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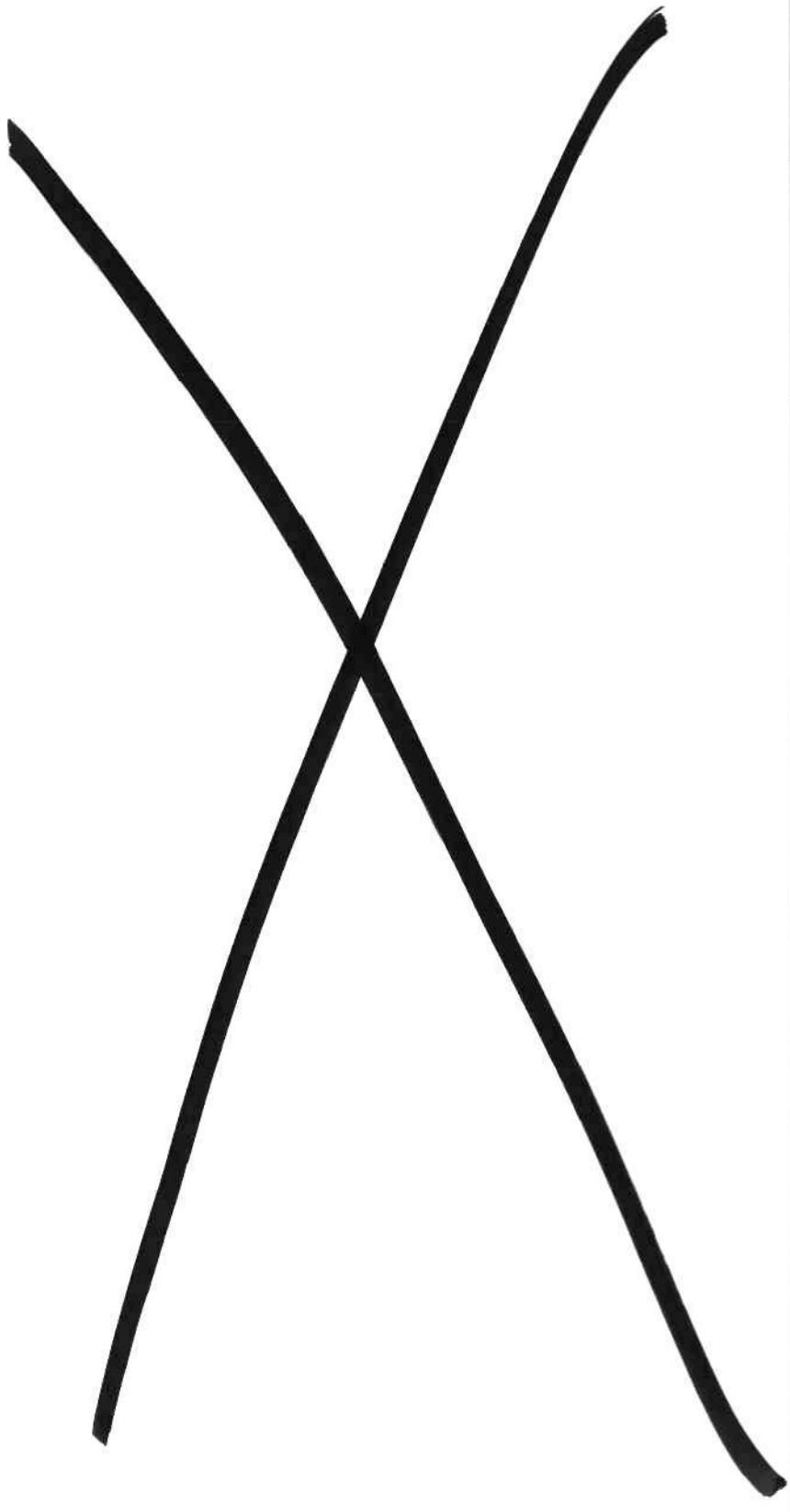

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• Market Statistics

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Japanese Fab Database

October 28, 1992

Source:
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Market Statistics

Semiconductors *Japan*

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Japanese Fab Database

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Japanese Fab Database

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Note: All tables show estimated data.

Japanese Fab Database

Background

The material in this document applies to the Japanese wafer fab database of Dataquest's Semiconductors Japan service. The wafer fab database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this document highlight both production and pilot line wafer fabs.

Research Methodology

Dataquest takes a three-pronged approach to wafer fab database research. Information is gained through extensive annual primary research. This survey work is further supplemented with comprehensive secondary research conducted on an ongoing basis. The database is updated daily, which allows Dataquest to provide a snapshot of the marketplace at any time. The information gathered through primary and secondary research is then further supplemented and cross-checked with Dataquest's various other information sources.

General Definitions

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

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

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

Definition of Table Columns

The Products Produced column contains information for seven product categories. The information in this column can be very detailed, depending on its 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
- FLASH—Flash memory
- NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
- FIFO—First-in/first-out memory
- SPMEM—Other specialty memory (such as dual-port, shift-register, color lookup)

• Microcomponents

- ASSP—Application-specific standard product
- BIT—Bit slice (subset of MPU functions)
- DSP—Digital signal processor
- MCU—Microcontroller unit
- MPR—Microperipheral
- MPRCOM—MPR digital communication (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computing 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

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available information on levels of metal, type of well, and logic structure. 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:

Stated Diameter	Approximate Diameter
4 inches (100mm)	3.938 inches
5 inches (125mm)	4.922 inches
6 inches (150mm)	5.906 inches
8 inches (200mm)	7.87 inches

Maximum Wafer Capacity is defined in the fab survey as the equipment-limited wafer start capacity per four-week period. Maximum 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.

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 Merchant or Captive column categorizes each fab line on the tables as one of these two types. Definitions 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.

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

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
AISHIN SEIKI	HANDA-SHI	AICHI	HANDA	AUTOMOTIVE	NA	0	0	0	0	NA	M
AISHIN SEIKI	HEKINAN-SHI	AICHI	SHINKAWA	AUTOMOTIVE	NA	0	0	0	0	NA	M
CANON	HIRATSUKA-SHI	KANAGAWA	NA	AMORPHOUS IMAGE SENSORS	GaAs	0	3	0	0	NA	C
CANON	HIRATSUKA-SHI	KANAGAWA	NA	ASIC	CMOS	0	6	3,000	0	10	C
CANON DENSHI	CHICHIBU-SHI	SAITAMA	NA	CCD	MOS	3.00	5	5,000	0	NA	C
CASIO	HACHIOJI-SHI	TOKYO	NA	ASIC	NA	0	4	11,000	0	NA	C
CLARION	KORIYAMA-SHI	FUKUSHIMA	NA	SAW CUSTOM	NA	0	4	5,000	0	NA	C
FUJI ELECTRIC	MATSUMOTO-SHI	NAGANO	NA	CUSTOM ASSP	CMOS BICMOS BIP	1.00	6	20,000	0	10	M
FUJI ELECTRIC	MATSUMOTO-SHI	NAGANO	NA	DIODE PWR TRAN PWR MOSFET	MOS	2.00	4	20,000	0	100	M
FUJI FILM MICRODEVICE	KUROKAWA-GUN	MIYAGI	NA	CCD	CMOS	1.00	6	3,000	2,463	1	C
FUJI XEROX	SUZUKA-SHI	MIE	NA	PWR ICs IMAGE SENSOR LOG	CMOS	3.00	5	3,000	0	NA	C
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 1 #1	ARRAYS LOG	CMOS	1.50	6	30,000	0	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 1 #2	ARRAYS LOG	CMOS	1.20	6	16,000	0	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 2 #1	ARRAYS CBIC 32-bit MCU	CMOS	0.70	6	15,000	5,251	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 1	DIS A/D D/A	BIP	2.00	5	30,000	0	NA	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 2	256K DRAM SRAM EPROM MPU	MOS CMOS	1.50	5	40,000	0	NA	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 3	1Mb DRAM SRAM ROM	CMOS MOS	1.00	6	20,000	0	10	M
FUJITSU	MINOKAMO-SHI	GIFU	MINOKAMO	PROTOTYPE ICs	CMOS	1.00	6	5,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 1	ARRAYS	BIP	1.20	6	15,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 2	ROM EPROM	MOS	1.50	5	32,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 3	1Mb DRAM 4Mb DRAM SRAM ROM	CMOS MOS POLY3	0.80	6	25,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 4	4Mb DRAM 16Mb DRAM SRAM ASIC	CMOS MOS POLY3	0.50	6	13,000	0	1	M
FUJITSU	KAWASAKI-SHI	KANAGAWA	NA	3D ICs JOSEPHSON JUNCTION	NA	0	5	15,000	0	NA	M
FUJITSU	KUWANA-GUN	MIE	NO. 1	ARRAYS	CMOS MOS	1.00	6	10,000	0	10	M
FUJITSU	KUWANA-GUN	MIE	NO. 2	LOG ARRAYS 4Mb DRAM	CMOS BIP	0.80	6	10,000	0	10	M
FUJITSU	KUWANA-GUN	MIE	NO. 3	4Mb DRAM 16Mb DRAM SRAM MPU	CMOS	0.80	6	500	0	NA	M
FUJITSU	NAKAKOMA-GUN	YAMANASHI	NA	FET LIN OPTO HEMT	GaAs	0	3	0	0	NA	M

