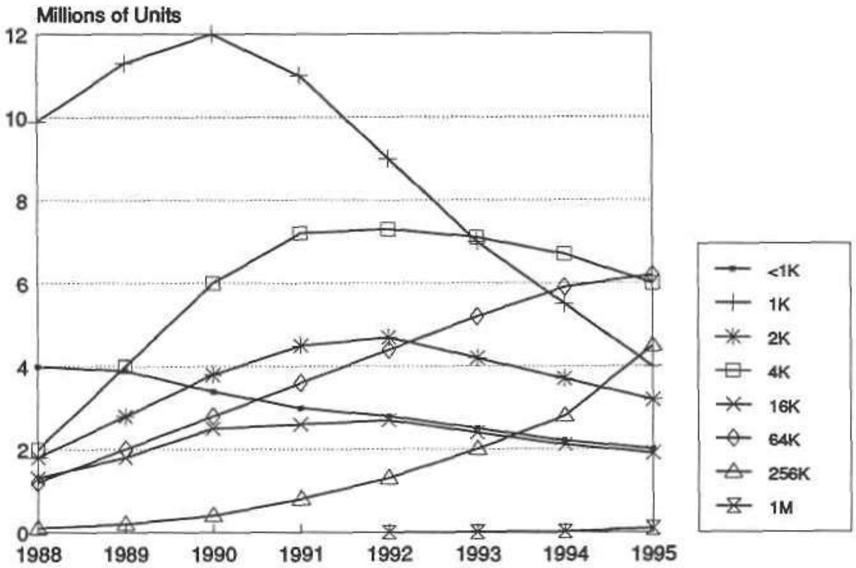
EEPROM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
<1K	4.0	3.9	3.4	3.0	2.8	2.5	2.2	2.0
1K	9.9	11.3	12.0	11.0	9.0	7.0	5.5	4.0
2K	1.8	2.8	3.8	4.5	4.7	4.2	3.7	3.2
4K	2.0	4.0	6.0	7.2	7.3	7.1	6.7	6.0
16K	1.3	1.8	2.5	2.6	2.7	2.4	2.1	1.9
64K	1.2	2.0	2.8	3.6	4.4	5.2	5.9	6.2
256K	0.1	0.2	0.4	0.8	1.3	2.0	2.8	4.5
1M					*	*	*	0.1
4M								*
Total	20.3	26.0	30.9	32.7	32.2	30.4	28.9	27.9
ASP (Dollars)								
<1K	$0.75	$0.65	$0.60	$0.62	$0.65	$0.68	$0.68	$0.70
1K	$1.10	$1.00	$1.00	$1.05	$1.10	$1.12	$1.15	$1.19
2K	$2.90	$2.50	$2.20	$2.20	$2.25	$2.30	$2.35	$2.40
4K	$4.50	$4.00	$3.90	$3.40	$3.20	$3.00	$3.00	$3.20
16K	$5.10	$4.35	$4.00	$3.50	$3.35	$3.20	$3.10	$3.20
64K	$10.00	$7.75	$6.20	$5.70	$5.30	$5.00	$4.75	$4.25
256K	$113.00	$55.00	$35.00	$26.00	$20.00	$18.00	$13.00	$10.50
1M					$165.00	$95.00	$65.00	$45.00
4M								$200.00
Weighted Average	$2.86	$2.77	$2.78	$3.03	$3.23	$3.65	$3.74	$4.23
TAM (Millions of Dollars)								
<1K	$3	$3	$2	$2	$2	$2	$1	$1
1K	11	11	12	12	10	8	6	5
2K	5	7	8	10	11	10	9	8
4K	9	16	23	24	23	21	20	19
16K	7	8	10	9	9	8	7	6
64K	12	16	17	21	23	26	28	26
256K	11	11	14	21	26	36	36	47
1M					**	**	1	5
4M								1
Total	$58	$72	$86	$99	$104	$111	$108	$118
Terabits	0.1	0.2	0.4	0.5	0.7	0.9	1.2	1.7

* Less than 0.01 million units
** Less than $1 million
TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 10.1

EEPROM Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 11

Flash

Analysis and Forecast

The European flash memory market grew from a small base in terms of units by 438.1 percent between 1989 and 1990. A 16.4 percent erosion in ASPs led to a growth of 350.0 percent in the value of the market. In 1990, 4 suppliers were active in the European flash memory market, but this is expected to rise to 14 by the end of 1991. The worldwide flash market was dominated by North American vendors in 1990, but most of the new entrants for 1991 are Japanese. We foresee these new entrants offering products that are compatible with existing standards. The flash memory market should grow strongly once this multisource environment is in place, driven by user confidence in stability of supply.

Applications exist for flash memory in solid-state notebook computers, memory cards, adaptable font storage, telecommunications equipment such as mobile phones and PBX, automotive engine management, and portable test equipment. In some applications it will probably replace EPROM and EEPROM, but there will be many more new applications to help provide it with independent growth.

The cost per bit of flash memory should reach around one-and-a-half times that of EPROM by 1995. But, many flash vendors are optimistic that they will be able to reduce this ratio even further. Obviously, the lower this ratio, the more attractive the product appears to users. Development of flash memory focuses on this cost reduction.

The flash memory market is expected to see strong growth, with a CAGR of 97.3 percent between 1990 and 1995. This market is forecast to be worth twice as much as the EEPROM market, and two-thirds the size of the EPROM market in 1995. We expect flash memory to replace EPROM for all generations above 16M during the period 1995 to 2000. Further analysis of the European flash memory market can be found in ESIS newsletter 1990-23 "Flash Memory—A European Projection."

European flash memory life cycles are shown in Figure 11.1. These life cycles reflect the dynamics of a product that is new to both vendors and users. The 64K gave way to the 256K part in the year of its introduction. The 256K part is expected to peak in 1993 and the 512K part in 1995. Also in this time frame, 1M, 2M, 4M, 8M, and 16M parts will be introduced, making the choice of which density to design in somewhat difficult one. However, the product is almost certainly guaranteed to be a success. Issues that need to be addressed include write-cycle lifetime and access speed.

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Table 11.1

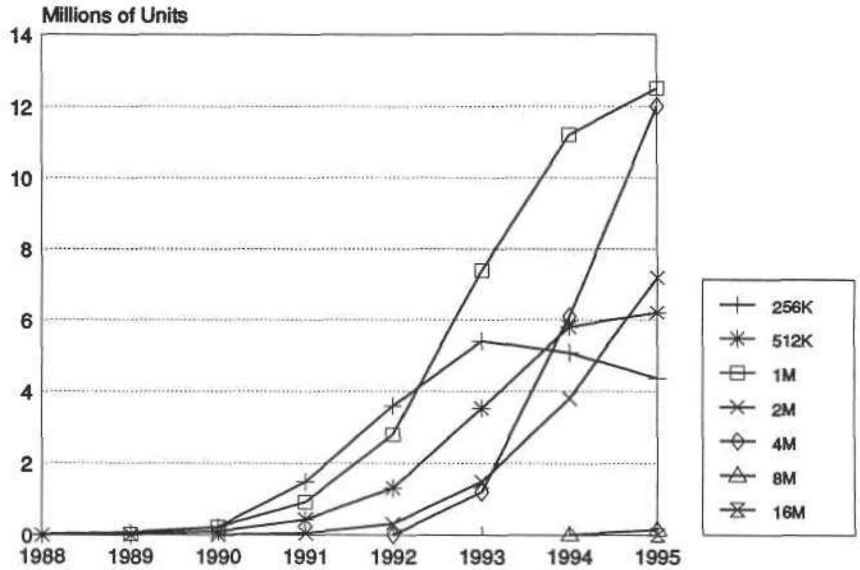
Flash Memory Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
64K	2							
256K	19	68	230	1,485	3,600	5,400	5,073	4,370
512K	4	8	102	433	1,316	3,534	5,800	6,200
1M		29	225	922	2,800	7,400	11,200	12,500
2M			5	50	320	1,488	3,804	7,200
4M					5	1,200	6,100	12,000
8M							10	150
16M								10
Total	25	105	562	2,890	8,041	19,022	31,987	42,430
ASP (Dollars)								
64K	$8.00							
256K	$36.47	$19.56	$7.40	$6.00	$5.00	$4.75	$4.60	$4.40
512K	$50.00	$37.50	$18.40	$12.50	$9.80	$7.50	$6.00	$5.00
1M		$51.72	$22.00	$14.00	$9.80	$7.80	$6.30	$5.45
2M			$37.00	$23.00	$15.00	$11.50	$9.00	$7.50
4M					$22.00	$12.95	$9.50	$7.85
8M							$32.20	$20.10
16M								$40.00
Weighted Average	$39.68	$19.14	$16.01	$9.69	$7.83	$7.57	$6.91	$6.34
TAM (Millions of Dollars)								
64K	*							
256K	$1	$1	$2	$9	$18	$26	$23	$19
512K	*	*	2	5	13	27	35	31
1M		1	5	13	27	58	71	68
2M			*	1	5	17	34	54
4M					*	16	58	94
8M							*	3
16M								*
Total	$1	$2	$9	$28	$63	$144	$221	$269
Terabits	**	0.1	0.3	1.6	5.1	18.4	47.6	80.6

* Less than $1 million
** Less than 0.1 terabits
TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 11.1

Flash Memory Unit Life Cycles in Europe



Source: Dataquest (March 1991)

Chapter 12

Mask ROM

Analysis and Forecast

The European mask ROM market grew by 1.4 percent in terms of units between 1989 and 1990. The value of the market grew by 14.3 percent from a small base, bolstered by a 12.7 percent increase in ASPs over the same period.

Europe is a very minor market for mask ROM, representing an estimated 1.8 percent of the total worldwide market. The primary application of mask ROM in the world market is in software cartridges for games machines. Europe has little presence in this particular industry at the moment. In 1990, approximately eight mask ROM suppliers were active in the European market, nearly all of which were Japanese.

Key applications in Europe are font storage in printers, spell checkers in portable word processors, and sound samples in electronic musical instruments. However, the largest application is in the storage of basic input/output systems (BI/OS) in personal computers, for which there is significant local demand.

Mask ROM is the cheapest form of memory when ordered in large volumes, but because the mask is customer-specific, a lead time is involved and it is not possible to make any changes once it has been produced. This is a major problem for systems manufacturers wanting to get a system to market as quickly as possible by developing the software in parallel with the hardware. Often, the software is not ready until just before, or even after, the hardware is in production. To order mask ROM at this point would put a major delay into the system launch. Therefore, many systems manufacturers choose to buy the more expensive EPROM and perform batch programming when the software is fully debugged.

Innovative mask ROM suppliers have attempted to address the above shortcomings of the product. Some manufacturers have halved the number of custom fabrication steps. This allows semicustom mask ROMs to be held in inventory until required for full customizing, thereby greatly reducing lead times. There are also suggestions that in order to allow limited user revision of code, the mask ROM die could incorporate a small amount of EEPROM or flash memory. This additional memory could intercept relevant addresses and supply its own user-programmable updates. However, this can only work with very minor software revisions.

The future of the European mask ROM market very much depends on investment coming from new users in Europe. In particular, investment in European production by games machine suppliers could turn the market around. As it is, the European mask ROM market is expected to see a CAGR of 21.9 percent between 1990 and 1995 from a small base.

European mask-programmable ROM life cycles are shown in Figure 12.1. In 1990, the most popular density of ROM was the 1M, although it is now in decline. This part is used primarily for storage of BI/OS in IBM-compatible PCs. The 4M part is expected to overtake the 1M in 1991. It is currently consumed in non-IBM-compatible PCs, and IBM-compatible machines are using it in increasing volumes.

Table 12.1

Mask-Programmable ROM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
Units (Millions)								
16K	0.1							
32K	0.3							
64K	1.6	0.4	0.1					
128K	0.9	0.2						
256K	2.1	1.0	0.2	0.1				
512K	1.6	0.6	0.2					
1M	2.7	2.8	2.6	2.3	1.8	1.2	0.8	0.6
2M	0.2	0.4	1.3	2.0	2.1	1.8	0.8	0.5
4M	0.5	1.5	2.2	3.1	3.2	3.0	2.3	1.8
8M		0.1	0.5	1.0	1.9	2.5	2.8	2.4
16M				0.1	0.5	1.2	2.0	2.4
32M					0.1	0.4	0.9	1.5
64M							0.1	0.5
Total	10.0	7.0	7.1	8.6	9.6	10.1	9.7	9.7
ASP (Dollars)								
16K	$2.50							
32K	$1.55	$1.60						
64K	$1.62	$1.65	$1.80					
128K	$1.65	$1.70						
256K	$1.94	$1.80	$1.90	$2.04				
512K	$3.23	$2.40	$2.40					
1M	$4.10	$3.50	$3.20	$2.97	$2.75	$2.64	$2.59	$2.70
2M	$5.80	$4.60	$4.50	$4.40	$3.52	$3.36	$3.25	$2.95
4M	$10.00	$7.00	$6.00	$5.10	$4.60	$4.00	$3.70	$3.40
8M		$12.00	$10.00	$9.00	$7.60	$6.90	$6.00	$5.70
16M				$26.00	$22.00	$18.00	$14.00	$10.00
32M					$38.00	$30.00	$22.00	$16.50
64M							$40.00	$28.00
Weighted Average	$3.00	$4.00	$4.51	$5.12	$5.83	$7.13	$8.56	$8.87

(Continued)

Table 12.1 (Continued)

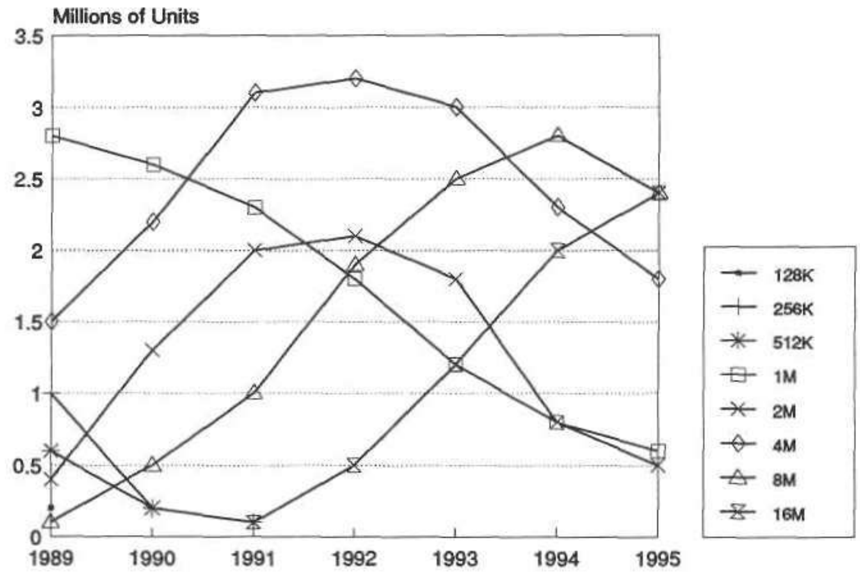
Mask-Programmable ROM Consumption Forecast in Europe

Product	1988	1989	1990	1991	1992	1993	1994	1995
TAM (Millions of Dollars)								
16K	*							
32K	*							
64K	$3	$1	*					
128K	1	*						
256K	4	2	*	*				
512K	5	1	*					
1M	11	10	$8	$7	$5	$3	$2	$2
2M	1	2	6	9	7	6	3	1
4M	5	11	13	16	15	12	9	6
8M		1	5	9	14	17	17	14
16M				3	11	22	28	24
32M					4	12	20	25
64M							4	14
Total	$30	$28	$32	$44	$56	$72	$83	$86
Terabits	6.7	11.0	18.2	28.3	45.2	68.8	101.2	146.4

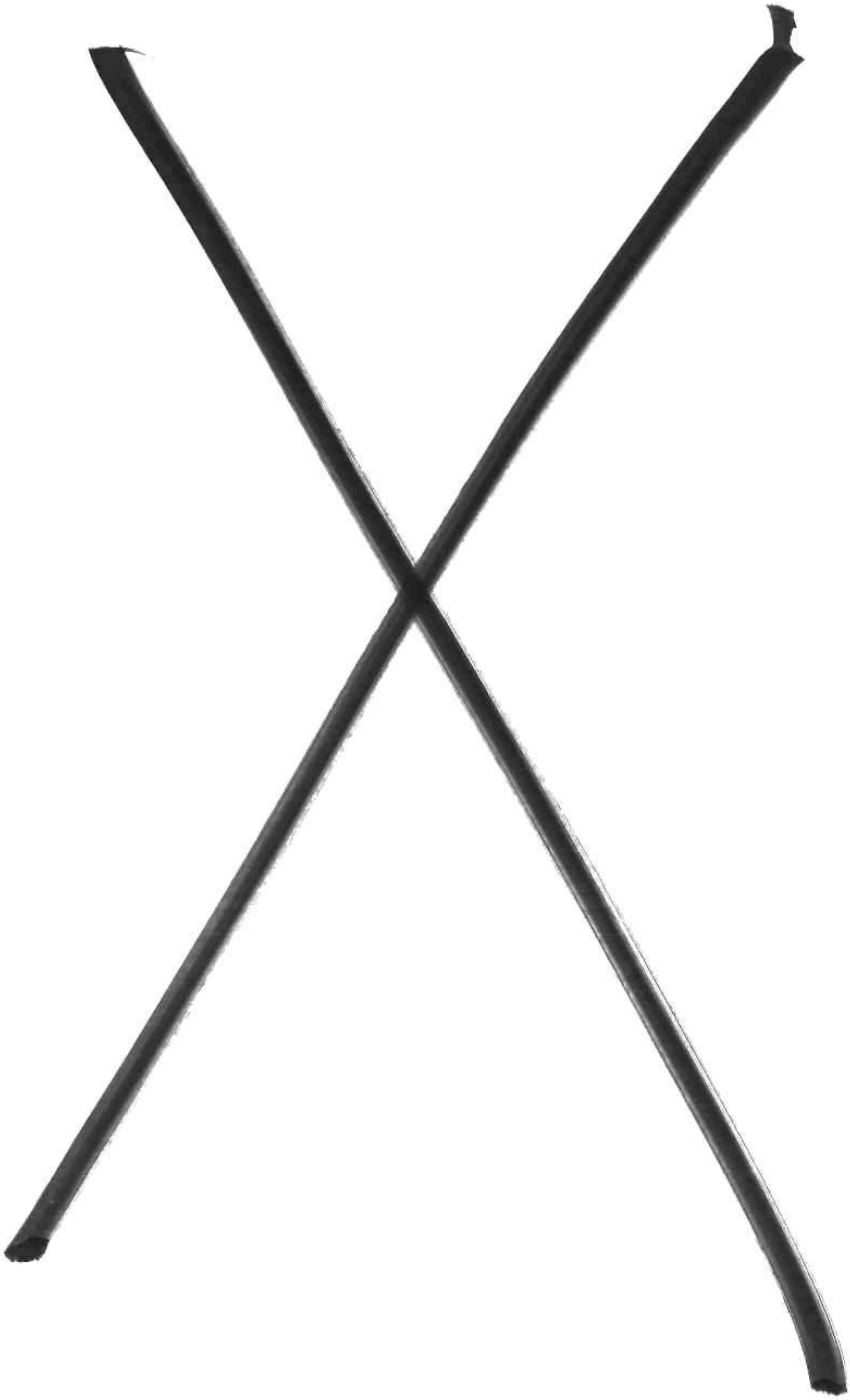
* Less than $1 million
TAM = Total Available Market
Source: Dataquest (March 1991)

Figure 12.1

Mask-Programmable ROM Unit Life Cycles in Europe



Source: Dataquest (March 1991)



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1992 European Unification

(Slide 1 – Agenda)

In the first part of my talk, I will introduce those issues which are unique to the market in Europe. I will later cover issues affecting the industry.

We at Dataquest are very confident for the future of both the market and the industry. I shall discuss why we believe this to be the case, and explain why "1992" figures so highly in our forecasts.

Finally, I shall identify where the opportunities are for you, as Japanese businessmen, to respond to events that arise from the 1992 reforms.

Let us turn firstly to look at the market in Europe ...

(Slide 2 – Worldwide Consumption: U.S., Europe and Japan)

Last year in 1988, the market in Europe was $8 billion (¥1.2 trillion), compared to $20 billion in Japan (¥3 trillion) and $15 billion (¥2.2 trillion) in the United States.

There is always a good correspondence between the market for semiconductors and the level of electronic equipment production in the same territory. From this graph you can also see that Europe's electronics production lags a long way behind Japan and the United States.

(Slide 3 – World Semiconductor Market Growth)

However, in growth terms, 1988 was a strong year for Europe.

Measured in local currencies, Europe showed a higher rate of growth compared to Japan or the United States. Growing nearly 10 percentage points faster than Japan and more than 4 points faster than the United States.

The European market came second only to the Rest of World, which is mainly South Korea and the Asia Pacific region. This year, in 1989, European growth will exceed even this region.

(Slide 4 – European Merchant Vendor Rankings)

Europe's high growth was translated into record billings for the market participants. Philips became the first company to break the billion dollar mark in Europe.

As you are well aware, 1988 was the year of heavy demand for memory chips. Toshiba made the most dramatic move by climbing a whole ten places to seventh place.

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(Slide 5 – Market Share by European, U.S. and Japanese Companies)

Market access and trade friction continues to dominate in Europe. Of the world markets, Europe's is the most international. Combined, Europe's indigenous suppliers held only 37 percent of their own local European market, coming second to North American suppliers who occupied 42 percent.

Compared to the Americans, Japanese companies held a comparatively small share of 17 percent – and you may be excused for questioning why there appears to be more trade friction between Europe and Japan than there is between Europe and the United States.

(Slide 6 – Growth by European, U.S. and Japanese Companies)

If we rank the top ten market shares in Europe by growth instead of revenue, the origin of this trade friction becomes clear.

Put simply – the indigenous European players are continuing to loose a grip on their own market. European companies, combined, came bottom of the growth league with an 18 percent growth rate.

(Slide 7 – Top Ten Ranked by Growth)

Last year it was Samsung, a South Korean company, that came highest in growth in Europe – 300 percent in one year. Samsung was followed by Toshiba with 107 percent. Inmos, a European company, now part of SGS–Thomson, came third with 100 percent.

However, both the European firms shown here, Inmos and Matra–Harris, are small companies.

(Slide 8 – Europe: Strong market – Weak industry)

So, to summarise recent history we have seen the European market grow faster than either Japan or the United States, but with European vendors losing their share of this growing market – in other words a strong market but a weak industry.

Let us look at the major causes behind Europe's market growth to see what role, if any, 1992 has played so far.

Two important factors pushed the growth in Europe's markets higher than either Japan or the United States last year ...

(Slide 9 – Yen Appreciation)

The first factor is that the Japanese yen has appreciated strongly in relation to the European currencies over the past few years – making offshore manufacture in Europe economically attractive.

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In 1987, for example, there was only one Japanese printer factory in Europe: Canon in France. Last year, in 1988, we counted 14. Similar trends have occurred with other products like photocopiers, facsimile machines, cellular telephones and low margin consumer products like video recorders and microwave ovens.

(Slide 10 – EC Anti-Dumping Measures)

The second factor underlying the growth in the European semiconductor market is the European Commission's policy towards dumping. Of this influx of new Japanese and South Korean owned factories in Europe, many were "screwdriver" facilities which assembled finished printed circuit boards imported from their home country.

Over the last few years the Commission has hardened its attitude to these operations on the basis that they are avoiding anti-dumping duties on imports by assembling these products in Europe from imported parts.

The result of its measures to enforce local content has been that of these plants are beginning to purchase semiconductors locally – particularly commodity parts like DRAM and standard logic.

(Slide 11 – EC Anti-Dumping Measures)

However, the majority of ASIC and other key custom parts continue to be supplied from the home country where they are designed and manufactured.

The total semiconductor value of most forms of electronic equipment is of the order of 10 percent of their average selling price. European local content rules typically stipulate that between 40 and 60 percent is purchased locally in Europe. So, you see, there is still scope for importing critical parts whilst retaining the minimum local content level.

Some precedents have already been set in the Commission's bid to encourage sourcing of even these key components. For instance, a new rule of origin came into force for photocopiers in July that explicitly excludes unsophisticated parts such as drums and rollers from being counted toward local content. We must wait to see how far the Commission will go in applying these so called "negative regulations" to other products.

To explain what influence there has been on the market in Europe so far, I have referred to a number of developments which are related to 1992 – but are not actually what 1992 itself is all about.

(Slide 12 – 1992 Directives)

1992 is the deadline by which 279 directives, which form part of the Single European Act, are to become law in each of the European Community's 12 member nations. These directives aim to remove barriers to the flow of money, goods and people between member states – but they say nothing about trade issues between Europe and the rest of the world.

Many of the Single European Act's directives have already been adopted. But it is true to say that none of the directives themselves have yet made a significant impact on the semiconductor market in Europe.

So what about the future?

I would like to share with you our long-term forecast for Europe in relation to the world scene. I shall then explain how our assumptions concerning 1992 justify this forecast.

(Slide 13 – Worldwide Semiconductor Forecasts (1988 to 1994))

After the Asia pack and the other Rest of World countries, we predict that, over the next five years, it will be Europe which shows the greatest growth – 1 percentage point greater than the United States and nearly 3 percentage points greater than Japan.

(Slide 14 – 1992 Factors)

Now, let us turn to look at the ways that 1992 will affect the electronic equipment industry in Europe.

There are too many directives to describe here how each will affect industry individually – but we can divide them into different types.

I have also broken the electronics industry into major functions to indicate where the 1992 reforms will be felt most.

(Slide 15 – Introduce Value Chain)

The top half of the diagram shows indirect support functions.

The top bar shows human resources. The second bar is technology, research and development. This includes not just research for new product development, but any know-how which contributes to competitive advantage – such as management information systems or production technology.

The lower half, from left to right, shows the primary functions in the production chain – starting with the purchase of raw materials ... to manufacture and assembly ... to the marketing and selling functions ... and, lastly, to the distribution of finished products to the customer.

(Slide 16 – Removal of Technical Barriers)

The first category of 1992 directive I want to mention are those which achieve "technical harmonisation". There are roughly 80 of these directives, of which more than half have been adopted by the European Commission so far.

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Examples which most affect the electronic equipment industry are the low voltage safety and electro-magnetic interference directives. Other directives cover telecommunications equipment explicitly.

These include moves toward setting up mutual recognition of national standards for terminal equipment and the setting up of a standards body in France, called ETSI, to draft future pan-European telecommunications standards.

The aim of course is to remove these technical barriers to trade between European states. However, harmonisation is good not just for trade within Europe, but also for trade with Europe.

If you are exporting from Japan, you will no longer be faced with 12 different sets of national standards - soon, you will only need to work with one!

(Slide 17 - Value Chain: Removal of Technical Barriers)

These harmonisation measures, when fully implemented, will have a profound impact on the economics of both production and product development in Europe. For the first time it will be possible to sell, say, the same telephone or facsimile machine into any EEC state without having to modify it to meet many national requirements.

Production runs will lengthen, with fewer interruptions because less changeover will be required to comply with regulations for individual markets.

Lower levels of inventory will be needed in distribution because one product variant, in a single set of packaging, will satisfy the whole Community.

(Slide 18 - Removal of Physical Barriers)

Turning to the next category of directive - the removal of physical barriers.

Frontier controls are perhaps the most striking reminder of how divided the European Community remains today. Besides being barriers to physical movement, they are constraints to economic efficiency.

By the end of 1992, internal frontiers posts will be removed and goods will travel the entire breadth of the Community without frontier bureaucracy and delay. This new-found freedom of movement will apply not just to goods but to people, and the qualifications they carry as well.

(Slide 19 - Value Chain : Removal of Physical Barriers)

For the electronics industry in Europe, this will represent major cost savings.

There will be important implications for the way semiconductor parts are distributed across Europe. At the present time, independent distributors supply approximately one quarter of the market (or $2 billion, ¥280 billion). These distributors are small and divided by national boundaries. They are also fragmented by the franchises they own.

At present these franchises are normally awarded by semiconductor vendors on a national, not European basis. Article 85, one of the founding Treaties of the Common Market, prohibits this practice. Come 1992, the European Commission is expected to apply increasing pressure on national governments to enforce this and other Treaties.

Consequently, as transport and administrative costs diminish, these distributors are expected to consolidate into a small number of large companies – each with a central warehouse facility for the whole of Europe.

(Slide 20 – Economies of Scale)

The European Commission proposes to adopt directives which ensure that procurement by national governments will be open to tender by any company registered within the Community.

In Europe, there has been a clear pattern where government procurement has favoured "strategic" local industries. Instead of becoming powerful global entities they have remained national ones.

This has been most true in the telecommunications, defence and computer industries – where companies like Italtel, Alcatel, Plessey, Thomson, ICL and Nixdorf each earn almost all of their revenue from one or two national markets.

At present, only 2 percent of government contracts in Europe for basic services like telecommunications go to companies outside national boundaries.

(Slide 21 – Value Chain: Economies of Scale)

Liberalisation of procurement will bring economies of scale. Other 1992 directives such as the competition rules are designed to achieve the same result. Fixed production and technology costs will be amortised across 12 markets ... not one.

The next five years will be a period for urgent rationalisation in Europe. Only the best electronics companies in Europe will survive. Those that do will become powerful global players ten years from now.

The process has only just begun. To name but a few examples:

In semiconductors: SGS-Thomson has acquired Inmos, and Siemens has acquired Plessey's semiconductor interests.

In electronic systems: Thomson has acquired RCA and Ferguson's consumer interests. In telecommunications, Alcatel has acquired ITT's European activities, and Ericsson has divested in order to focus on its core telecommunications business.

(Slide 22: Science and Technology)

It is the European Commission's clear strategy to strengthen the impact of 1992 on the electronics industry by giving it the same quality of leadership that MITI gives to your industry here in Japan.

After agricultural and regional development, it is the Community's research programmes which take the greatest share of its budget. This year, the Commission will spend ¥200 billion (ECU 1.3 billion) on cross-border research. This will double by 1991.

It is worth pausing one moment to look at three of the most significant programmes for European electronics.

(Slide 23 – ESPRIT)

ESPRIT is a ten-year programme in two phases. It has another five years to run and is about to commence the second phase. The first phase of ESPRIT has involved some 200 collaborations between industry, universities and research institutes. The second phase is a "follow-up" phase, and will apply the research conducted so far. The main activities include microelectronics, design, manufacturing software and office systems.

50 percent of the funding for ESPRIT projects comes from the European Commission. The remainder comes from industry. Foreign companies are eligible for participation in ESPRIT provided it conducts the research work within the Community.

(Slide 24 – EUREKA)

EUREKA differs from ESPRIT in the sense that the European Commission does not impose a tightly defined programme – there is no beginning or end. Companies and research institutes are free to apply for funding as and when opportunities arise.

Unlike ESPRIT, EUREKA is open to participation from outside the Community – including the EFTA countries, Finland and Turkey. However, EUREKA has no Community funding. Instead, funding is split between industry and the national governments.

Non-European participation is less clear than for ESPRIT.

(Slide 25 – JESSI (Joint European Submicron Silicon))

One EUREKA project of special significance to the semiconductor industry in Europe was the definition and planning phase for the Joint European Submicron Silicon initiative (or JESSI).

JESSI will be a seven-year project with the objective to give the European electronics industry leading edge capability in the full high technology chain from basic long term research ... to semiconductor materials and equipment ... to process development ... to putting specific applications onto silicon.

First silicon from JESSI is scheduled for the end of next year – with a long-term goal to reach pilot production of 64-Mbit DRAMs using 0.3-micron geometries by the end of 1996.

Plans are to implement with JESSI funding those applications which have strategic importance to European industry. These include the HD-MAC HDTV chip set, the 64-kbps videophone, consumer facsimile, ISDN components and the digital cellular telephone.

Funding for the JESSI programme has to come from national governments and is not yet fully approved. Altogether, it is likely to exceed ¥550 billion (ECU 3.8 billion).

(Slide 26 – Value Chain: Cross-Border Research)

We expect centrally funded research projects like ESPRIT, EUREKA and JESSI to have a major effect on the electronics industry in Europe.

Firstly, they provide central coordination for research across Europe's many national companies.

Secondly, the individual projects in these programmes provide a platform for European companies to take a more pro-active approach towards developing standards for Europe and worldwide.

(Slide 27 – Value Chain : 1992 Overall Impact)

Any one of the factors I have described is sufficient to make a major impact on the industry and semiconductor consumption in Europe.

In short, the whole economic and political environment in Europe is changing – and all these factors must be taken into account when forecasting the future for the semiconductor market and the semiconductor industry in Europe.

(Slide 28 – Opportunities for Japanese Business)

To conclude, what opportunities exist for you, as a Japanese semiconductor manufacturer, to take advantage of 1992?

I have no doubt that, as trade between European member states begins to accelerate in Europe – trade with Europe will become harder. For small Japanese and American companies who cannot spread their operations into Europe – this is clearly a threat.

The most costly decision you may need to face is: "Do I invest in a fabrication plant in Europe?"

Earlier this year, the European Commission announced that it was changing its definition of local origin for integrated circuits. Today, these devices must be diffused in Europe to be counted as European and escape import duties. It is no longer sufficient merely to package, assemble and test them in Europe.

Other related events are the recent trade agreements between the European Commission and certain Japanese manufacturers on floor prices for the export to Europe of certain key devices like 256-kbit and 1-Mbit DRAMs.

(Slide 29 – Fabrication in Europe)

Over the past year, many non-European companies have already made the decision to site semiconductor facilities in Europe. We have seen announcements from Fujitsu, Intel and Texas Instruments. Other companies like Hitachi, Matsushita, Mitsubishi, Samsung and Sony have expressed their intention to set up facilities in Europe.

One question you may ask is: "Will there soon be overcapacity in Europe?" We believe the answer is clearly "no."

(Slide 30A – European Semiconductor Production)

Last year we estimate that, of the $8.5 billion (¥1.2 trillion) market for semiconductors in Europe, only $5.3 billion worth (¥0.76 trillion) were actually fabricated there – this $3.2 billion deficit is a major undercapacity.

Considered in conjunction with our forecast that European demand will grow faster than elsewhere – this deficit will take a long time to clear. Taking into account the plans of the companies I have mentioned, we estimate that Europe's net imports will fall from 37 percent of its internal consumption last year – to 21 percent in 1992.

However, in absolute revenue, we forecast this deficit will hardly fall – from $3.2 billion to $3.0 billion.

(Slide 31 – Fabrication in Europe – Opportunities)

Let us consider one moment the advantages for those Japanese manufacturers who do fabricate within the Community.

Firstly, these plants are not affected by the Commission's "diffusion rule" – nor will they be affected by the floor price agreements.

Secondly, these producers are becoming preferred suppliers to Japanese customers who themselves need to maximise local content to comply with anti-dumping rules.

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Thirdly, many of your customers in Europe are also your customers here in Japan. If you cannot supply these global customers with prompt and competitively priced semiconductors in Europe – you will lose their custom everywhere.

Fourthly, placing design centres in Europe, as well as a fabrication plant in Europe, would qualify your Company for participation in many of the European projects I have mentioned – particularly those connected with ESPRIT.

These will give you better access to many of the new applications which are flowing out of Europe, such as HD-MAC and the digital cellular standards.

(Slide 32 – Conclusions)

Finally, I would like to close with the following remarks.

The fact that so many believe 1992 will stimulate the electronics industry in Europe will be enough to make it happen on its own.

Evidence for this can be seen from the large amount of restructuring that has occurred already, whether this is internal structuring as was the case in Philips and Siemens... or whether it is in the form of external merger or acquisitions – as we have seen with SGS-Thomson and Inmos.

Beyond 1992 – there are other opportunities just around the corner. Reforms are taking place not just inside the Community, but also on its borders. Consider the opening of East Germany's and Czechoslovakia's frontiers for the first time in nearly 30 years. The very prospect of an annexation between East and West Germany may further accelerate the process of 1992 inside the present Community.

These changes will bring opportunities to West European and Japanese companies alike to site labour-intensive production in neighbouring low-cost states. By being inside Europe now, the world's largest unified market – you will also be positioned to take advantage of these new opportunities as they arise.