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

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
HAMAMATSU PHOTONICS	HAMAMATSU-SHI	SHIZUOKA	NA	OPTO	NA	0	3	15,000	0	NA	M
HITACHI	MOBARA-SHI	CHIBA	D1	ASIC MCU EPROM	MOS CMOS	1.50	5	30,000	4,182	NA	M
HITACHI	MOBARA-SHI	CHIBA	D2	1Mb DRAM 4Mb DRAM	CMOS	0.80	5	30,000	4,182	NA	M
HITACHI	MOBARA-SHI	CHIBA	D3	1Mb DRAM 4Mb DRAM	CMOS M2	0.80	6	30,000	4,182	10	M
HITACHI	TAKASAKI-SHI	GUNMA	NA	256K SRAM 4Mb DRAM MCU	CMOS BICMOS	0.80	6	20,000	0	NA	M
HITACHI	TAKASAKI-SHI	GUNMA	NO. 1	LIN EPROM PWR MOSPET SRAM	BIP MOS CMOS	2.00	5	20,000	0	100	M
HITACHI	CHITOSE-SHI	HOKKAIDO	CHITOSE	1Mb SRAM 4Mb DRAM MPU	CMOS	0.80	6	15,000	1,859	10	M
HITACHI	CHITOSE-SHI	HOKKAIDO	CHITOSE	4Mb DRAM 1Mb SRAM EEPROM ROM	CMOS	0.80	6	15,000	0	10	M
HITACHI	HITACHI-SHI	IBARAKI	NA	PWR GTO THYRISTERS	BIP STTL	4.00	5	20,000	0	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	N-2	4Mb DRAM 16Mb DRAM	CMOS	0.50	8	10,000	0	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	NA	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	20,000	1,859	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	N1-1	4Mb DRAM 1Mb SRAM	CMOS	0.80	6	15,000	0	NA	M
HITACHI	KOMORO-SHI	NAGANO	KOMORO	LASER TELECOM	CMOS GaAs	1.50	3	15,000	1,859	NA	M
HITACHI	KODAIRA-SHI	TOKYO	DDC	LOG LIN	BIP	2.00	4	15,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4-Bit MPU 8-Bit MCU	MOS	2.00	4	20,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4-bit 8-bit MCU	MOS	1.50	5	30,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4Mb DRAM 16Mb DRAM	CMOS	0.50	6	8,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	R&D	MPU SRAM DRAM ARRAYS CBIC	CMOS M2	1.30	6	15,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	R&D	MPU MEM CBIC	CMOS M2	1.20	5	15,000	0	10	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	IMASUWA	4Mb DRAM 4Mb SRAM 16Mb PROTO DRAM	CMOS	0.60	6	25,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	K-2	4Mb DRAM 16Mb DRAM	CMOS	0	8	3,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	LSI	NA	MOS	3.00	4	30,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K2-1	NA	NA	2.00	4	15,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K2-2	NA	MOS	2.00	5	20,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K3	64K SRAM	MOS	1.50	5	15,000	3,997	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-1	MEM MPU LOG	MOS	2.00	5	20,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-2	1Mb DRAM	CMOS	1.00	6	20,000	0	NA	M

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Table 1 (Continued)
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HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-3	4Mb DRAM 1Mb SRAM EPROM	CMOS MOS	0.80	6	10,000	0	100	M
HONDA	HAGA-GUN	TOCHIGI	NA	ENG. CONTROL SENSORS MMIC	GaAs	0	3	0	0	NA	C
IBM	YASU-GUN	SHIGA	NA	4Mb DRAM 16Mb DRAM	CMOS	0.60	8	10,000	3,717	NA	M
IBM	YASU-GUN	SHIGA	NA	ARRAY 1Mb DRAM MPU ROM	CMOS	1.00	5	30,000	4,554	NA	M
IWATSU	HACHIOJI-SHI	TOKYO	NA	NA	CMOS	1.50	5	6,000	0	NA	C
JVC	YOKOSUKA-SHI	KANAGAWA	NA	1K ARRAYS DSP CUSTOM	CMOS	3.00	3	9,000	0	NA	C
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	NA	256K SRAM CBIC ARRAYS	CMOS	0.80	6	10,000	0	NA	M
KODENSHI	UJI-SHI	KYOTO	PLANT 3	DIS DIODE TRAN	GaAs GaP	0	0	0	0	NA	M
KTI SEMICONDUCTOR	NISHIWAKI-SHI	HYOGO	NA	16Mb DRAM 4Mb DRAM	CMOS	0.50	8	9,000	0	1	C
KYOTO SEMICONDUCTOR	KYOTO-SHI	KYOTO	NA	LED TRAN IMAGE SENSOR	GaAs GaP	0	0	0	0	10,000	M
MATSUSHITA	HIOKI-GUN	KAGOSHIMA	NA	OPTO LED HEMT	GaP MOS	0	0	0	0	100	M
MATSUSHITA	KYOTO-SHI	KYOTO	LAB	16Mb DRAM	CMOS	0	8	1,000	0	NA	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	PWR TRAN	BIP	3.00	4	20,000	0	1,000	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	TTL LOG PWR TRAN CUSTOM	MOS	2.00	4	15,000	0	1,000	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	TRAN CCD DIODE	MOS	0	5	18,000	0	NA	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	LOG PWR TRAN CUSTOM	CMOS	2.00	4	15,000	0	NA	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB B-3	DRAM SRAM MPU	MOS	2.00	5	45,000	0	NA	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB C-1	CCD	MOS	1.50	4	15,000	0	100	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB C-2	DRAM SRAM MPU ROM	MOS	1.50	5	35,000	0	100	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB D	LOG LIN CCD	BIP	3.00	5	20,000	0	100	M
MATSUSHITA	UTSUNOMIYA-SHI	TOCHIGI	KIYAHARA	SST DIODE	MOS	0	4	8,000	0	NA	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB A-1	16-bit MPU ARRAYS	CMOS	1.50	5	15,000	0	100	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB A-2	MPU ROM EPROM EEPROM	MOS	1.50	5	15,000	0	100	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB B	MPU MCU EEPROM	CMOS	1.00	6	25,000	0	10	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB C-1	4Mb DRAM 1Mb DRAM	CMOS	0.80	6	20,000	0	10	M

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

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
MATSUSHITA	UOZU-SHI	TOYAMA	FAB C-2	16Mb DRAM 64Mb DRAM SRAM	CMOS	0.80	6	8,000	0	1	M
MEIDENSHA	NUMAZU-SHI	SHIZUOKA	NA	GTO THYRISTOR	NA	0	5	7,000	0	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	A-1F	4Mb DRAM 16Mb DRAM	CMOS M2	0.50	8	5,000	5,576	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	A-2F	4Mb DRAM 16Mb DRAM	CMOS M2	0.50	6	20,000	5,576	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	B	ASIC MCU MPU	CMOS M1	1.20	5	38,000	4,002	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	C	8-BIT MCU MPU ASIC	CMOS M2	0.80	5	38,000	4,002	10	M
MITSUBISHI	FUKUOKA-SHI	FUKUOKA	#1	PWR TRAN DIODE	BIP	3.00	4	25,000	0	NA	M
MITSUBISHI	FUKUOKA-SHI	FUKUOKA	#2	LOG LIN A/D D/A DIS	BIP	2.00	6	25,000	0	NA	M
MITSUBISHI	ITAMI-SHI	HYOGO	NA	ARRAYS OPTO LASER	CMOS MOS	2.00	5	28,000	651	10	M
MITSUBISHI	ITAMI-SHI	HYOGO	NA	FET OPTO HEMT	GaAs	0	3	0	0	NA	M
MITSUBISHI	ITAMI-SHI	HYOGO	R&D	16Mb DRAM	CMOS	0.35	8	1,000	0	1	M
MITSUBISHI	KAMI-GUN	KOCHI	FAB A (TA-1F)	4Mb DRAM 1Mb SRAM	CMOS	1.00	6	25,000	0	NA	M
MITSUBISHI	KAMI-GUN	KOCHI	NA	8-bit MCU 16-bit MCU 32-bit MCU ASIC	CMOS	1.00	6	10,000	0	10	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	B-1F	EPROM	CMOS	1.50	5	30,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	B-2F	ARRAYS	CMOS	2.00	4	42,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	C-1F	EPROM	CMOS	1.50	5	25,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	C-2F	1Mb SRAM 1Mb ROM ARRAYS	MOS CMOS	0.80	5	25,000	0	NA	M
MITSUMI	ATSUGI-SHI	KANAGAWA	NA	LOG DIS	BIP	0	4	30,000	0	100	M
MORIRICA ELECTRONICS	YOKOHAMA-SHI	KANAGAWA	NA	OPTO	GaP	0	0	0	0	NA	M
MOTOROLA	YAMA-GUN	FUKUSHIMA	MOS 7	CBIC MCU SRAM ROM PWR ICs	CMOS MOS M1	1.80	4	25,000	2,212	100	M
MURATA MANUFACTURING	KYOTO-SHI	KYOTO	NA	FET MMIC	GaAs	0.80	0	0	0	NA	M
NEC	HIGASHI HIROSHIMA-SHI	HIROSHIMA	PHASE 1	4Mb DRAM SRAM MPU 4Mb ROM	CMOS	0.60	6	30,000	3,602	1	M
NEC	IZUMI-SHI	KAGOSHIMA	NA	LIN TELECOM LASER	BIP GaAs	0.80	4	4,200	0	NA	M
NEC	KAWASAKI-SHI	KANAGAWA	NA	ASIC EPROM MCU MPU	CMOS MOS	1.40	5	20,000	0	NA	M
NEC	SAGAMIHARA-SHI	KANAGAWA	BLDG. UL	EPROM ASIC MPU MCU	CMOS	1.20	5	12,000	5,403	NA	M
NEC	SAGAMIHARA-SHI	KANAGAWA	G-1	4Mb DRAM ASIC MPU 4Mb ROM	CMOS BICMOS	0.80	6	10,000	4,302	10	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 3	EPROM ROM	MOS	2.00	5	20,000	0	NA	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 4	ASIC EPROM MCU MPU	CMOS MOS	1.40	5	20,000	4,182	100	M