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1992 EUROPEAN UNIFICATION

THE SEMICONDUCTOR INDUSTRY

Jonathan Drazin

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1992 - SEMICONDUCTORS

AGENDA

- European Market
- 1992 Factors
- Industrial and Trade Issues
- Opportunities for Japanese Companies

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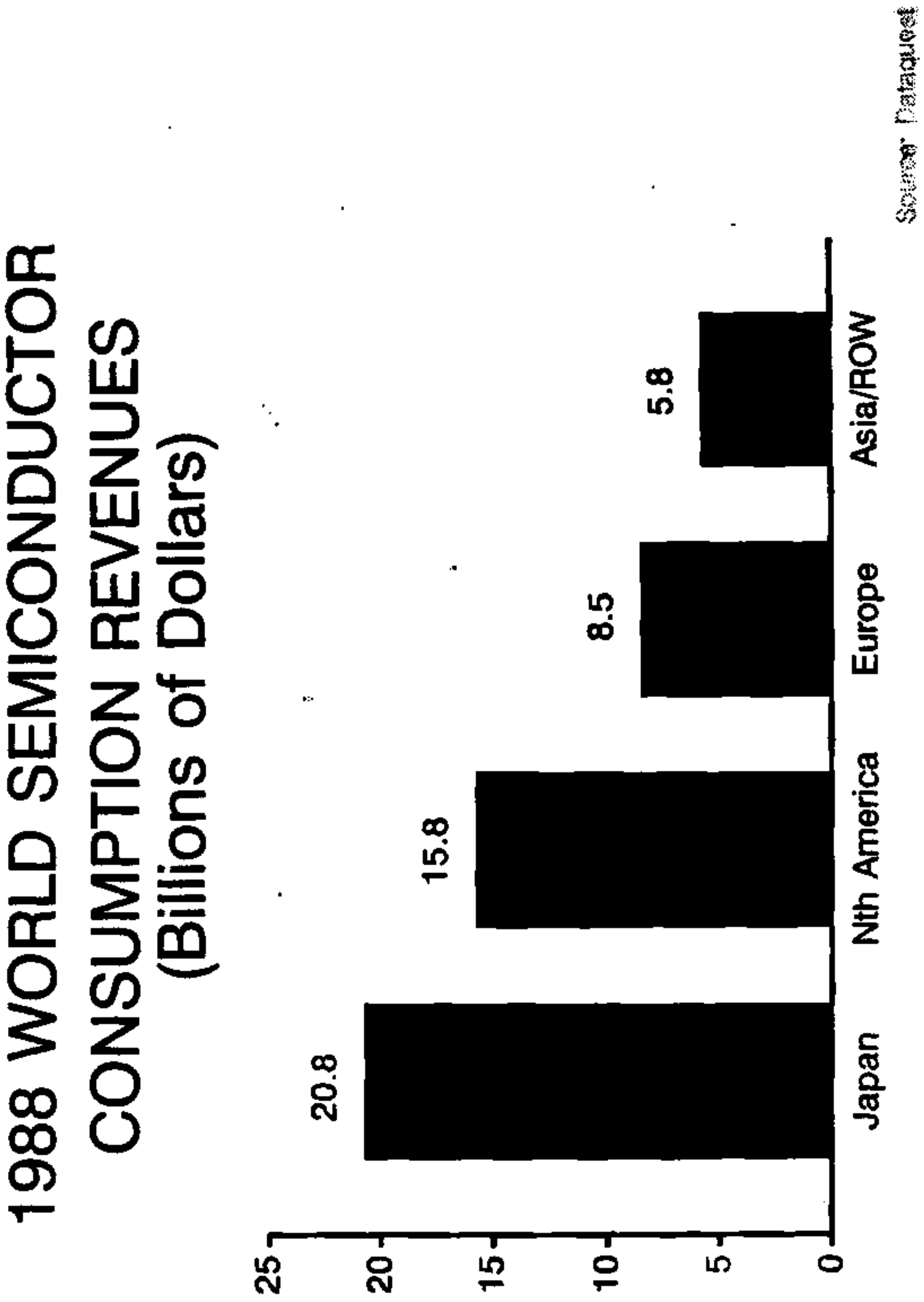

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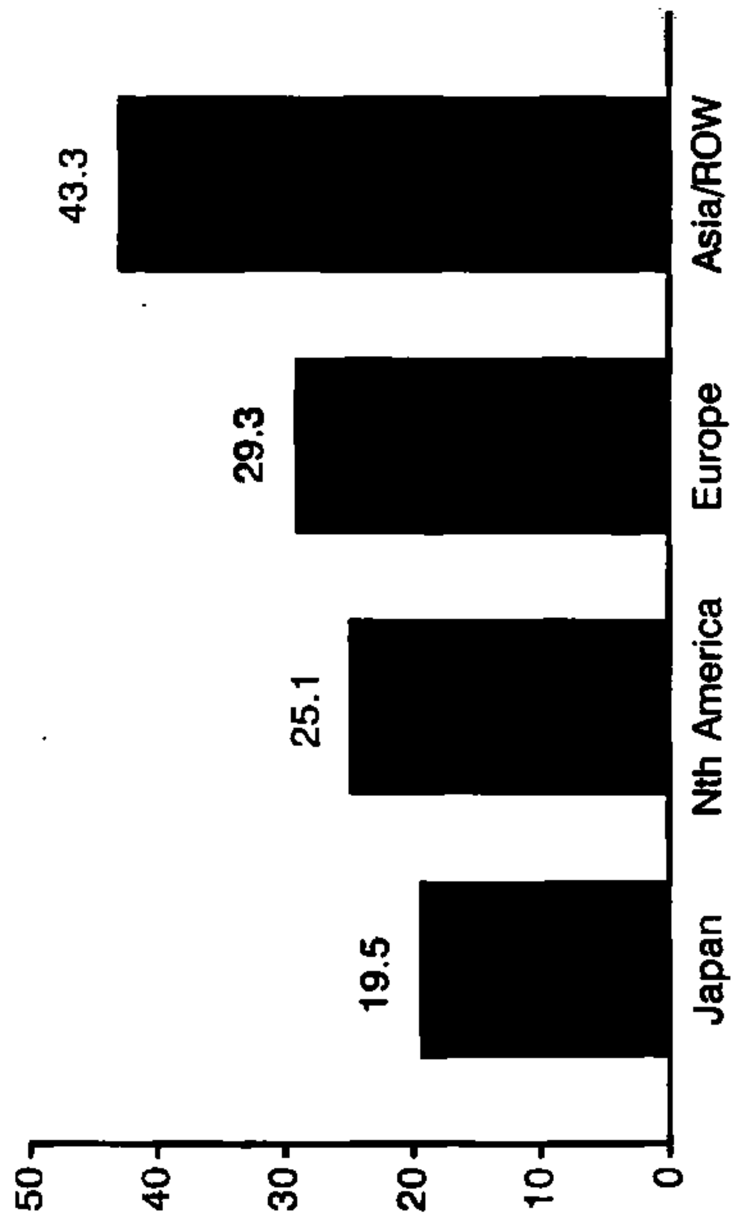
1987/1988 WORLD SEMICONDUCTOR MARKET GROWTHS
(Percent - Local Currencies)



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1988 EUROPEAN MERCHANT SEMICONDUCTOR SUPPLIERS' RANKING

	$billion
1. Philips	1018
2. SGS - Thomson	652
3. Texas Instruments	647
4. Motorola	616
5. Siemens	569
6. Intel	485
7. Toshiba	390
8. NEC	387
9. National Semiconductor	386
10 AMD	277

Source: Dataquest

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EUROPEAN SEMICONDUCTOR MARKET SHARE

Total = $8491 million
1988

Source: Dataquest

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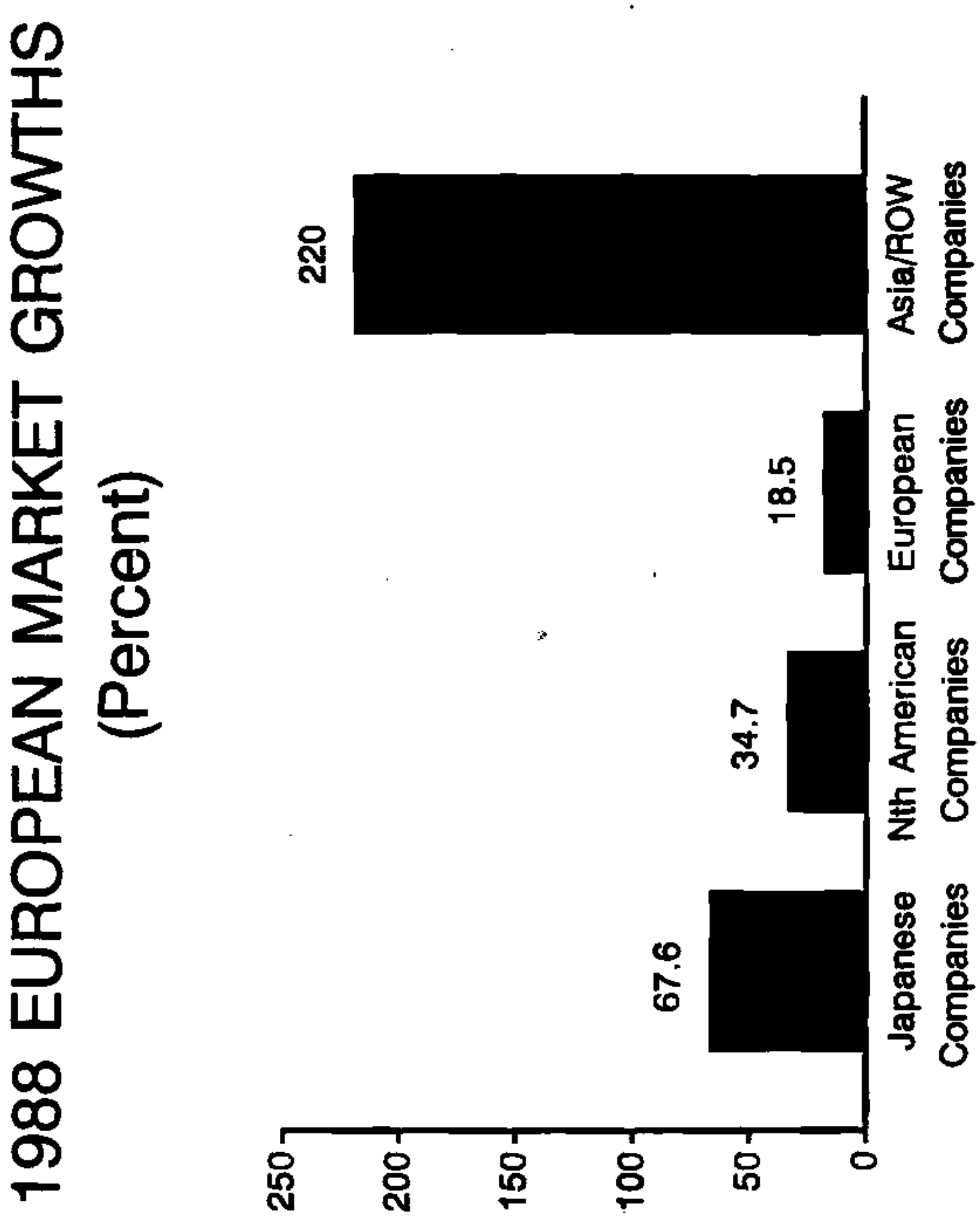

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1988 EUROPEAN MERCHANT SEMICONDUCTOR SUPPLIERS' REVENUES

Top Ten Ranked by Growth
(Percent of US dollars)

1.	Samsung	300
2.	Toshiba	107
3.	Inmos	100
4.	Matsushita	77
5.	Intel	71
6.	Mitsubishi	64
7.	Hitachi	57
8.	NEC	55
9.	LSI Logic	50
10.	Matra-Harris	49

Source: Dataquest

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1992 - SEMICONDUCTORS

YEN APPRECIATION

- Spectacular increase in local Far Eastern production:
  - Printers
  - Photocopiers
  - Facsimile
  - Cellular telephones
  - Video recorders
  - Compact disk
  - Colour televisions

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1992 - SEMICONDUCTORS

EUROPE

- Strong market
- Weak Industry

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1992 - SEMICONDUCTORS

EC ANTI-DUMPING

- Hardened EC attitude
- "Screwdriver" plants beginning to purchase locally
- Purchasing commodity parts

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1992 - SEMICONDUCTORS

EC ANTI-DUMPING

- Still scope to import critical parts
- What effect "negative regulation"?

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1992 - SEMICONDUCTORS

1992 FACTORS

- Does not cover trade with rest of world
- Little direct 1992 impact - so far

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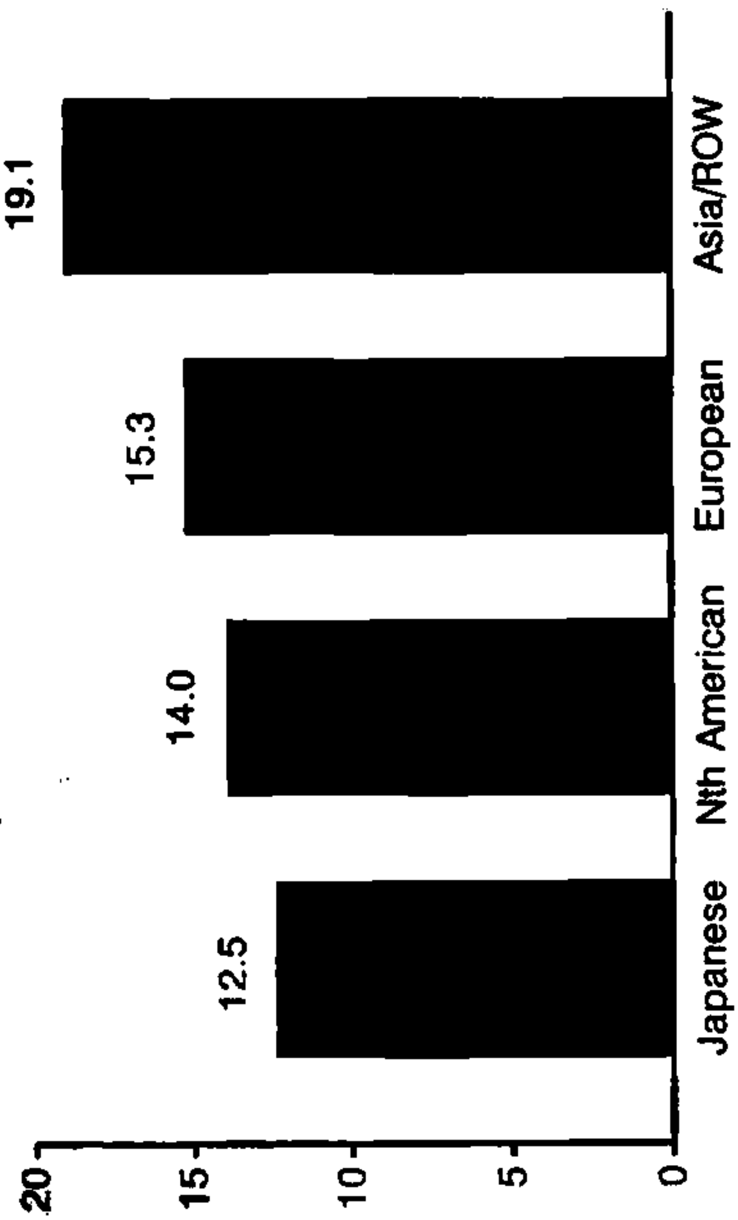
1988 - 1994 FORECAST WORLD SEMICONDUCTOR MARKET GROWTHS
(Percent CAGR)



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1992 - SEMICONDUCTORS

1992 FACTORS

- 279 directives

- Analysis by:
  - Directive type
  - Industry function

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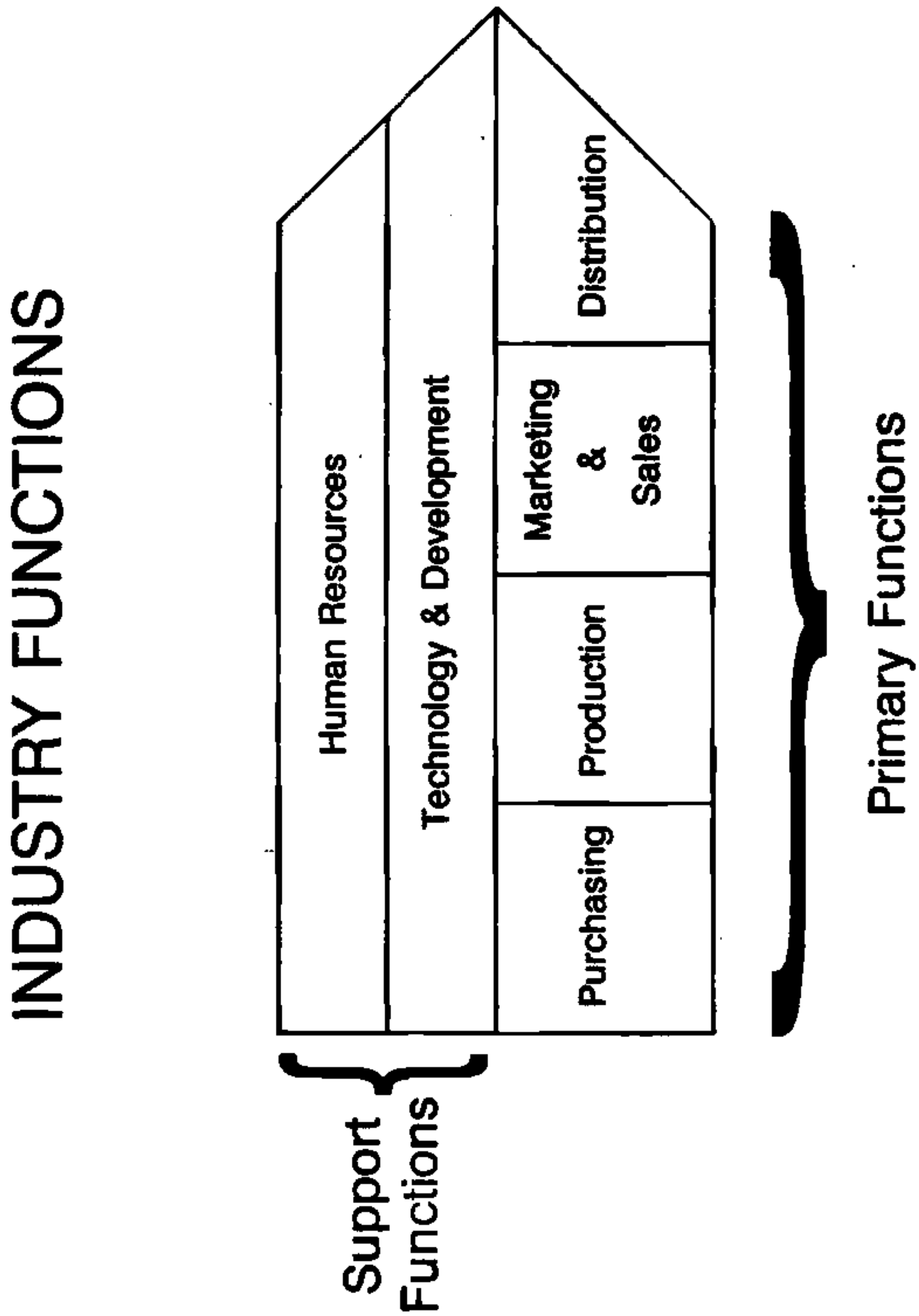
INDUSTRY FUNCTIONS
Human Resources
Technology & Development
Purchasing
Production
Marketing & Sales
Distribution
Support Functions
Primary Functions

1992 - SEMICONDUCTORS

REMOVAL OF TECHNICAL BARRIERS

- Safety and Interference
- Telecommunications
- Pan-European standards
  - CENELEC
  - ETSI
- Good for trade <u>with</u> Europe

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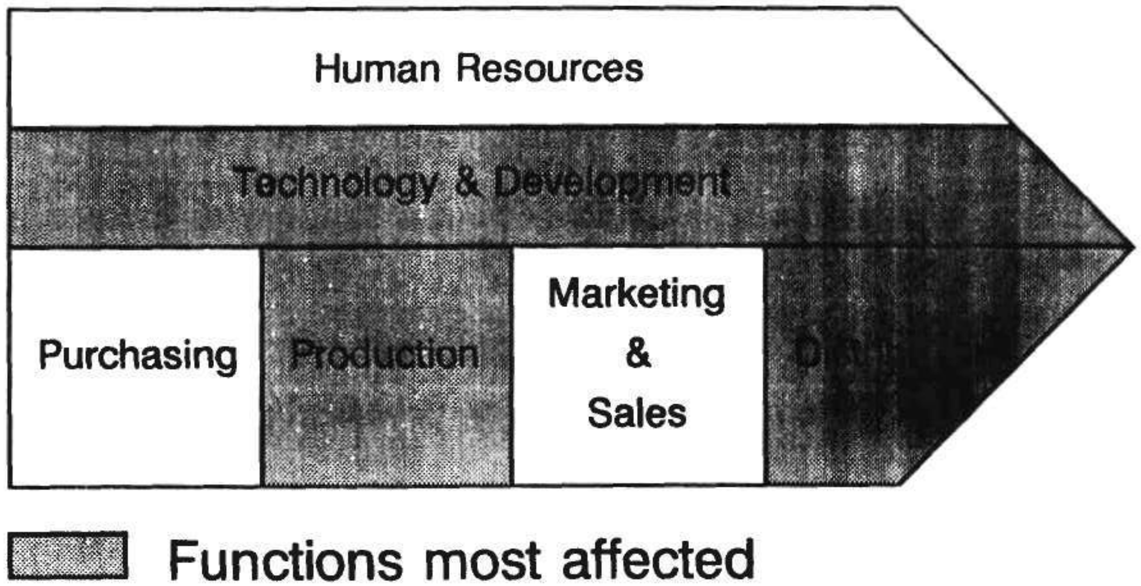
REMOVAL OF TECHNICAL BARRIERS

- Longer production runs
- Lower development costs
- Lower inventory



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1992 - SEMICONDUCTORS

REMOVAL OF PHYSICAL BARRIERS

- Frontier controls removed
- Cheaper transport
- Less delay
- Free movement of:
  - goods
  - people
  - money

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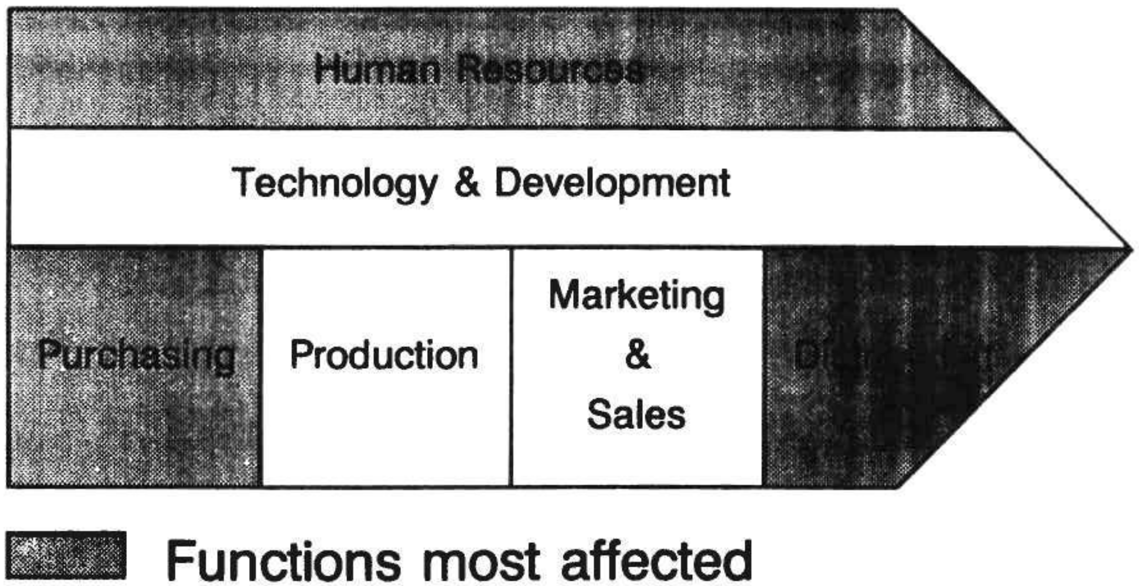
REMOVAL OF PHYSICAL BARRIERS

- Consolidation of distribution
- Shift from national to pan-European franchises
- Centralized warehousing



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1992 - SEMICONDUCTORS

ECONOMIES OF SCALE

- Open procurement
- Mutual recognition

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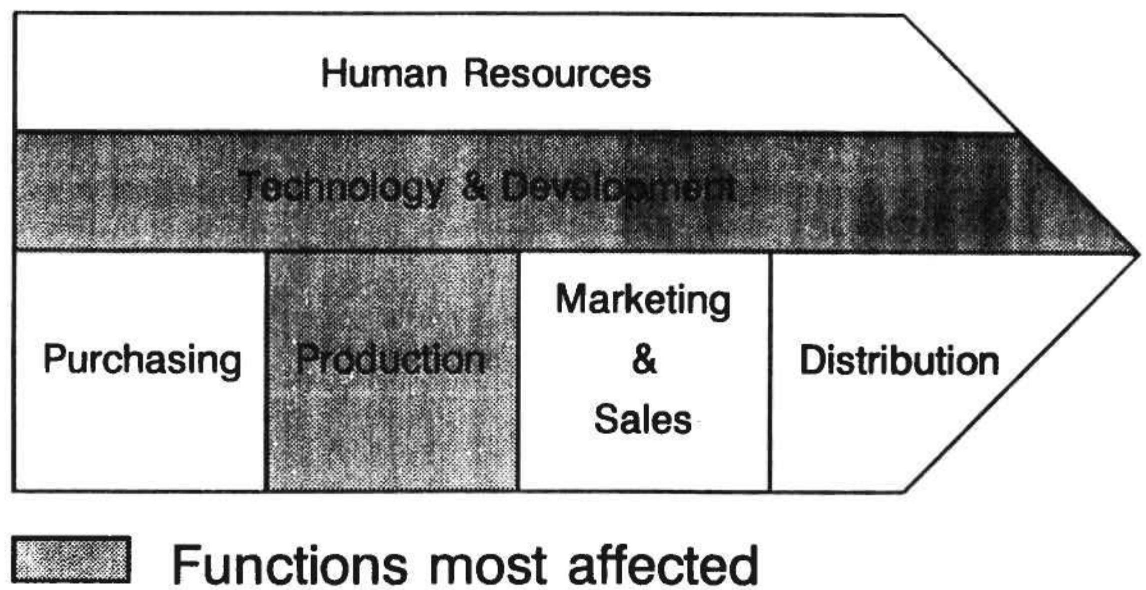
ECONOMIES OF SCALE

- Fixed costs amortized over 12 markets - not 1
- Rationalization of core activities



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1992 - SEMICONDUCTORS

CROSS BORDER RESEARCH

- EC aims to give central funding and leadership
- 1.3 billion ECU's spent in 1989
- Spending to double by 1991

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1992 - SEMICONDUCTORS

ESPRIT

- 10 year program in 2 phases
- Key activities:
  - Microelectronics
  - Software technology
  - Computer integrated manufacture
- Funding: 50% community 50% industry
- Foreign participation <u>if</u> research conducted within EEC
- 1600 million ECU's spent since 1984

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1992 - SEMICONDUCTORS

EUREKA

- Program not defined by EC
- Open to additional European states
- No community funding:
  - Industry
  - National government
- Non-European participation difficult
- 5000 million ECU's spent since 1985

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1992 - SEMICONDUCTORS

JESSI

- Aims to restore leading edge capability
- Seven year program: 1989-1996
- 64Mbit DRAM by 1996
- Marries applications to process development:
  - HD-MAC
  - ISDN
  - GSM
- Awaiting 3.8 billion ECU's funding
  - 50% national government
  - 50% community

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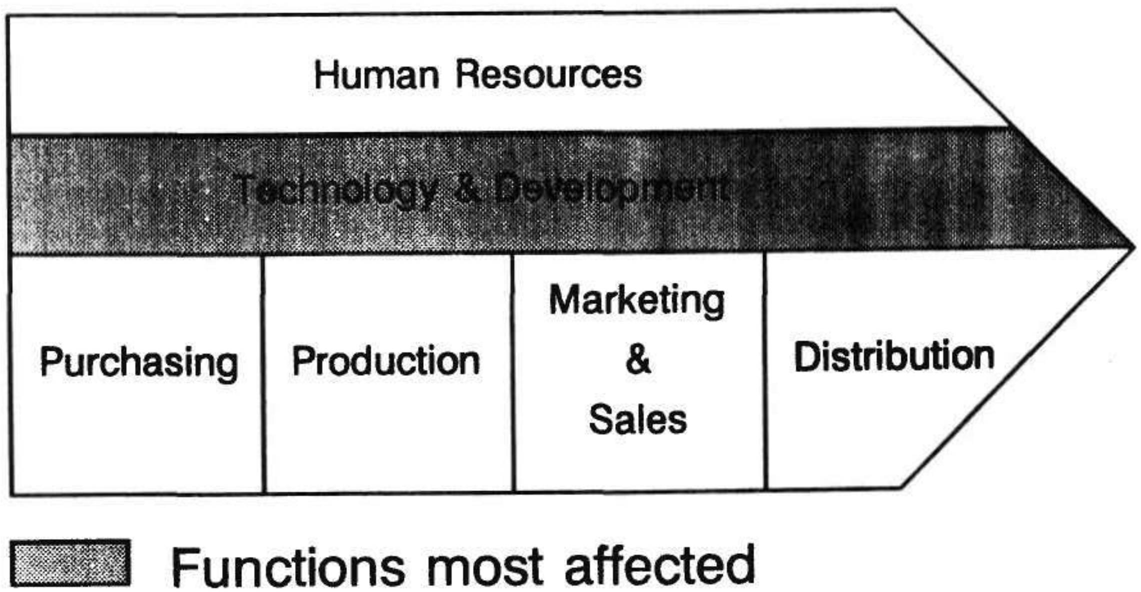
CROSS BORDER RESEARCH

- Central coordination
- Pan-European standards



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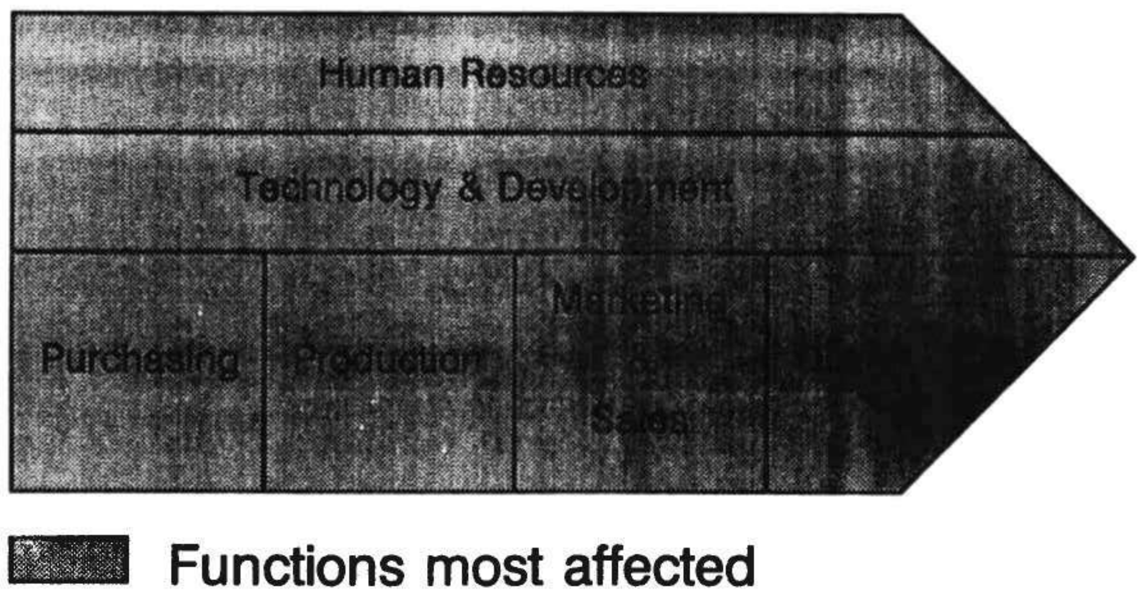
1992 - OVERALL IMPACT

- EVERY FUNCTION AFFECTED!
- Cannot ignore other dimensions
  - competition
  - fiscal
  - social



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1992 - SEMICONDUCTORS

JAPAN - BUSINESS OPPORTUNITIES

- Invest in Europe?
- Local origin - diffusion
- Floor prices on exports

1992 - SEMICONDUCTORS

FABRICATION IN EUROPE

- Announcements: Fujitsu, Intel, Texas Instruments
- More announcements expected
- Severe undercapacity - $3 billion

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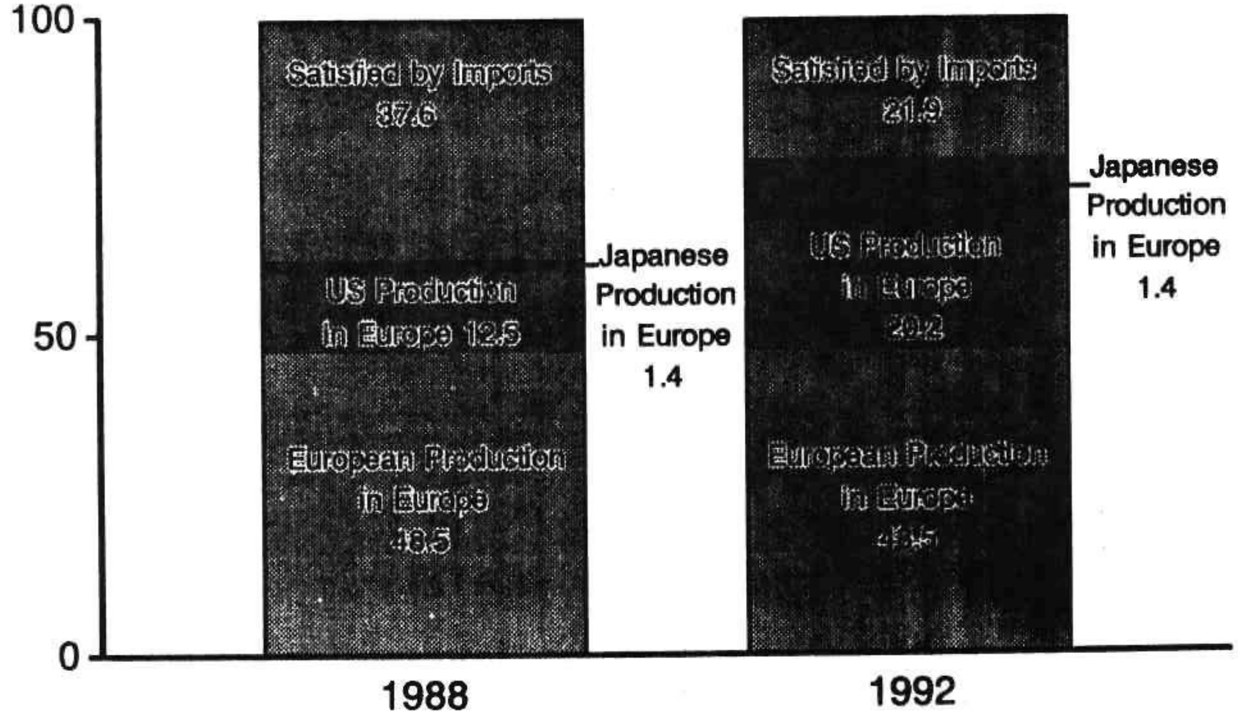
ESTIMATED EUROPEAN SEMICONDUCTOR BY PRODUCTION ORIGIN
(Percentage European Consumption)



Source: Dataquest

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1992 - SEMICONDUCTORS

LOCAL FABRICATION - OPPORTUNITIES

- Avoids local origin and floor prices issues
- Local Japanese producers become preferred suppliers
- Global customers need global suppliers
- Access to European standards

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1992 - SEMICONDUCTORS

CLOSING REMARKS

- European electronics believes in 1992
- European industry is restructuring now
- Beyond 1992 - new opportunities

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European MOS Microcomponent Market Consumption Forecast 1987-1995 and Market Share Rankings

European Semiconductor Industry Group

Published by Dataquest Europe Limited

July 1991

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Footnotes to the Tables

Inmos	Inmos revenue is included in SGS-Thomson's revenue from 1989 onward.
GEC Plessey Semiconductors	GEC Plessey Semiconductors was formed in 1989 from the merger of Marconi Electronic Devices Ltd (MEDL) and Plessey Semiconductors.
MEDL	MEDL revenue is included in GEC Plessey Semiconductors' revenue from 1990.
Plessey	Plessey revenue is included in GEC Plessey Semiconductors' revenue from 1990.
SGS-Thomson	SGS-Thomson's revenue includes Inmos' revenue from 1989 onward. SGS-Thomson's revenue included 30 percent of Thomson Composants Militaries et Spatiaux' (TMS) revenue until 1989. SGS-Thomson's revenue includes Thomson's revenue from 1986.
Thomson	Thomson's revenue is included in SGS-Thomson's revenue from 1986.
TMS	Thomson Composants Militaires et Spaitaux' revenue was formerly included in SGS-Thomson's revenue (30 percent) and the European Others category (70 percent) until 1989.
Fairchild	Fairchild's revenue is included in National Semiconductor's revenue from 1986.
GE Solid State	GE Solid State's revenue is included in Harris's revenue from 1989. GE Solid State's revenue includes RCA's revenue from 1986.
Harris	Harris's revenue includes GE Solid State's revenue from 1989.
National Semiconductor	National Semiconductor's revenue includes Fairchild's revenue from 1986.
RCA	RCA's revenue is included in GE Solid State's revenue from 1986.

European MOS Microcomponent Market Consumption Forecast 1987-1995

Introduction

The European MOS microcomponent market will continue to grow faster than the European semiconductor market as a whole over the next five years. Dataquest estimates that by 1995, the European MOS microcomponent market will be worth $5,197 million. This represents a compound annual growth rate (CAGR) of 23.1 percent over the five years from 1990 to 1995. The CAGR for the European semiconductor market over the same period is 12.2 percent.

Microcomponent Overview

Regions

A quick analysis of the four largest regions shows that the largest market in Europe in 1990 was the United Kingdom and Eire. Following closely was Germany, together, these two markets represent over half of the total European market for MOS microcomponents. The dominance of the European market by these two regions is not forecast to change over the next five years. The strength of the data processing, communications and industrial segments in these two countries is the main reason for their dominance of the European MOS microcomponent market.

The growth of the microprocessor market in France over the period 1990 to 1995 is mainly because of the expansion of Bull's factory, which will manufacture PCs starting in 1991. The performance of the microperipheral market is closely tied to that of the microprocessor market, and the growth of the peripheral market in France is also tied to the expansion of this factory.

The recession in the United Kingdom badly affected the economy in 1990, apparent from the revenue for that year. Conditions are expected to improve leading to a better UK economy by the end of 1991.

The unification of east and west Germany is costing significantly more than was first anticipated. This is reducing economic growth for Germany, and microcomponents will not escape this slowing of growth. The high cost is likely to have a longer-term effect on the slowing of the German economy, previously one of the strongest in Europe.

Italy retains a strong presence in European microcomponents, with a market share only slightly smaller than France. IBM manufactures PC motherboards, workstations and AS/400s in Italy, and of course Olivetti manufactures its PCs and office equipment there. Italy will retain its ranking as the fourth-largest market in Europe for microcomponents, as its growth matches that of Europe as a whole.

Applications

The largest use of microcomponents is in data processing applications. This segment is forecast to lose market share, mainly to communications, over the period 1990 to 1995. This is chiefly because of the high growth in communications applications for microcomponents rather than because of a decline in data processing applications. The growing use of 32-bit microprocessors for controlling telecoms switches, and the use of digital signal processing (DSP) chips for line interfacing and mobile telecommunications are the driving features behind the high growth of the communications segment. The communications market is one of the highest-growth segments of the semiconductor market; this is reflected in the growing use of microcomponents within communications applications.

The emergence of multimedia applications will give strong growth to the data processing segment, with a large demand for processors, controllers and peripherals. The development of multimedia standards for image and data compression has prompted the design of chip sets for this, and these chip sets will fall under the microperipheral category.

Technologies

The main process technology used for microcomponent manufacture is CMOS. This provides a good trade-off between integration, cost and performance for the devices. The development of the BiCMOS process has provided a higher-performance capability, but at a higher cost. This means that its use will be limited to the areas where high performance is critical. No microcomponent devices in volume production use this process, but several are planned. The BiCMOS process gives a better trade off between performance, power use, integration and cost than ECL; so the development of some ECL microprocessors has been delayed to allow the investigation of a BiCMOS alternative. These processors are now more likely to be introduced using BiCMOS as the manufacturing process, rather than ECL. The introduction of high-performance microcomponents using BiCMOS as the manufacturing technology will spur the development of BiCMOS as mainstream. This will bring down the cost of the process, resulting in the introduction of many more BiCMOS-based microcomponents.

The biggest development in microprocessors in recent years has been the introduction of reduced-instruction-set microprocessors. These products trade off a wide range of instructions against higher processor performance. The range of RISC processors is small, but the most successful has been the Transputer from Inmos, part of SGS-Thomson, followed by those companies which adopted the SPARC architecture from Sun Microsystems, and the MIPS architecture from MIPS. Acorn's ARM has a high installed base, but the Transputer, SPARC and MIPS products are now outselling the ARM processor. Table 1 shows the range of RISC architectures available.

The main focus for RISC processors has been for use in workstations, but this market is limited. The RISC suppliers have, therefore, been adjusting their product development towards embedded control. This is a much larger market in terms of unit shipments and so provides a greater opportunity for RISC suppliers. However, the size of the market is related to the price per unit for the controllers, and many RISC devices are expensive. Few products require the high performance of RISC processors, so the embedded control market may well become a ferocious battleground as all the manufacturers fight for market share. The availability of software to run on the processor is likely to be a significant contributing feature in the success of the processor. The use of high-level languages, such as "C" is improving the development time of control systems, and these languages are becoming an absolute requirement for control systems applications.

The quest for more performance from processors has driven the word length to 32 bits for mainstream applications. Data processing requires 32 bits but most control applications require much less. The largest unit shipments have been for 4-bit and 8-bit controllers. However, the relatively low price of these products reduces the value of the market in dollars.

Table 1

RISC Architectures

Company	Design	Sources
Motorola	88000	Motorola, Thomson
Intel	i860, i960	Intel
Sun	SPARC	BIT, Cypress, Fujitsu, LSI Logic, Philips, Texas Instruments, Matra-MHS, Matsushita
MIPS	Rxxxx	IDT, LSI Logic, NEC, Siemens, Performance, Sony
Acorn	ARM	Sanyo, VLSI Technology
AMD	AM29000	AMD
Intergraph	Clipper	Intergraph, Samsung
RSRE	Viper 1A	GEC Plessey Semiconductors
Hewlett-Packard	Spectrum P.A.	Hitachi, Samsung
Inmos	Transputer	Inmos

Source: Dataquest (July 1991)

The majority of processors execute a single instruction at a time, but this standard is changing. The ability to execute more than one instruction at a time improves device performance but makes large demands of the bandwidth of the processor bus. The extension of word lengths to 64 bits allows instructions to be loaded in parallel and reduces the clock speed requirements of the processor bus. The performance of the system can thus be improved significantly by adopting a 64-bit multiple-instruction architecture, and the performance limit of the manufacturing process can be sidestepped by paralleling instructions in this manner. The cost of using multiple instructions is an increase in die size, as the core functions, such as the ALU, have to be duplicated.

Segment Analysis

Microprocessor

The microprocessor segment of the microcomponent market will grow at an above-average rate over the next five years. By 1995, the European microprocessor market will be worth $1,488 million. This is a CAGR of 23.8 percent over the period 1990 to 1995. The high growth of the microprocessor market is mainly from the communications sector. The increasing use of 32-bit processors for motor control, telecoms switch control and in DSP applications will ensure high growth in this market.

The massive growth forecast for laptop and notebook computers will also stimulate the demand for 32-bit microprocessors and microperipherals. The development of multimedia applications will also contribute to the above-average growth of the microprocessor market in Europe. The largest segment of the microprocessor market by 1995 will remain 32-bit processors. Very few processors exist with 64-bit capability; and these will have very limited applications over the next five years. The development of multi-instruction (superscalar) processors will stimulate the growth of the 64-bit market, but the highest growth will be beyond 1995. Regionally, the areas with the greatest data processing strength—the United Kingdom and Eire, and Germany—are those with the strongest microprocessor revenue. The expansion of Bull's manufacturing plant in France will boost the consumption of microprocessors in this country.

Data processing represents the largest application segment for microprocessors, and will continue to do so over the next five years. However, data processing's share of the microprocessor market will fall. This is not because of a decline in this market, but a reflection on the higher growth of communications and industrial applications. The extension of word lengths up to 32 bits for some industrial control applications has meant that embedded microprocessors rather than single-chip microcontrollers are used for these embedded control applications. The functions performed in these applications are more compute-intensive than input/output-intensive. This has increased the growth of the industrial segment of the microprocessor market, particularly in 1994 and 1995.

Microcontroller

The microcontroller market will also grow at an above-average rate over the period 1990 to 1995. By 1995 the microcontroller market in Europe will be worth $2,367 million, a CAGR of 24.3 percent. The largest use of microcontrollers will be in 4-bit applications, but the lower unit cost of 4-bit controllers in most applications means that 8-bit controllers have a higher share of the total microcontroller revenue. The increase in word length has given greater performance to the controllers, but the number of applications which need this higher performance is limited. The unit prices of these products are much higher, however, giving a greater value to the market. The introduction of 32-bit microprocessors has enabled very compute-intensive applications to benefit from high-performance control, but these devices are not single-chip controllers. The microprocessors are embedded into the control application together with the peripheral devices, which make up the control system. There are applications for single-chip 32-bit controllers, but these are few. The main emphasis for high-performance control is on embedded control, not single-chip controllers.

The move away from single-chip controllers for high-performance applications is reflected in the fall in market share of the industrial segment of the microcontroller market. The greatest growth is for communications applications. The development of DSP chips for communications applications such as Groupe Spéciale Mobile (GSM) signal processors and ISDN has opened a large market. The progressive digitization of Europe's telecommunications systems is creating a very large market for the single-chip, digital signal processors. These DSP products are mainly 16-bit devices.

Other applications showing high growth are consumer and transportation. The growth in consumer applications is due to the greater semiconductor content in products, and the rise in use of consumer products such as VCRs and compact discs. The increased manufacture of compact disc players in Europe is in response to antidumping charges levied at the Japanese compact disc manufacturers. These companies are now growing their European manufacture of compact disc players. By contrast, Thomson is moving more of its consumer manufacture to the Far East, having a small balancing effect on the use of microcontrollers for consumer products. This will effect a decline in microcontroller use in France, but little change in other regions will be seen.

The semiconductor content of cars is increasing, as more cars adopt microcontrollers for engine management and other control functions, resulting in an above-average growth for the transportation segment.

Microperipheral

The microperipheral market follows the microprocessor market quite closely. This market has the lowest CAGR of the three microcomponent segments, and will grow to $1,342 million by 1995, a CAGR of 20.6 percent. While this growth is the lowest of the microcomponent segment, it is still higher than for the total semiconductor market.

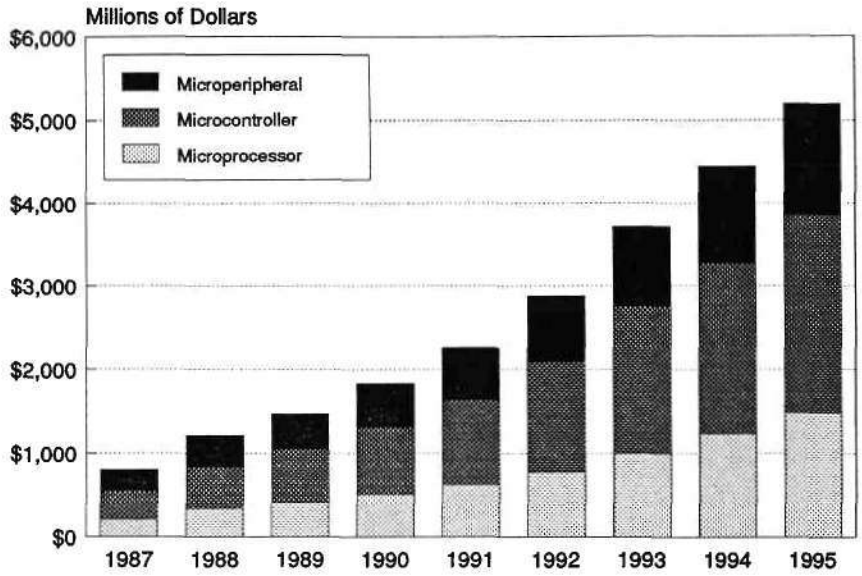
Data processing is the largest application segment of the microperipheral market, and the growth in multimedia applications will give strong long-term demand for microperipheral products. The development of chip sets for still and moving-image data compression will stimulate demand. The inclusion of floating-point processors onto the microprocessor chip will, however, slow the growth in the highly profitable product area of coprocessors. The growth segment for the microperipheral market in the short term is with communications applications. These are products such as local area network (LAN) chips. The rise in networking of PCs has created more demand for networking cards, and these cards obviously need LAN chips. Demand is also high for modem chips in products such as facsimile machines.

Little has changed in the regional share of microperipheral products, with the exception of France, where the expansion of Bull's factory has increased share. The strong data processing markets of the United Kingdom and Eire and Germany are also the strongest regional markets for microperipheral products.

MOS Microcomponent

Figure 1

European MOS Microcomponent Revenue History and Forecast



Source: Dataquest (July 1991)

Table 2

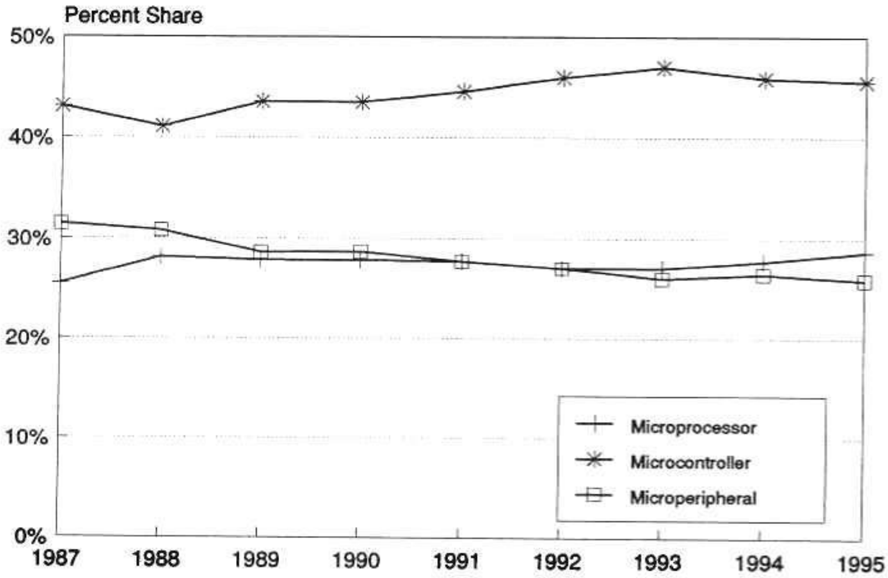
Estimated European MOS Microcomponent Revenue 1987-1995

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Millions of Dollars										
Microcomponent	805	1,212	1,469	1,836	2,263	2,873	3,706	4,447	5,197	23.1%
Microprocessor	205	341	409	511	627	776	1,001	1,232	1,488	23.8%
Microcontroller	347	498	640	799	1,009	1,321	1,742	2,041	2,367	24.3%
Microperipheral	253	373	420	526	627	776	963	1,174	1,342	20.6%
Percent Share										
Microcomponent	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Microprocessor	25%	28%	28%	28%	28%	27%	27%	28%	29%	
Microcontroller	43%	41%	44%	44%	45%	46%	47%	46%	46%	
Microperipheral	31%	31%	29%	29%	28%	27%	26%	26%	26%	

Source: Dataquest (July 1991)

Figure 2

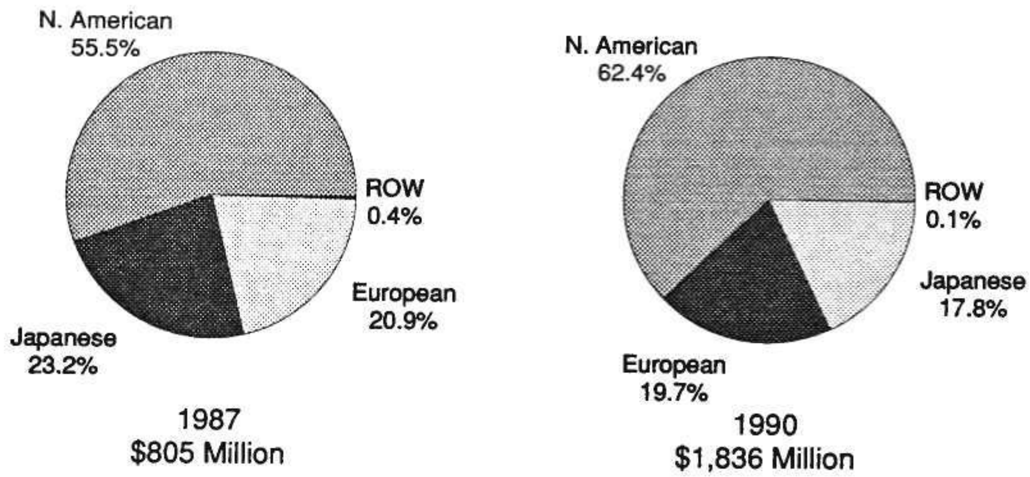
European MOS Microcomponent Market Share by Word Length



Source: Dataquest (July 1991)

Figure 3

European MOS Microcomponent Market Share by Vendor Origin



Source: Dataquest (July 1991)

Table 3

Estimated European MOS Microcomponent Revenue by Company
(Millions of Dollars)

	1987	1988	1989	1990
Total Shipments	805	1,212	1,469	1,836
European Companies	168	220	265	362
Eurosil	2	1	1	3
GEC Plessey Semiconductors*	0	0	0	6
Inmos*	13	21	0	0
Matra-MHS	15	14	20	24
MEDL*	1	1	1	0
Philips	54	55	62	112
Plessey*	0	0	2	0
SGS-Thomson*	60	77	101	126
Siemens	23	51	67	83
TMS*	0	0	11	8
North American Companies	447	735	890	1,145
AMD	33	33	34	47
Analog Devices	3	6	6	6
AT&T	1	1	4	4
Cypress	0	0	2	3
GE Solid State*	9	15	0	0
Harris*	6	6	21	31
IDT	2	6	3	3
Intel	162	351	416	528
ITT	10	7	18	21
LSI Logic	0	0	6	2
Motorola	96	150	179	233
National Semiconductor*	35	40	45	50
Rockwell	8	0	9	9
Texas Instruments	38	48	60	99
TRW	0	0	0	1
VLSI Technology	3	5	17	28
Western Digital	10	17	23	18
Zilog	15	19	16	17
North American Others	16	31	31	45
Japanese Companies	187	253	310	327
Fujitsu	4	9	10	12
Hitachi	44	71	75	77
Mitsubishi	6	8	48	10
NEC	90	109	122	151
Oki	12	16	18	19
Sharp	1	1	1	1
Sanyo	9	12	1	1
Toshiba	21	27	35	56
Rest of World	3	4	4	2
Rest of World Others	3	4	4	2

* See Footnotes (page iv)
Source: Dataquest (July 1991)

Table 4

European 1990 Microcomponent Market Share Rankings (Millions of Dollars)

1990 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1990 Sales ($M)	1989-90 Annual Growth (%)	1990 Cum. Sum ($M)	1990 Market Share (%)	1990 Cum. Sum (%)
1	1	0	Intel	351	416	528	26.9	528	28.8	28.8
2	2	0	Motorola	150	179	233	30.2	761	12.7	41.4
3	3	0	NEC	109	122	151	23.8	912	8.2	49.7
4	4	0	SGS-Thomson	77	101	126	24.8	1,038	6.9	56.5
5	7	2	Philips	55	62	112	80.6	1,150	6.1	62.6
6	8	2	Texas Instruments	48	60	99	65.0	1,249	5.4	68.0
7	6	-1	Siemens	51	67	83	23.9	1,332	4.5	72.5
8	5	-3	Hitachi	71	75	77	2.7	1,409	4.2	76.7
9	11	2	Toshiba	27	35	56	60.0	1,465	3.1	79.8
10	10	0	National Semiconductor	40	45	50	11.1	1,515	2.7	82.5
11	12	1	AMD	33	34	47	38.2	1,562	2.6	85.1
12	14	2	Harris	6	21	31	47.6	1,593	1.7	86.8
13	18	5	VLSI Technology	5	17	28	64.7	1,621	1.5	88.3
14	15	1	Matra-MHS	14	20	24	20.0	1,645	1.3	89.6
15	17	2	ITT	7	18	21	16.7	1,666	1.1	90.7
16	16	0	Oki	16	18	19	5.6	1,685	1.0	91.8
17	13	-4	Western Digital	17	23	18	-21.7	1,703	1.0	92.8
18	19	1	Zilog	19	16	17	6.3	1,720	0.9	93.7
19	21	2	Fujitsu	9	10	12	20.0	1,732	0.7	94.3
20	9	-11	Mitsubishi	8	48	10	-79.2	1,742	0.5	94.9
21	22	1	Rockwell	0	9	9	0.0	1,751	0.5	95.4
22	20	-2	TMS	0	11	8	-27.3	1,759	0.4	95.8
23	-	NA	GEC Plessey Semiconductors*	0	0	6	NA	1,765	0.3	96.1
24	24	0	Analog Devices	6	6	6	0.0	1,771	0.3	96.5
25	25	0	AT&T	1	4	4	0.0	1,775	0.2	96.7
26	26	0	IDT	6	3	3	0.0	1,778	0.2	96.8
27	32	5	Eurosil	1	1	3	200.0	1,781	0.2	97.0
28	28	0	Cypress	0	2	3	50.0	1,784	0.2	97.2
29	23	-6	LSI Logic	0	6	2	-66.7	1,786	0.1	97.3
30	-	NA	TRW	0	0	1	NA	1,787	0.1	97.3
31	29	-2	Sharp	1	1	1	0.0	1,788	0.1	97.4
32	30	-2	Sanyo	12	1	1	0.0	1,789	0.1	97.4
-	27	NA	Plessey	0	2	0	-100.0	1,789	0.0	97.4
-	31	NA	MEDL	1	1	0	-100.0	1,789	0.0	97.4
-	-	NA	Inmos	21	0	0	NA	1,789	0.0	97.4
-	-	NA	GE Solid State	15	0	0	NA	1,789	0.0	97.4
			Others Europe	0	0	0	NA	1,789	0.0	97.4
			Others North American	31	31	45	45.2	1,834	2.5	99.9
			Others Japan	0	0	0	NA	1,834	0.0	99.9
			Others Rest of World	4	4	2	-50.0	1,836	0.1	100.0
			Total All Companies	1,212	1,469	1,836	25.0			
			Total European	220	265	362	36.6		19.7	
			Total North American	735	890	1,145	28.7		62.4	
			Total Japanese	253	310	327	5.5		17.8	
			Total Rest of World	4	4	2	-50.0		0.1	

NA = Not Applicable
Source: Dataquest (July 1991)

MOS Microprocessor

Table 5

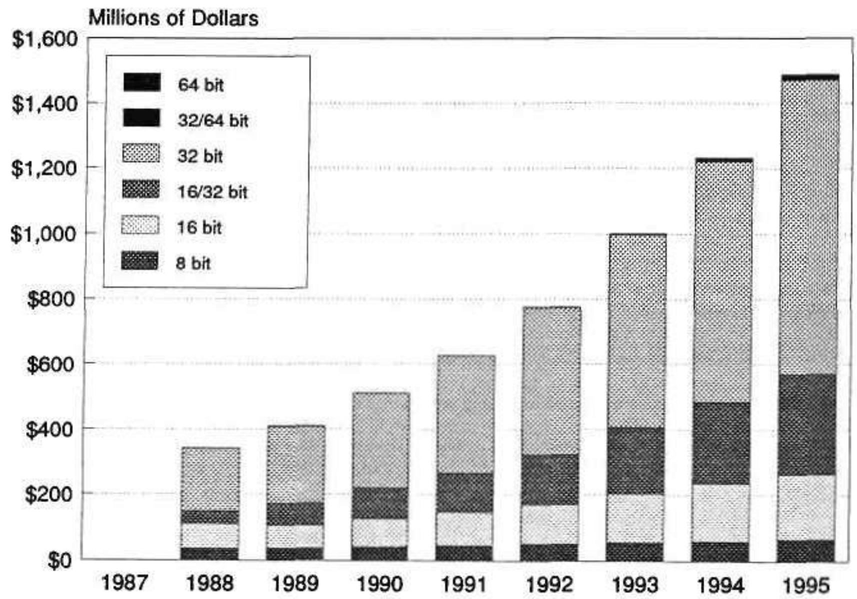
Estimated European MOS Microprocessor Revenue

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Millions of Dollars										
Microcomponent	805	1,212	1,469	1,836	2,263	2,873	3,706	4,447	5,197	23.1%
Microprocessor	205	341	409	511	627	776	1,001	1,232	1,488	23.8%
Microcontroller	347	498	640	799	1,009	1,321	1,742	2,041	2,367	24.3%
Microperipheral	253	373	420	526	627	776	963	1,174	1,342	20.6%
Microprocessor	205	341	409	511	627	776	1,001	1,232	1,488	23.8%
8 Bit	N/A	34	37	41	46	50	56	60	65	9.6%
16 Bit	N/A	75	70	85	101	120	147	174	198	18.4%
16/32 Bit	N/A	40	66	94	119	151	203	250	307	26.7%
32 Bit	N/A	191	237	291	361	454	591	737	900	25.3%
32/64 Bit	N/A	0	0	0	0	1	4	10	15	NA
64 Bit	N/A	0	0	0	0	0	0	1	3	NA
Percent Share										
Microcomponent	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Microprocessor	25%	28%	28%	28%	28%	27%	27%	28%	29%	
Microcontroller	43%	41%	44%	44%	45%	46%	47%	46%	46%	
Microperipheral	31%	31%	29%	29%	28%	27%	26%	26%	26%	
Microprocessor	25%	28%	28%	28%	28%	27%	27%	28%	29%	
8 Bit	N/A	10%	9%	8%	7%	7%	6%	5%	4%	
16 Bit	N/A	22%	17%	17%	16%	15%	15%	14%	13%	
16/32 Bit	N/A	12%	16%	18%	19%	20%	20%	20%	21%	
32 Bit	N/A	56%	58%	57%	58%	58%	59%	60%	61%	
32/64 Bit	N/A	0%	0%	0%	0%	0%	0%	1%	1%	
64 Bit	N/A	0%	0%	0%	0%	0%	0%	0%	0%	

NA = Not Applicable
N/A = Not Available
Source: Dataquest (July 1991)

Figure 4

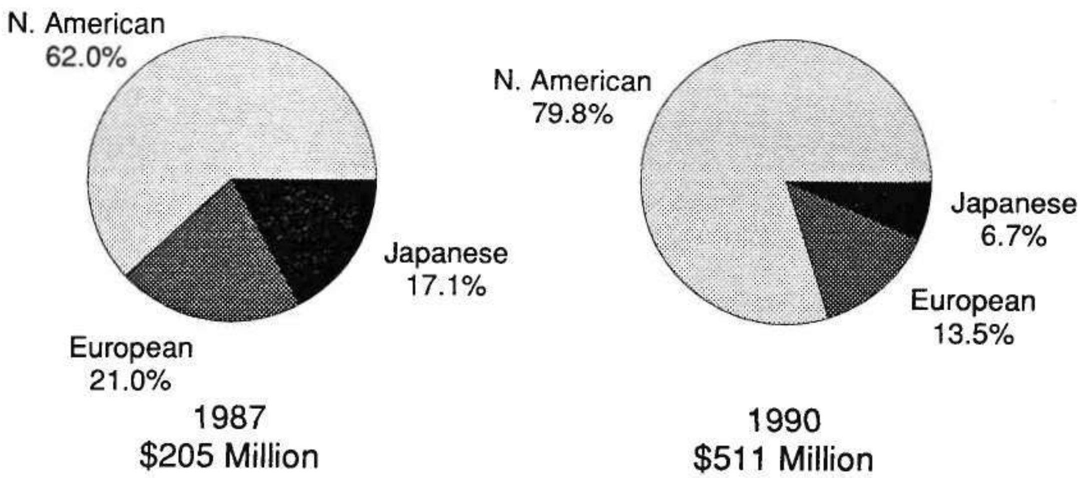
European MOS Microprocessor Market Share by Word Length



Source: Dataquest (July 1991)

Figure 5

European MOS Microprocessor Market Share by Vendor Origin



Source: Dataquest (July 1991)

Table 6

Estimated European MOS Microprocessor Revenue by Company
(Millions of Dollars)

	1987	1988	1989	1990
Total Shipments	205	341	409	511
European Companies	43	51	59	69
GEC Plessey Semiconductors	0	0	0	6
Inmos	9	9	0	0
Matra-MHS	1	0	0	0
MEDL	0	1	1	0
Philips	9	5	5	3
SGS-Thomson	17	20	32	36
Siemens	7	16	16	20
TMS	0	0	5	4
North American Companies	127	248	318	408
AMD	17	15	13	13
AT&T	0	0	1	0
Cypress	0	0	1	2
GE Solid State	1	2	0	0
Harris	6	6	3	6
IDT	0	0	1	1
Intel	53	150	208	291
ITT	1	0	0	0
LSI Logic	0	0	1	1
Motorola	31	49	61	67
National Semiconductor	9	10	11	12
Rockwell	1	0	1	1
Texas Instruments	2	4	5	4
TRW	0	0	0	1
VLSI Technology	0	1	2	1
Zilog	4	5	4	4
North American Others	2	6	6	4
Japanese Companies	35	42	32	34
Fujitsu	1	2	2	2
Hitachi	7	11	11	11
Mitsubishi	1	0	1	1
NEC	18	18	6	7
Oki	2	3	1	1
Toshiba	6	8	11	12
Rest of World	0	0	0	0

Source: Dataquest (July 1991)

Table 7

European 1990 MOS Microprocessor Market Share Rankings
(Millions of Dollars)

1990 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1990 Sales ($M)	1989-90 Annual Growth (%)	1990 Cum. Sum ($M)	1990 Market Share (%)	1990 Cum. Sum (%)
1	1	0	Intel	150	208	291	39.9	291	56.9	56.9
2	2	0	Motorola	49	61	67	9.8	358	13.1	70.1
3	3	0	SGS-Thomson	20	32	36	12.5	394	7.0	77.1
4	4	0	Siemens	16	16	20	25.0	414	3.9	81.0
5	5	0	AMD	15	13	13	0.0	427	2.5	83.6
6	7	1	National Semiconductor	10	11	12	9.1	439	2.3	85.9
7	8	1	Toshiba	8	11	12	9.1	451	2.3	88.3
8	6	-2	Hitachi	11	11	11	0.0	462	2.2	90.4
9	9	0	NEC	18	6	7	16.7	469	1.4	91.8
10	14	4	Harris	6	3	6	100.0	475	1.2	93.0
11	-	NA	GEC Plessey Semiconductors	0	0	6	NA	481	1.2	94.1
12	11	-1	Texas Instruments	4	5	4	-20.0	485	0.8	94.9
13	12	-1	Thomson	0	5	4	-20.0	489	0.8	95.7
14	13	-1	Zilog	5	4	4	0.0	493	0.8	96.5
15	10	-5	Philips	5	5	3	-40.0	496	0.6	97.1
16	18	2	Cypress	0	1	2	100.0	498	0.4	97.5
17	15	-2	Fujitsu	2	2	2	0.0	500	0.4	97.8
18	19	1	IDT	0	1	1	0.0	501	0.2	98.0
19	20	1	LSI Logic	0	1	1	0.0	502	0.2	98.2
20	22	2	Mitsubishi	0	1	1	0.0	503	0.2	98.4
21	23	2	Oki	3	1	1	0.0	504	0.2	98.6
22	-	NA	Rockwell	0	1	1	0.0	505	0.2	98.8
23	-	NA	TRW	0	0	1	NA	506	0.2	99.0
-	16	NA	VLSI Technology	1	2	1	-50.0	507	0.2	99.2
-	17	NA	AT&T	0	1	0	-100.0	507	0.0	99.2
-	-	NA	GE Solid State	2	0	0	NA	507	0.0	99.2
-	-	NA	Inmos	9	0	0	NA	507	0.0	99.2
-	21	NA	MEDL	1	1	0	NA	507	0.0	99.2
			Others Europe	0	0	0	NA	507	0.0	99.2
			Others North America	6	6	4	-33.3	511	0.8	100.0
			Others Japan	0	0	0	NA	511	0.0	100.0
			Others Rest of World	0	0	0	NA	511	0.0	100.0
			Total All Companies	341	409	511	24.9			
			Total European	51	59	69	16.9		13.5	
			Total North American	248	318	408	28.3		79.8	
			Total Japanese	42	32	34	6.3		6.7	
			Total Rest of World	0	0	0	NA		0.0	

NA = Not Applicable
Source: Dataquest (July 1991)

MOS Microcontroller

Table 8

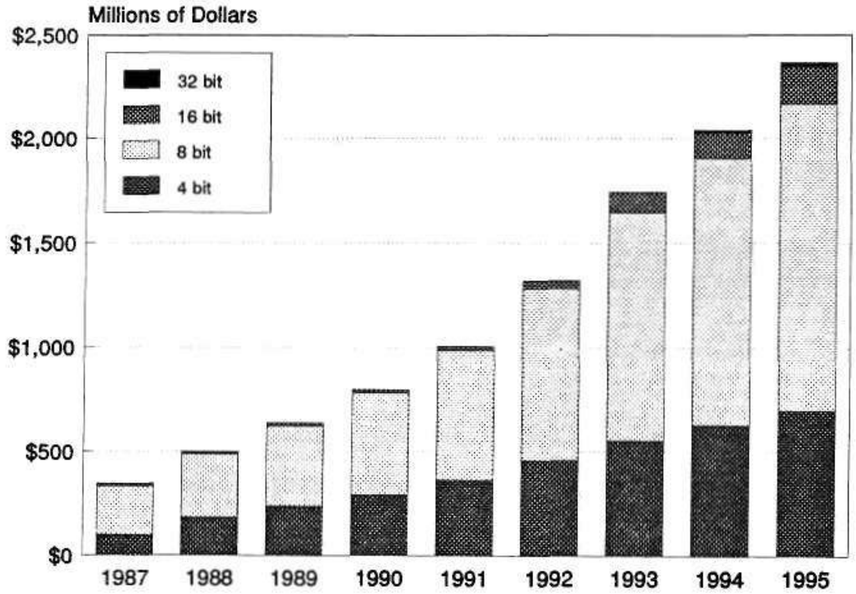
Estimated European MOS Microcontroller Revenue

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Millions of Dollars										
Microcomponent	805	1,212	1,469	1,836	2,263	2,873	3,706	4,447	5,197	23.1%
Microprocessor	205	341	409	511	627	776	1,001	1,232	1,488	23.8%
Microcontroller	347	498	640	799	1,009	1,321	1,742	2,041	2,367	24.3%
Microperipheral	253	373	420	526	627	776	963	1,174	1,342	20.6%
Microcontroller	347	498	640	799	1,009	1,321	1,742	2,041	2,367	24.3%
4 Bit	100	182	236	292	364	458	556	631	698	19.0%
8 Bit	234	304	388	489	622	822	1,089	1,274	1,468	24.6%
16 Bit	13	12	15	18	23	40	94	127	185	59.4%
32 Bit	0	0	0	0	0	1	3	10	17	NA
Percent Share										
Microcomponent	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Microprocessor	25%	28%	28%	28%	28%	27%	27%	28%	29%	
Microcontroller	43%	41%	44%	44%	45%	46%	47%	46%	46%	
Microperipheral	31%	31%	29%	29%	28%	27%	26%	26%	26%	
Microcontroller	43%	41%	44%	44%	45%	46%	47%	46%	46%	
4 Bit	29%	37%	37%	37%	36%	35%	32%	31%	29%	
8 Bit	67%	61%	61%	61%	62%	62%	63%	62%	62%	
16 Bit	4%	2%	2%	2%	2%	3%	5%	6%	8%	
32 Bit	0%	0%	0%	0%	0%	0%	0%	1%	1%	

NA = Not Applicable
Source: Dataquest (July 1991)

Figure 6

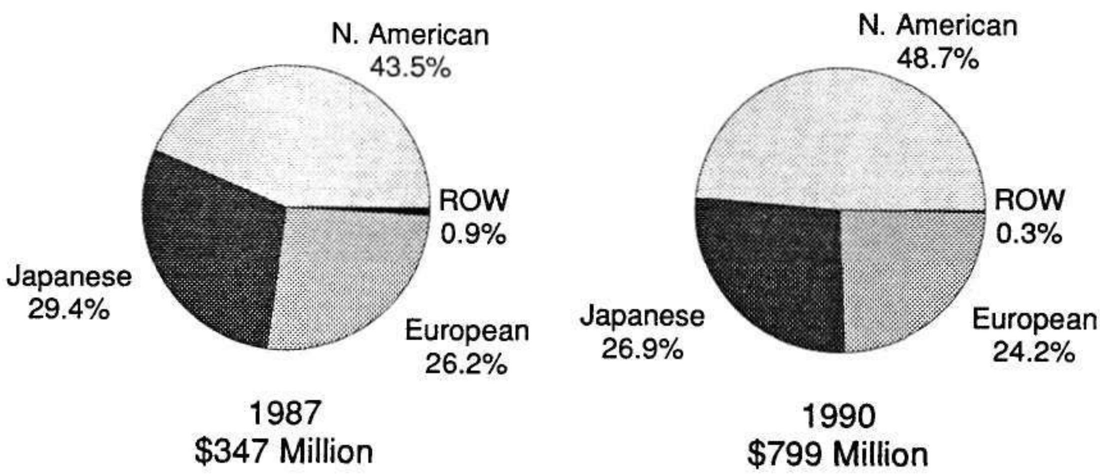
Estimated European MOS Microcontroller Market Share by Word Length