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

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 6	1Mb DRAM MPU ARRAYS	MOS POLY2	1.00	6	45,000	4,647	100	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 7	MCU 4Mb DRAM ASIC	CMOS BICMOS	1.00	6	30,000	6,506	10	M
NEC	OTSU-SHI	SHIGA	GaAs	PWR TRAN DIS CCD	GaAs	4.00	2	2,000	0	NA	M
NEC	OTSU-SHI	SHIGA	NO. 1	PWR TRAN DIS CCD	BIP	4.00	4	12,000	0	1,000	M
NEC	OTSU-SHI	SHIGA	NO. 2	LIN CCD	MOS	3.00	4	12,000	0	1,000	M
NEC	OTSU-SHI	SHIGA	NO. 3	ARRAYS SRAM 8-bit MPU	CMOS MOS	2.00	5	6,000	0	NA	M
NEC	OTSU-SHI	SHIGA	NO. 4	ARRAYS MCU SRAM 4Mb DRAM	CMOS	0.80	6	20,000	0	100	M
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	LOG LIN DIS	BIP	3.00	4	20,000	0	NA	M
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	LOG LIN	BIP	2.00	5	20,000	0	NA	M
NEC	ASA-GUN	YAMAGUCHI	PHASE 1	1Mb DRAM 4Mb DRAM	CMOS MOS	0.80	6	30,000	0	10	M
NEC	ASA-GUN	YAMAGUCHI	PHASE 2	4Mb DRAM 1Mb SRAM MPU	CMOS BICMOS	0.80	6	30,000	2,301	10	M
NEC	OTSUKI-SHI	YAMANASHI	NA	OPTO	NA	2.00	5	30,000	0	100	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	OP AMP A/D D/A REG	BIP	0	4	17,000	0	1,000	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	IED FET DIODE	GaAs GaAlAs	1.50	3	2,800	0	NA	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	CUSTOM LOG A/D D/A OPTO	CMOS	1.20	5	20,000	0	10	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	OP AMP	BIP	0	3	25,000	0	NA	M
NIHON INTER ELECTRONICS	HADANO-SHI	KANAGAWA	NA	MOSFET DIODE RECTIFIER	BIP	0	3	20,000	0	NA	M
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 1	ARRAYS CBIC	CMOS	1.00	6	4,700	4,423	10	M
NIPPONDENSO	KARIYA-SHI	AICHI	BLDG. 1	LOG CUSTOM MCU OPTO	MOS	1.50	5	2,000	0	NA	M
NIPPONDENSO	KARIYA-SHI	AICHI	NA	DIODE LOG CUSTOM MCU	BIP MOS	3.00	4	10,000	0	NA	M
NIPPON PRECISION CIRC.	NASU-GUN	TOCHIGI	NA	A/D D/A DSP LOG ASSP	CMOS	0.80	6	20,000	2,001	1	M
NIPPON PRECISION CIRC.	NASU-GUN	TOCHIGI	NA	LOG LIN A/D D/A MODEM	CMOS	2.00	4	13,000	3,001	1,000	M
NIPPON STEEL	SAGAMIHARA-SHI	KANAGAWA	SEMICONDUCTOR DEVICE R&D CTR.	ASIC	NA	0.80	6	0	0	NA	M
NISSAN	YOKOSUKA-SHI	KANAGAWA	NA	MCU CUSTOM	CMOS	2.00	5	500	1,501	10	C

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Table 1 (Continued)
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NKK	AYASE-SHI	KANAGAWA	PHASE 1	1Mb SRAM 4Mb SRAM MASK ROM RISC 256K SRAM MPU ASIC	NA	0.80	8	6,000	0	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M1	256K DRAM 8-BIT MPU ASIC	CMOS	1.20	5	20,000	3,996	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M2	1Mb DRAM FLASH	CMOS M1	0.80	6	15,000	3,996	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M3	4Mb DRAM	CMOS	0.50	6	15,000	0	1	M
OKI	KUROKAWA-GUN	MIYAGI	NA	ARRAYS 1Mb DRAM VRAM LOG	CMOS	0.80	6	20,000	0	10	M
OKI	KUROKAWA-GUN	MIYAGI	S1	4Mb DRAM VRAM 1Mb SRAM	CMOS	0.60	6	25,000	0	NA	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M1	DRAM SRAM ARRAYS MPU	CMOS	1.50	4	30,000	0	100	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M2	DRAM EEPROM ASIC	CMOS	1.00	5	20,000	2,801	10	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M3	4Mb DRAM 16Mb DRAM 90K ARRAYS	CMOS	0.50	6	15,000	8,400	NA	M
OKI	HACHIOJI-SHI	TOKYO	V-1	NA	MOS GaAs	0	3	50,000	0	NA	M
OKI	HACHIOJI-SHI	TOKYO	V-2	ARRAYS CBIC MPU	BIP BICMOS	2.00	4	40,000	0	100	M
OKI	HACHIOJI-SHI	TOKYO	V-3	16Mb DRAM 64Mb DRAM	CMOS BICMOS	0.30	8	500	2,601	NA	M
OLYMPUS	KAMIINA-GUN	NAGANO	NA	SIT IMAGE SENSOR	CMOS	3.00	5	5,000	0	NA	C
OMRON	KOUKA-GUN	SHIGA	NA	OPTO IMAGE SENSOR	BIP GaP	3.00	4	1,000	1,321	NA	M
OMRON	KOUKA-GUN	SHIGA	NA	OPTO IMAGE SENSOR	BIP GaP	0	4	20,000	4,622	NA	M
ORIGIN ELECTRIC	OYAMA-SHI	TOCHIGI	NA	TRAN DIODE DIS	BIP	0	4	17,000	0	NA	M
PIONEER VIDEO	KOFU-SHI	YAMANASHI	NA	ARRAYS LOG SAW CCD	CMOS	3.00	5	8,000	0	NA	C
RICOH	IKEDA-SHI	OSAKA	NA	ARRAYS ROM PLD LOG	BICMOS CMOS	2.00	4	15,000	1,421	100	M
RICOH	IKEDA-SHI	OSAKA	NA	256K ROM ARRAYS CBIC	CMOS MOS	1.30	6	7,000	0	100	M
RICOH	IKEDA-SHI	OSAKA	NA	ARRAYS	CMOS	1.00	6	10,000	0	NA	M
ROHM	CHIKUGO-SHI	FUKUOKA	NA	TRAN DIS	BIP	0	4	20,000	0	NA	M
ROHM	KYOTO-SHI	KYOTO	NA	MPU LASER MODEM TRAN LED	BIP GaAs	0	4	25,000	0	NA	M
ROHM	KYOTO-SHI	KYOTO	NA	MCU ARRAYS SRAM EEPROM	CMOS BICMOS	1.20	6	15,000	2,509	10	M
ROHM	KASAOKA-SHI	OKAYAMA	NA	TRAN DIODE LIN	BIP	0	4	20,000	0	1,000	M
SANKEN	NIIZA-SHI	SAITAMA	NA	PWR TRAN DIODE LED	NA	0	3	15,000	0	1,000	M
SANKEN	NIIZA-SHI	SAITAMA	NA	PWR TRAN DIODE LED	NA	0	5	6,000	0	NA	M

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

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
SANKEN	HIGASHINE-SHI	YAMAGATA	NA	PWR TRAN DIODE LED	NA	0	5	10,000	0	1,000	M
SANSHA	KATSUTA-GUN	OKAYAMA	NA	PWR TRAN PWR DIODE	BIP	0	4	25,000	0	NA	M
SANYO	ANPACHI-GUN	GIFU	F	CCD SRAM ARRAYS CBIC ROM	CMOS	1.00	5	25,000	0	10	M
SANYO	ANPACHI-GUN	GIFU	G	CCD ARRAY CBIC	CMOS	1.00	5	15,000	0	10	M
SANYO	OURA-GUN	GUNMA	NA	TRAN DIODE LIN	MOS	2.00	4	40,000	4,182	1,000	M
SANYO	OURA-GUN	GUNMA	NA	LIN	BIP	2.00	4	30,000	4,647	10	M
SANYO	OURA-GUN	GUNMA	R&D CENTER	SRAM DRAM	CMOS	0.80	6	5,000	0	10	M
SANYO	OJIYA-SHI	NIIGATA	A #1	LOG MPU MCU MPR	CMOS	1.20	5	30,000	0	10	M
SANYO	OJIYA-SHI	NIIGATA	A #2	LIN	BIP	2.00	5	25,000	3,502	1,000	M
SANYO	OJIYA-SHI	NIIGATA	B #3	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	20,000	0	NA	M
SANYO	OJIYA-SHI	NIIGATA	C #4	ASIC PLD 1Mb SRAM 16-BIT MPU	CMOS BICMOS	1.00	6	20,000	0	NA	M
SANYO	OJIYA-SHI	NIIGATA	C #5	16-BIT MCU DSP 4Mb DRAM	CMOS BICMOS	1.00	6	20,000	0	NA	M
SANYO	TOTTORI-SHI	TOTTORI	NA	LASER LED	GaAs GaP	5.00	3	20,000	3,001	1,000	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. A	ARRAYS 256K SRAM EPROM	CMOS	1.50	5	30,000	0	100	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. B	ARRAYS CBIC SRAM EEPROM	CMOS MOS	2.00	4	40,000	0	100	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. D	1Mb SRAM ASIC	CMOS BICMOS	0.80	6	25,000	0	NA	M
SEIKO EPSON	SAKATA-SHI	YAMAGATA	NA	250K ARRAYS CBIC 1Mb SRAM	CMOS BICMOS	0.80	6	20,000	0	10	M
SEIKO INSTRUMENTS	MATSUDO-SHI	CHIBA	BLDG. B	TELECOM	CMOS	2.00	4	10,000	0	NA	C
SEIKO INSTRUMENTS	MATSUDO-SHI	CHIBA	NA	SRAM ARRAYS CBIC EEPROM	CMOS	1.25	6	3,000	0	10	C
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 1	1Mb DRAM SRAM ARRAYS ROM	MOS	1.00	5	35,000	3,502	10	M
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 2 #1	1Mb DRAM SRAM ROM ASIC	CMOS	0.80	6	24,000	4,182	1	M
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 2 #2	4Mb DRAM 16Mb DRAM ROM ASIC	CMOS	0.80	6	24,000	4,182	NA	M
SHARP	KITA KATSURAGI-GUN	NARA	NA	DIODE TRAN COUPLERS	NA	0	4	25,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 1	LOG LIN	BIP	3.00	4	20,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 2	OPTO	CMOS MOS	2.00	4	20,000	0	NA	M

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Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
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SHARP	TENRI-SHI	NARA	NO. 3	ARRAYS CBIC	CMOS MOS BIP	1.20	5	20,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 4	NA	MOS	1.50	5	10,000	0	NA	M
SHARP	TENRI-SHI	NARA	TRIAL LINE	ARRAYS	CMOS	0.80	6	1,650	0	10	M
SHARP	YAMATO KORIYAMA-SHI	NARA	NA	LASER LED OPTO	GaAs	0	3	22,000	0	NA	M
SHINDENGEN	HONJO-SHI	AKITA	BLDG. 1	DIODE THYRISTOR	BIP	0	4	20,000	0	NA	M
SHINDENGEN	HONJO-SHI	AKITA	BLDG. 2	DIODE THYRISTOR	BIP	0	5	30,000	1,801	NA	M
SHINDENGEN	HANNO-SHI	SAITAMA	NA	DIS LIN	BIP	0	4	10,000	0	1,000	M
SHINDENGEN	HANNO-SHI	SAITAMA	NA	PWR MOSFET LIN LOG	MOS BIP	2.00	5	22,000	1,861	100	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 1	TRAN DIODE	NA	0	4	15,000	0	1,000	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 2 MOS	CUSTOM	CMOS MOS	2.00	5	25,000	2,538	NA	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 2 DIS.	TRAN DIODE LIN	BIP	0	5	30,000	2,538	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#2	DIS	NA	3.00	4	15,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#3	LIN A/D D/A	BIP	2.00	4	25,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#4	SRAM MPU CCD	MOS CMOS	1.30	5	30,000	0	10	M
SONY	KOKUBU-SHI	KAGOSHIMA	#6	LOG MEM MPU LIN DIS OPTO	CMOS BiCMOS	0.80	6	20,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	NA	CCD	MOS	1.50	4	20,000	0	NA	M
SONY	ATSUGI-SHI	KANAGAWA	NA	FET LASER CCD HEMT	GaAs	0	3	0	0	NA	M
SONY	ATSUGI-SHI	KANAGAWA	NA	EEPROM 4Mb VRAM 4Mb SRAM	CMOS	0.80	6	12,000	0	100	M
SONY	ATSUGI-SHI	KANAGAWA	NA	LIN	BIP	2.00	4	24,000	0	NA	M
SONY	ISAHAYA-SHI	NAGASAKI	1G	256K SRAM CCD	CMOS	1.00	6	20,000	2,323	10	M
SONY	ISAHAYA-SHI	NAGASAKI	2G	CCD 256K SRAM 1Mb SRAM	CMOS	0.80	6	20,000	0	NA	M
SONY	ISAHAYA-SHI	NAGASAKI	3G	1Mb SRAM 4Mb VRAM CCD	CMOS	0.80	6	40,000	0	NA	M
STANLEY	HADANO-SHI	KANAGAWA	NA	LASER LED	NA	0	4	10,000	0	NA	M
SUMITOMO METAL INDUSTRIES	AMAGASAKI-SHI	HYOGO	NA	4Mb DRAM ARRAYS	NA	0.80	6	300	0	NA	C
TEXAS INSTRUMENTS	INASHIKI-GUN	IBARAKI	MIHO 5	ASSP ASIC MCU DSP CBIC	MOS	1.00	5	25,700	3,532	10	M
TEXAS INSTRUMENTS	INASHIKI-GUN	IBARAKI	MIHO 6	1Mb DRAM 4Mb DRAM ASSP RISC	CMOS	0.80	6	21,600	5,576	1	M
TEXAS INSTRUMENTS	HAYAMI-GUN	OITA	HIJI 1	LOG LIN ARRAYS	BIP	1.00	5	8,000	1,673	100	M
TEXAS INSTRUMENTS	HAYAMI-GUN	OITA	HIJI 8	4Mb DRAM 16Mb DRAM	CMOS BICMOS	0.50	8	10,000	1,487	1	M
TEXAS INSTRUMENTS	HATOGAYA-SHI	SAITAMA	HATO	ASIC	CMOS NMOS	1.00	5	17,700	1,208	100	M

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Table 1 (Continued)
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TOHOKU SEMICONDUCTOR	SENDAI-SHI	MIYAGI	PHASE 1	1Mb DRAM MCU ARRAYS	CMOS	0.80	6	15,000	1,952	10	M
TOHOKU SEMICONDUCTOR	SENDAI-SHI	MIYAGI	PHASE 2	4Mb DRAM SRAM MPU ARRAYS	CMOS BICMOS	0.70	6	20,000	1,952	10	M
TOKIN	SENDAI-SHI	MIYAGI	NA	POWER SIT	BIP	0	3	10,000	0	NA	C
TOKO	IRUMA-GUN	SAITAMA	NA	A/D D/A TELECOM DIODE	BIP	3.50	5	20,000	0	NA	M
TOKO	IRUMA-GUN	SAITAMA	NA	NA	MOS	3.00	5	15,000	0	NA	M
TOREX SEMICONDUCTOR	IBARA-SHI	OKAYAMA	NA	NA	CMOS BIP	1.20	5	12,000	0	NA	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	KUBIC 1	LASER LED	GaAs	2.00	3	25,000	1,601	NA	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	KUBIC 2	ASIC OPTO LOG	BICMOS BIP	2.00	5	30,000	2,001	100	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	NA	LIN	BIP	3.00	5	30,000	4,002	NA	M
TOSHIBA	HIMEJI-SHI	HYOGO	NA	PWR FET GTO TRAN DIODE	CMOS BIP	1.00	5	45,000	0	NA	M
TOSHIBA	HIMEJI-SHI	HYOGO	NA	TRAN DIODE	BIP	3.00	4	30,000	0	NA	M
TOSHIBA	NOMI-GUN	ISHIKAWA	NA	DIS	NA	0	5	40,000	15,007	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 1	ARRAYS CBIC MPU CUSTOM	CMOS	1.50	5	20,000	0	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 2	4Mb ROM 4Mb EEPROM	CMOS	1.00	6	15,000	0	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 2	ARRAYS CCD	CMOS	1.50	5	20,000	0	NA	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 3	4Mb EPROM ROM 172K ARRAYS	BICMOS CMOS	0.80	5	24,000	0	NA	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 3	ARRAYS CBIC	CMOS BICMOS	0.70	6	10,000	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	FAB B	4Mb DRAM 16Mb DRAM	CMOS	0.50	8	1,300	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	NA	1Mb DRAM 4Mb DRAM 16Mb DRAM	CMOS	0.80	6	10,000	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	NA	LOG LIN	BIP	2.00	5	15,000	0	NA	M
TOSHIBA	YOKKAICHI-SHI	MIE	PHASE 1	4Mb DRAM 16Mb DRAM	CMOS	0.60	8	15,000	3,717	1	M
TOSHIBA	OITA-SHI	OITA	C-1	256K DRAM 1Mb DRAM	CMOS MOS	1.00	5	30,000	0	100	M
TOSHIBA	OITA-SHI	OITA	C-2	1Mb DRAM	CMOS	1.00	5	30,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-3 #1	1Mb DRAM	CMOS	1.00	6	14,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-3 #2	1Mb DRAM	CMOS	1.00	6	15,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-4 #1	4Mb DRAM 256K SRAM ASIC	CMOS	0.80	6	15,000	0	NA	M

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(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
TOSHIBA	OITA-SHI	OITA	C-4 #2	4Mb DRAM	CMOS	0.80	6	15,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	LSI 1	MPU LOG	MOS	2.00	4	20,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	LSI 2	MPU LOG ROM EPROM	CMOS MOS	1.50	5	45,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	STEP 4	4Mb DRAM 16Mb DRAM VRAM	NA	0.50	6	40,000	0	1	M
TOSHIBA COMPONENTS	KIMITSU-SHI	CHIBA	PHASE 1	DIODE RECTIFIER THYRISTOR	BIP	0	4	20,000	0	NA	M
TOSHIBA COMPONENTS	KIMITSU-SHI	CHIBA	PHASE 2	DIODE RECTIFIER THYRISTOR	BIP	0	5	18,000	0	NA	M
TOYODA AUTOMATIC LOOM WORKS	OBU-SHI	AICHI	KYOWA	AUTOMOTIVE	NA	0	0	0	0	NA	M
TOYODA MACHINE WORKS	KARIYA-SHI	AICHI	HIGASHI KARIYA	AUTOMOTIVE	NA	0	0	0	0	NA	M
TOYOTA MOTOR	TOYOTA-SHI	AICHI	NA	MCU PWR ICs CUSTOM	CMOS BIP	2.00	5	500	0	100	C
UNIZON	ITAMI-SHI	HYOGO	NA	ZENER DIODE REG ARRAYS	BIP	0	5	15,000	0	NA	M
YAMAHA	AIRA-GUN	KAGOSHIMA	NA	LIN ROM CBIC ASSP MPR	CMOS MOS	1.20	5	8,000	0	NA	M
YAMAHA	AIRA-GUN	KAGOSHIMA	NA	ROM CBIC ASSP	CMOS	0.80	6	8,000	0	NA	M
YAMAHA	IWATA-GUN	SHIZUOKA	EE DEV CTR	CBIC LOG	CMOS	0.80	6	6,000	0	10	M
YOKOGAWA IMT	KAMIINA-GUN	NAGANO	NA	TRAN DIODE OPTO	BIP CMOS	3.00	4	7,000	0	100	M

NA = Not available
Source: Dataquest (October 1992)