Source: Dataquest (July 1991)

Figure 7

European MOS Microcontroller Market Share by Vendor Origin



Source: Dataquest (July 1991)

Table 9

Estimated European MOS Microcontroller Revenue by Company (Millions of Dollars)

	1987	1988	1989	1990
Total Shipments	347	498	640	799
European Companies	91	118	146	193
Eurosil	2	1	1	3
Inmos	0	1	0	0
Matra-MHS	12	12	20	24
Philips	44	49	51	71
Plessey	0	0	2	0
SGS-Thomson	25	37	37	50
Siemens	8	18	35	45
North American Companies	151	227	287	389
AMD	6	4	7	8
Analog Devices	3	6	6	6
AT&T	1	1	2	3
Cypress	0	0	1	1
GE Solid State	1	5	0	0
Harris	0	0	8	13
IDT	0	0	1	1
Intel	49	81	98	121
ITT	6	7	18	21
LSI Logic	0	0	1	1
Motorola	49	77	84	127
National Semiconductor	17	19	21	24
Rockwell	1	0	1	1
Texas Instruments	11	22	35	52
Zilog	2	2	3	3
North American Others	5	3	1	7
Japanese Companies	102	149	203	215
Fujitsu	2	6	7	9
Hitachi	20	35	38	40
Mitsubishi	3	7	38	8
NEC	45	61	83	106
Oki	7	8	12	13
Sharp	1	1	1	1
Sanyo	9	12	1	1
Toshiba	15	19	23	37
Rest of World	3	4	4	2
Rest of World Others	3	4	4	2

Source: Dataquest (July 1991)

Table 10

European 1990 Microcontroller Market Share Rankings
(Millions of Dollars)

1990 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1990 Sales ($M)	1989-90 Annual Growth (%)	1990 Cum. Sum ($M)	1990 Market Share (%)	1990 Cum. Sum (%)
1	2	1	Motorola	77	84	127	51.2	127	15.9	15.9
2	1	-1	Intel	81	98	121	23.5	248	15.1	31.0
3	3	0	NEC	61	83	106	27.7	354	13.3	44.3
4	4	0	Philips	49	51	71	39.2	425	8.9	53.2
5	9	4	Texas Instruments	22	35	52	48.6	477	6.5	59.7
6	7	1	SGS-Thomson	37	37	50	35.1	527	6.3	66.0
7	8	1	Siemens	18	35	45	28.6	572	5.6	71.6
8	5	-3	Hitachi	35	38	40	5.3	612	5.0	76.6
9	10	1	Toshiba	19	23	37	60.9	649	4.6	81.2
10	12	2	Matra-MHS	12	20	24	20.0	673	3.0	84.2
11	11	0	National Semiconductor	19	21	24	14.3	697	3.0	87.2
12	13	1	ITT	7	18	21	16.7	718	2.6	89.9
13	15	2	Harris	0	8	13	62.5	731	1.6	91.5
14	14	0	Oki	8	12	13	8.3	744	1.6	93.1
15	17	2	Fujitsu	6	7	9	28.6	753	1.1	94.2
16	16	0	AMD	4	7	8	14.3	761	1.0	95.2
17	6	-11	Mitsubishi	7	38	8	-78.9	769	1.0	96.2
18	18	0	Analog Devices	6	6	6	0.0	775	0.8	97.0
19	20	1	AT&T	1	2	3	50.0	778	0.4	97.4
20	23	3	Eurosil	1	1	3	200.0	781	0.4	97.7
21	19	-2	Zilog	2	3	3	0.0	784	0.4	98.1
22	22	0	Cypress	0	1	1	0.0	785	0.1	98.2
23	24	1	IDT	0	1	1	0.0	786	0.1	98.4
24	25	1	LSI Logic	0	1	1	0.0	787	0.1	98.5
25	26	1	Rockwell	0	1	1	0.0	788	0.1	98.6
26	27	1	Sanyo	12	1	1	0.0	789	0.1	98.7
27	28	1	Sharp	1	1	1	0.0	790	0.1	98.9
-	-	NA	GE Solid State	5	0	0	NA	790	0.0	98.9
-	-	NA	Inmos	1	0	0	NA	790	0.0	98.9
-	21	NA	Plessey	0	2	0	-100.0	790	0.0	98.9
			Others Europe	0	0	0	NA	790	0.0	98.9
			Others North America	3	1	7	600.0	797	0.9	99.7
			Others Japan	0	0	0	NA	797	0.0	99.7
			Others Rest of World	4	4	2	-50.0	799	0.3	100.0
			Total All Companies	498	640	799	24.8			
			Total European	118	146	193	32.2		24.2	
			Total North American	227	287	389	35.5		48.7	
			Total Japanese	149	203	215	5.9		26.9	
			Total Rest of World	4	4	2	-50.0		0.3	

NA = Not Applicable
Source: Dataquest (July 1991)

MOS Microperipheral

Table 11

European MOS Microperipheral Revenue 1987-1995

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995	CAGR 1990-95
Millions of Dollars										
Microcomponent	805	1,212	1,469	1,836	2,263	2,873	3,706	4,447	5,197	23.1%
Microprocessor	205	341	409	511	627	776	1,001	1,232	1,488	23.8%
Microcontroller	347	498	640	799	1,009	1,321	1,742	2,041	2,367	24.3%
Microperipheral	253	373	420	526	627	776	963	1,174	1,342	20.6%
Microperipheral	253	373	420	526	627	776	963	1,174	1,342	20.6%
Percent Share										
Microcomponent	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Microprocessor	25%	28%	28%	28%	28%	27%	27%	28%	29%	
Microcontroller	43%	41%	44%	44%	45%	46%	47%	46%	46%	
Microperipheral	31%	31%	29%	29%	28%	27%	26%	26%	26%	
Microperipheral	31%	31%	29%	29%	28%	27%	26%	26%	26%	

Source: Dataquest (July 1991)

Table 12

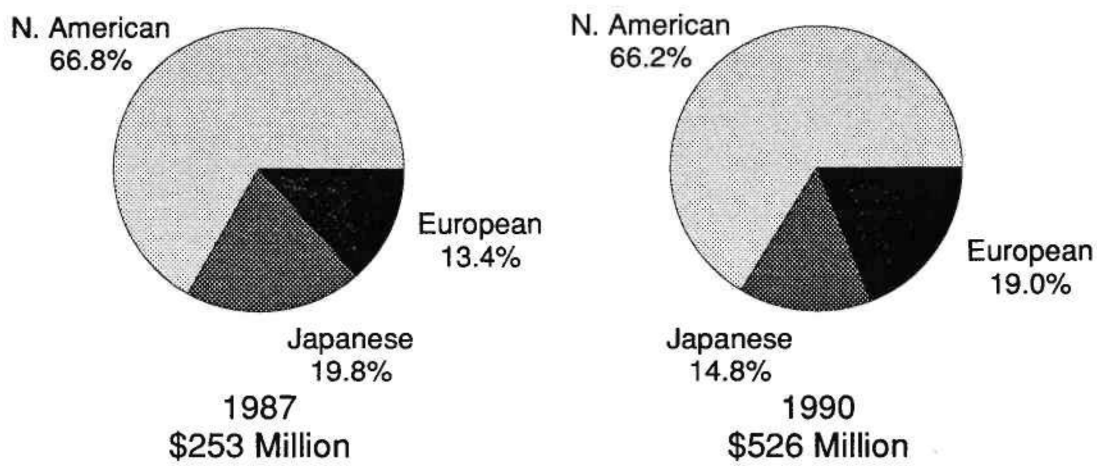
Estimated European MOS Microperipheral Revenue by Company
(Millions of Dollars)

	1987	1988	1989	1990
Total Shipments	253	373	420	526
European Companies	34	51	60	100
Inmos	4	11	0	0
Matra-MHS	2	2	0	0
MEDL	1	0	0	0
Philips	1	1	6	38
SGS-Thomson	18	20	32	40
Siemens	8	17	16	18
TMS	0	0	6	4
North American Companies	169	260	285	348
AMD	10	14	14	26
AT&T	0	0	1	1
GE Solid State	7	8	0	0
Harris	0	0	10	12
IDT	2	6	1	1
Intel	60	120	110	116
ITT	3	0	0	0
LSI Logic	0	0	4	0
Motorola	16	24	34	39
National Semiconductor	9	11	13	14
Rockwell	6	0	7	7
Texas Instruments	25	22	20	43
VLSI Technology	3	4	15	27
Western Digital	10	17	23	18
Zilog	9	12	9	10
North American Others	9	22	24	34
Japanese Companies	50	62	75	78
Fujitsu	1	1	1	1
Hitachi	17	25	26	26
Mitsubishi	2	1	9	1
NEC	27	30	33	38
Oki	3	5	5	5
Toshiba	0	0	1	7
Rest of World	0	0	0	0

Source: Dataquest (July 1991)

Figure 8

European MOS Microperipheral Market Share by Vendor Origin



Source: Dataquest (July 1991)

Table 13

European 1990 Microperipheral Market Share Rankings
(Millions of Dollars)

1990 Rank	1989 Rank	Change in Rank	Ranked Companies	1988 Sales ($M)	1989 Sales ($M)	1990 Sales ($M)	1989-90 Annual Growth (%)	1990 Cum. Sum ($M)	1990 Market Share (%)	1990 Cum. Sum (%)
1	1	0	Intel	120	110	116	5.5	116	22.1	22.1
2	7	5	Texas Instruments	22	20	43	115.0	159	8.2	30.2
3	4	1	SGS-Thomson	20	32	40	25.0	199	7.6	37.8
4	2	-2	Motorola	24	34	39	14.7	238	7.4	45.2
5	3	-2	NEC	30	33	38	15.2	276	7.2	52.5
6	16	10	Philips	1	6	38	533.3	314	7.2	59.7
7	9	2	VLSI Technology	4	15	27	80.0	341	5.1	64.8
8	10	2	AMD	14	14	26	85.7	367	4.9	69.8
9	5	-4	Hitachi	25	26	26	0.0	393	4.9	74.7
10	8	-2	Siemens	17	16	18	12.5	411	3.4	78.1
11	6	-5	Western Digital	17	23	18	-21.7	429	3.4	81.6
12	11	-1	National Semiconductor	11	13	14	7.7	443	2.7	84.2
13	12	-1	Harris	0	10	12	20.0	455	2.3	86.5
14	14	0	Zilog	12	9	10	11.1	465	1.9	88.4
15	15	0	Rockwell	0	7	7	0.0	472	1.3	89.7
16	23	7	Toshiba	0	1	7	600.0	479	1.3	91.1
17	18	1	Oki	5	5	5	0.0	484	1.0	92.0
18	17	-1	Thomson	0	6	4	-33.3	488	0.8	92.8
19	20	1	AT&T	0	1	1	0.0	489	0.2	93.0
20	21	1	Fujitsu	1	1	1	0.0	490	0.2	93.2
21	22	1	IDT	6	1	1	0.0	491	0.2	93.3
22	13	-9	Mitsubishi	1	9	1	-88.9	492	0.2	93.5
23	-	NA	GE Solid State	8	0	0	NA	492	0.0	93.5
-	-	NA	Inmos	11	0	0	NA	492	0.0	93.5
-	19	NA	LSI Logic	0	4	0	-100.0	492	0.0	93.5
-	-	NA	Matra-MHS	2	0	0	NA	492	0.0	93.5
			Others Europe	0	0	0	NA	492	0.0	93.5
			Others North America	22	24	34	41.7	526	6.5	100.0
			Others Japan	0	0	0	NA	526	0.0	100.0
			Others Rest of World	0	0	0	NA	526	0.0	100.0
			Total All Companies	373	420	526	25.2			
			Total European	51	60	100	66.7		19.0	
			Total North American	260	285	348	22.1		66.2	
			Total Japanese	62	75	78	4.0		14.8	
			Total Rest of World	0	0	0	NA		0.0	

NA = Not Applicable
Source: Dataquest (July 1991)

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Matra-Harris Semiconducteurs

BACKGROUND AND OVERVIEW

Matra-Harris Semiconducteurs (MHS) was formed in 1979 as a joint-venture company between Matra of France and Harris Corporation of the United States. The venture was supported by the then French government, which was keen to develop high technology in France. The Company built a 12,000-square-meter factory near Nantes, France, an area designated for industrial development. This allowed MHS to gain government financial assistance for the scheme.

Prior to this formal link, Matra and Harris had made agreements for CMOS technology transfer. Initial wafer production at the Nantes plant began in December 1980. Production capability has now reached 80,000 five-inch wafers per year, and MHS ships more than 12 million circuits annually.

In 1981, MHS signed an agreement with Intel Corporation covering the manufacture of NMOS circuits in Nantes and the establishment of a joint-design facility called Cimetal for telecom chips and video controllers. Following this agreement with Intel, MHS was able to manufacture Intel's 8086, 8088, 8051, and 8052, as well as Harris' 80C86/88. MHS was also entitled to design CMOS versions of the 8051 MCU family, which is now one of MHS' key areas.

MHS increasingly has become involved in joint ventures. In 1985, MHS and SGS Microelectronics (now SGS Thomson Microelectronics) signed an agreement to develop a fully automated assembly and test line for integrated circuits. In a deal with Cypress Semiconductor of the Silicon Valley, MHS received licensing rights to manufacture Cypress fast 16K and 64K CMOS SRAMs and to use Cypress fast 1.2 and 0.8 micron processes. In April 1988, MHS extended its links with Cypress in a deal that will provide $4.75 million for MHS' research into bipolar technology.

MHS developed an advanced submicronic process (Super-CMOS) with France's national telecom research labs (CNET), to combine speed and low power consumption. Most new devices will be designed using this process, which is now ramping-up at MHS.

MHS has also signed a second-source agreement with NEC covering the mutual manufacture and design rights to NEC's 78312 16-bit microcontroller family.

From 1982 to 1986, MHS and Harris had common marketing operations in Europe. In 1986, they separated their sales forces and distributor networks to permit both companies to have direct and independent access to European customers. In 1987, MHS totally separated its marketing from Harris, and now has its own worldwide sales and distribution network, with direct subsidiaries in Santa Clara, London, Milan, Munich, Hong Kong, and Stockholm. As a result, MHS and Harris no longer sell each other's products.

Matra currently controls more than 80 percent of MHS.

Matra-Harris Semiconducteurs

PRODUCTS AND MARKETS SERVED

MHS offers four main product areas, all in CMOS. Most circuits are available in commercial, industrial, and military temperature ranges.

MHS is also a manufacturer of hi-rel devices for military, aeronautics, and space applications; its factory has been qualified AQAP-1, and a variety of products have been approved by the corresponding agencies.

Below is a listing of MHS products.

Static RAMs

- Fast 16K and 64K devices: HM65728/767/768 (down to 15ns) and HM65764/787-790, and a fast 8Kx9:HM65779
- Very low power 16K and 64K memories (6 transistors per cell): HM65162/262 and HM65641 (8Kx8, 55ns, 1uA)
- 64K SRAM, such as HM65687:35ns, 1uA

Microcontrollers

The 8051 family in CMOS, for which MHS is one of the leaders:

- ROM capacity from 4K to 16Kbytes: 80C51, 83C154
- Low-voltage (2.7V), fuse-protected "secret ROM," high-speed (18 MHz) versions and a specific single-chip keyboard controller: 80C752

CMOS ASIC

- Five gate-array families, with gate counts from 250 to 55,000 gates, ultrafast CMOS arrays, proprietary software tools running on VAX or turnkey systems such as Daisy, Hewlett Packard, Mentor, and Valid
- Two families of composite arrays mixing optimized blocks (RAM, ROM, and others) with regular gate arrays
- Specific smart software for system analysis and logical synthesis
- Digital and/or analog custom design capabilities using standard software from Genesil, GDT, and Silicon Compilers Systems Inc.

Dedicated Telecom Products

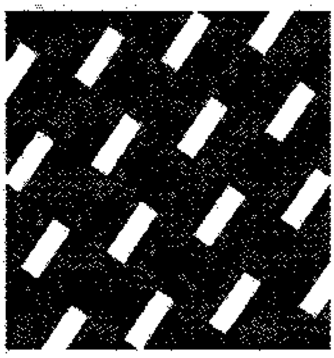
- A family of combo devices (HC3054/57) compatible with a market standard (NS)

- Specific chips for modem applications, the 29C42 error correction circuit for V42 modems, the HC55421 21 interface, etc.

OUTLOOK

MHS is conducting a major development effort to introduce a semiconductor family dedicated to ISDN PABX, terminals and adapters. These products, to be made available in 1989, are targeted for next–generation equipment.

MHS' strategy is to develop its position as a specialist in CMOS system integration—a "toolbox" methodology that uses all basic functions (e.g., microcontrollers, memories, DSP, etc.) with the best–suited design tools and the Super–CMOS process to offer semiconductor solutions for specific applications.



Economic Outlook 1988–1989

Dataquest

a company of
The Dun & Bradstreet Corporation

Published by Dataquest Incorporated

Executive Preface

Why You Should Take an Hour to Read This Report

We are entering an era of global markets. The electronics industry is a primary force in the creation of this era, and this is the same industry that stands to profit the most from it. Successful businesspeople in this era will add two new skills to the traditional set:

- They will understand the appropriate uses of technology in their field.
- They will anticipate opportunities and competitive moves on an international basis.

Every business and every individual will be influenced by global economic events, willingly or not. Some effects will be more obvious or dynamic than others. Regardless of whether the decision is where to design system software or where to open the next sales office, an understanding of economic factors is fundamental to the specific business skills needed for success.

This report is written for Dataquest clients. About 60 percent of the material concerns the United States, and 40 percent relates to major U.S. trading partners and markets. The report summarizes events leading to the current position of the United States in the world economy. For the future, economic trends and forces are described that will directly affect both global and domestic markets for electronics industry products in 1988-1989.

The most significant forecasts in this document are as follows:

- United States real economic growth in 1988 will be similar to 1987 at 2.8 percent; but 1989 will be slower, particularly in the second half. Consumer and government spending will continue to weaken, but export trade growth will compensate for a large part of these declines.
- 1989 federal tax increases and congressional legislation will have little real effect in reducing the federal budget deficit.
- Structural shifts in the United States economy will tend to stabilize wage and employment rates. The largest contribution to inflation in the United States will come in the form of consumer spending for imported goods.
- The focus of international trade for the United States will sharpen on the Pacific region, which accounts for 60 percent of its trade deficit and only 20 percent of its export markets.
- The most positive domestic prospects for 1988-1989 among major U.S. trading partners belong to Japan, Canada, the United Kingdom, and Italy.

Much of the macroeconomic data presented in this report is used by Dataquest analysts to put together specific industry market forecasts. As informed Dataquest clients, your understanding of this material will enhance the information value of every Dataquest service.

Contents

Introduction

As the end of the 1980s approaches, a new economic era is dawning. Global markets are becoming a reality, with electronics, steel, and automotive products leading the way and providing new opportunities on an unprecedented scale. Yet these developments are also making the economic relationships between nations, industries, and markets increasingly complex. As a result, there is a rapidly growing need for accurate insights and sources of information to improve marketing, planning, and decision-making within the electronic industry.

Change is rarely painless, since it requires doing things differently from the way they were done in the past. In particular, the structural economic changes of the 1980s are increasingly forcing analysts and managers to focus their research more on current conditions, since historical trends have become less meaningful. Evidence of this can be clearly seen in the daily newspapers. The most closely watched indicators of economic activity today are the dollar exchange rates, interest rates, international stock and commodity markets, and consumer spending and sentiment. The one characteristic these variables all share is their short-term volatility.

Given this constantly changing environment, one way to achieve a clearer U.S. perspective is to focus on the realities of the marketplace as viewed by the actual participants—businesspeople in large and small companies across the country. Dun & Bradstreet, Dataquest's parent company, makes important contributions toward understanding current trends with its quarterly surveys of business expectations.

For example, D&B post-stock market crash surveys of sales expectations for 1988 showed levels of optimism equal to the high levels of 1985 through 1987. In another D&B post-crash survey of corporate buyers, roughly 75 percent of the respondents said that their capital spending plans were not affected by the October stock market slump. A third year-end survey of 1,500 plant managers showed an immediate but small reduction in 1988 production plans.

In formulating Dataquest forecasts, we utilize many of the D&B business surveys. The perceptions of Main Street are substantially more important than those of Wall Street. Given the insights provided in part by these survey results, our economic forecast for 1988 of 2.8 percent growth expected in the inflation-adjusted gross national product (GNP) reflects a pace of activity that is similar to 1987. Looking further ahead, we expect U.S. economic growth in 1989 to be about 2.2 percent, with the first half of the year showing more strength than the second half.

Growth in 1988 will be driven by significantly different factors from those of recent years. A brief overview of these factors and the circumstances leading to their emergence is presented in the next section. For reference, key economic statistics appear later in this document.

The 1980s in Review

To a great degree, the economic events of 1987 represent the culmination of a number of trends that have been developing throughout this decade.

Inflation was undoubtedly the most dominant issue in terms of shaping the U.S. economy in the early 1980s. Oil prices and high wages forced double-digit increases in the consumer price index in the beginning of the decade, reflecting problems created in the late 1970s. High real and nominal interest rates were exacerbated by a large dose of Federal Reserve tightening, which sharply limited the supply of loanable funds in the economy. The recessions in 1980 and 1982 were the price that was paid to end this wage-price spiral.

During the early 1980s, three key events occurred that played major roles in shaping today's economic environment:

- First, President Reagan's massive individual tax cuts took effect. The average tax rate on taxable personal income fell from 13.2 percent in 1981 to 11.1 percent in 1984. With only a minor slowdown in federal spending, the federal budget deficit, which had been almost nil in 1979, exploded to 5.2 percent of GNP in 1983 and now hovers in the 3.4 percent range.

- Second, the pattern of financial deregulation that started in the late 1970s began to influence money and equity markets in significant ways. New financial institutions and instruments began to offer individuals and firms a wide range of competitive investment choices.
- Third, technology began to have a profound impact on business information processing and communication during this period. Through the application of information technology, financial institutions expanded through the scope and sophistication of their analyses to interpret and evaluate vast amounts of macroeconomic and microeconomic data. Stock markets began to react in unison to global economic events. The more aggressive businesses began to apply technology to sharpen their control of "mission-critical" sales, manufacturing, and customer service activities.

The tax cuts served as the starting gun that set the U.S. economic expansion off and running. America rapidly emerged as the engine of economic growth for the industrialized world. The United States, with its relatively high interest rates, strong domestic markets, and sophisticated financial infrastructure, became a magnet for foreign investors. As a result, the dollar exchange rate soared and prices of imported goods in the United States fell.

In response, U.S. consumers flexed their increased disposable income muscles, courtesy of the Reagan tax cuts, and voraciously bought these low-priced imported goods. Unfortunately, this was not what was intended. The tax cuts were designed to stimulate the U.S. economy by increasing disposable income and, hence, demand for *domestically* produced goods. However, consumers found better value in imports, and the dollars flowed both into the U.S. economy and abroad. At the same time, savings as a percentage of disposable income fell from 7.5 percent in 1981 to about 3.6 percent in 1987, due to new and convenient ways to borrow. By comparison, the Japanese savings rate is 17.5 percent, and most Europeans average about 14.0 percent.

In capital markets, savings must necessarily match investment. Given the shortage of domestic savings and an excess demand for capital by both consumers and government, foreign capital filled the void. In September 1985, this instability was formally recognized by the finance ministers of the G-7 industrialized countries (Canada, Germany, the United Kingdom, France, Italy, Japan, and the United States), and efforts were initiated to systematically devalue the dollar.

The goals of the devaluation were to discourage U.S. consumption of imports by raising imported prices, and to make U.S.-produced goods more competitive abroad.

This devaluation has succeeded in stimulating U.S. exports. In terms of volume, the U.S. trade deficit has started to improve slightly, but a turnaround has yet to occur in terms of current dollars, because import price increases have compensated for the decline in demand. Meanwhile, U.S. export prices have been flat, indicating that current export markets are both highly competitive and somewhat weak. U.S. exports on a constant-dollar basis increased 17.5 percent in 1987, while imports were up only 3.1 percent. Which U.S. industries led the export surge? Many of the same ones that had suffered earlier—textiles, paper, and agricultural products. Others are also the most visible beneficiaries of American productivity and quality improvements—metals, chemicals, aircraft, machinery, instruments, and computer equipment.

However, the earlier import wave has left the United States in 1988 in the position of a debtor nation after 50 years of creditor status. American assets owned by foreigners exceed the value of foreign assets owned by Americans.

Other factors make a shift in the U.S. balance of trade an uphill battle. For example, goods from newly industrialized countries (NICs), such as Taiwan and South Korea, are increasingly being substituted for other import sources, such as Japan. The dollar has fallen relatively little against the currencies of many of these countries. In other cases, such as Mexico, the dollar has appreciated. As a result, NIC products are still a bargain when priced in dollars. So, while the mix of trading partners has changed, the U.S. trade deficit has not yet been substantially reduced. The Japanese have held onto a major piece of the action by setting up plants in Taiwan and Singapore, for example, and by building their products with low-cost components from these countries.

In recognition of this shift in manufacturing sources, the United States has increased pressure on NICs to revalue their currencies. However, NIC revaluations constitute a two-edged sword. Although imports would indeed become more costly in the United States, many of the current international sources of inexpensive goods and labor would also be eliminated. The result would be increased inflationary pressures on the U.S. economy.

To summarize, the 1980s to date have been characterized by consumption-driven growth of the U.S. GNP. Though trade improvements contributed to final demand early in the decade, by 1983 the swelling trade deficit began to have a negative impact on U.S. economic growth, an impact that was overshadowed only by the exuberant levels of consumer spending. Nevertheless, the current expansion is now 64 months old and continuing, the second longest expansion in the post-war period.

Figure 1 shows the shift in factors that contribute to U.S. economic growth. This illustration clearly shows that growth in the mid-1980s was exceptional, despite the tremendous drag from the trade deficit. The Dun & Bradstreet forecast for 1988-1989 has real GNP growing annually at a lower rate compared with the initial phases of the current expansion. Consumption growth also is expected to be lower in the years ahead, but will remain on par with growth in the '60s and '70s. Meanwhile, contributions to GNP from improvements in trade will help to offset a large part of this reduction in consumer-spending growth.

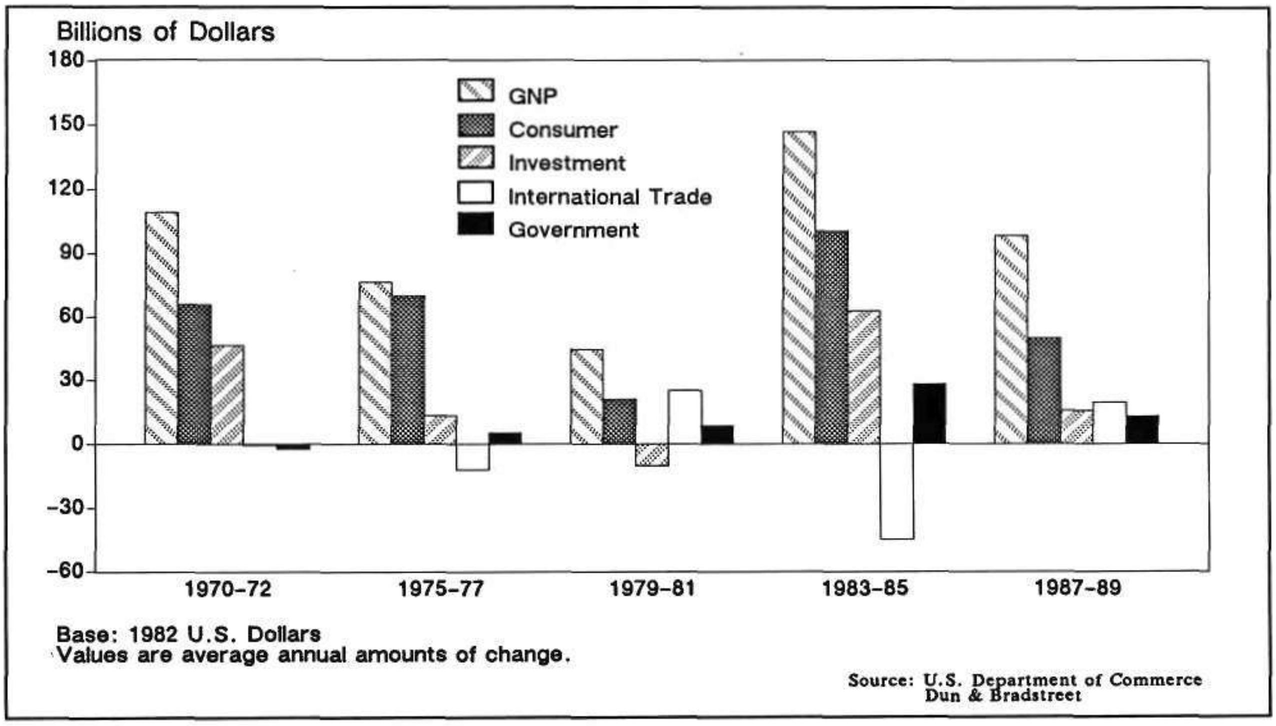


Figure 1. Components of U.S. Real GNP Growth

Key Factors in the U.S. Economy of the 1990s

The key issues for the future are the trade and federal budget deficits, and the steps that will be taken to reduce them. Reducing the federal deficit will, in the long run, reduce U.S. demand for capital, thereby relieving upward pressure on interest rates. However, for the near term, measures to reduce the federal deficit will hurt industries and individuals directly dependent upon the federal government.

Cutting the trade deficit will be more difficult. Basically, the deficit can be reduced by increasing exports or decreasing imports, with export growth having far more beneficial side effects. Currently, 90 percent of all American manufacturers concentrate exclusively on the domestic market. To enlarge their horizons and expand exports, of course, it is essential for U.S. manufacturers to develop export markets. Overseas market development requires development of the fundamental skills, with an international accent:

- Thorough market research
- Products designed with the features to appeal to those markets
- Professional sales and service organizations
- The capability of delivering those products on time at the right price

U.S. manufacturers can hope to be the beneficiaries of any further erosion of the dollar's value, or they can pursue a more aggressive strategy of improving their industrial productivity, and so reduce unit costs.

Productivity gains require that capital spending must increase, and that other input costs, such as labor and scrapped material, must decrease as a percentage of the total. Federal policies must be put into place to stimulate investment and induce individuals to save rather than to spend. This is crucial if the United States is to increase domestic sources of investment funds. In addition, some of this reduced consumption would inevitably lower the volume of imported goods, further helping the trade deficit. The forecast is for very modest increases in personal savings rates, from a 1987 level of 3.7 percent of disposable income to about 4.0 percent in 1988-1989.

To the extent that U.S. domestic spending is curtailed, many production-oriented businesses must find growth opportunities outside the United States. There are many emerging opportunities in Asia, Europe, and the Americas, but U.S. companies will have to adapt their products and sales strategies to compete effectively outside the familiar domestic arena.

Demographic shifts will also occur in the '90s as they have in each decade in the postwar period. Household formation will slacken as baby-boomers reach their thirties and forties. The demand for starter housing will ebb, being replaced by a market for step-up homes. Dual income households will increasingly dominate spending trends, especially for upscale consumer items and time-saving services.

Capital investments in manufacturing automation will continue to be extended and upgraded. The shakeout of firms that have not chosen—or cannot afford—to improve productivity and quality by modernizing will continue in a bigger way. Dispersal and subcontracting of production, where smaller firms produce components for larger firms, will increase. Thus, the current trend in which new small businesses provide much of the employment growth will continue.

Dataquest's View of the U.S. Economy

In recent years, most economic analysts have compiled rather poor records in forecasting important economic developments. All a good economist can do is to assimilate as much information as possible, and interpret it with the maximum amount of skill. However, the major structural changes occurring in the U.S. economy in conjunction with international events make it difficult to foresee major developments and dangerous to rely too much on historical patterns. Dataquest expects the U.S. economy to continue its evolution in ways that bear little resemblance to the past. Hence, analyses of historical relationships are of limited value.

Under these conditions, information directly from business decision makers and major participants in the economic system is especially valuable. It is important to grasp how business people perceive the environment and to recognize how the status of their order books directly affects their business plans.

For example, a Dun's 5000 survey at the end of 1987 asked businesses whether the October decline in the stock market and the subsequent turmoil in the capital markets affected their 1988 capital spending plans. Capital spending is a good proxy for the general health of the economy. Firms invest when they wish to increase capacity or enhance productivity, and both situations require confidence in future economic conditions.

About 75 percent of the respondents said their capital spending plans for 1988 were not affected by the October 1987 crash. The remaining respondents were unsure or said their spending plans were negatively impacted. The responses were uniform across most industries and firm sizes. The two exceptions were among the smallest firms (1 to 19 employees) and among construction companies, for reasons one might expect. Small firms typically pull back during periods of uncertainty to avoid risking their limited financial resources, and construction firms routinely turn pessimistic when interest rates appear to be heading upward. Both types of companies are the most flexible about spending plans and become conservative during periods of economic uncertainty.

The quarterly Dun & Bradstreet Business Expectations survey (See Figure 2), querying about 1,400 business people, asked executives

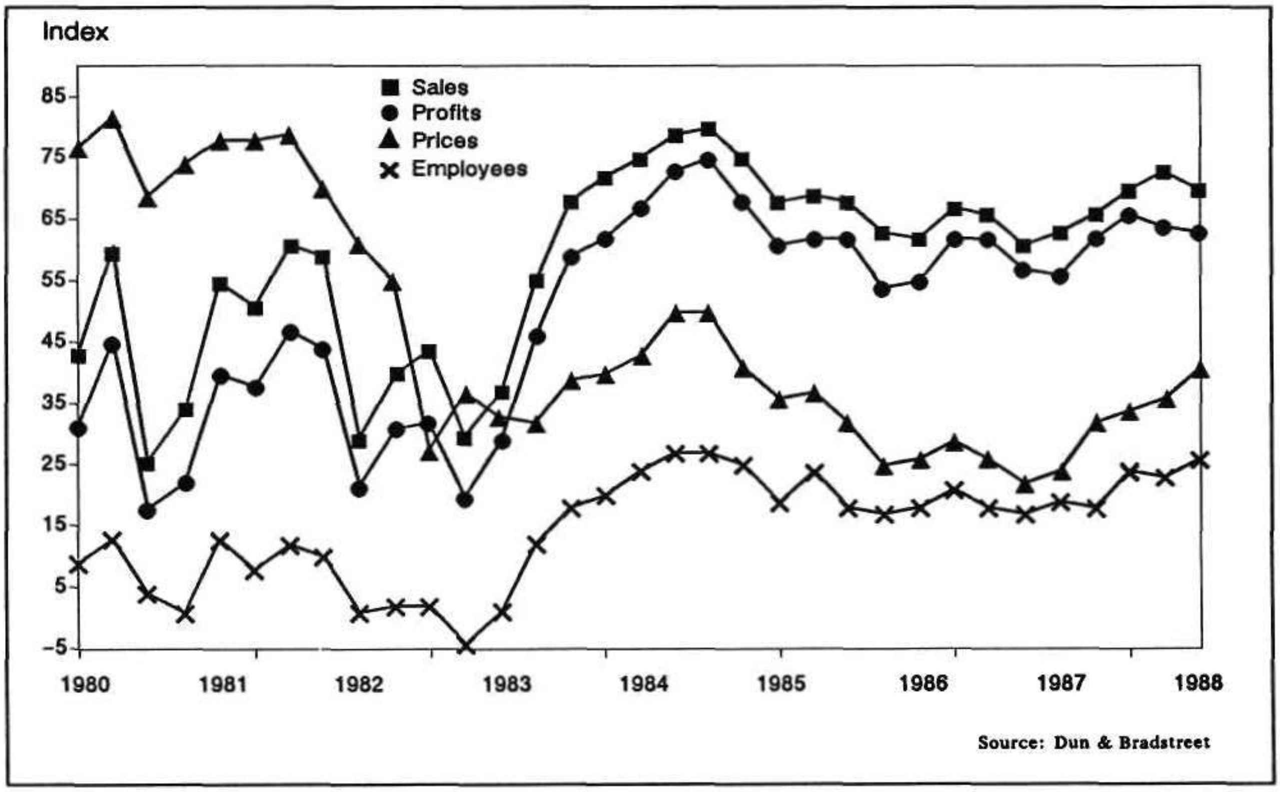


Figure 2. Dun & Bradstreet Business Expectations Survey

about their outlook for their businesses in the first quarter of 1988. The results showed that the outlook for sales and profits was down only slightly compared with their expectations for the fourth quarter of 1987, measured prior to the crash. What is more remarkable is that hiring plans for the first quarter of 1988 actually increased compared with plans in the fourth quarter of 1987.

The survey also showed an increase in the number of executives anticipating price increases in the beginning of 1988. Several inferences may be made from this. First, prices usually increase during periods of economic strength, not weakness, so comparatively few of the respondents expect a recession soon. Second, these anticipated price increases could be related to expectations of a continued decline in the dollar or concerns over an expansionary trend in monetary policy, both of which could increase inflation down the road. Lastly, given the recent rise in prices of many imported goods, some firms will seek to exploit this reduced competition by raising their own prices.

Dun & Bradstreet's statistical series on business starts and failures are two other key sources of insight into U.S. economic trends. Regional and industry breakdowns provide information on the business environment that is not easily available from other sources.

Business starts through November 1987 decreased 7.6 percent compared with the same period in 1986. Despite this decline, the overall level remains high, given that the current economic expansion is more than five years old. Stronger regions include the Northeast and the Pacific Coast, both of which have been strong for some time. The Midwest, with its large industrial sector, is benefiting from the surge in exports and is an emerging area of strength.

D&B data on business failures shows that the growth in bankruptcies, which had continued unabated for eight years, finally leveled off in 1987. Similar to business starts, the decrease in failures occurred in all industry sectors except agriculture and services. The increase in agriculture failures was related to tax law changes and the introduction of Chapter 12 reorganization for farmers, giving them the opportunity to reorganize rather than liquidate. Business failures in the service sector of the economy reflect the entrepreneurial quality of growth in the past few years. Overall, we conclude that the business sector is healthy and optimistic about prospects for 1988. We now will examine the factors that have shaped this outlook.

Factors Affecting the Economic Environment in 1988-1989

As noted earlier, the outlook for 1988 is for continued moderate growth of 2.8 percent. However, this growth will come more from improvements in trade and capital spending than from consumers. Consumer spending will be as weak this year as it was in 1987, while government spending growth will be impeded somewhat by Gramm-Rudman-Hollings expenditure cuts.

Nineteen eighty-nine growth will be a bit weaker than 1988, with the first half of 1989 stronger than the second half. Trade gains will be waning and higher interest rates will inhibit capital purchases later in the year. Consumer and government spending will remain weak. While 1989 will not be a recessionary year, the absence of any sparkling growth sectors will hold GNP expansion to about 2.2 percent in 1989.

Figure 3 shows the quarterly pattern of growth during 1986-1987. Two measures of growth are illustrated: real GNP and real final sales to domestic purchasers. Real GNP is the total of all goods and services produced in the economy. GNP includes items produced but not sold in this country. In contrast, final sales to domestic purchasers excludes unsold inventory and exports to foreign markets, while including imported goods in the total.

While GNP measures all economic activity, final sales to domestic purchasers measures only the portion of GNP that is actually spent within the

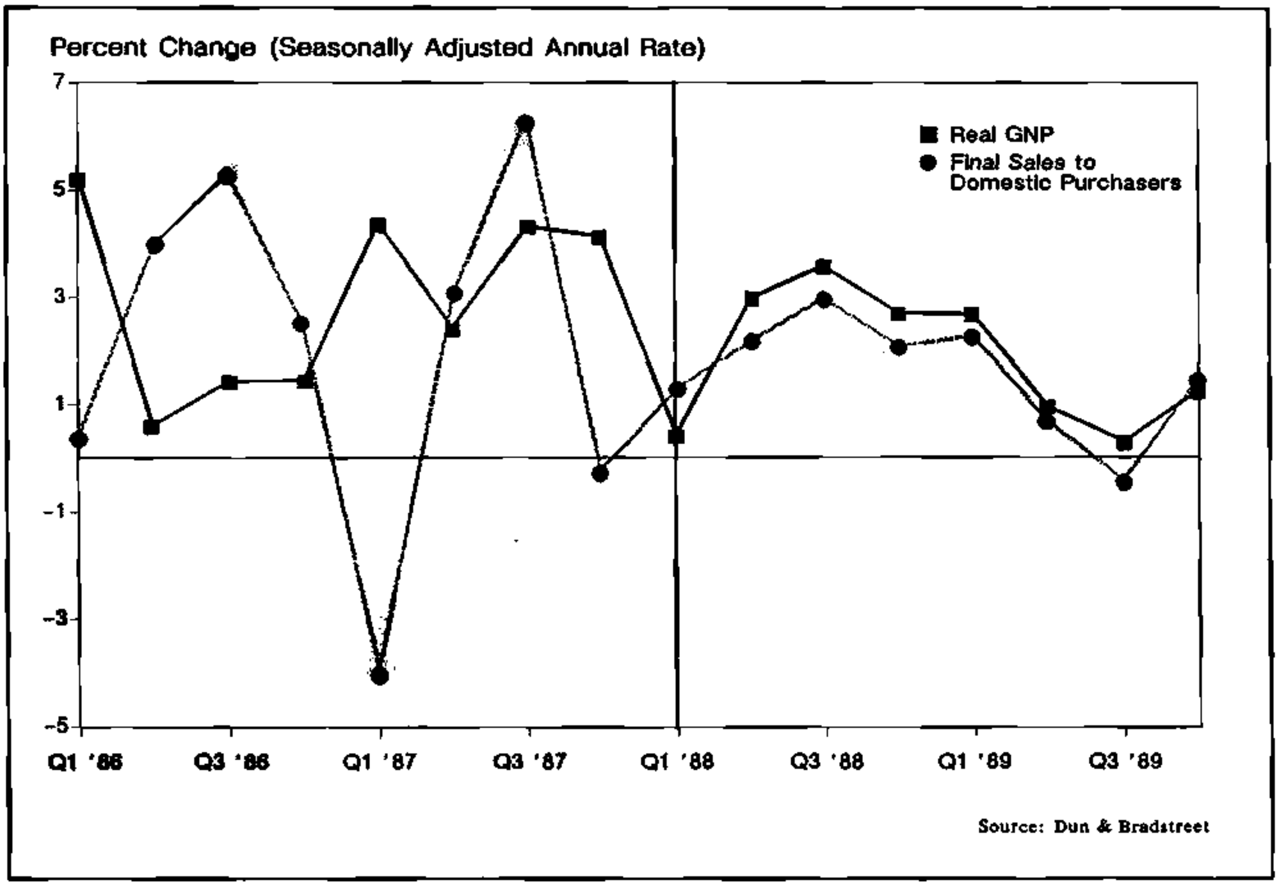


Figure 3. Forecast of U.S. Economic Growth (Seasonally Adjusted)

United States. The higher final sales measure in 1986 indicates that GNP was reduced by a degradation of the real trade balance. That is, the volume of imports into the United States exceeded the volume of exports.

The wide discrepancies between the two measures in several quarters are caused by massive inventory swings, particularly for consumer electronics, apparel, and automobiles, toward the end of 1987. When a car is built but not sold, it counts as part of GNP but not as part of final sales. The carmakers' incentive programs in the third quarters of 1986 and 1987 increased car purchases and, hence, final sales. But these cars were built earlier in each year, particularly in the first quarters, adding to GNP at that time. The important fact is that both measures of output should be used to properly gauge the direction of the economy.

The Trade Deficit and the Dollar

The trade deficit and the dollar will be among the most closely watched indicators in the next two years. Since last year's stock market plunge, the trade-weighted value of the dollar has fallen by an additional 10 percent, in addition to the more than 40 percent it had already dropped from its peak in March 1985. The dollar value now is about the same as in the fourth quarter of 1980. This stimulated export sales of price-sensitive U.S. goods and commodities, such as chemicals, lumber, and pharmaceuticals, then broadened into more durable goods and equipment.

It is important to remember that what happens in the United States as a result of a lower dollar occurs in reverse in the countries against whose currencies the dollar falls. A lower dollar means eventual improvements in the U.S. trade balance, but leads to trade deterioration abroad. In addition, a lower dollar leads to increases in domestic inflation and interest rates. Countries whose currencies have appreciated against the dollar experience deflationary effects from cheaper imports. These countries can also reduce their interest rates because of the lower inflation.

Typically, these inflation and interest rate hikes that follow a drop in the dollar take place only after a period of several months to two years. In other words, the aftershocks of recent falls in the dollar will probably occur after the 1988 election.

In the meantime, the Federal Reserve System can either support the dollar or fix interest rates at some antirecessionary level. These objectives are contradictory because interest rates are used as a tool to attract foreign funds into this country, ultimately affecting the dollar exchange rates. Immediately after the stock market crash, the Federal Reserve Board allowed the dollar to drop, preferring to encourage lower interest rates to ward off adverse effects of the crash. In pursuing this policy, bank reserves were increased to make certain that the stock market crash did not result in a liquidity crunch.

Because of the dichotomous monetary policy goals of the Federal Reserve Board, Dataquest assumes the Fed will walk a tightrope, trying its best to avoid a recession while also attempting to achieve stable dollar exchange rates. As a result, the best the Fed can do is to achieve partial success on both fronts. Interest rates will slowly edge upward, while the dollar will continue to decline, albeit at a much slower pace, bottoming out in the second half of 1989.

This policy can succeed only with international support and coordination. If other countries such as Japan or West Germany reduce their interest rates, this also reduces upward pressure on U.S. interest rates. This eases the Fed's balancing act. Such economic stimulation from abroad can help solve the U.S. trade imbalance by increasing worldwide demand. The key point, however, is that U.S. producers *must* capture the lion's share of any new demand. The current U.S. share of world markets is about 13 percent. To eliminate the U.S. trade deficit solely by increasing exports would require this share to double. Some U.S. import restrictions would seem to be inevitable.

On the import side, the dollar's 50 percent drop over the last three years will eventually channel U.S. demand away from imports and toward domestic goods as the price advantages of U.S. producers become more pronounced. Figure 4 illustrates a forecast of 7.9 percent and 8.6 percent increases in the average prices of imported goods in 1988 and 1989, stemming from continued erosion in dollar exchange rates. Government policies that encourage increased levels of saving and investment can go far to reduce import demand.

Clearly, many economic and political events have to occur to achieve improvements in the U.S. balance of trade. However, U.S. businesses must take upon themselves the responsibility for changes to their own internal cultures and attitudes in order to be successful internationally. Attention and effort must be directed toward selling a higher percentage of U.S. production abroad rather than domestically, even in circumstances when demand in the U.S. market is strong. American industry would do well to follow the example of U.S. computer and semiconductor manufacturers, and seek ways to pool commercial R&D resources in cooperative efforts to perfect manufacturing technology and regain a competitive edge.

The free trade agreement signed January 2 by President Reagan and Prime Minister Mulroney is intended to gradually phase out all trade barriers and investment restrictions between the United States and Canada, the world's largest trading relationship. The agreement is currently being converted to legislation for review and ratification by Congress and the Canadian Parliament. Although some industries and regions on both sides of the border will have to make adjustments, the agreement has a 10-year implementation period for that purpose. The net result will be significant bilateral market development, particularly for Canadian lumber and apparel and U.S. investors.

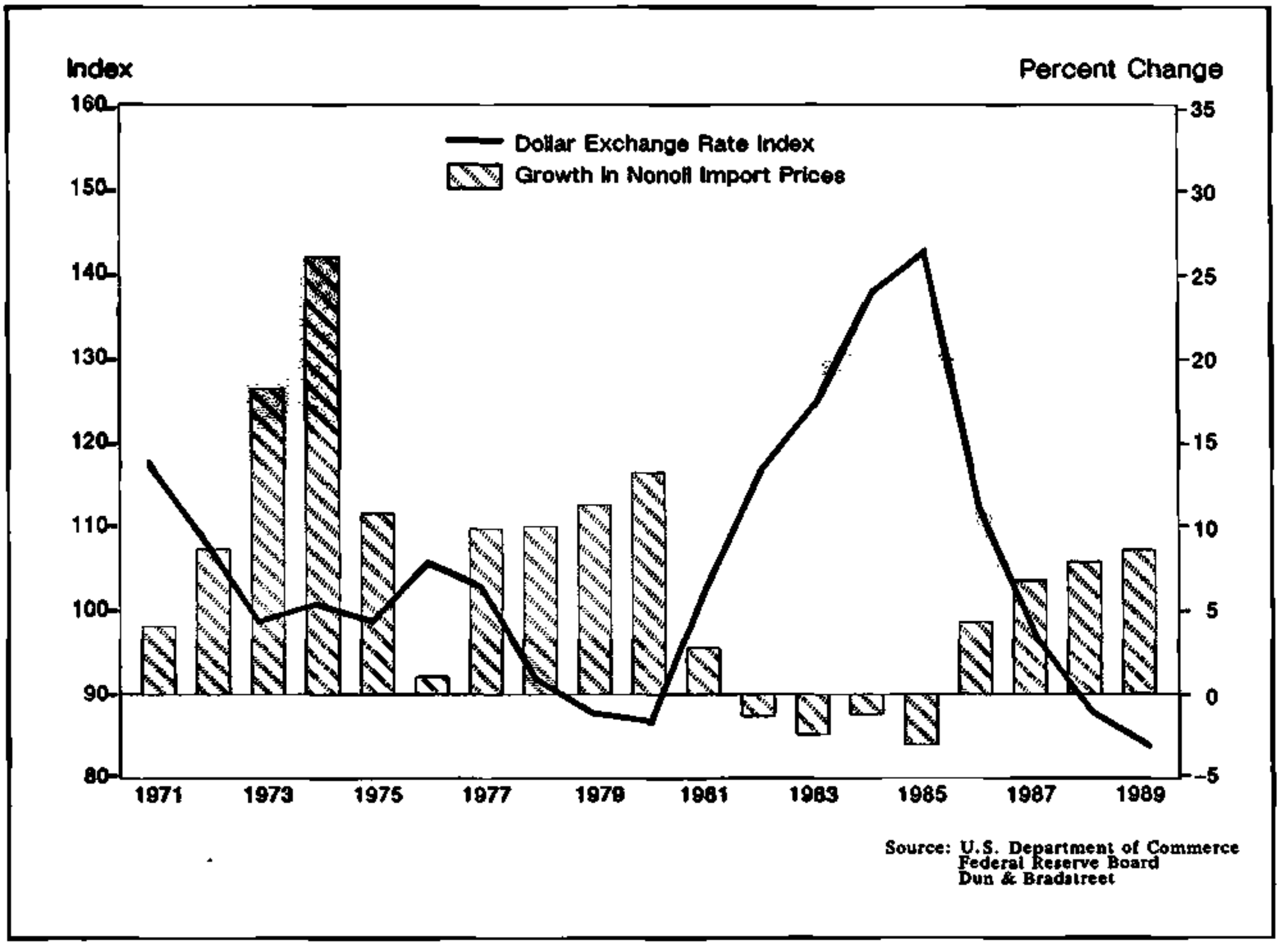


Figure 4. Imported Inflation and the Dollar

It is interesting to speculate on the free trade agreement and the prospect for an eventual North American common market encompassing Canada, the U.S., and Mexico. Figure 5 shows the 1987 U.S. balance of trade with Canada and Mexico. The elimination of import tariffs on goods traveling between the three countries would most directly benefit Canada and Mexico, which ship 80 percent and 75 percent of their respective exports to the United States. By comparison, the United States sells 25 percent of its exports to its bordering neighbors. The primary benefits to the United States would be freer commercial investment opportunities, a favorable climate for development of lower-cost manufacturing operations close to home, and preferential pricing on Canadian and Mexican petroleum.

Interest Rates, Bonds, and the Stock Market

The large federal deficit has created a global market of considerable size in U.S. Treasury securities, a market which recently has more movement and effect on monetary policy than the Federal Reserve Board. Government bond rates rose beyond 10 percent in early October, responding to a booming global economy, and helped to trigger the stock market meltdown. Bond prices dipped and then recovered immediately after the crash, as the Federal Reserve's flood of liquidity pushed interest rates down again.

While the long-term relationship between bonds and stocks is tenuous, the two instruments currently interact closely. As money flows from

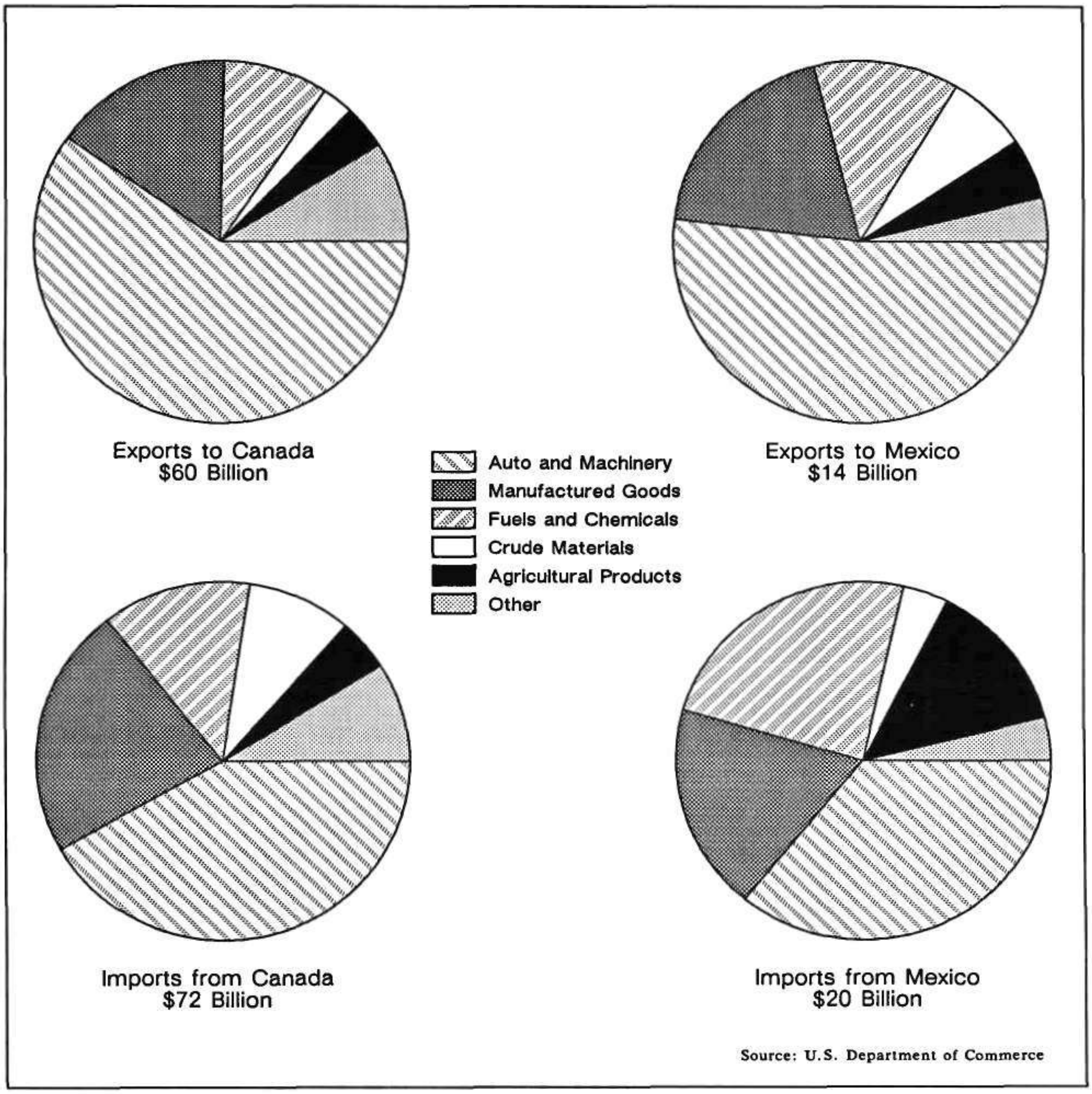


Figure 5. U.S. Merchandise Trade with Canada and Mexico—1987

stock markets into bonds, the price of stocks fall, raising the price of bonds and lowering bond yields, i.e., interest rates. Psychological factors play a big role in this relationship, too. If negative expectations about the economy form, then downward expectations about interest rates and stock prices follow, and the demand for bonds increases.

Thus, the bond market also serves as a handy economic buffer. When the total market value of the U.S. stock market fell by about $1 trillion from an original total of $3 trillion in last year's fourth quarter, the value of bonds increased about $700 billion, representing a 10 percent gain on a $7 trillion base. This may help explain why businesses and consumers remained relatively calm in the weeks after the crash.

Expectations for continued declines in the dollar and a subsequent increase in inflation suggest interest rates will rise over the next two years. Long-term bonds, which currently yield just over 9.0 percent, should yield between 9.5 and 10.0 percent by the end of the year, and between 10.0 and 10.5 percent by the end of 1989. Risk factors that might increase rates beyond these ranges include higher inflation rates or a rebound in the stock market, which could drain liquidity from bonds. About the only source of downward pressure on interest rates is a recession or "growth pause" in final demand, reducing the demand for loanable funds.

The Federal Sector: The 1988 Election and the Budget Deficit

Given the lagging consequences of actions taken in 1986 and 1987, the direction of the economy in 1989 depends very little on who occupies the White House and Congress, especially considering the start-up period of several months required before a new administration can begin to implement its own policies.

Gramm-Rudman-Hollings restrictions on federal spending will also hinder the implementation of new policy initiatives. The distribution of the Gramm-Rudman-Hollings cuts, or of any avoidance measures, may vary depending on the party or person in power. However, any cuts will probably net out to elaborate accounting maneuvers rather than real spending reductions.

The Gramm-Rudman-Hollings budget cuts will also mean little to the macroeconomy, and very little to capital markets. The recently passed legislation calls for $30 billion in deficit reduction in fiscal 1988, and an additional $46 billion in fiscal 1989. With these cuts, the federal deficit is still likely to exceed $170 billion in 1988 and $150 billion in 1989, compared with $149 billion in fiscal 1987. The deficit reductions mean even less compared with the $2.4 trillion cumulative federal budget debt. Figure 6 illustrates the enormous bulge since 1981 in federal deficit spending.

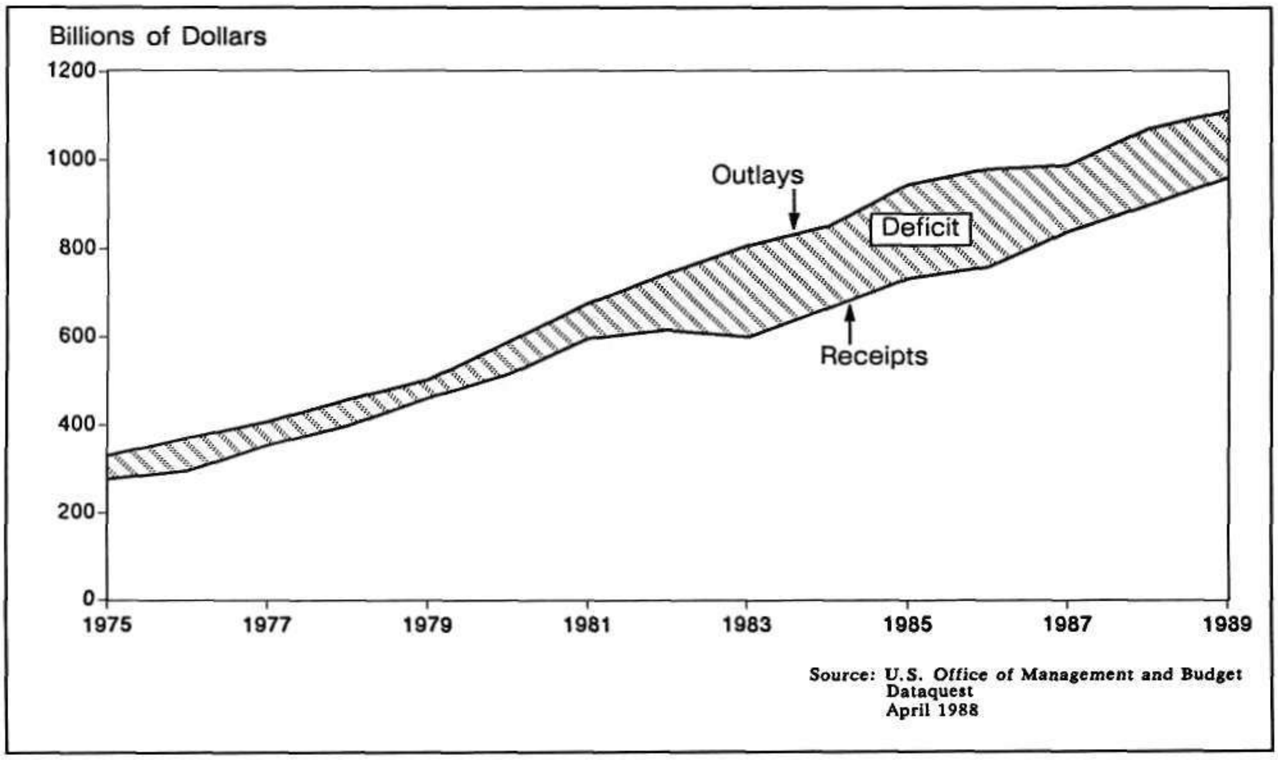


Figure 6. Federal Budget Receipts and Outlays—1975 to 1989

Since a portion of these cuts merely transfers the demand for capital from the government to the private sector, the cuts will have little impact on reducing the U.S. demand for capital and, hence, little impact on interest rates. For example, private acquisition of federal assets to be sold in the deficit reduction plan requires private financing, merely replacing federal debt with individual or corporate debt.

Difficult budget decisions have been postponed to the future. Eventually, elected officials will have to address out of balance national entitlement programs such as Medicare and Social Security that consume 9.5 percent of the GNP.

Thus, any economic fallout from the federal sector will probably be psychological. Until the 1988 presidential election is decided, and the winner's policies become clear, there will be a cloud of uncertainty surrounding the outlook for the economy. To the degree any leading presidential candidates propose a peculiar or uncertain economic or political agenda, this uncertainty may add a downbeat note to the economy.

The Consumer

In the measurement of U.S. GNP, consumer spending accounts for about two-thirds of the total. The economic realities of the late 1980s are affecting three primary factors that have a direct impact on the consumer—personal income, debt, and psychology.

The first and most obvious factor is household income. The best measure of this is *real disposable income*, which necessarily takes inflation and taxes into account. When the second part of the 1986 tax reform act's tax cut took effect on January 1, 1988, tax liabilities of individuals were reduced by about 4 percent. Offsetting a large part of this increase was a substantial increase in social security tax payments. On balance, tax payments will be reduced in 1988, but because of the change in the Oval Office in 1989, taxes can be expected to increase thereafter.

Also affecting disposable income, of course, are wage rates. Slight increases in compensation are expected over the next two years because of gradually tightening labor markets in some regions and industry sectors. In addition, inflation is expected to rise slightly in 1988-1989, offsetting much of the buying power of these gains. Therefore, real disposable income is expected to remain largely unchanged from 1987.

Another factor that affects the consumer is *debt*. Consumer debt-to-disposable-income ratios are currently high, but can be explained in part by the increased use of credit cards over the past five years. The use of credit cards is a convenience rather than a debt purchase if the credit card bill is paid off in full each month. However, as far as the credit accounts are concerned, debt is debt, even though consumers may not regard it as such.

The explosion of home equity loans and adjustable rate mortgages have in the past provided consumers with reduced interest rates for debt payments of all types. However, this debt involves flexible rather than fixed interest rates, and so ties debt payments more closely to current interest rates. Thus, if interest rates increase, more current income would be required to pay off old debt, reducing consumption growth.

The net effect of consumer debt on expenditures remains a complex issue. Compounding the problem of analysis is the third factor affecting consumption decisions: *consumer psychology*. What is certain is that consumers are less likely to incur debts if they have doubts about their future prosperity.

If consumers fear a recession is coming, they will withhold spending in favor of increasing savings as a hedge against bad times. Because the economy is in a period of notable transition, there is a great deal of uncertainty. The University of Michigan conducts regular surveys of consumer attitudes, and the results provide some insight into spending plans. Figure 7 shows historical values for consumer sentiment and spending, with projections for 1988 and 1989. The survey's consumer sentiment index took a large dip immediately after the October crash,

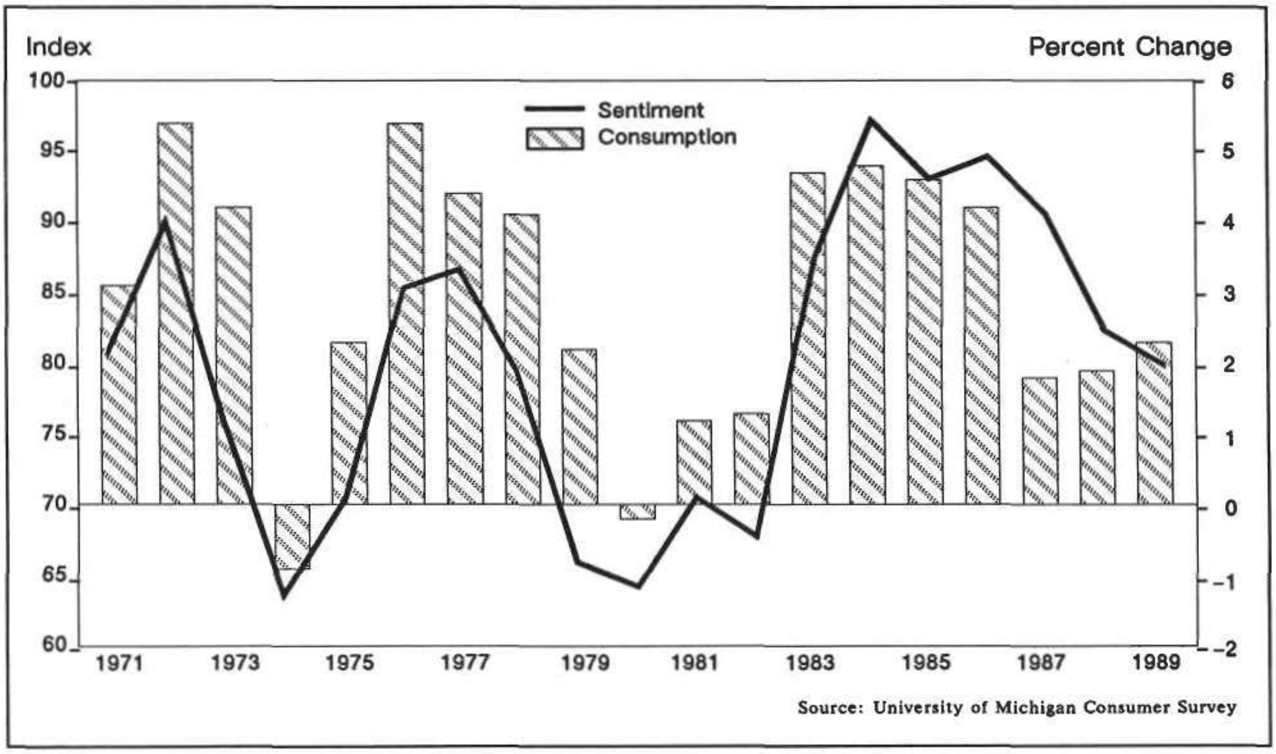


Figure 7. U.S. Consumer Sentiment and Consumption

stabilized in November, and then rose modestly in December. The resiliency evident in consumer sentiment makes it likely that changes would occur only after sustained stress or sustained improvement in the general economy.

The outlook for consumer spending is weak, but not weak enough to cause a recession. While GNP is expected to grow 2.8 percent in 1988, consumption is anticipated to grow only 2.0 percent. Dataquest views this as a favorable trend for two reasons:

- Roughly 21 percent of U.S. *merchandise imports* in 1987 were consumer goods, and another 21 percent were automobiles and auto parts. Therefore, a cutback in consumer spending would clearly help reduce the U.S. trade deficit.
- Because income must be either spent or saved, a reduction in consumer spending means an increase in savings, which flow back into capital investments in plant and equipment. Capital investments will be necessary to expand production capacity for export.

Consumer spending reductions will help hold prices and inflation down, and will restrict further excesses in the level of American personal debt.

The Household Balance Sheet

An analysis of consumer spending requires a brief examination of the health of the consumer. A look at the balance sheet of households—total assets and liabilities—can provide insight into the longer-term trends of consumer behavior.

This is especially important today because much has been written about the so-called "wealth effects" of the stock market decline killing off personal spending. Scant empirical evidence is available to support the view that wealth effects are important, and there are many arguments against this type of forecast:

- If wealth effects indeed exist, there would have been a surge in spending when the stock market was on the way up during the first nine months of last year. Consumption expenditures were flat during this period.
- The period in which wealth effects are measured is likely to be quite long. It is doubtful that individuals would make consumption decisions on potentially fleeting paper profits.
- Only 20 percent of individuals own stock. Many of these individuals are either long-term investors who ignore short-term fluctuations, or simply are well enough off to withstand the stock market's bearish intervals.
- Much of the lost wealth in the value of stocks was made up by the gains in the bond markets.

These arguments imply that the long-term health of the consumer is dependent on all of the net assets of the household, not just on income flows. As a result, it is necessary to look at all sources of household wealth and all liabilities supported by this wealth.

Using an accountant's point of view, the ratio of household liabilities to assets has generally been stable at around 20 to 24 percent since 1960. In 1986, this ratio reached a 24 percent cyclical peak. Increases in mortgage and installment debt exceeded increases in wealth, including stocks. And in 1986, economists were forecasting a mild consumer retrenchment for 1987, which in fact occurred.

In 1987, the household liability/asset ratio dropped to 22 percent, signaling an increase in the long-term solvency of the consumer. The most pessimistic projections of lost wealth in the fourth quarter from the stock market crash would raise the liability/asset ratio from 22 percent back to the 1986 level of 24 percent.

Two conclusions can be reached from this analysis. First, based on calculations from the aggregate household balance sheet, 1988 and 1989 will see a continuation of weak spending growth, much like 1987. Second, the economy, at this time, can survive mild consumer retrenchments and still avoid a recession.

Inflation and Unemployment

Near-term inflation will be the resultant combination of three forces: oil prices, wage rates, and import prices.

Oil prices should decrease relative to the general inflation rate in 1988. This is due to OPEC's failure to reduce its overall production quotas below 17.5 million barrels per day, the lack of success in controlling unofficial discounting by OPEC members, widespread non-OPEC third-world production increases, and very small increases in worldwide demand. OPEC oil prices should average \$17 per barrel in 1988, and rise gradually to about \$18 per barrel by the end of 1989.

In the labor market, it would appear that the currently low unemployment rate would suggest future labor shortages if the economy expands any further, causing large future increases in wages. However, outside the Northeast, this simply is not so. With the unemployment rate at 5.8 percent, there is still room for further expansion without generating wage pressures. Since the last time the unemployment rate fell this low was in 1979, the average age of the labor force has increased. With this maturation, fewer people are changing jobs, and this job stability is reflected in the unemployment rate.

The gradual shift in the U.S. economy from manufacturing toward service industries and the trimming of corporate payrolls have reduced many potential downside effects. In addition, the focus of labor contracts has shifted from wage increases to job stability. Average annual wage increases in negotiated labor contracts are running between 2 and 3 percent. Also, new entrepreneurial activity is responsible for many new jobs in smaller businesses, which generally pay less than their large business counterparts and offer fewer direct employee benefits. Therefore, unemployment and inflation rate comparisons with the past are not necessarily valid. We see the unemployment rate bottoming out at 5.6 percent by the end of 1988 and rising from 5.8 percent to 6.0 percent in 1989.

A major source of inflation comes from abroad. With a decreasing dollar value, foreign goods cost more. To the extent that U.S. markets see higher prices for foreign goods, U.S. competitors may also choose to raise their prices. Imports other than oil represent about 10.0 percent of GNP, so if prices for these goods increase by 8.0 percent, and if prices of substitute domestic goods increase by about 6.0 percent, this can add about one percentage point to current inflation rates. Overall, Dataquest expects inflation rates to rise through 1988 to the 4.5 to 5.0 percent range, until peaking at about 5.4 percent in mid-1989.

Capital Spending

The projected growth in capital spending is an important factor in our forecast of 2.8 percent real GNP growth for 1988 and 2.2 percent in 1989. Although the outlook for purchases of plant and equipment is influenced by many of the same considerations as consumer spending, two additional factors will make this sector a major source of growth. First, U.S. production facilities are currently running at an average 82.0 percent of capacity. The export boom, if sustained, will strain industrial capacity in many export-oriented industries and thus force expansion. Second, corporate profits in 1987 were quite strong, providing funds for investment in 1988. Much of this investment will go into equipment rather than construction because of the shorter payback period.