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Table 2
Japanese Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City or District	Prefecture	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Width (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room (Square Meters)
Production Begins: 1993											
ASAHI KASEI	NOBEOKA-SHI	MIYAZAKI	NA	ASIC SRAM	CMOS	F	12/31/93	0.80	6	16,500	4,433
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 2 #2	ARRAYS CBIC 32-bit MCU	CMOS	F	NA	0.50	6	15,000	5,251
FUJITSU	IZAWA-GUN	IWATE	NO. 4-2	16Mb DRAM	CMOS	F	NA	0.50	8	15,000	0
MATSUSHITA	TONAMI-SHI	TOYAMA	FAB #1	4Mb & 16Mb DRAM ASIC MPU MCU	CMOS	F	06/01/93	0	6	20,000	0
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 8	16Mb DRAM 4Mb SRAM RISC MPU	CMOS	F	04/15/93	0.50	8	20,000	3,716
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	ASIC MCU	CMOS	F	04/01/93	0.60	6	20,000	0
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 2	ARRAYS CBIC MPU 1Mb SRAM	NA	F	05/01/93	0.80	6	25,000	4,180
NIPPONDENSO	NUKATA-GUN	AICHI	NA	MCU CUSTOM	MOS	F	NA	0	6	10,000	0
SHARP	FUKUYAMA-SHI	HIROSHIMA	FAB 3	4Mb SRAM MASK ROM FLASH	CMOS	F	03/01/93	0.50	8	12,000	0
TOYODA GOSEI	NISHI KASUGAI-GUN	AICHI	NA	LED	COMPOUND SEMICONDUCTOR	F	12/31/93	25.00	2	0	0
Production Begins: 1994											
FUJITSU	NA		NA	EPROM FLASH	CMOS	F	12/31/94	0.50	8	20,000	0
MOTOROLA	SENDAI-SHI	MIYAGI	MOS 10	4Mb DRAM MPU CUSTOM	CMOS	F	04/01/94	0.80	6	25,000	2,323
Production Begins: 1995											
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	PHASE 2	SRAM DRAM ARRAYS	CMOS	F	NA	0	6	20,000	0
NEC	HIGASHI HIROSHIMA-SHI	HIROSHIMA	PHASE 2	EPROM 4Mb DRAM 16Mb DRAM	CMOS	F	05/01/95	0.60	8	30,000	0
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 3	ASIC CBIC MPU SRAM MPR	CMOS BICMOS	F	NA	0.50	8	20,000	4,180
NISSAN	NA	NA	NA	CUSTOM	NA	FAT	NA	0	0	0	0
OKI	MIYAZAKI-GUN	MIYAZAKI	M4	16Mb DRAM	CMOS	F	03/31/95	0.50	8	20,000	8,400
SANYO	OJIYA-SHI	NIIGATA	D #6	16Mb DRAM 64Mb DRAM	CMOS	F	NA	0	8	15,000	0

(Continued)

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Table 2 (Continued)
Japanese Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City or District	Prefecture	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Width (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room (Square Meters)
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. E	SRAM ARRAYS	CMOS BICMOS	NFAT	NA	0	0	0	0
TOSHIBA	OITA-SHI	OITA	STEP 5	NA	NA	F	NA	0	8	20,000	0
Production Begins: 1999											
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	PHASE 3	16Mb DRAM SRAM ARRAYS	CMOS	F	NA	0	6	15,000	0

NA = Not available
Notes:
F = Production fab
A = Assembly
T = Test
N = Nondedicated foundry
Source: Dataquest (October 1992)

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Japanese Electronic Equipment Production Forecast

September 21, 1992

Source: Dataquest

Market Statistics

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Semiconductors *Japan*

SCJA-SVC-MS-9202

Japanese Electronic Equipment Production Forecast

September 21, 1992

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Market Statistics

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Semiconductors *Japan*
SCJA-SVC-MS-9202

File behind the *Market Statistics* tab inside the binder labeled **Semiconductors** *Japan*

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Japanese Electronic Equipment Production Forecast

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Note: All tables show estimated data.

Japanese Electronic Equipment Production Forecast

Introduction

Electronic equipment production is an important determinant of semiconductor market activity because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. That is, the demand for semiconductors is a positive (or increasing) function of the demand for electronic systems. Therefore, the forecast of expected electronic systems production is an essential component to assessing expected future semiconductor market activity.

This document contains tables detailing the spring 1992 electronic equipment production forecast. Japanese production is estimated for the years 1986 to 1996. Production tables contain both historical data and forecasts. In most tables, historical data begin with 1986 and end with 1991, while forecast data provide estimates for 1992 through 1996. Tables detail the type of production data by application market and unit of measure.

Definitions and Conventions

The objective of analyzing electronic systems production activity is to estimate its important implications for semiconductor consumption. Therefore, generalized economic concepts such as production and consumption are tailored to best isolate these implications.

The value of production is estimated as factory revenue. Dataquest defines factory revenue as the exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution, as is the case with military systems, factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material input are transformed into the goods and services desired for consumption and investment. As such, production can span both time and geography. For example, a Japanese color television company may minimize its cost of production by manufacturing (that is, consuming chips) its products in Asian countries. We would estimate this as Asia/Pacific data video production, because we are interested in that portion of the production process that relates particularly to semiconductor consumption. Production would be valued as the exchange value of the transaction between the Japanese company's Asian operations (which is factory revenue) and the European distributor or final user.

Production is segmented into the following regions:

- North America—This region includes the United States, Puerto Rico, and Canada.
- Europe—This region includes Austria, Belgium, France, Germany, Italy, Luxembourg, The Netherlands, the Scandinavian countries (Denmark, Finland, Norway, and Sweden), Spain, the United Kingdom and Ireland, and the rest of Europe.
- Japan—The third region is the only single-country region.
- Asia/Pacific-ROW—This region includes South Korea, Taiwan, Hong Kong, Singapore, China, India, and all other countries not listed.

Electronic equipment is disaggregated into the following six semiconductor application markets and is further disaggregated into the designated segments. Japanese production is further disaggregated into specific types of equipment systems.

- Data Processing
  - Computers
  - Data storage
  - Terminals
  - Input/output units
  - Dedicated systems

- Communication
  - Customer premises
  - Public telecommunication
  - Radio equipment
  - Broadcast and studio
  - Other telecom
- Industrial
  - Security/energy management
  - Instrumentation
  - Manufacturing systems
  - Medical equipment
  - Other industrial systems
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer
- Military/Aerospace
- Transportation
  - Entertainment
  - Control unit
  - Safety and convenience

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Japanese production statistics compiled and published by the Ministry of International Trade and Industry
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices

Dataquest believes that the estimates presented here are the most accurate and meaningful generally available today.

Valuation of Production

Japanese production is expressed in Japanese yen and translated into U.S. dollars. To make the worldwide tables in this document useful in comparing different regions, it is necessary to express all values in a common currency, and we choose the U.S. dollar for convenience. However, the choice of the U.S. dollar or any other currency brings with it some problems that require the reader's careful consideration in interpreting the data, as follows:

- Inflation—No adjustment has been made in the historical or forecast data to account for the effects of past inflation or expected future inflation. Production is expressed in current dollars (that is, dollars that include the effects of inflation and changes in exchange rates).
- Exchange rates—Construction of the European tables involves combining data from many countries, each of which has a different and changing exchange rate. Dataquest uses the Annual Foreign Exchange Rate for each year as published by the International Monetary Fund. We prepare our estimates in terms of local currencies before conversion to U.S. dollars as much as possible. Exchange rates during the forecast period are held constant at their 1991 values.

Japanese Electronic Equipment Production Definitions

Data Processing Equipment

Defined as computers, data storage devices, terminal equipment, input/output units, and dedicated systems, as follows:

- Computers includes general-use computers, office-use computers, personal-use computers, and control-use computers.
- Data storage devices includes rigid disk drives, flexible disk drives, and other drives.

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- Terminal equipment includes general-use terminals, terminals for special use, and supporting systems.
- Input/output unit includes printers, display units, and other input/output units.
- Dedicated system includes calculators, cash registers, copying machines, typewriters, and word processors.

Communications Equipment

Defined as customer premises, public telecommunication, radio, broadcasting and studio, and other public telecommunication, as follows:

- Customer premises include telephones (standard, multifunction, cordless, and others), applied telephone, facsimile, PBX telephone system, key telephone system, and modems.
- Public telecommunication includes carrier transmission equipment and central office switching.
- Radio includes radio communication (radio base station equipment, mobile radio equipment, and mobile communications equipment) and applied radio equipment.
- Broadcast and studio includes all electronic equipment used to make information public by means of radio and television.
- Other communications equipment includes communications control units and other communications equipment.

Industrial Equipment

Defined as security/energy management systems, instrumentation, manufacturing systems, medical equipment, and other industrial equipment, as follows:

- Security/energy management systems includes alarm systems (intrusion detection and fire detection) and energy management (air conditioners for industrial use).
- Instrumentation includes meter units, measuring instruments, industrial meters, and other instrumentation equipment such as analyzers.
- Manufacturing systems includes NC machines, robotics, and ultrasonic applied equipment.
- Medical equipment includes X-ray systems, measuring systems, and other medical equipment such as radio isotope equipment.
- Other industrial equipment includes vending machines, automatic service equipment, commercial-type washers, electron microscopes, ultrasonic equipment, and all other industrial equipment not accounted for in the preceding segments.

Consumer Equipment

Defined as audio equipment, video equipment, personal electronics, electronic/electrical appliances, and other consumer equipment, as follows:

- Audio equipment includes audio amplifiers, digital audio disk players, radios, stereo sets, tape recorders, headphone stereos, musical instruments, and other audio equipment (tuners and turntables).
- Video equipment includes videocassette recorders (VCRs), video cameras, videodisk players, color televisions, and LCD televisions.
- Personal electronics includes cameras, clocks, electronic toys, and watches.
- Electronic/electrical appliances includes air conditioners for home use, microwave ovens, refrigerators, and washers and dryers.
- Other consumer equipment includes gas heaters, gas fan heaters, oil fan heaters, electric heaters, fans, electric water heaters, gas water heaters, oil water heaters, electric pots, rice cooker and rice jar combination, gas rice cookers, sewing machines, electric irons, vacuum cleaners, other consumer equipment.