The pivot point in this forecast concerns interest rates. Since firms usually plan major capital expenditures many months in advance, it is unlikely that any minor uptick in interest rates would adversely affect corporate spending in 1988. The recent Dun's 5000 Survey on 1988 capital expenditure plans confirms this. In 1989, investment expenditures for larger firms would still be interest-rate insensitive up to a point. In other words, larger businesses generally pay more attention to the sales prospects for their products than to interest rates when planning their capital spending.

Financial Industries

With the declines in the stock markets, the financial sector is one of the weakest in the economy. The banking industry must deal with a weak portfolio, including large amounts of nonperforming third world debt, plus weak loans in the agricultural, energy, and real estate sectors. Higher interest rates can exacerbate these problems by raising the cost of obtaining new funds. The good news for bankers is that they are not working for Wall Street brokerage houses, which instituted 10 percent personnel cutbacks after meteoric expansion over the past several years. At the same time, many of these same firms express commitments to continue purchases of communications and data processing equipment in 1988, in order to retain their competitive position.

The risk of a potential banking crisis appears to have passed. However, because of the general economic sluggishness ahead, any turnaround will be slow. While government regulatory agencies appear to consider most bank and brokerage house problems under control, the situation remains precarious.

One additional factor to consider in this sector may come from repeal of regulatory restrictions preventing banks, brokers, and insurance companies from engaging in each other's activities. With new markets open to these institutions, an expansion followed by a shakeout of the new megabanks will occur. The end result may be a stronger industry, but the route to this end is likely to be painful.

Tables 1 and 2 contain key statistics concerning the U.S. economic outlook and GNP components.

Table 1. U.S. Economic Outlook (Billions of U.S. Dollars)

	1987	1988				1989			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Nominal GNP	$4,486	$4,641	$4,723	$4,818	$4,904	$4,989	$5,060	$5,123	$5,197
% Change SAAR	7.2%	3.8%	7.2%	8.3%	7.4%	7.1%	5.8%	5.1%	5.9%
% Change Year Ago	5.9%	6.0%	6.2%	6.5%	6.7%	7.5%	7.1%	6.3%	6.0%
Real GNP	$3,820	$3,880	$3,909	$3,944	$3,970	$3,997	$4,006	$4,009	$4,022
% Change SAAR	3.6%	0.5%	3.0%	3.6%	2.7%	2.7%	1.0%	0.3%	1.3%
% Change Year Ago	2.8%	2.9%	3.0%	2.8%	2.4%	3.0%	2.5%	1.7%	1.3%
GNP Deflator	117.5	119.6	120.8	122.2	123.5	124.8	126.3	127.8	129.2
% Change SAAR	3.5%	3.2%	4.1%	4.5%	4.5%	4.3%	4.8%	4.7%	4.6%
% Change Year Ago	3.0%	3.0%	3.2%	3.6%	4.1%	4.4%	4.5%	4.6%	4.6%
Industrial Production	129.8	134.0	134.6	135.8	136.9	137.8	138.6	139.1	139.5
% Change SAAR	5.0%	3.0%	2.0%	3.6%	3.2%	2.8%	2.1%	1.6%	1.2%
% Change Year Ago	3.6%	5.6%	5.0%	3.7%	3.0%	2.9%	2.9%	2.4%	1.9%
Capacity Utilization (%)	81.0%	83.1%	83.6%	83.6%	83.7%	83.7%	83.4%	83.0%	82.7%
Unemployment Rate (%)	6.1%	5.8%	5.8%	5.7%	5.6%	5.8%	5.9%	6.0%	6.0%
Number Employed (M)	102.1	103.2	103.7	104.9	106.6	106.8	105.9	104.0	104.4
% Change Year Ago	2.5%	2.1%	2.0%	2.5%	3.2%	3.5%	2.1%	(0.9%)	(2.1%)
Real Final Sales	$3,785	$3,827	$3,848	$3,877	$3,897	$3,920	$3,927	$3,923	$3,938
% Change SAAR		1.3%	2.2%	3.0%	2.1%	2.3%	0.7%	(0.4%)	1.5%

Notes: Nominal GNP = GNP measured in current dollars
Real GNP = GNP measured in constant dollars from 1982 base year
SAAR = Seasonally adjusted annual rate
Industrial Production = Base 100 in 1977.

Source: Dun & Bradstreet

Table 2. U.S. GNP Components (SAAR*, 1982 Billions of U.S. Dollars)

	1987	1988				1989			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Consumer Spending	$2,495	$2,514	$2,531	$2,556	$2,569	$2,586	$2,596	$2,608	$2,611
Nonresidential Fixed Invest	447	467	473	481	490	502	507	509	506
Residential Fixed Invest	196	195	197	196	196	193	189	185	185
Government Purchases	773	784	781	789	796	792	788	796	800
Inventory Change	42	29	24	20	16	11	14	0	4
Net Foreign Trade	(134)	(109)	(97)	(98)	(97)	(87)	(88)	(89)	(84)
GNP	$3,819	$3,880	$3,909	$3,944	$3,970	$3,997	$4,006	$4,009	$4,022

*Seasonally adjusted annual rate

Source: Dun & Bradstreet

Conclusion—the U.S. Economy

The next two years are expected to be about as strong as 1987, but the economy will rely on different sources to achieve similar levels of growth.

On the downside, there are several realistic scenarios in which a recession could develop as early as this summer. Such possibilities include a massive divestment of dollars by foreign investors, a drop in consumer confidence, or a jump in oil prices from extraordinary military developments in the Persian Gulf.

Positive risks include larger-than-expected export gains or increased international coordination to reduce interest rates, which could bring about a capital spending and housing boom.

In any event, careful planning will be required to keep pace with the evolving economy. The nature and location of markets for all firms will be changing in the next two years. Profitability will depend on the ability to exploit these changes to their fullest advantage.

1988-1989 Outlook for Major U.S. Trading Partners

Figure 8 shows the volume and composition of U.S. international transactions in goods and services during 1987, illustrating the large share attributable to imported consumer goods (15.5 percent), even excluding automobiles. The bar graphs in Figures 9 and 10 rank U.S. trading partners in descending order by value of imported goods into the United States. Three conclusions are particularly worth noting:

- Japan accounts for 36 percent of the 1987 U.S. merchandise trade deficit, and the NICs of the Pacific region account for a rapidly growing 23 percent.

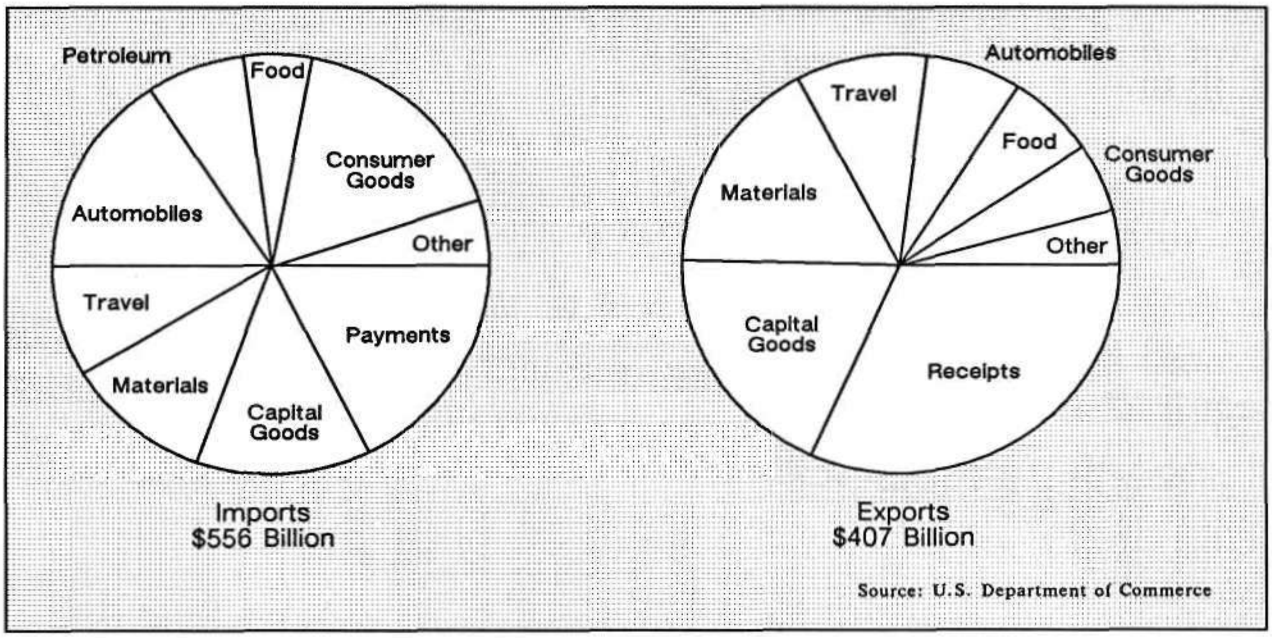


Figure 8. U.S. International Transactions—1987 ($ Billions)

- The negative aspect of the 1987 U.S. trade results, while weighted so heavily by Pacific area countries, still permeates almost all U.S. trading relationships. In scanning the list, the reader will note that the U.S. balance is negative until reaching the nineteenth area, Australia and New Zealand.
- The first- and third-ranking country-markets for U.S. exports are its bordering neighbors, Canada and New Mexico. Many of the U.S. exports to these countries are related to automotive and electronic assembly operations, the products of which are reimported into the United States.

Japan

As international markets shift toward new equilibrium points, the Japanese are reshaping their economy with increased emphasis on domestic demand as the primary driving force, and less dependence on exports. The years of 20 percent-plus export growth in the 1960s and early 1970s, which made Japan the world's largest creditor nation, are dampening to a steady 3.50 percent. Meanwhile, total domestic demand grew at 4.00 percent rates in 1986 and 1987, and is expected to continue at this rate through 1988 before slowing to 3.25 percent in 1989. This is in comparison with a healthy 3.50 percent to 3.00 percent real GNP growth in 1988 and 1989. The primary components of domestic spending are as follows:

- Sharp spending increases in 1987 by central and local governments on airport and railway construction projects, telecommunications facilities, conference centers, highways, and electric power generation and distribution networks will continue through 1988-1989. The U.S. government is seeking rights for American companies to bid on parts of the $17 billion construction and expansion program.
- Corporate capital spending plans for 1988 are moderate overall. Sizable spending in industries closely related to domestic markets, such as construction, banking, insurance, and food, will be counterbalanced by decreases in the shipbuilding, steel, mining, and automobile industries.

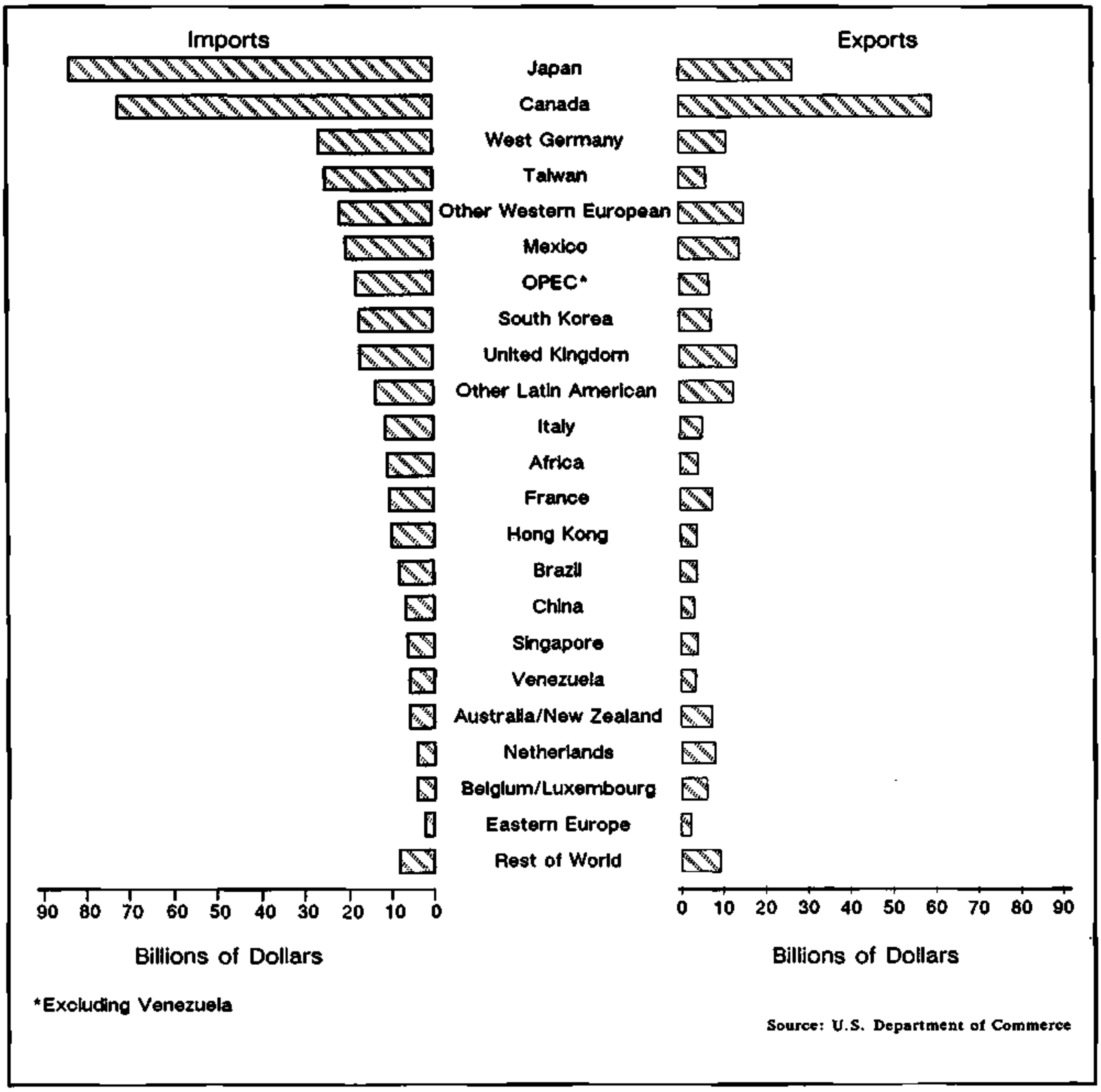


Figure 9. U.S. Merchandise Trade—1987 ($ Value, Billions)

- Modest wage increases, stable consumer prices, and historically low interest rates combined to spur Japanese consumption 3.75 percent in 1987. Consumer spending will continue to increase 5.00 percent per year through 1988-1989, primarily for housing and household goods, automobiles, and travel. To date, the benefits of yen appreciation on imported goods have been retained as profits within the complex multilayered Japanese distribution network, and have not been passed through to the ultimate consumer.

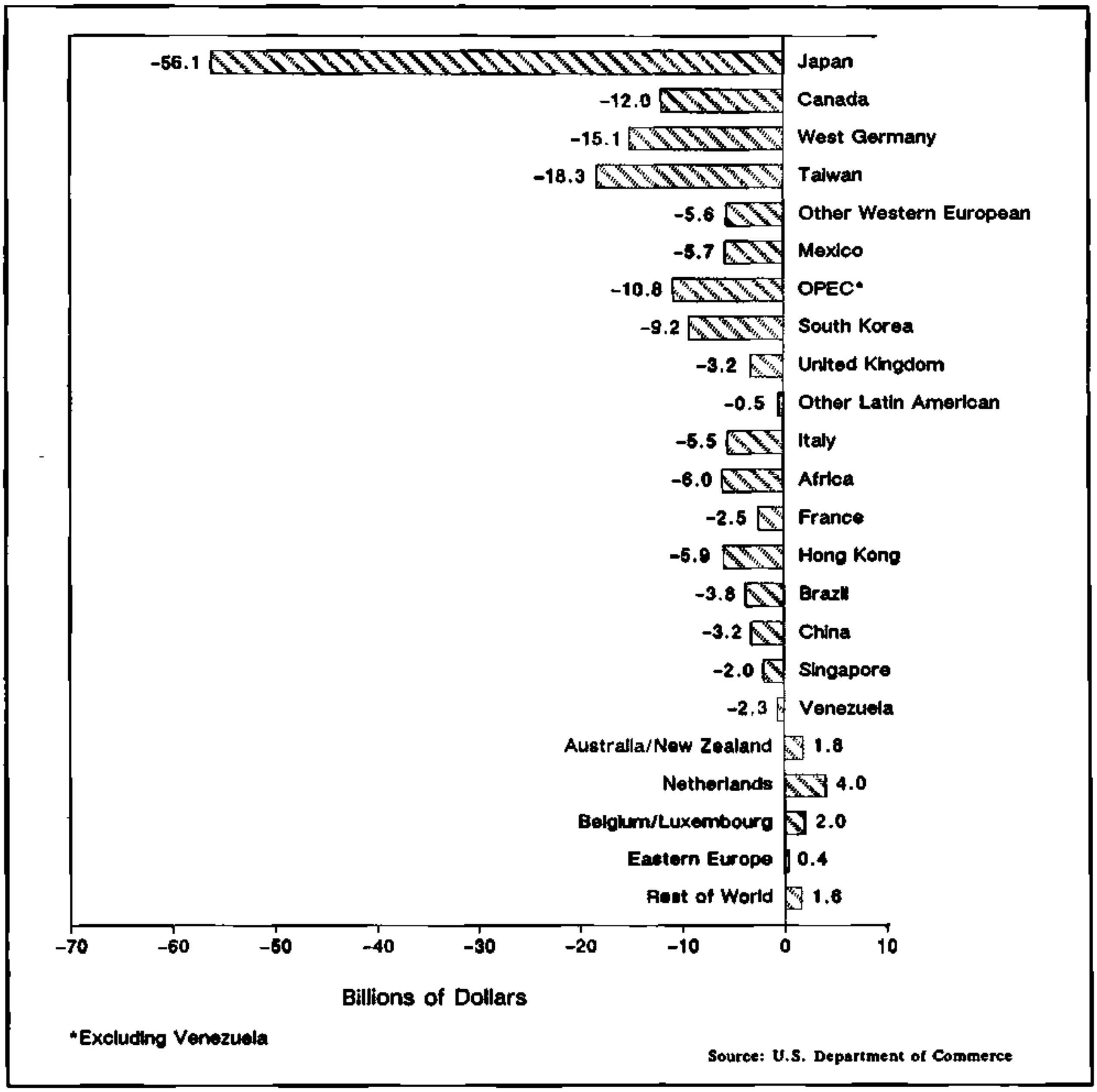


Figure 10. U.S. Merchandise Balance of Trade—1987 ($ Value, Billions)

As developing countries emulate the Japanese industrial success model, and the strong yen is a major factor in international trade balances, the Japanese face a number of pressing domestic issues.

The Japanese baby-boom generation of 1947 through 1949 numbers 10 million, about 20.0 percent greater in size than the generations just before and after. These workers, hired in the mid-1960s period of rapid expansion, are now competing for a limited number of promotions. Japan's rigid labor market still regards job-hopping as disloyalty, and pay systems are based heavily on seniority. The national unemployment rate has been steady at 2.8 percent.

Consequently, there is growing corporate pressure on the over-50 generation to take early retirements. By 2010, the ratio of adults over 65 to working adults will exceed 0.4 and put increasing stress on government and family health care budgets.

Japanese agricultural import restrictions and controls have kept domestic food prices at much higher levels than in many other countries. The most prominent example is rice, which is regarded as a strategic national resource and supported at a price four times the U.S. price. The magnitude of all agricultural subsidies is such that they would add 1 percent to the Japanese GNP if redirected.

Japan's post-war development has concentrated a disproportionate share of political, industrial, and financial power in the Kanto region surrounding Tokyo. Tokyo's population now strains the limits of municipal services. The Kansai region to the west, with its major cities of Kyoto, Osaka, and Kobe, has thus been eclipsed economically. Indeed, foreign companies seeking entry to Japanese markets would do well to investigate the more receptive Kansai.

Service industry employment now accounts for 60 percent of the total work force, as the Japanese domestic economy tracks the global trend. However, large portions of the work force remain in export-oriented manufacturing and subsidized agriculture, and are more vulnerable to fluctuations in foreign exchange rates, trade restrictions, and government budget constraints.

Japanese manufacturers have opened many foreign production subsidiaries, to move closer to ultimate markets and cope with exchange rates and trade barriers. This trend is accelerating, particularly regarding U.S. locations. Public concerns and debates about "exporting jobs" continue, as in the United States. As a perspective, Dataquest estimates the cumulative Japanese overseas manufacturing investment at $23.6 billion at year-end 1987, compared with an estimated U.S. figure of $110 billion.

West Germany

West Germany, another beneficiary of the U.S. import shopping spree, has experienced a decrease to zero real growth in exports of goods and services in the last two years. Germany was able to sustain a significant positive trade balance with the United States through the mid-1980s, second only to that of Japan. The effective appreciation of the deutsche mark has hindered exports of machinery and automobiles, slowing industrial production and creating some upward pressure on unemployment figures. The German economy in 1987 was generally weak and erratic across many sectors, but was rescued from a chill by a notable rise in consumer spending during the second half of the year.

Dataquest expects West German exports to show a modest recovery to 1.0 percent real growth in 1988 and 1989, accompanied by a 3.5 percent per year rise in the value of imported goods. The result will be a contraction of the German foreign trade balance by about negative 1.0 percent annually. More attention will be focused on sales efforts in European and newly industrialized world markets for German exports, where the deutsche mark has appreciated less than against the dollar. In the battle to retain its competitive export position, Dataquest also expects German industry to be a leader in making substantial investments in shop floor control systems, factory networks, and design automation.

The Germans have done the best job among major industrial countries in managing central government budgets, averaging less than a 1.4 percent annual deficit since 1980. Domestic demand will grow at about 2.0 percent per year. Family disposable income will grow at 3.5 percent, and consumer spending is projected to increase at 4.0 percent per year, with imported goods getting a considerable share. Automobiles, electronics, and household goods will be high on German shopping lists. Given the above, GNP is expected to grow at 1.3 percent per year. In addition to recent and pending tax reform legislation, these projections are based on assumptions of continued low rates of inflation, interest, and wage increases.

France

The French economy is a vessel with her sails luffed in the wind. Real GDP growth was 1.5 percent in 1987, and Dataquest projects the same 1.5 percent growth in 1988, before slowing further to 1.3 percent in 1989. French GDP growth has ranked as the lowest of the major Western European economies since 1983. The rate of unemployment is currently the highest in Western Europe, at 10.8 percent of the French labor force. Inflation and average annual wage increases were both a little more than 3.0 percent in 1987.

In a time of shifting international trade balances, France's $2 billion trade deficit in 1986 slid to a negative $10 billion in 1987, or 1.3 percent of GDP, and will continue in this direction by about a negative $1 billion per year through 1989. The problem is not as much the increasing value of imports, as it is the flat export growth rate. Between 1969 and 1974, the value of French exports grew an average of 13.4 percent per year, second only to the 14.9 percent annual growth in Japanese exports. However, a large proportion of French exports went to oil-exporting and developing countries, both sensitive to dollar exchange rates and growing more slowly than the average. As the franc appreciated against the dollar in the early 1980s, the price competitiveness of French exports declined. Finally, the total value of exports slipped below the value of imports in 1982.

The government began to take stringent measures to improve the economic picture in early 1986 by deregulating many sectors of the economy, and by privatizing a number of large state-owned companies. The privatization process has been successful in liberalizing and stimulating some industries, though the program is far from complete. Whether it will be continued depends upon the socialist-conservative composition of the government after the May 1988 election, and the market value of companies under consideration.

Private and corporate disposable incomes will improve when the government reduces income and corporate tax rates by 3.0 percent and 4.0 percent, respectively, in 1988. French value-added tax rates will be reduced progressively through 1992, to align with the internal European community. Corporate investment and private consumption spending should show modest increases as a result. Over time, the value-added tax reductions could add 0.5 percent per year to French GDP growth.

Generally, the French have been slower than the Germans and quicker than the English to make investments in manufacturing automation, and have been slow to adapt their products and distribution organizations to match changing market demands. Both domestic and international market share have been lost, and it is unlikely that near-term reversals in the trade deficit trend will occur. U.S. computer companies now control more than 60 percent of the French market, with only a 24 percent share going to French companies.

Domestically, the government has moved to improve employment figures by offering retraining, tax, and various subsidy incentives to new employers, including foreign firms. In view of the labor market and prospects for moderate wage increases through 1990, U.S. firms should seize the opportunity to open new offices and production facilities in France.

Italy

The Italian economy is a dramatic play of extremes. With 2.8 percent GDP growth in 1987, Italy pulled past Britain and France to rank as the fourth largest capitalist economy, behind the United States, Japan, and West Germany. The fastest annual growth rate over the last decade among major European countries has generated much talk of an Italian economic miracle. Inflation has dropped to 5.0 percent, down from 21.0 percent in 1980. Thousands of new small businesses have sprung from the fertile ground of a high household savings rate, 23.0 percent of disposable income, and plenty of individual entrepreneurial drive. Dispersion of production to networks of these small businesses is common, enabling the smaller subcontractors to contribute substantial added value to the finished products of big firms.

But beneath the gleam of GDP growth lie economic fault lines. As in the United States, the two largest problems are the balance of trade and the government budget deficit.

The Italian international trade balance, which popped into a surplus condition in 1986, dropped back to the deficit side in 1987. Imports of manufactured goods, energy, and food shot up 6.3 percent, occupying an increasing share of the domestic market. At the same time, Italian exports were weak, declining 1.0 percent in aggregate value shipped. Domestic demand will grow in 1988 and 1989 at a faster rate than GDP because imports will continue to outpace exports and detract from the total GDP figure. Unemployment seems destined to climb from the 1987 level of 10.8 percent to 11.5 percent within the next two years.

A disproportionate share of Italian exports are low-technology manufactured goods. For example, 14 percent of the 1987 total was clothing and textiles, which will become increasingly vulnerable to future competition from newly developing countries. In the high-technology sector, Olivetti is the largest Italian data processing equipment company and tenth largest worldwide, but is the only Italian company within the industry's top 100 firms. Funds for high-technology investment within the economy are limited, and R&D spending is half that of other major industrial economies, as a percentage of GDP. Much of the effective progress in technology advancement has come through acquisitions and strategic partnerships with foreign firms. Higher relative unit labor costs and slow productivity growth in the 1980s continue to hamper the competitive position of manufacturers. Given the foregoing, Dataquest projects that the Italian trade deficit will continue to widen through 1988 and 1989, due to heavy import traffic and only modest export growth.

In the United States, where credit cards are quite common, many consumers know firsthand how difficult it can be to recover from a large accumulated debt. Monthly payments to reduce the debt and cover interest must be squeezed from cash that otherwise would go to normal monthly activities. The debt to income ratio determines the degree of constraint in selecting options. On a national scale, Americans can easily see the problems posed by the U.S. budget deficit.

By comparison, Italy has a GDP one-sixth the size of the U.S. GNP, but had a 1987 budget deficit two-thirds the size of the U.S. deficit. The accumulated Italian government debt is equal to 93 percent of the annual GDP. By another measure, the debt is equivalent to $628 billion, or one-fourth the size of the huge U.S. public debt.

The tightly regulated Italian financial system, which severely restricts competition for financial assets, has thus far enabled government securities to sell very well in the domestic economy. However, as a member of the EEC, Italy must bring its banking and financial systems into accord with the other nations by 1992. The pending liberalization of capital flows means the government must ultimately increase the yield on its securities and come to grips with the deficit size. The most realistic hope for progress lies in a series of reductions in government spending. For fiscal 1988, a series of budget cutbacks and increases in direct taxes are expected to compress the Italian deficit to 12 percent of the GDP.

United Kingdom

The United Kingdom can boast the highest average rate of real GNP/GDP growth (3.6 percent) over the last three years among the major industrialized countries. This has been fueled chiefly by very strong private consumption and healthy exports. Industrial employment, which had dropped 25.0 percent in the United Kingdom since 1979, finally rose slightly in 1987 in conjunction with the growth in industrial output. Previous declines in manufacturing jobs have been partially countered by employment growth in the services sector since 1982. Total unemployment, which had risen to a 1986 peak of 11.6 percent of the work force, dropped below 10.0 percent by the end of 1987.

The above factors have enabled the British government to do an outstanding job of budget management in the 1980s, turning in a revenue-expense performance against plan second only to the record of the German government. Government spending will decrease slightly as a percentage of GDP in 1988, as will the small government budget deficit. The strength of the economy has also translated to good tax revenues, and the prospects are excellent for more supply-side incentives in the form of 1988 tax rate reductions.

Real GDP is forecast to increase by 2.8 percent in 1988, slowing to 1.8 percent in 1989. Economic growth will be led by continued expansion of consumer spending, in anticipation of tax cuts, moderate 3.5 percent to 4.0 percent inflation rates and further small decreases in the unemployment rate. Good order backlogs have caused business sentiment to remain very bullish regarding domestic markets, and many companies expect to make substantial investments in equipment and real estate to increase manufacturing capacity.

The primary drag on future economic growth will be from a deterioration in the United Kingdom's international competitive position, and decreasing demand from the United States, which in recent years has taken 14.0 to 16.0 percent of the United Kingdom's exports. A strong pound, declining North Sea oil production and recent weakening world oil prices will contribute negatively to the trade deficit in the near term. Exports are expected to show real growth of 2.0 percent in 1988, declining to 1.5 percent in 1989. A 4.0 to 4.5 percent growth in the value of imports will result in a growth in negative trade balance of approximately 0.8 percent of GDP per year.

Canada

Nineteen eighty-seven brought more good economic news for the United States' largest trading partner. The Canadian economy continued very robust growth in 1987, chalking up a real 3.6 percent increase. A glance at the table at the end of this section, which contains the 1983 through 1989 GNP/GDP growth, shows the Canadian average of 3.7 percent to be the highest average growth rate among the seven countries.

Fuel for the 1988-1989 economic engine will be provided by strong domestic investment in capital equipment and plant construction. Exports will continue to grow at 3.5 percent in 1988, with 78 percent of Canadian merchandise exports going into the United States. The Canada-U.S. free trade agreement, signed last year and officially taking effect in 1989, will begin having a substantial positive impact in 1988 in anticipation of the phased elimination of all tariffs and most other constraints on trade and investments. Canada's international trade balance is positive, with Can$125 billion in merchandise leaving the country and Can$114 coming in during 1987. U.S. manufacturers supply fully 70 percent of Canada's import purchases. Of the incoming goods from the U.S. in 1987, about 36 percent was automobiles and parts, 14 percent was industrial machinery and equipment, and 9 percent was communications and electronics equipment.

The Canadian economy is based around forestry, automobile manufacturing, petroleum, and mining. While smaller by comparison, the dynamic Canadian electronics industry is a major U.S. export market and a worldwide supplier of sophisticated products for telecommunications, geophysical exploration, natural resource processing and refining, and defense electronics. Many of the leading Canadian electronics companies are subsidiaries of U.S. or British firms, but there are an increasing number of examples in the opposite direction, such as Northern Telecom and Mitel Corporation.

With the exception of oil-related industries, Canadian manufacturers will continue to make heavy investments in capital equipment to sustain their growth, and U.S. exporters will continue to have the lion's share of that market. Many Canadian companies are actively seeking joint-venture manufacturing or sales partnerships with U.S. companies, and probably constitute the best learning opportunity for U.S. companies looking to expand into international markets.

Nineteen eighty-eight will see the lowering and restructuring of Canadian corporate and personal tax rates, as part of the government's long-range tax reform program. The general plan includes the probability of a national sales tax in 1990, replacing the current sales tax on manufacturers. If the government can keep spending relatively controlled, the federal budget deficit should improve to the range of 2.4 to 3.0 percent of GDP in 1988 and 1989.

As always, the big swing factor affecting prospects for Canadian economic growth is the health of U.S. markets. The good news/bad news about having such a good customer for exports on your southern border is that the United States accounts for so much of Canada's international business. Since a great part of the Canadian export industry centers on automobiles and lumber, it is especially sensitive to levels of U.S. consumer spending and residential construction. When the North American economies are moving along well, the Canadians generally do very well. Historically, the effects of slowdowns also tend to be more pronounced on Canada, and the economy underperforms that of the United States. Most current indications are cause for optimism, however, and the prospects for business activity in Canada remain good.

Newly Industrializing Countries

Figure 11 charts the 1987 gross domestic product data for five newly industrializing countries. Each country has its unique problems and unique strategies for long-range industrial success. The role of import-export trade in relation to total GDP should be especially noted. The most prominent trade example is Singapore, where import and export trade volumes were $37 billion in 1987, while GDP was $17 billion.

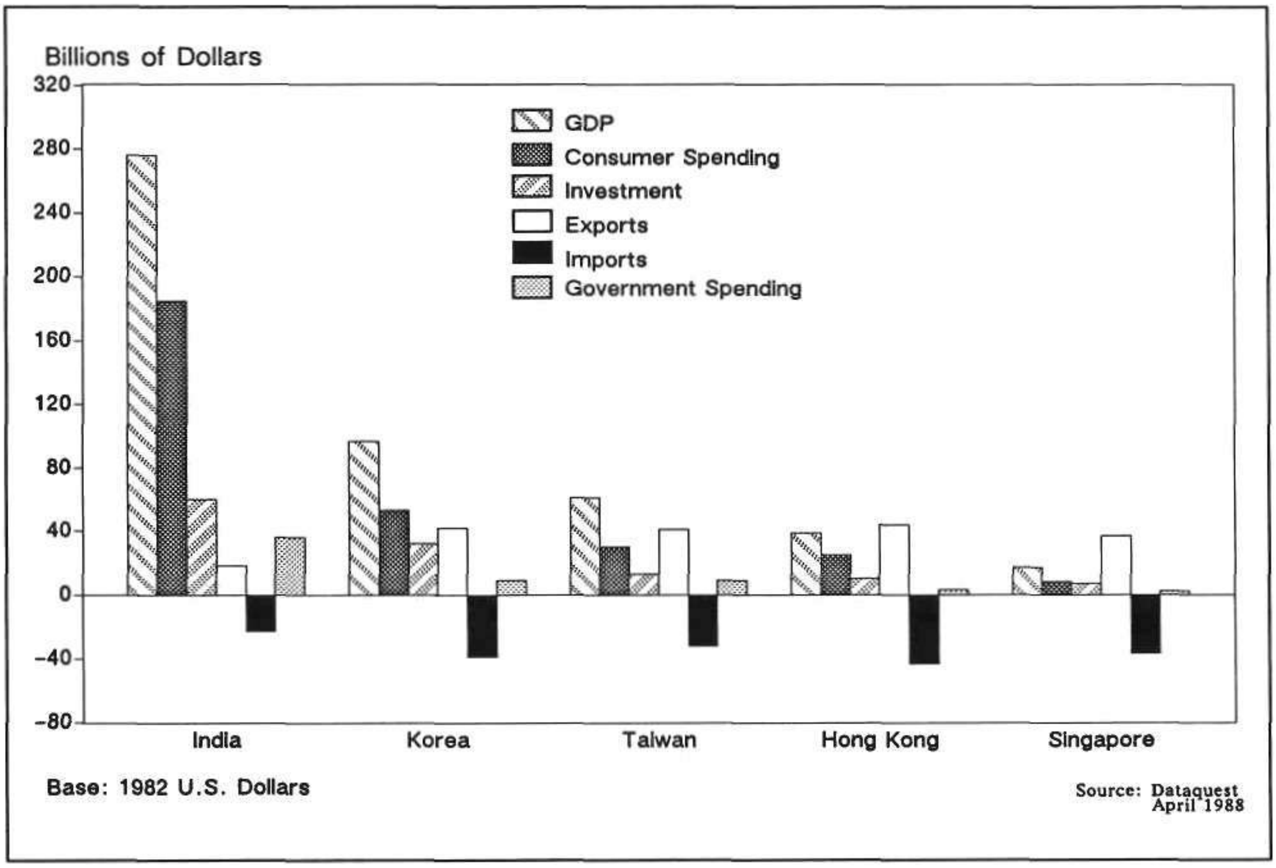


Figure 11. Newly Industrializing Countries' Components of 1987 GDP

Asian NICs continue to take advantage of the manufacturing opportunities and export markets opened by a weak dollar and strong yen. The countries of choice for United States and Japanese manufacturing investment have grown beyond the basic industry stage in many sectors, and have begun to successfully challenge for international market share. In particular, Taiwan and South Korea posted record levels of exports to the United States in 1987, ranking fourth and eighth on the list of U.S. suppliers. The most striking aspect in this can be seen in Figure 10, where the 1987 $18.3 billion U.S. trade deficit with Taiwan is second only to Japan, and has increased $3.6 billion over 1986. The U.S.-Korea deficit at $9.2 billion is half the Taiwan deficit size, but is growing at a faster rate. The pending U.S. removal of Taiwan, Korea, Hong Kong, and Singapore from the U.S. Generalized System of Preferences recognizes the U.S. status as 40 to 50 percent of their export markets, the relative restriction of their own domestic markets, and the consequent contribution to the U.S. trade deficit.