Military/Aerospace Equipment

Defined as electronic systems for the Defense Agency such as communications equipment and instrumentation.

Transportation Equipment

Defined as in-car entertainment systems, control units, and safety and convenience electronics.

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- In-car entertainment includes FM/AM radios, radio cassette combination systems, and car stereo cassette units.
- Control units include electronics control equipment for engine, body, and power train.
- Safety and convenience includes in-car equipment for safety and convenience such as car air conditioners.

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Electronic Equipment—Database Tables

Section 1—Worldwide Electronic Equipment Production Forecast

Table 1.1
Worldwide Electronic Equipment Production Forecast
(Factory Revenue in Millions of Dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	Growth Rate (%) 1991-1992	CAGR (%) 1991-1996
Data Processing										
Computers	103,435	108,120	103,255	108,940	114,089	121,892	129,438	139,600	5.5	6.2
Data Storage	20,511	20,476	21,125	21,703	23,457	23,756	24,433	25,237	2.7	3.6
Terminals	15,319	16,105	16,664	17,293	18,377	19,630	20,803	22,238	3.8	5.9
Input/Output	22,929	25,209	27,252	28,009	30,091	32,283	34,028	35,816	2.8	5.6
Dedicated Systems	19,444	19,026	20,113	20,810	22,248	23,500	24,723	26,241	3.5	5.5
Total	181,638	188,936	188,409	196,755	208,263	221,062	233,425	249,132	4.4	5.7
Communication										
Premises Telecom	35,156	38,066	40,701	42,624	46,073	49,017	51,965	54,588	4.7	6.0
Public Telecom	24,446	28,450	30,763	32,842	35,874	37,925	40,065	43,052	6.8	7.0
Mobile Communication	13,382	15,264	16,887	18,197	19,961	21,863	25,991	28,046	7.8	10.7
Broadcast and Studio	3,484	3,921	4,164	4,492	5,019	5,448	5,923	6,487	7.9	9.3
Other Communication	8,025	8,759	8,826	9,360	9,967	10,359	10,886	11,282	6.1	5.0
Total	84,492	94,461	101,340	107,515	116,893	124,612	134,831	143,455	6.1	7.2
Industrial										
Security and Energy Management	10,103	11,015	12,788	13,922	15,512	17,158	18,813	20,874	8.9	10.3
Manufacturing Systems/Instruments	55,320	61,276	62,174	62,854	67,338	71,964	76,050	80,745	1.1	5.4
Medical Equipment	12,833	14,261	15,005	15,599	16,887	18,111	19,328	20,616	4.0	6.6
Other Industrial	12,684	12,587	12,547	12,528	13,382	13,954	14,504	15,251	-0.2	4.0
Total	90,940	99,139	102,514	104,902	113,119	121,187	128,695	137,486	2.3	6.0
Consumer										
Audio	15,809	16,849	19,964	21,098	23,483	25,764	28,176	31,124	5.7	9.3
Video	39,659	42,508	46,043	47,053	51,184	54,590	58,876	63,545	2.2	6.7
Personal Electronics	14,363	16,790	17,871	18,969	20,859	21,992	23,186	24,493	6.1	6.5
Appliances	45,074	45,768	50,394	52,247	57,162	61,515	65,079	69,871	3.7	6.8
Other Consumer	9,321	9,533	10,182	9,851	11,114	11,845	12,237	12,944	-3.3	4.9
Total	124,226	131,448	144,454	149,218	163,803	175,705	187,554	201,976	3.3	6.9
Military/Aerospace	86,731	86,730	81,918	82,366	85,564	88,416	91,056	93,515	0.5	2.7
Transportation	19,590	20,992	22,000	23,319	25,693	27,658	29,670	31,725	6.1	7.6
Total Equipment	587,617	621,707	640,635	664,075	713,334	758,639	805,231	857,289	3.7	6.0

Source: Dataquest (September 1992)

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Table 1.2
Worldwide Electronic Equipment Production Forecast
(Annual Growth by Percentage)

	1989	1990	1991	1992	1993	1994	1995	1996
Data Processing								
Computers	12.3	4.5	-4.5	5.5	4.7	6.8	6.2	7.9
Data Storage	3.3	-0.2	3.2	2.7	8.1	1.3	2.8	3.3
Terminals	1.7	5.1	3.5	3.8	6.3	6.8	6.0	6.9
Input/Output	7.2	9.9	8.1	2.8	7.4	7.3	5.4	5.3
Dedicated Systems	3.2	-2.1	5.7	3.5	6.9	5.6	5.2	6.1
Total	8.6	4.0	-0.3	4.4	5.8	6.1	5.6	6.7
Communication								
Premises Telecom	13.7	8.3	6.9	4.7	8.1	6.4	6.0	5.0
Public Telecom	-1.9	16.4	8.1	6.8	9.2	5.7	5.6	7.5
Mobile Communication	8.1	14.1	10.6	7.8	9.7	9.5	18.9	7.9
Broadcast and Studio	3.2	12.6	6.2	7.9	11.7	8.5	8.7	9.5
Other Communication	3.9	9.1	0.8	6.1	6.5	3.9	5.1	3.6
Total	6.5	11.8	7.3	6.1	8.7	6.6	8.2	6.4
Industrial								
Security and Energy Management	3.2	9.0	16.1	8.9	11.4	10.6	9.6	11.0
Manufacturing Systems/Instruments	5.5	10.8	1.5	1.1	7.1	6.9	5.7	6.2
Medical Equipment	1.0	11.1	5.2	4.0	8.3	7.2	6.7	6.7
Other Industrial	5.8	-0.8	-0.3	-0.2	6.8	4.3	3.9	5.2
Total	4.6	9.0	3.4	2.3	7.8	7.1	6.2	6.8
Consumer								
Audio	-1.6	6.6	18.5	5.7	11.3	9.7	9.4	10.5
Video	-0.2	7.2	8.3	2.2	8.8	6.7	7.9	7.9
Personal Electronics	8.8	16.9	6.4	6.1	10.0	5.4	5.4	5.6
Appliances	6.2	1.5	10.1	3.7	9.4	7.6	5.8	7.4
Other Consumer	-0.6	2.3	6.8	-3.3	12.8	6.6	3.3	5.8
Total	2.8	5.8	9.9	3.3	9.8	7.3	6.7	7.7
Military/Aerospace	2.1	0.0	-5.5	0.5	3.9	3.3	3.0	2.7
Transportation	7.3	7.2	4.8	6.0	10.2	7.6	7.3	6.9
Total Equipment	5.4	5.8	3.0	3.7	7.4	6.4	6.1	6.5

Source: Dataquest (September 1992)

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Table 1.3
Worldwide Electronic Equipment Production Forecast
(Percentage of Total Equipment)

	1989	1990	1991	1992	1993	1994	1995	1996
Data Processing								
Computers	17.6	17.4	16.1	16.4	16.0	16.1	16.1	16.3
Data Storage	3.5	3.3	3.3	3.3	3.3	3.1	3.0	2.9
Terminals	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Input/Output	3.9	4.1	4.3	4.2	4.2	4.3	4.2	4.2
Dedicated Systems	3.3	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Total	30.9	30.4	29.4	29.6	29.2	29.1	29.0	29.1
Communication								
Premises Telecom	6.0	6.1	6.4	6.4	6.5	6.5	6.5	6.4
Public Telecom	4.2	4.6	4.8	4.9	5.0	5.0	5.0	5.0
Mobile Communication	2.3	2.5	2.6	2.7	2.8	2.9	3.2	3.3
Broadcast and Studio	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8
Other Communication	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3
Total	14.4	15.2	15.8	16.2	16.4	16.4	16.7	16.7
Industrial								
Security and Energy Management	1.7	1.8	2.0	2.1	2.2	2.3	2.3	2.4
Manufacturing Systems/Instruments	9.4	9.9	9.7	9.5	9.4	9.5	9.4	9.4
Medical Equipment	2.2	2.3	2.3	2.3	2.4	2.4	2.4	2.4
Other Industrial	2.2	2.0	2.0	1.9	1.9	1.8	1.8	1.8
Total	15.5	15.9	16.0	15.8	15.9	16.0	16.0	16.0
Consumer								
Audio	2.7	2.7	3.1	3.2	3.3	3.4	3.5	3.6
Video	6.7	6.8	7.2	7.1	7.2	7.2	7.3	7.4
Personal Electronics	2.4	2.7	2.8	2.9	2.9	2.9	2.9	2.9
Appliances	7.7	7.4	7.9	7.9	8.0	8.1	8.1	8.2
Other Consumer	1.6	1.5	1.6	1.5	1.6	1.6	1.5	1.5
Total	21.1	21.1	22.5	22.5	23.0	23.2	23.3	23.6
Military/Aerospace	14.8	14.0	12.8	12.4	12.0	11.7	11.3	10.9
Transportation	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.7
Total Equipment	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Dataquest (September 1992)

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Table 1.4
Worldwide Electronic Equipment Production Forecast
(Percentage of Application Market)

	1989	1990	1991	1992	1993	1994	1995	1996
Data Processing								
Computers	56.9	57.2	54.8	55.4	54.8	55.1	55.5	56.0
Data Storage	11.3	10.8	11.2	11.0	11.3	10.7	10.5	10.1
Terminals	8.4	8.5	8.8	8.8	8.8	8.9	8.9	8.9
Input/Output	12.6	13.3	14.5	14.2	14.4	14.6	14.6	14.4
Dedicated Systems	10.7	10.1	10.7	10.6	10.7	10.6	10.6	10.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Communication								
Premises Telecom	41.6	40.3	40.2	39.6	39.4	39.3	38.5	38.1
Public Telecom	28.9	30.1	30.4	30.5	30.7	30.4	29.7	30.0
Mobile Communication	15.8	16.2	16.7	16.9	17.1	17.5	19.3	19.6
Broadcast and Studio	4.1	4.2	4.1	4.2	4.3	4.4	4.4	4.5
Other Communication	9.5	9.3	8.7	8.7	8.5	8.3	8.1	7.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Industrial								
Security and Energy Management	11.1	11.1	12.5	13.3	13.7	14.2	14.6	15.2
Manufacturing Systems/Instruments	60.8	61.8	60.6	59.9	59.5	59.4	59.1	58.7
Medical Equipment	14.1	14.4	14.6	14.9	14.9	14.9	15.0	15.0
Other Industrial	13.9	12.7	12.2	11.9	11.8	11.5	11.3	11.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Consumer								
Audio	12.7	12.8	13.8	14.1	14.3	14.7	15.0	15.4
Video	31.9	32.3	31.9	31.5	31.2	31.1	31.4	31.5
Personal Electronics	11.6	12.8	12.4	12.7	12.7	12.5	12.4	12.1
Appliances	36.3	34.8	34.9	35.0	34.9	35.0	34.7	34.6
Other Consumer	7.5	7.3	7.0	6.6	6.8	6.7	6.5	6.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Military/Aerospace	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Transportation	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Equipment	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Dataquest (September 1992)

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Section 2—Regional Electronic Equipment Production Forecast

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Table 2.1
Regional Electronic Equipment Production Forecast
(Factory Revenue in Millions of Dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	Growth Rate (%) 1991-1992	CAGR (%) 1991-1996
North America										
Data Processing	77,501	81,234	73,691	75,861	78,258	82,433	85,554	90,265	2.9	4.1
Communication	28,360	29,935	31,832	34,037	36,375	38,882	41,470	43,888	6.9	6.6
Industrial	32,302	33,687	33,909	35,483	37,959	40,548	43,396	46,479	4.6	6.5
Consumer	17,082	16,995	16,660	17,312	18,216	19,161	20,155	21,127	3.9	4.9
Military/Aerospace	59,876	60,569	55,257	54,937	56,068	57,463	58,924	60,132	-0.6	1.7
Transportation	4,153	4,115	3,881	4,252	4,694	4,996	5,265	5,51	9.6	7.3
Total	219,274	226,535	215,230	221,882	231,570	243,483	254,764	267,407	3.1	4.4
Japan										
Data Processing	47,941	46,771	51,342	51,246	53,581	55,827	57,762	60,510	-0.2	3.3
Communication	19,752	21,337	22,926	23,298	24,535	25,748	26,899	28,311	1.6	4.3
Industrial	24,861	26,412	28,719	27,646	29,848	32,270	34,591	37,357	-3.7	5.4
Consumer	52,474	54,439	61,773	59,633	63,750	66,275	69,059	72,849	-3.5	3.4
Military/Aerospace	1,825	1,602	1,583	1,567	1,603	1,595	1,612	1,635	-1.0	0.7
Transportation	9,199	9,469	9,931	9,935	10,533	11,018	11,411	11,854	0.0	3.6
Total	156,052	160,031	176,275	173,325	183,849	192,732	201,334	212,516	-1.7	3.8
Europe										
Data Processing	31,242	33,575	30,392	31,850	34,733	36,713	38,879	41,282	4.8	6.3
Communication	27,436	32,734	35,102	36,956	40,440	42,355	46,427	48,484	5.3	6.7
Industrial	31,111	35,981	36,356	37,756	40,878	43,382	45,335	47,593	3.9	5.5
Consumer	30,777	32,241	33,817	35,706	39,237	42,346	44,706	47,959	5.6	7.2
Military/Aerospace	21,749	20,976	21,171	21,544	22,893	23,851	24,531	25,266	1.8	3.6
Transportation	4,613	5,556	6,064	6,681	7,610	8,348	9,214	10,169	10.2	10.9
Total	146,928	161,063	162,902	170,493	185,791	196,995	209,092	220,753	4.7	6.3
Asia/Pacific-ROW										
Data Processing	24,954	27,356	32,984	37,798	41,691	46,089	51,230	57,075	14.6	11.6
Communication	8,944	10,455	11,480	13,224	15,543	17,627	20,035	22,772	15.2	14.7
Industrial	2,666	3,059	3,530	4,017	4,434	4,987	5,373	6,057	13.8	11.4
Consumer	23,893	27,773	32,204	36,567	42,600	47,923	53,634	60,041	13.5	13.3
Military/Aerospace	3,281	3,583	3,907	4,318	5,000	5,507	5,989	6,482	10.5	10.7
Transportation	1,625	1,852	2,124	2,451	2,856	3,296	3,780	4,186	15.4	14.5
Total	65,363	74,078	86,228	98,375	112,124	125,429	140,041	156,613	14.1	12.7
Worldwide										
Data Processing	181,638	188,936	188,409	196,755	208,263	221,062	233,425	249,132	4.4	5.7
Communication	84,492	94,461	101,340	107,515	116,893	124,612	134,831	143,455	6.1	7.2
Industrial	90,940	99,139	102,514	104,902	113,119	121,187	128,695	137,486	2.3	6.0
Consumer	124,226	131,448	144,454	149,218	163,803	175,705	187,554	201,976	3.3	6.9
Military/Aerospace	86,731	86,730	81,918	82,366	85,564	88,416	91,056	93,515	0.5	2.7
Transportation	19,590	20,992	22,000	23,319	25,693	27,658	29,670	31,725	6.0	7.6
Total	587,617	621,707	640,635	664,075	713,334	758,639	805,231	857,289	3.7	6.0

Source: Dataquest (September 1992)

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Table 2.2
Electronic Equipment Production Forecast
(Annual Growth by Percentage)

	1990	1991	1992	1993	1994	1995	1996
North America							
Data Processing	4.8	-9.3	2.9	3.2	5.3	3.8	5.5
Communication	5.6	6.3	6.9	6.9	6.9	6.7	5.8
Industrial	4.3	0.7	4.6	7.0	6.8	7.0	7.1
Consumer	-0.5	-2.0	3.9	5.2	5.2	5.2	4.8
Military/Aerospace	1.2	-8.8	-0.6	2.1	2.5	2.5	2.1
Transportation	-0.9	-5.7	9.6	10.4	6.4	5.4	4.8
Total	3.3	-5.0	3.1	4.4	5.1	4.6	5.0
Japan							
Data Processing	-2.4	9.8	-0.2	4.6	4.2	3.5	4.8
Communication	8.0	7.4	1.6	5.3	4.9	4.5	5.2
Industrial	6.2	8.7	-3.7	8.0	8.1	7.2	8.0
Consumer	3.7	13.5	-3.5	6.9	4.0	4.2	5.5
Military/Aerospace	-12.2	-1.2	-1.0	2.3	-0.5	1.1	1.4
Transportation	2.9	4.9	0.0	6.0	4.6	3.6	3.9
Total	2.5	10.2	-1.7	6.1	4.8	4.5	5.6
Europe							
Data Processing	7.5	-9.5	4.8	9.1	5.7	5.9	6.2
Communication	19.3	7.2	5.3	9.4	4.7	9.6	4.4
Industrial	15.7	1.0	3.9	8.3	6.1	4.5	5.0
Consumer	4.8	4.9	5.6	9.9	7.9	5.6	7.3
Military/Aerospace	-3.6	0.9	1.8	6.3	4.2	2.9	3.0
Transportation	20.4	9.1	10.2	13.9	9.7	10.4	10.4
Total	9.6	1.1	4.7	9.0	6.0	6.1	5.6
Asia/Pacific-ROW							
Data Processing	9.6	20.6	14.6	10.3	10.5	11.2	11.4
Communication	16.9	9.8	15.2	17.5	13.4	13.7	13.7
Industrial	14.7	15.4	13.8	10.4	12.5	7.7	12.7
Consumer	16.2	16.0	13.5	16.5	12.5	11.9	11.9
Military/Aerospace	9.2	9.0	10.5	15.8	10.1	8.8	8.2
Transportation	14.0	14.7	15.4	16.5	15.4	14.7	10.7
Total	13.3	16.4	14.1	14.0	11.9	11.6	11.8
Worldwide							
Data Processing	4.0	-0.3	4.4	5.8	6.1	5.6	6.7
Communication	11.8	7.3	6.1	8.7	6.6	8.2	6.4
Industrial	9.0	3.4	2.3	7.8	7.1	6.2	6.8
Consumer	5.8	9.9	3.3	9.8	7.3	6.7	7.7
Military/Aerospace	0.0	-5.5	0.5	3.9	3.3	3.0	2.7
Transportation	7.2	4.8	6.0	10.2	7.6	7.3	6.9
Total	5.8	3.0	3.7	7.4	6.4	6.1	6.5

Source: Dataquest (September 1992)

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Table 2.3
Electronic Equipment Production Forecast
(Percentage of Regional Total)