Korea, along with Taiwan, has been the major beneficiary of the yen's appreciation against the U.S. dollar, the Korean won, and the Taiwanese dollar. Trade surpluses, a drop in oil prices, and lower international interest rates have enabled the Korean government to halt foreign borrowing and begin to repay existing debts. Real GDP growth in 1987 was 12.5 percent, repeating 1986. Korean industry has been heavily dependent on imported Japanese capital equipment to continue manufacturing expansion, and this has been the source of a growing trade deficit with Japan, as well as an added stimulus in the Korean competitive attitude toward Japan. In efforts to reduce the trade deficit with Japan and the surplus in U.S. trade, the Korean government is pressuring manufacturers to shift part of their export sales efforts to Japan and away from the United States. Real GDP growth is expected to continue at a 9.0 percent rate through 1988-1989.

Taiwan has a far more decentralized industrial base than Korea, and as a percent of GDP, spends one-third less overall than the Koreans on fixed investments and capital equipment. The Taiwanese rate of growth in industrial production is, not surprisingly, 85 percent of the Korean rate, and is more concentrated in textiles and other light manufactured products, which are more vulnerable to foreign trade legislation. In programs to assist the capitalization and expansion of Taiwanese industry, the government is sponsoring centralized industrial parks and technology research institutions, with some notable successes. The administration of these programs is very active in promoting strategic alliances with Taiwanese and foreign companies for joint R&D, manufacturing, and East Asian market development.

Singapore is a recognized base for multinational manufacturing, and electronics and is becoming the central theme in the economy. More than 180 foreign companies have now established plants in the city-state, responding to a series of generous government incentives. In an aggressive move to accelerate this process, the Singaporean government will cover 74 percent of the construction costs for a $40 million wafer-fabrication plant to be built this year, in conjunction with National Semiconductor and Sierra Semiconductor, who have 9 and 17 percent shares, respectively.

Hong Kong, like Singapore, is a reexporting economy. A record 14.8 percent GDP growth in 1987 followed 11.0 percent the previous year, and is expected to continue at 9.0 percent through 1989. Textiles and apparel make up more than 40.0 percent of Hong Kong's exports and the bulk of shipments to the United States. Exports to the United States were up by 14.0 percent, while the Hong Kong-U.S. trade surplus increased by $119 million, or 2.0 percent. Strong domestic demand and increased trade with China will be major contributors to 1988 growth.

Hong Kong exporters have benefited from the Hong Kong dollar's stability against the U.S. dollar since 1985, in comparison with the Korean and Taiwanese currencies, which have appreciated 15 percent and 30 percent, respectively. The domestic economy has not suffered unduly, primarily because 45 percent of Hong Kong's consumer goods and food comes from the People's Republic of China

(PRC), and the Chinese reminbi has dropped 20 percent in value relative to the dollar. A revaluation of the Hong Kong dollar in the near term is unlikely.

India's 1987 4 percent growth in real GDP will continue through 1988 and 1989. International trade runs a $5 billion per year deficit. The government's past constraints on competition have effectively protected most of the domestic market, but the lack of stimulation has produced little technological innovation. This is beginning to change. The government has begun loosening restrictions on imports of systems, peripherals, and components. Efforts to encourage hardware assembly, especially software development in joint partnerships with foreign companies, have seen some modest successes. Indians believe that the most promising opportunities lie in matching their large pool of technically trained, English-speaking manpower with the worldwide demand for software. If the weighty Indian bureaucracy and start-up productivity levels can be overcome, Indian software technology will become a world force.

The reference statistics in Table 3 comprise GNP/GDP growth rates for the United States and its trading partners that were discussed in this document.

Table 3. Reference Statistics (Percentage Changes from Previous Period, SAAR*)

	1983	1984	1985	1986	1987	1988	1989
Growth of Real GNP/GDP							
United States	3.6	6.8	3.0	2.9	2.8	2.8	2.2
Japan	3.2	5.1	4.7	2.4	3.5	3.5	3.0
West Germany	1.9	3.3	2.0	2.5	1.5	1.3	1.3
France	0.7	1.4	1.7	2.0	1.5	1.5	1.3
United Kingdom	3.3	2.7	3.6	3.3	3.8	2.8	1.8
Italy	0.5	3.5	2.7	2.7	2.8	2.0	1.8
Canada	3.2	6.3	4.3	3.3	3.6	2.8	2.3
Growth of Private Consumption							
United States	4.6	4.8	4.6	4.2	1.9	2.0	2.3
Japan	3.2	2.7	2.6	2.7	3.3	3.3	3.0
West Germany	1.7	1.5	1.8	4.3	2.5	2.8	2.3
France	0.9	1.0	2.4	3.3	1.8	1.5	1.0
United Kingdom	4.0	2.1	3.7	5.8	4.5	3.3	2.3
Italy	0.4	2.2	2.7	3.2	4.5	2.5	2.0
Canada	3.4	4.3	5.2	3.9	4.0	2.3	2.3
Growth of Government Consumption							
United States	1.1	4.4	7.3	3.8	1.8	1.9	0.8
Japan	2.9	2.8	2.0	6.6	(0.3)	2.5	3.0
West Germany	0.2	2.4	2.1	2.3	2.0	1.8	1.5
France	2.1	1.1	3.2	2.7	2.5	2.0	1.8
United Kingdom	1.9	0.8	(0.1)	0.9	0.5	1.0	1.0
Italy	2.8	2.0	3.5	3.0	2.8	2.5	1.8
Canada	1.4	1.5	2.7	1.0	2.0	1.8	1.0

(Continued)

Table 3. Reference Statistics
(Percentage Changes from Previous Period, SAAR*) (Continued)

	1983	1984	1985	1986	1987	1988	1989
Growth of Gross Fixed Investment							
United States	8.2	16.8	5.5	1.8	0.5	4.8	3.0
Japan	(0.3)	4.9	5.6	6.6	8.5	4.8	3.1
West Germany	3.1	0.8	0.1	3.1	1.0	1.5	1.0
France	(3.6)	(2.3)	1.1	3.1	3.0	2.5	2.3
United Kingdom	5.2	8.2	3.1	0.3	4.8	5.8	3.5
Italy	(1.6)	4.4	3.3	1.2	2.8	2.5	1.3
Canada	(0.7)	1.6	8.1	5.1	8.0	3.0	2.3
Growth of Real Exports							
United States	(3.8)	6.8	(1.7)	3.3	12.0	14.3	9.3
Japan	4.2	17.5	5.3	(4.8)	2.0	3.0	3.5
West Germany	(0.5)	9.0	7.2	(0.1)	0.0	1.0	1.0
France	3.7	7.1	2.1	(0.7)	(0.8)	2.5	2.5
United Kingdom	2.0	7.0	5.7	3.1	5.5	2.0	1.5
Italy	2.3	7.6	4.0	3.1	(1.0)	3.5	3.0
Canada	6.4	18.8	6.0	4.7	3.8	3.5	3.3
Growth of Real Imports							
United States	9.6	23.9	3.9	10.5	5.0	1.3	2.3
Japan	(5.1)	11.1	(0.1)	3.6	6.3	7.5	4.8
West Germany	0.6	5.3	4.7	3.5	3.3	3.5	3.5
France	(2.7)	2.8	4.7	6.9	4.8	3.0	3.0
United Kingdom	5.8	9.8	2.8	6.2	5.8	4.5	4.0
Italy	(1.6)	11.3	5.3	5.1	6.3	4.8	4.3
Canada	9.0	16.6	8.3	7.2	4.5	3.5	3.0

*Seasonally adjusted annual rate

Source: Dataquest
April 1988

Glossary

balance of payments. A double-entry accounting of the value of all exchanges and transfers of goods, services, capital loans, investments, and gold and international reserves between the public and private sectors of a given country and the rest of the world over a given time, usually one year. Balance of payments is divided into three accounts—current, capital, and the reserve and gold account.

balance of trade. The difference between the value of a country's exports and imports of *tangible goods* over a given period, usually one year.

balance on current account. See **current account.**

capacity utilization. The ratio of actual production output to potential production output, with existing plant, workers, and equipment.

capital account. Balance of payments category for the inward and outward flow of investment capital.

capital goods. All goods used for the *production* of other goods and services. See also **consumer goods.**

consumer. An individual who buys goods and services for personal use, rather than for manufacturing, processing, or resale.

consumer goods. Products used directly to satisfy human needs or wants, such as food and clothing. The distinction between consumer and capital goods lies in how products are *used* rather than in the products themselves.

consumer price indices (CPI). Monthly measures by the U.S. Bureau of Labor Statistics of the average retail prices of products commonly bought by households, compared with the average prices of a selected base year.

consumption. Expenditures for durable goods, nondurable goods, and services.

current account. Balance of payments category for goods and services. The difference between total exports and imports of goods and services is the **balance on current account.**

disposable income. An individual's income remaining after any payments to government (taxes, fines), and thus available for either spending or saving.

durable goods. Items that yield their services over an extended period of time, generally three years or more. Durables are often divided into the categories of *producer durables* (e.g., metals, machinery, equipment), and *consumer durables* (e.g., automobiles, appliances).

external debt. The total sum of a country's public and private debt owed to foreigners.

federal debt, federal deficit. See **public debt, public deficit.**

fixed investment. Assets for production of goods or services that cannot be quickly converted into money without disrupting operations, such as plant and equipment.

goods. Tangible items of trade, such as automobiles or shoes. Merchandise.

gross domestic product (GDP). The total market value of all goods and services produced each year within the domestic borders of a nation.

gross national product (GNP). GNP equals GDP plus the net of income accrued by domestic residents from investments abroad minus income earned in the domestic market by foreigners abroad.

gross national product deflator. A revision in the calculation of GNP derived by adjusting each component of GNP for price changes, then summing each into a weighted total. The result thus measures both changes in prices and shifts in consumption patterns.

industrial production index. A monthly measure of the quantity of U.S. output in mining, manufacturing, and utilities industries compared with a base year and seasonally adjusted.

inflation. A sustained increase in the average level of all prices.

internal debt. The total sum of a country's public and private debt owed to citizens of the same country.

investment. Expenditures for capital goods.

invisibles. Items of foreign trade that are intangible, such as banking, insurance, tourism, and transportation. Unlike visibles, such items are not recognized by customs and until recently were not reported in trade statistics.

nominal GDP/GNP. GDP/GNP valued in prices prevailing at the time of measurement. Year-to-year changes then reflect differences in both quantities and market prices.

nondurable goods. Items that yield their services over a short period of time, generally less than three years. Examples are food, clothing, paper, chemicals, petroleum, rubber.

private. Relating to individuals and businesses, rather than government.

producer price indices (PPI). Monthly measures by the U.S. Bureau of Labor Statistics of the prices of 2,800 representative commodities compared with those prices of a given base year.

public. Relating to local, state, or national governments.

public debt. The sum of debts outstanding of local, state, and national governments in a given country. Debt of the national government alone is the *national public debt* or *national debt*. In effect, the public debt is a measure of the extent to which government expenditures are financed by borrowing rather than taxation.

public deficit. Circumstance where government outlays for goods and services exceed receipts for a fiscal year.

real GDP/GNP. GDP/GNP valued in *constant* prices prevailing in a reference base year—1982 in this publication. Year-to-year changes thus reflect changes only in *quantities* produced.

recession. A broad downward movement of the economy over an extended time. Generally defined for the U.S. as two successive quarterly decreases in U.S. GNP.

seasonal variation. A regularly recurring pattern of change in economic activity owing to factors such as periodic climate changes, holidays, and vacations. Seasonal variations are commonly adjusted for in the analysis of data to clarify overall trends.

services. Intangible items of trade, such as education, transportation, banking, legal and medical care.

terms of trade. The ratio of the average price of a country's exports to the average price of its imports.

visibles or visible goods. Tangible items of foreign trade.

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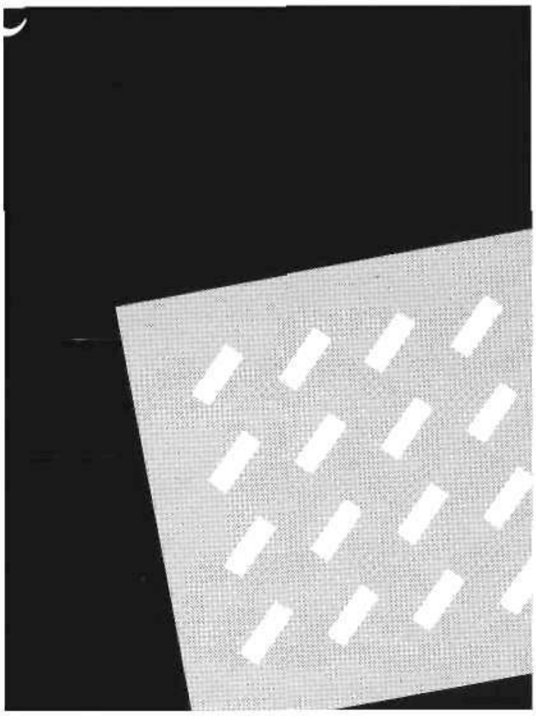

Economic Outlook Update

1988–1990

Dataquest

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The Dun & Bradstreet Corporation

Published by Dataquest Incorporated

Preface

This report is an update to the *Economic Outlook 1988-1989* that was published by Dataquest in early 1988. As such, many references and definitions in this report assume the reader will use it as a continuation of the data and projections in the previous report.

Highlights contained in this report are:

- Real U.S. GNP growth will continue at an average 3.4 percent annualized rate through the first quarter of 1989 then will slow through the last three quarters of that year. Overall 1989 real GNP will be 2.8 percent greater than the record for 1988. A recession is forecast in the first two quarters of 1990, followed by a sharp rebound led by consumer spending and private investment in the second half of the year.

- The rate of U.S. domestic spending on capital equipment and production capacity improvement that saw double-digit growth in the first half of 1988 will gradually slow until reaching negative growth in the fourth quarter of 1989. Investment spending will continue to decrease in early 1990, particularly in the second quarter. Improvement will follow in the second half.

- The U.S. trade deficit will show steady improvement toward a negative $50 billion annualized level by mid-1990, when higher interest rates and a stronger dollar will begin to attenuate the rate of progress.

- The U.S. federal budget deficit will be largely unaffected by the national elections and existing Gramm-Rudman legislation. New federal programs in 1990 will be funded by additional consumption taxes, changes in personal income tax ceilings, reductions in some personal tax credits and federally mandated shifts in some worker-related program funding to corporations.

Introduction

The last years of the 1980s are an exciting time. Political and economic events are unfolding in the United States and throughout the world in a vast interactive network. The influence of these economic developments is significant in our daily lives, in the prospects for business endeavors, and from the perspective of strategic national interests. The international influence of nations is based on their relative economic strengths, and long-term economic changes are resulting in unmistakable geographical shifts of power.

During autumn of 1988, we will see developments on many issues important to the nations listed below, that may cause reverberations in the economic outlooks of other nations:

United States

In the United States, Americans are wrestling with massive deficits in the federal budget and in international trade. Both problems will be treated with platitudes in the upcoming national elections due to the political realities of playing for votes and avoiding special-interest sensitivities. However, after the election, both issues will affect greatly the programs of the new president and his administration's performance rating.

Canada

Political debate is reaching a climax in Canada and the United States on the pending free trade agreement between the two countries. The Liberal opposition to Prime Minister Mulroney has threatened to delay action until Mr. Mulroney calls parliamentary elections, which in effect is a national referendum on free trade.

Japan

What country is the world's biggest donor of foreign aid, the second-largest contributor to the United Nations, and has the world's third-largest defense budget? Answer: Japan, with a $10 billion budget for foreign aid in 1988, pushing past the United States' $9.2 billion program. The Japanese are just beginning to formulate the manner and direction in which they will exercise their new economic power and wealth.

U.S.S.R.

The fascinating cultural and political experiments by Mikhail Gorbachev in attempt to rejuvenate the Soviet economy, coupled with the warming of U.S.-Soviet relations, have already resulted in benefits to U.S. electronics companies through a relaxation of U.S. technology export regulations.

Iran and Iraq

Iran and Iraq appear to be approaching a cease-fire that, if realized, will directly affect crude oil production and prices as the two countries boost output to help recover from the destruction and $300 billion expense of their eight-year war.

EEC

The 12-country European Economic Community (EEC) is proceeding steadily toward its target of standardizing internal financial regulations and eliminating *internal* trade restrictions by 1992. There are growing indications that the Europeans will implement strong protectionist measures to favor European "national champion" computer and telecommunications companies in the form of import quotas, bidding restrictions on government contracts, and minimum local content requirements on hardware.

In effect, they may replace national trade barriers with one large trade barrier around the entire community.

Taiwan and the Peoples' Republic of China

Taiwan and the Peoples' Republic of China are quickly warming to the possibilities of increased cooperation in bilateral trade, investment, and travel. China has raw materials, cheap labor, and is starved for foreign capital, while Taiwan needs to reduce manufacturing costs and continue to expand into new markets.

How will these events affect the electronics industry? What new opportunities will emerge? What are the best strategies to anticipate these changes? For U.S. multinational companies, the answers are based in part on expectations for the outlook for the U.S. economy through 1990.

United States International Trade

U.S. exports continue to surge ahead in the third quarter of 1988, at a pace 30 percent greater than the same period to date in 1987. U.S. industry's export record in 1987 was itself the largest one-year increase this decade: an 11 percent increase over 1986. The bulk of U.S. export volume is in chemicals, auto parts and subassemblies, industrial machinery (including computers and associated hardware) and raw materials. Many of these exporting industries were forced to restructure and upgrade production processes earlier in the decade in order to stay competitive when the dollar's value was peaking. The dollar's three-year (1985-1988) slide has since been accompanied by an acceleration of international sales.

Exporting companies began to feel the effects of the cheaper dollar in mid-1985, as the dollar began to decline and significant international orders followed shortly thereafter. This key relationship between dollar exchange rates and export sales is illustrated in Figures 1 and 2. Dollar exchange rates reached bottom in early 1988 and have shown a recent tendency to creep upward. Dataquest expects the index of dollar exchange rates against trade-weighted currencies will remain close to current levels through 1989, before mid-1990 increases bring the dollar back up to 1986 levels.

Where are U.S. exports going? Figure 3 ranks geographical markets in descending order by aggregate merchandise export value from January through May this year, compared with the same period last year. Western Europe alone accounts for more than $7 billion of the $30 billion export increase so far in 1988. When U.S. exports to Canada and Japan are included, these three market areas constitute 62 percent of the export trade, and 52 percent of the 1988 year-to-date increase. Percentage increases in export values through May of 1988 compared with the same period in 1987 are graphed in Figure 4.

It is worth noting in the midst of this success that most of the 1988 improvement in U.S. international trade has come in established markets, such as Western Europe, that are growing at slower rates than Pacific Rim economies. U.S. companies still focus their export strategies largely toward Europe, and think of Asian countries primarily in terms of defensive marketing strategies. U.S. exporters must quickly recognize that the Pacific Rim is a top priority market equal in value to the U.S. export trade with Western Europe, and will be twice the value of U.S.-European trade before the turn of the century.

U.S. import activity for 1988 to date is compared with the same period in 1987 in Figure 5, reflecting some percentage shifts toward new sources of imports from Asia and South America.

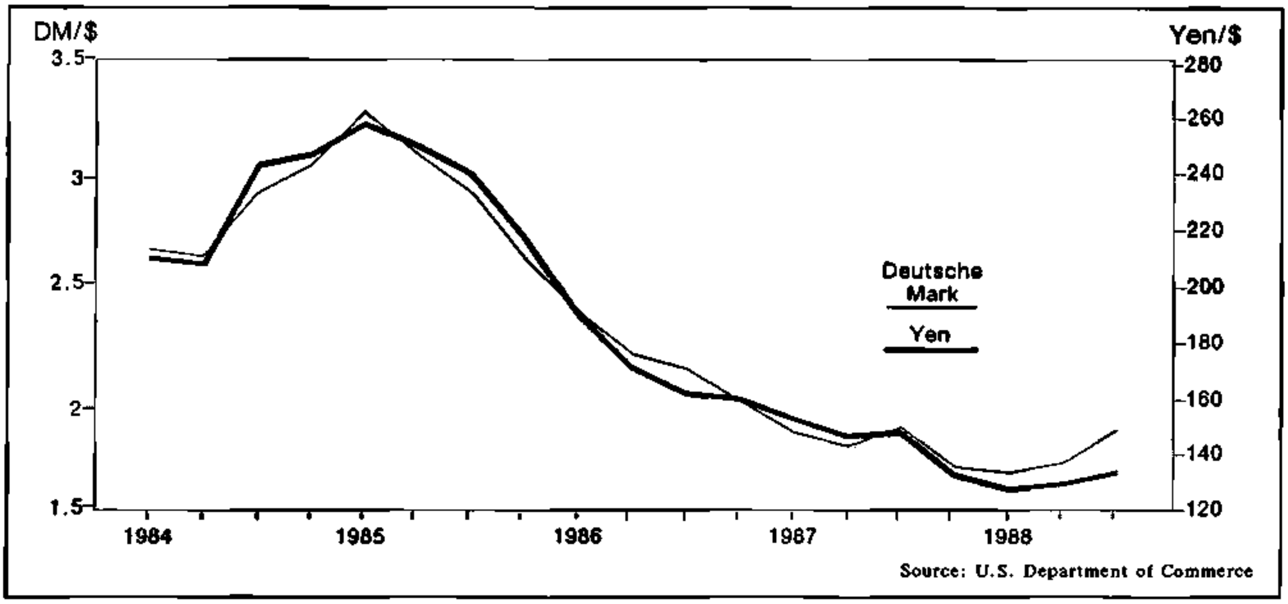

Figure 1. Dollar Exchange Rates (Quarterly Averages) 1984-1988

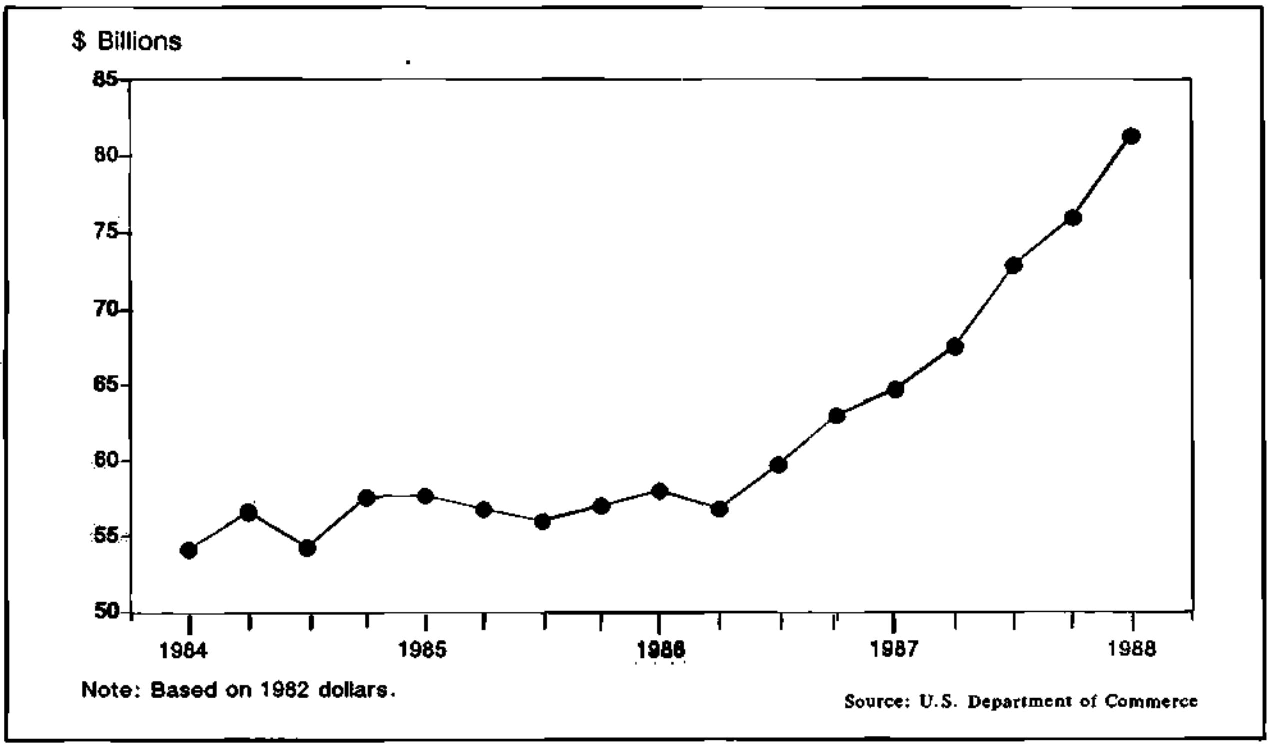

Figure 2. U.S. Merchandise Exports (Quarterly) 1984-1988

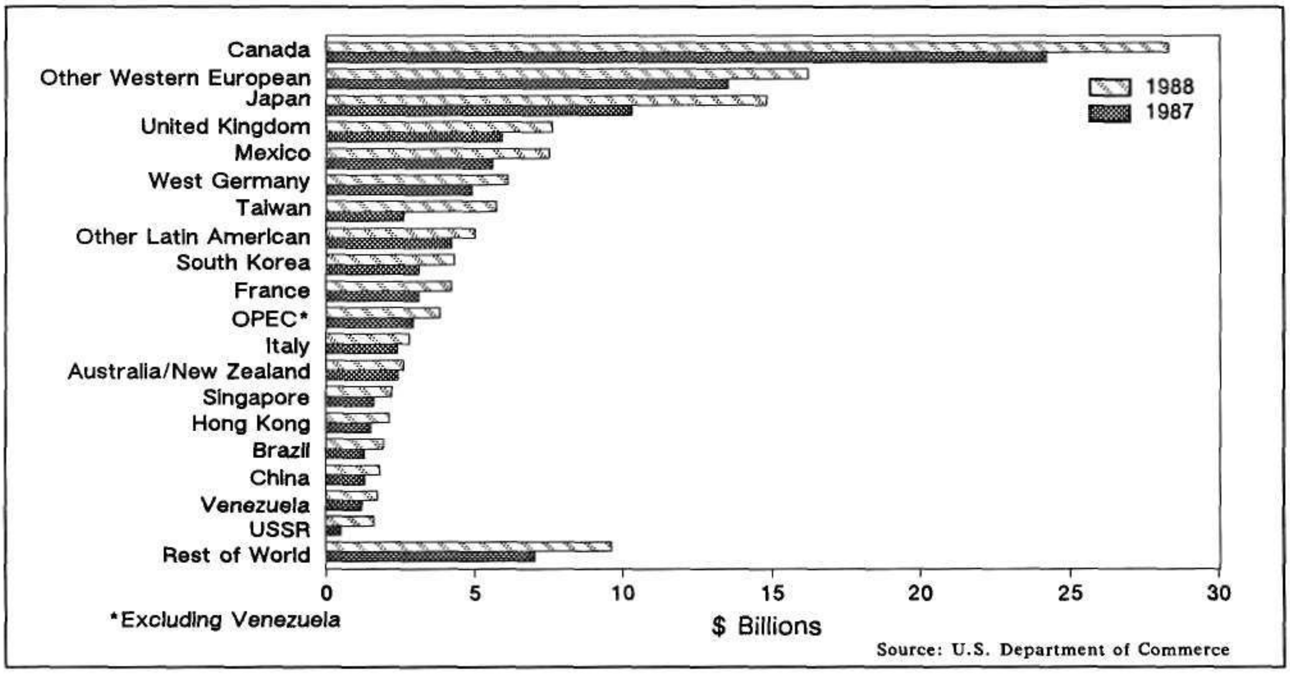

Figure 3. Comparison of U.S. Export Markets, January-May 1988 versus January-May 1987 (Bilions of Dollars)

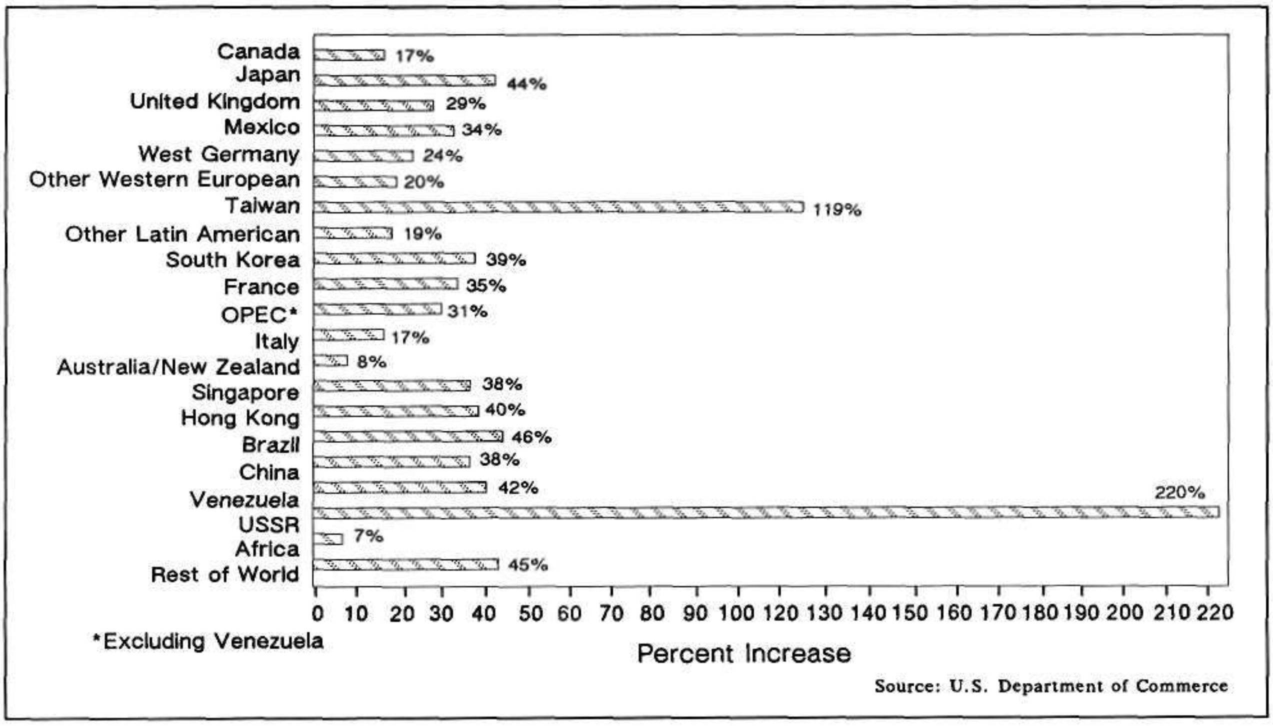

Figure 4. U.S. Merchandise Exports—Percentage Increases January-May 1988 versus January-May 1987

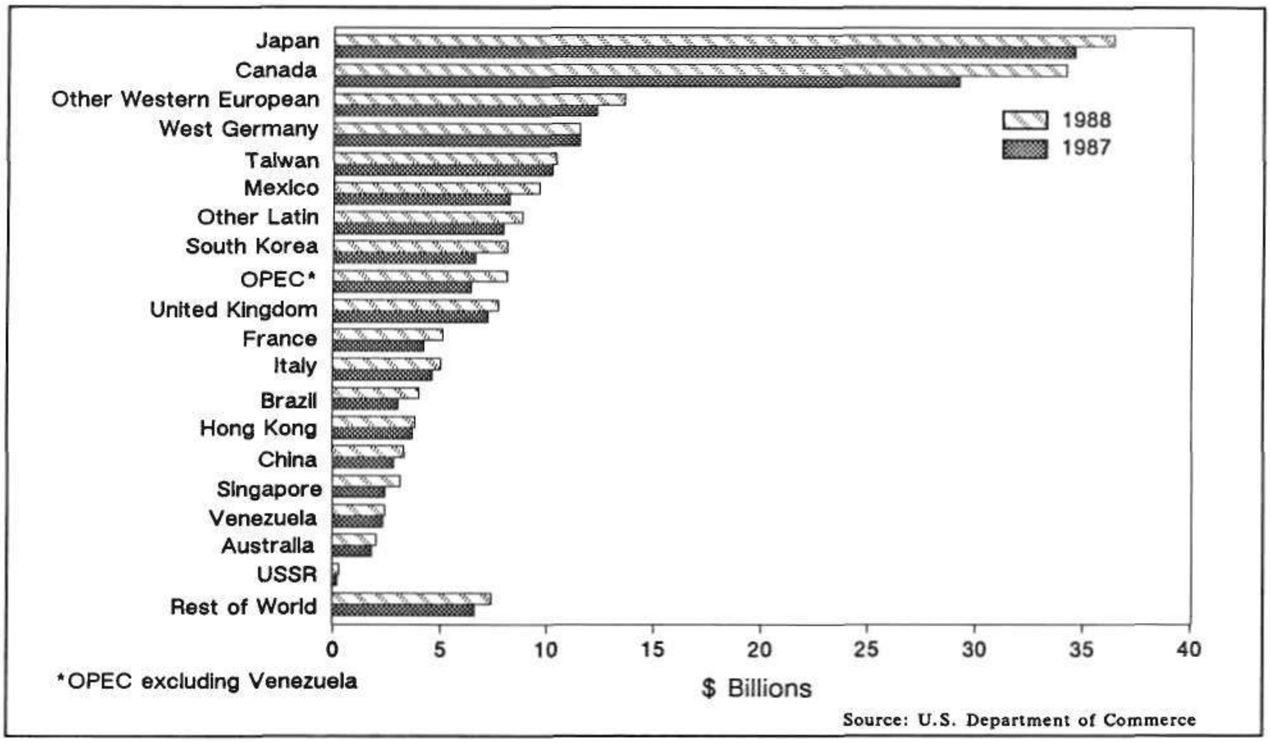

Figure 5. Comparison of U.S. Import Activity, January-May 1988 versus January-May 1987 (Bilions of Dollars)

What about the specific markets for electronics goods? Figure 6 ranks the top twelve national markets for three basic categories of American electronic products: computers, semiconductors, and telecommunications equipment. Canada, the United Kingdom, and Japan remain the top three markets in a pattern and product mix very similar to that of 1987. Figures 7 and 8 compare 1988 and 1987 electronics import and export activity through April of each year. In general, computer equipment shows the largest absolute increase: $1.9 billion in exports so far this year compared with the same period in 1987, a 36 percent increase. Telecommunications equipment accounted for the largest rise with an increase in export value of 40 percent.

Imports of foreign goods into the U.S. have slackened slightly, as importers have struggled to remain price-competitive in the face of weak dollar exchange rates. A significant part of this process has been a growing shift toward less-expensive imports from newly industrializing countries, particularly the Republic of Korea, Brazil, Singapore, and China. The American consumer's passion for imports has not diminished; it has been transferred to other, cheaper, sources of supply.

Figure 9 demonstrates the continuing close linkage between U.S. consumption, measured by final sales to domestic purchasers, and the value of imported goods into the United States. Final sales is an accurate measure of domestic demand in that it includes import sales and excludes unsold inventory and exports. Dataquest forecasts diminishing annual rates of increase in final sales, measured quarterly, through the remainder of 1988 and into early 1990. These and other projections are contained in Table 1. Along with a forecast of continued export strength, a corresponding decrease in the U.S. international trade deficit is projected, lowering it to an annualized $50 billion level by the middle of 1990. Figure 10 shows the history and Dataquest forecast of total merchandise trade on a quarterly basis through 1990.

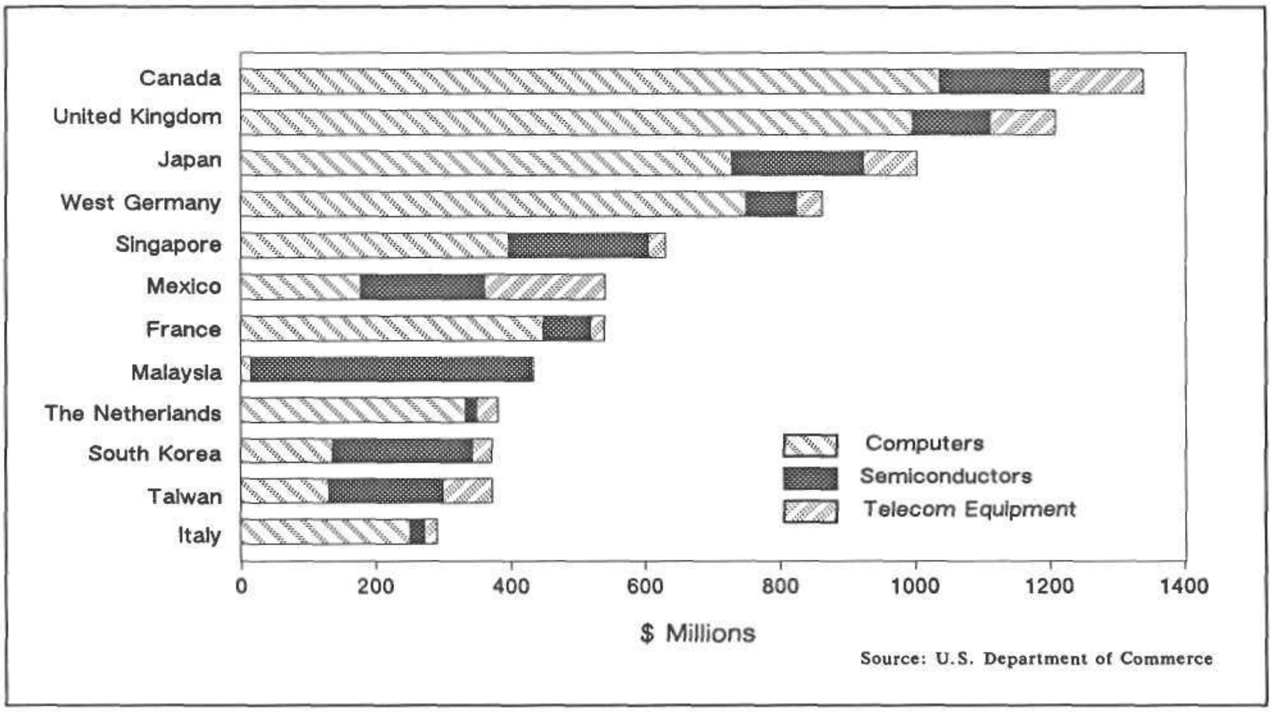

Figure 6. U.S. Electronics Exports—January-April 1988, Top Twelve Markets

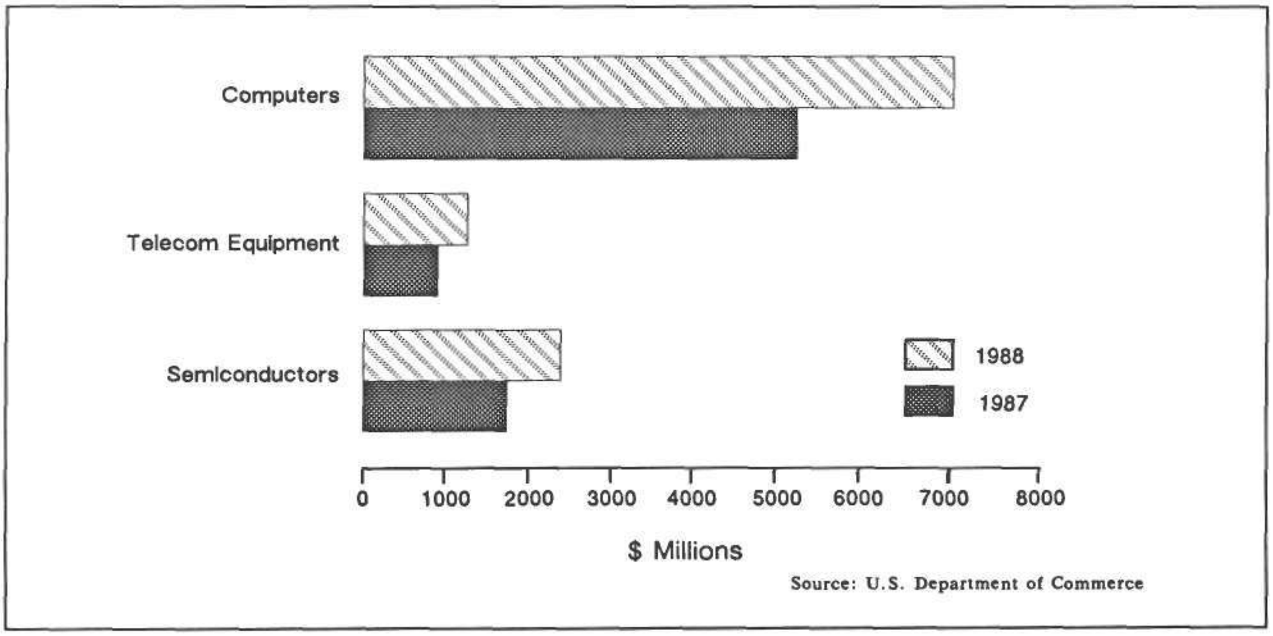

Figure 7. U.S. Electronics Exports January-April 1988 versus January-April 1987

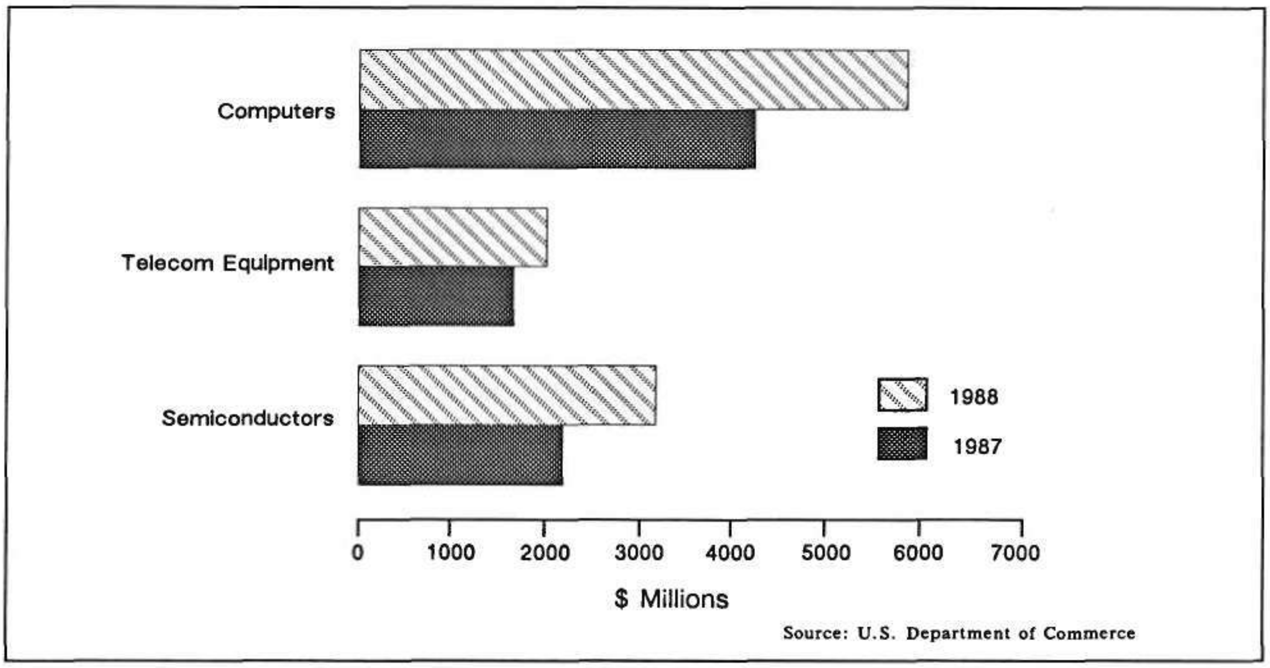

Figure 8. U.S. Electronics Imports January-April 1988 versus January-April 1987

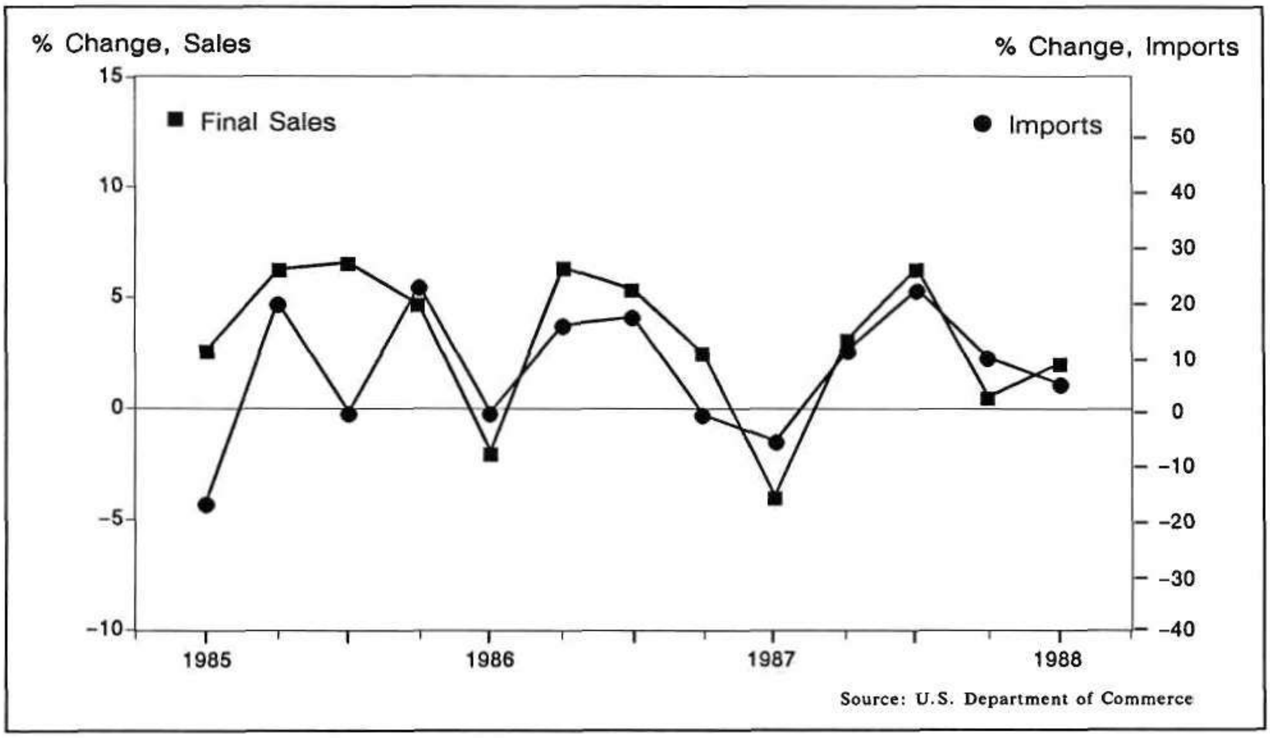

Figure 9. Final Sales to Domestic Purchasers versus Imports (Quarter-to-Quarter Changes) 1985-1988

Table 1. Dataquest Economic Forecast, 1988-1990

	1988 Q1	1988 Q2	1988 Q3	1988 Q4	Average 1988	1989 Q1	1989 Q2	1989 Q3	1989 Q4	Average 1989	1990 Q1	1990 Q2	1990 Q3	1990 Q4	Average 1990
Real GNP, SAAR	$3,956	$3,988	$4,015	$4,049	$4,002	$4,084	$4,110	$4,127	$4,134	$4,114	$4,109	$4,092	$4,132	$4,185	$4,129
% Change, Year Ago	4.8%	4.3%	3.9%	3.2%		2.4%	3.0%	2.8%	2.1%		0.6%	(0.4%)	0.1%	1.2%	
% Change, Annual Rate	3.4%	3.3%	2.6%	3.4%		3.4%	2.7%	1.7%	0.7%		(2.4%)	(1.6%)	3.9%	5.1%	
Consumer Spending	2,560	2,576	2,591	2,612	2,585	2,630	2,643	2,651	2,656	2,645	2,641	2,638	2,668	2,703	2,663
% Change, Year Ago	2.8%	2.4%	1.8%	3.2%		2.1%	2.7%	2.3%	1.7%		0.5%	(0.1%)	0.6%	1.7%	
% Change, Annual Rate	4.5%	2.5%	2.3%	3.3%		2.7%	2.1%	1.2%	0.7%		(2.1%)	(0.3%)	4.4%	5.0%	
Fixed Investment	473	489	501	512	494	520	526	529	527	525	518	503	505	514	510
% Change, Year Ago	13.2%	12.5%	8.2%	10.2%		9.8%	7.6%	5.7%	2.8%		(0.3%)	(4.5%)	(4.6%)	(2.3%)	
% Change, Annual Rate	7.6%	16.0%	9.7%	9.7%		5.8%	5.3%	2.1%	(2.0%)		(6.2%)	(11.3%)	1.5%	7.7%	
Equipment Investment	349	362	372	384	367	392	399	402	400	398	392	377	379	388	384
% Change, Year Ago	17.6%	15.3%	11.2%	15.3%		12.1%	10.3%	8.1%	4.3%		0.1%	(5.5%)	(5.7%)	(3.0%)	
% Change, Annual Rate	21.6%	14.8%	12.2%	12.8%		8.4%	7.5%	3.2%	(2.0%)		(7.3%)	(14.5%)	2.1%	10.1%	
Residential Investment	190	191	190	189	190	190	190	191	191	190	189	190	195	204	194
Government Purchases	776	777	792	796	785	799	802	810	812	806	806	808	815	820	812
% Change, Year Ago	0.5%	0.6%	1.2%	0.4%		2.9%	3.1%	2.3%	2.0%		0.9%	0.8%	0.5%	1.0%	
% Change, Annual Rate	(7.9%)	0.4%	8.0%	1.8%		1.5%	1.4%	4.4%	0.8%		(3.1%)	1.1%	3.3%	2.8%	
Net Exports	(109)	(90)	(96)	(93)	(97)	(88)	(83)	(77)	(67)	(79)	(55)	(48)	(48)	(51)	(50)
Inventory Change	66	45	37	33	45	33	32	23	15	26	10	1	(3)	(5)	1
Final Sales to Domestic Purchasers	3,975	4,019	4,049	4,077	4,030	4,093	4,101	4,117	4,132	4,111	4,136	4,157	4,196	4,235	4,181
% Change, Year Ago	3.0%	3.3%	2.5%	3.1%		3.0%	2.0%	1.7%	1.3%		1.1%	1.4%	1.9%	2.5%	
% Change, Annual Rate	1.9%	4.5%	3.0%	2.9%		1.6%	0.8%	1.5%	1.5%		0.4%	2.1%	3.8%	3.7%	
Dollar Exchange Rate Index	147	149	150	149	149	146	143	140	140	142	144	148	152	156	150
% Change, Year Ago	(0.3%)	1.8%	0.5%	0.4%		(0.7%)	(4.0%)	(6.7%)	(6.0%)		(1.4%)	3.5%	8.6%	11.4%	
% Change, Annual Rate	0.1%	5.4%	2.7%	(2.7%)		(8.1%)	(8.2%)	(8.4%)	0.0		11.4	11.1%	10.8%	10.5%	
Unemployment Rate	5.7%	5.4%	5.3%	5.2%	5.4%	5.4%	5.5%	5.7%	6.0%	5.7%	6.6%	7.4%	7.4%	7.3%	
Interest Rates															
3-Month T-Bills	5.7%	6.2%	6.9%	7.0%	6.5%	7.2%	7.9%	8.4%	8.9%	8.1%	8.6%	8.1%	7.7%	7.3%	7.9%
30-Year T-Bonds	8.6%	9.1%	9.2%	9.6%	9.1%	10.2%	10.6%	10.9%	10.1%	10.4%	9.3%	9.0%	8.8%	9.0%	9.0%
Savings Rate	4.7%	4.4%	4.3%	4.3%	4.4%	4.4%	4.6%	4.7%	4.3%	4.6%	4.4%	4.5%	4.4%	4.2%	4.4

Note: Values shown are billions of 1982 dollars and are seasonally adjusted annual rates.

Source: U.S. Department of Commerce
Dun & Bradstreet
Dataquest
September 1988

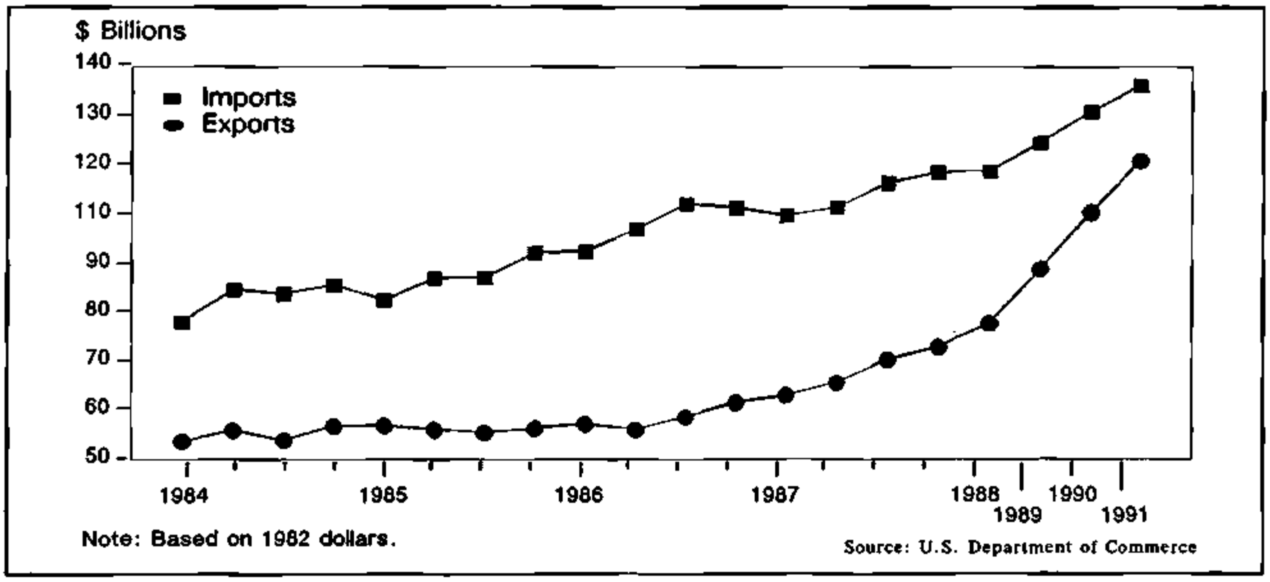

Figure 10. U.S. Merchandise Trade, Quarterly 1984-1990

The status of U.S. trade from February through May 1988 is shown in Figure 11. The predominant roles of Japan and Canada in the current U.S. trade position can be seen clearly, as can the broad distribution of the U.S. deficit across many markets. The fruitful relationship between the United States and Canada offers the United States more near-term possibilities for improved trade activity than does the U.S.-Japan trade relationship. This potential improvement centers on the pending free-trade agreement now being debated in both national legislatures. Seventy-five percent of the $140 billion value of goods passing between the two countries is currently duty free, while the remainder is subject to Canadian duties averaging 9.9 percent and U.S. duties of 3.3 percent. The agreement will remove all tariffs and many nontariff barriers to bilateral trade over 10 years, establishing rules for trade in services, investments, hydroelectric and petroleum energy, and government procurement activity. Studies by the two governments have concluded that this stimulus to direct trade ultimately could add as much as 10.0 percent to the Canadian GNP and 1.0 percent to that of the United States. Congress likely will approve the measure by September, but Liberal and New Democratic opposition leaders in the Canadian Parliament may force national elections this fall as a trade referendum. Canadian objections to final approval relate to the regulation of subsidies, procedures for settlement of disputes, and deep Canadian concern about dilution of their cultural and economic sovereignty by their southern partner.

More than 24 percent of U.S. exports go to Canada, while 17 percent of imports into the U.S. come from Canada, but in 1987 the net difference was a U.S. trade deficit of $12 billion. By comparison, 11 percent of U.S. exports are shipped to Japan, and 21 percent of U.S. imports are Japanese goods. U.S. exports to Japan are accelerating much faster than imports, 44 percent from January through May 1988 compared with the same period in 1987. However, the United States has a huge gap to bridge against the higher aggregate value of imported Japanese goods into the U.S., which rose only 5 percent.

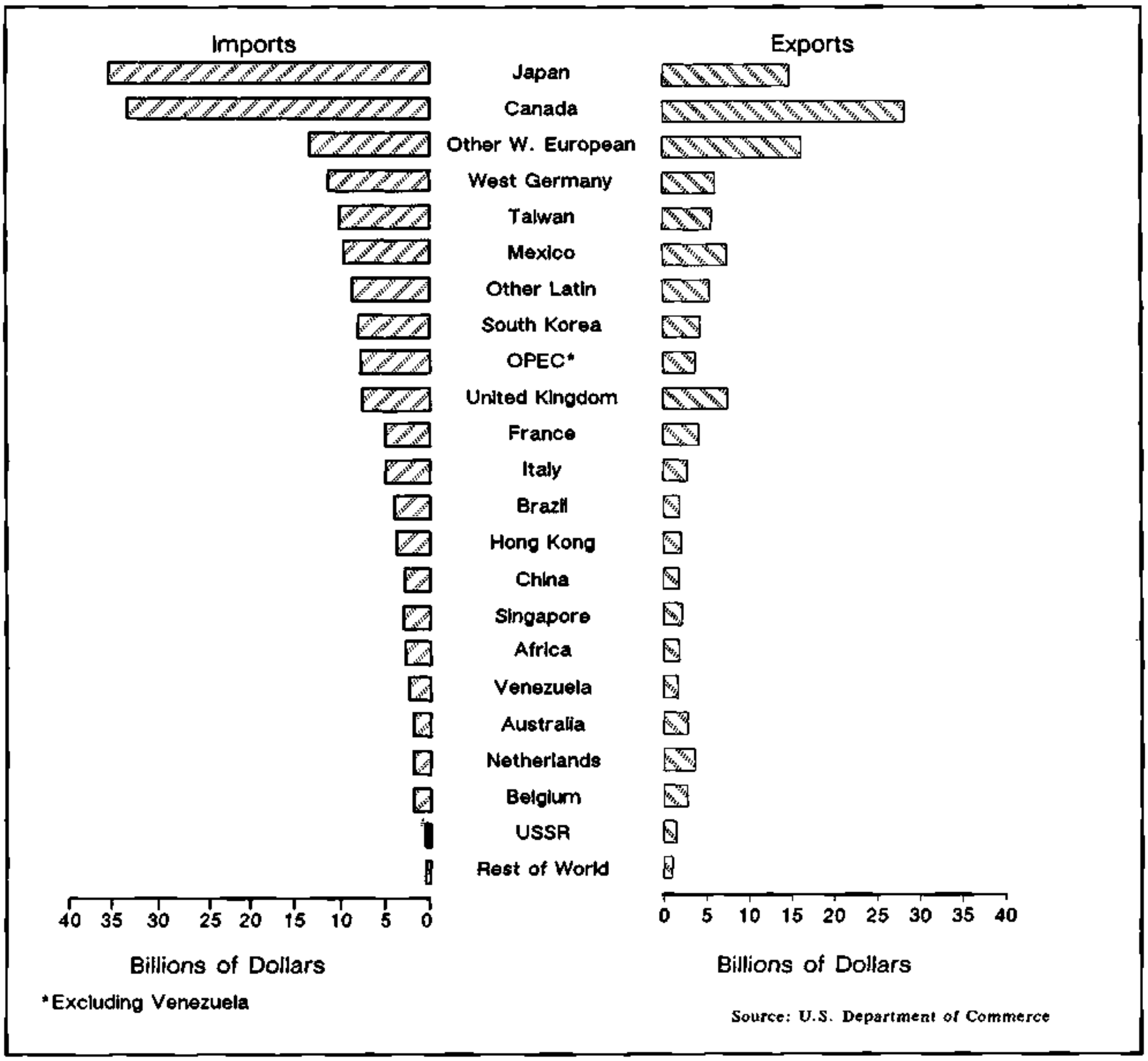

Figure 11. U.S. Merchandise Trade—January-May 1988 (Dollars in Billions)

U.S. Domestic Economic Outlook—downturn In The First Half Of 1990

The Dataquest outlook is for continued strong economic growth through the first three quarters of 1989. Robust exportation and domestic capital spending, coupled with healthy employment growth and a moderating level of consumer spending on imports, all translate into an optimistic economic forecast, particularly for sales of electronic goods and equipment.

There are, of course, many potentially destabilizing factors. When demand for skilled workers exceeds supply and limitations on production capacity are reached, manufacturers must train new workers and invest in additional plant and equipment. To the extent that these additional costs are not reflected directly in additional production, they are inflationary. A continuing deficit at the federal level itself creates inflationary pressures and affects consumer and business confidence. Any increases in the discount rate by the Federal Reserve Board in attempts to keep economic growth and inflation rates within reasonable limits are followed closely by increases in general interest rates. As interest rates in the United States increase, thedollar.becomes more attractive and its exchange value against other currencies rises. Ultimately, a stronger dollar makes imported goods less expensive and U.S. goods more costly in foreign markets, tending to reverse U.S. trade gains.

Aside from catastrophic external events, the onset and magnitude of a general economic downturn are caused by the *coincident* rise of many of these separate factors to significant levels. Dataquest believes that the likelihood of a downturn is increasingly probable by late 1989, as outlined in the introduction to this report and in Table 1. Dataquest anticipates that the most likely scenario involves 1989 increases in interest rates by the Federal Reserve Board, coupled with plans for higher taxes and continued government spending. Declines in consumer sentiment and spending will result in a more pessimistic mood in the business community and subsequent capital spending cuts from the fourth quarter of 1989 through the second quarter of 1990.

The negative GNP growth is forecast to last only two quarters, with a maximum quarterly decrease of 2.4 percent. However, the equipment investment component of the economy is hypersensitive to interest rates and demand and will have a longer cycle of decline, consisting of three consecutive negative growth quarters. The Dataquest forecast shows equipment investment declining to negative 14.5 percent annualized growth in the second quarter of 1990 before beginning recovery in the third quarter. Purchases of computers, peripherals, and telecommunications equipment represent about 45.0 percent of U.S. equipment investment spending, and while they are more resistant to recession than many capital items, they will still be affected adversely by an economic slowdown.

As discussed in the *Economic Outlook 1988-1989*, Dataquest sees little prospect for significant improvement in the U.S. federal budget deficit through 1990, regardless of who become the new occupants of the White House and congress. In an election year, no one in Washington expects to gain any votes with tough talk about the deficit. After the election, there will be strong bipartisan interest to increase spending in a number of domestic areas that have seen lean times over the last eight years, such as health care, drug enforcement, environmental issues, and construction. The most likely budget scenario through 1989-1990 is one in which new program increases are balanced by raising personal income tax ceilings, elimination of some existing personal tax credits, increasing consumption taxes on tobacco, alcohol and gasoline, and modifying the corporate tax structure. Some programs that might otherwise have been federally funded, such as child care and worker retraining, will be shifted to corporate shoulders.

Dataquest projects federal deficits of $166 billion in 1988, $160 billion in 1989, and $145 billion in 1990, measured in current dollar terms. Figure 12 shows the 1976 to 1987 federal budget history, and projects the budget picture through 1990.

While Dataquest sees no perceptible slowdown in federal spending for computers, peripherals, and telecommunications equipment in civilian programs, the outlook is not good for the military budget. There is growing congressional sentiment for cuts of as much as 20 percent in the Pentagon's current annual spending level of $300 billion. Dataquest projects that the military's budget will be held to no real growth over the next two to three years. Our recommendation to related industries is to diversify into more commercial applications where possible, and into international markets where opportunities present themselves.

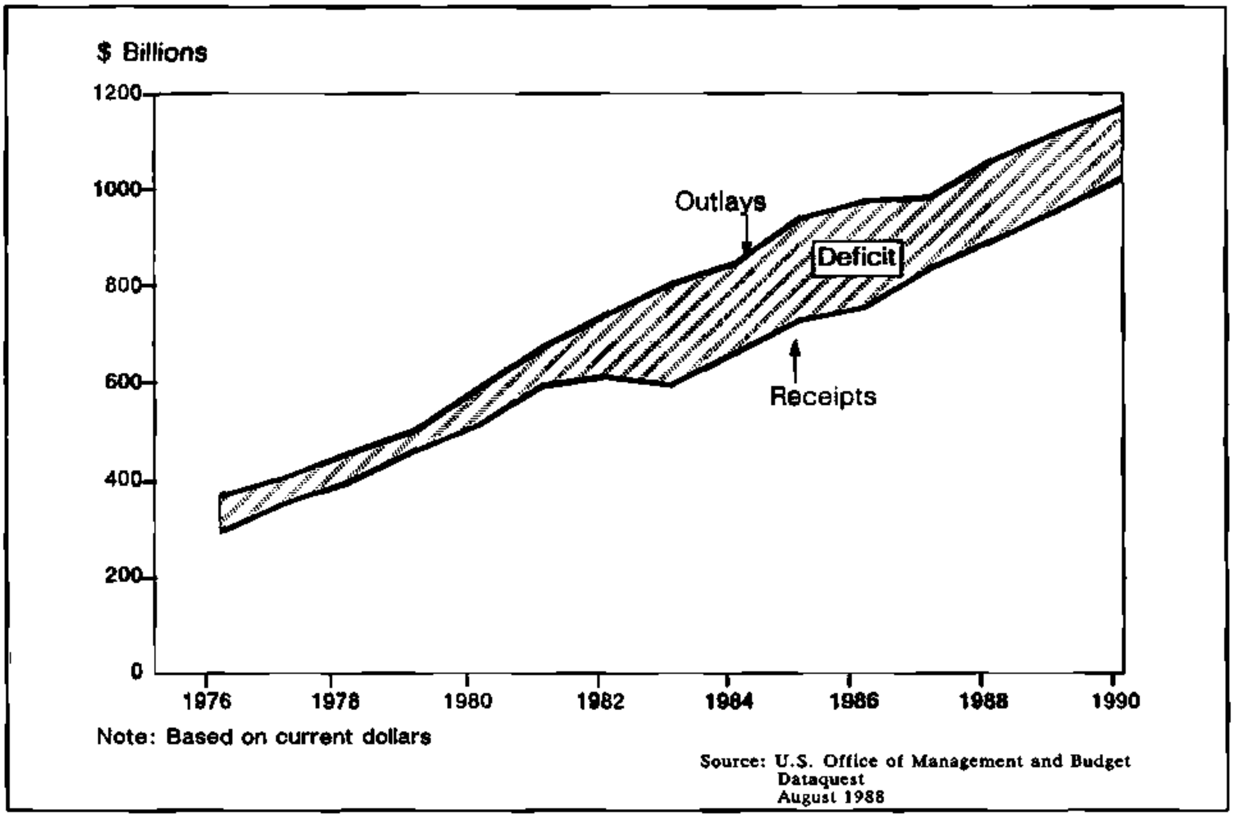

Figure 12. Federal Budget Receipts and Outlays—1976-1990

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Exchange Rate Tables

Dataquest's European exchange rate tables include data from all Western European countries, each of which has different and variable exchange rates against the US dollar. Where applicable, Dataquest estimates are prepared in terms of local currencies before conversion (where necessary) to US dollars. Dataquest uses exchange rates taken from the *Wall Street Journal*, which are in turn taken from the Bankers Trust Co. All exchange rates previous to 1990 were sourced from the International Monetary Fund (IMF).

All forecasts are prepared using fixed exchange rates based on the last complete historical quarter (currently the fourth quarter of 1990). To maintain consistency across all its analyses, Dataquest makes ongoing adjustments to its forecasts for these currency changes during the year. As a result of this policy, forecast growth rates can become distorted when comparing dollar growth rates with European currency growths.

Table 1 provides a summary of yearly average exchange rates in local currency per US dollar for each European region and Japan from 1979 to 1990. Included in Table 1 is the European Currency Unit (ECU). This unit, which was established in March 1979, is the weighted average of the currencies of all member countries of the European Community (EC). It is calculated by the IMF from each country's gross national product (GNP) and foreign trade. Table 2 shows the quarterly exchange rate for 1990 for each of these regions.

Also included is the Semiconductor Industry Weighted Average (SIWA). This unit is based on the semiconductor consumption of each European country featured here (EC and non-EC members) and uses the base year 1980 equal to 100 as a reference point. The SIWA is useful for interpreting the effect of European currency fluctuations with respect to the US dollar, specifically for the European semiconductor industry.

Dataquest's European local currency forecasts and historical data has previously been recorded using the SIWA as a measure of local currency. Since September 1990 we have changed to using ECUs. As it is becoming increasingly common for companies to publish their annual reports in ECUs, all future local currency forecasts prepared by Dataquest will be published in ECUs.

Table 1

European Currencies—1979 to 1990
(Local Currency per US Dollar)

Region	1979	1980	1981	1982	1983	1984
Austria	13.37	12.94	15.93	17.06	17.97	20.00
Belgium	29.32	29.25	37.13	45.69	51.13	57.78
Denmark	5.26	5.64	7.13	8.33	9.15	10.36
Finland	3.90	3.73	4.31	4.82	5.57	6.01
France	4.25	4.23	5.43	6.57	7.62	8.74
Ireland	0.49	0.49	0.62	0.70	0.80	0.92
Italy	830.90	856.50	1,136.80	1,352.50	1,518.90	1,757.00
Luxembourg	29.32	29.24	37.13	45.69	51.13	62.34
Netherlands	2.01	1.99	2.49	2.67	2.85	3.21
Norway	5.06	4.94	5.74	6.45	7.29	8.16
Portugal	48.92	50.07	61.55	79.48	110.78	146.39
Spain	67.13	71.70	92.31	109.86	143.43	160.76
Sweden	4.29	4.23	5.06	6.28	7.67	8.27
Switzerland	1.66	1.67	1.96	2.03	2.10	2.35
United Kingdom	0.47	0.43	0.49	0.57	0.66	0.75
West Germany	1.83	1.82	2.26	2.43	2.55	2.85
ECU	0.69	0.76	0.92	1.02	1.12	1.27
Japan	219.14	226.75	220.54	249.05	237.52	237.44
SIWA (Base 1980 = 100)	101.66	100.00	123.69	141.30	157.59	178.06

(Continued)

Table 1 (Continued)

European Currencies—1979 to 1990
(Local Currency per US Dollar)

Region	1985	1986	1987	1988	1989	1990
Austria	20.69	15.26	12.64	12.35	13.24	11.36
Belgium	59.41	44.66	37.34	36.77	39.44	33.41
Denmark	10.60	8.09	0.84	6.73	7.32	6.18
Finland	6.20	5.07	4.40	4.18	4.30	3.82
France	8.98	6.92	6.01	5.96	6.39	5.44
Ireland	0.94	0.75	0.67	0.66	0.71	0.60
Italy	1,909.50	1,490.00	1,296.10	1,301.00	1,373.60	1,197.22
Luxembourg	59.38	44.66	37.34	36.77	39.44	33.41
Netherlands	3.32	2.45	2.03	1.98	2.12	1.82
Norway	8.60	7.39	6.74	6.52	6.91	6.25
Portugal	170.40	149.54	140.88	143.96	157.62	142.40
Spain	170.05	139.97	123.56	116.49	118.55	102.03
Sweden	8.60	7.12	6.34	6.13	6.45	5.92
Switzerland	2.46	1.80	1.49	1.46	1.64	1.39
United Kingdom	0.77	0.68	0.61	0.56	0.61	0.56
West Germany	2.94	2.17	1.80	1.76	1.88	1.62
ECU	1.31	1.02	0.87	0.84	0.92	0.79
Japan	238.54	168.49	144.43	128.11	138.07	144.71
SIWA (Base 1980 = 100)	184.70	145.89	125.52	121.46	130.20	113.78

Source: Dataquest (March 1991)

Table 2

1990 Quarterly European Currencies
(Local Currency per US Dollar)

Region	1Q90	2Q90	3Q90	4Q90	1990
Austria	11.90	11.80	11.21	10.54	11.36
Belgium	35.29	34.60	32.81	30.93	33.41
Denmark	6.52	6.39	6.08	5.74	6.18
Finland	3.99	3.96	3.75	3.59	3.82
France	5.74	5.64	5.34	5.05	5.44
Ireland	0.64	0.63	0.59	0.56	0.60
Italy	1,254.66	1,231.66	1,176.27	1,126.28	1,197.22
Luxembourg	35.29	34.60	32.81	30.93	33.41
Netherlands	1.91	1.89	1.80	1.69	1.82
Norway	6.53	6.49	6.15	5.85	6.25
Portugal	148.86	147.90	140.62	132.22	142.40
Spain	109.08	105.60	98.60	94.85	102.03
Sweden	6.15	6.08	5.86	5.60	5.92
Switzerland	1.51	1.44	1.33	1.27	1.39
United Kingdom	0.61	0.60	0.54	0.51	0.56
West Germany	1.69	1.68	1.59	1.50	1.62
ECU	0.83	0.82	0.77	0.73	0.79
Japan	147.92	155.35	145.07	130.50	144.71
SIWA (Base 1980 = 100)	120.18	118.61	111.06	105.26	113.78

Source: Dataquest (March 1991)