	1989	1990	1991	1992	1993	1994	1995	1996
North America								
Data Processing	35.3	35.9	34.2	34.2	33.8	33.9	33.6	33.8
Communication	12.9	13.2	14.8	15.3	15.7	16.0	16.3	16.4
Industrial	14.7	14.9	15.8	16.0	16.4	16.7	17.0	17.4
Consumer	7.8	7.5	7.7	7.8	7.9	7.9	7.9	7.9
Military/Aerospace	27.3	26.7	25.7	24.8	24.2	23.6	23.1	22.5
Transportation	1.9	1.8	1.8	1.9	2.0	2.1	2.1	2.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Japan								
Data Processing	30.7	29.2	29.1	29.6	29.1	29.0	28.7	28.5
Communication	12.7	13.3	13.0	13.4	13.3	13.4	13.4	13.3
Industrial	15.9	16.5	16.3	16.0	16.2	16.7	17.2	17.6
Consumer	33.6	34.0	35.0	34.4	34.7	34.4	34.3	34.3
Military/Aerospace	1.2	1.0	0.9	0.9	0.9	0.8	0.8	0.8
Transportation	5.9	5.9	5.6	5.7	5.7	5.7	5.7	5.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Europe								
Data Processing	21.3	20.8	18.7	18.7	18.7	18.6	18.6	18.7
Communication	18.7	20.3	21.5	21.7	21.8	21.5	22.2	22.0
Industrial	21.2	22.3	22.3	22.1	22.0	22.0	21.7	21.6
Consumer	20.9	20.0	20.8	20.9	21.1	21.5	21.4	21.7
Military/Aerospace	14.8	13.0	13.0	12.6	12.3	12.1	11.7	11.4
Transportation	3.1	3.4	3.7	3.9	4.1	4.2	4.4	4.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Asia/Pacific-ROW								
Data Processing	38.2	36.9	38.3	38.4	37.2	36.7	36.6	36.4
Communication	13.7	14.1	13.3	13.4	13.9	14.1	14.3	14.5
Industrial	4.1	4.1	4.1	4.1	4.0	4.0	3.8	3.9
Consumer	36.6	37.5	37.3	37.2	38.0	38.2	38.3	38.3
Military/Aerospace	5.0	4.8	4.5	4.4	4.5	4.4	4.3	4.1
Transportation	2.5	2.5	2.5	2.5	2.5	2.6	2.7	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Worldwide								
Data Processing	30.9	30.4	29.4	29.6	29.2	29.1	29.0	29.1
Communication	14.4	15.2	15.8	16.2	16.4	16.4	16.7	16.7
Industrial	15.5	15.9	16.0	15.8	15.9	16.0	16.0	16.0
Consumer	21.1	21.1	22.5	22.5	23.0	23.2	23.3	23.6
Military/Aerospace	14.8	14.0	12.8	12.4	12.0	11.7	11.3	10.9
Transportation	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Dataquest (September 1992)

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Table 2.4
Electronic Equipment Production Forecast
(Percentage of Worldwide Total)

	1989	1990	1991	1992	1993	1994	1995	1996
North America								
Data Processing	42.7	43.0	39.1	38.6	37.6	37.3	36.7	36.2
Communication	33.6	31.7	31.4	31.7	31.1	31.2	30.8	30.6
Industrial	35.5	34.0	33.1	33.8	33.6	33.5	33.7	33.8
Consumer	13.8	12.9	11.5	11.6	11.1	10.9	10.7	10.5
Military/Aerospace	69.0	69.8	67.5	66.7	65.5	65.0	64.7	64.3
Transportation	21.2	19.6	17.6	18.2	18.3	18.1	17.7	17.4
Total	37.3	36.4	33.6	33.4	32.5	32.1	31.6	31.2
Japan								
Data Processing	26.4	24.8	27.3	26.0	25.7	25.3	24.7	24.3
Communication	23.4	22.6	22.6	21.7	21.0	20.7	20.0	19.7
Industrial	27.3	26.6	28.0	26.4	26.4	26.6	26.9	27.2
Consumer	42.2	41.4	42.8	40.0	38.9	37.7	36.8	36.1
Military/Aerospace	2.1	1.8	1.9	1.9	1.9	1.8	1.8	1.7
Transportation	47.0	45.1	45.1	42.6	41.0	39.8	38.5	37.4
Total	26.6	25.7	27.5	26.1	25.8	25.4	25.0	24.8
Europe								
Data Processing	17.2	17.8	16.1	16.2	16.7	16.6	16.7	16.6
Communication	32.5	34.7	34.6	34.4	34.6	34.0	34.4	33.8
Industrial	34.2	36.3	35.5	36.0	36.1	35.8	35.2	34.6
Consumer	24.8	24.5	23.4	23.9	24.0	24.1	23.8	23.7
Military/Aerospace	25.1	24.2	25.8	26.2	26.8	27.0	26.9	27.0
Transportation	23.5	26.5	27.6	28.7	29.6	30.2	31.1	32.1
Total	25.0	25.9	25.4	25.7	26.0	26.0	26.0	25.8
Asia/Pacific-ROW								
Data Processing	13.7	14.5	17.5	19.2	20.0	20.8	21.9	22.9
Communication	10.6	11.1	11.3	12.3	13.3	14.1	14.9	15.9
Industrial	2.9	3.1	3.4	3.8	3.9	4.1	4.2	4.4
Consumer	19.2	21.1	22.3	24.5	26.0	27.3	28.6	29.7
Military/Aerospace	3.8	4.1	4.8	5.2	5.8	6.2	6.6	6.9
Transportation	8.3	8.8	9.7	10.5	11.1	11.9	12.7	13.2
Total	11.1	11.9	13.5	14.8	15.7	16.5	17.4	18.3
Worldwide								
Data Processing	30.9	30.4	29.4	29.6	29.2	29.1	29.0	29.1
Communication	14.4	15.2	15.8	16.2	16.4	16.4	16.7	16.7
Industrial	15.5	15.9	16.0	15.8	15.9	16.0	16.0	16.0
Consumer	21.1	21.1	22.5	22.5	23.0	23.2	23.3	23.6
Military/Aerospace	14.8	14.0	12.8	12.4	12.0	11.7	11.3	10.9
Transportation	3.3	3.4	3.4	3.5	3.6	3.6	3.7	3.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Dataquest (September 1992)

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Section 3—Japanese Electronic Equipment Production Forecast

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Table 3.1
Japanese Electronic Equipment Production
(Factory Revenue in Billions of Yen)

	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Data Processing							
Computers	1,551	1,781	2,167	2,623	2,666	2,937	13.6
Data Storage	956	1,023	1,115	1,221	1,199	1,186	4.4
Terminals	642	754	795	804	882	812	4.8
Input/Output	688	772	914	906	954	973	7.2
Dedicated Systems	973	881	942	1,062	1,034	1,074	2.0
Total	4,811	5,210	5,934	6,616	6,735	6,983	7.7
Communication							
Premise Telecom Equipment	788	838	979	1,058	1,020	992	4.7
Public Telecom Equipment	481	647	713	628	835	826	11.4
Radio Equipment	596	678	757	777	900	1,009	11.1
Broadcast and Studio	67	61	70	74	94	99	8.2
Other Telecom Equipment	142	141	168	189	224	192	6.2
Total	2,074	2,365	2,686	2,726	3,073	3,118	8.5
Industrial							
Security/Energy Management	300	327	433	453	537	669	17.4
Instrumentation	663	658	788	850	900	928	6.9
Manufacturing Systems	745	609	843	1,104	1,306	1,295	11.7
Medical Equipment	252	271	294	318	331	326	5.3
Other Industrial Equipment	467	476	608	705	729	687	8.0
Total	2,427	2,341	2,966	3,431	3,803	3,906	10.0
Consumer							
Audio	1,101	967	1,035	990	1,010	1,127	0.5
Video	2,887	2,559	2,770	2,693	2,862	3,043	1.1
Personal Electronics	909	797	915	1,033	1,253	1,257	6.7
Appliances	1,493	1,497	1,600	1,578	1,712	1,965	5.7
Other Consumer Equipment	872	860	925	947	1,002	1,009	3.0
Total	7,261	6,679	7,246	7,241	7,839	8,401	3.0
Military/Aerospace	NA	NA	260	252	231	215	NA
Transportation	934	1,037	1,142	1,269	1,364	1,351	7.7
Total Electronic Industry	17,506	17,634	20,234	21,535	23,044	23,973	6.5

(Continued)

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Table 3.1 (Continued)
Japanese Electronic Equipment Production
(Factory Revenue in Billions of Yen)

	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Data Processing							
Computers	2,937	2,958	3,100	3,218	3,324	3,488	3.5
Data Storage	1,186	1,167	1,206	1,262	1,289	1,317	2.1
Terminals	812	782	807	838	875	923	2.6
Input/Output	973	976	1,032	1,098	1,157	1,238	4.9
Dedicated Systems	1,074	1,087	1,141	1,177	1,210	1,263	3.3
Total	6,983	6,969	7,287	7,592	7,856	8,229	3.3
Communication							
Premise Telecom Equipment	992	976	1,019	1,068	1,111	1,163	3.2
Public Telecom Equipment	826	824	859	890	908	932	2.4
Radio Equipment	1,009	1,078	1,159	1,236	1,323	1,424	7.1
Broadcast and Studio	99	101	105	107	110	117	3.3
Other Telecom Equipment	192	190	195	200	206	214	2.2
Total	3,118	3,169	3,337	3,502	3,658	3,850	4.3
Industrial							
Security/Energy Management	669	738	830	924	1,021	1,153	11.5
Instrumentation	928	872	916	962	996	1,035	2.2
Manufacturing Systems	1,295	1,220	1,316	1,439	1,571	1,723	5.9
Medical Equipment	326	294	315	333	350	361	2.1
Other Industrial Equipment	687	636	682	731	766	809	3.3
Total	3,906	3,760	4,059	4,389	4,704	5,081	5.4
Consumer							
Audio	1,127	1,056	1,127	1,174	1,218	1,279	2.6
Video	3,043	2,911	3,099	3,216	3,377	3,616	3.5
Personal Electronics	1,257	1,301	1,421	1,488	1,572	1,676	5.9
Appliances	1,965	1,906	2,047	2,130	2,205	2,295	3.1
Other Consumer Equipment	1,009	935	976	1,005	1,021	1,042	0.6
Total	8,401	8,110	8,670	9,013	9,392	9,907	3.4
Military/Aerospace	215	213	218	217	219	222	0.7
Transportation	1,351	1,351	1,433	1,498	1,552	1,612	3.6
Total Electronic Industry	23,973	23,572	25,004	26,212	27,381	28,902	3.8

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.2
Japanese Electronic Equipment Production
(Factory Revenue in Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Data Processing							
Computers	9,287	12,365	16,672	19,010	18,511	21,599	18.4
Data Storage	5,723	7,101	8,576	8,851	8,329	8,717	8.8
Terminals	3,846	5,238	6,113	5,823	6,123	5,971	9.2
Input/Output	4,123	5,364	7,033	6,563	6,625	7,157	11.7
Dedicated Systems	5,828	6,116	7,249	7,694	7,183	7,898	6.3
Total	28,806	36,184	45,643	47,941	46,771	51,342	12.3
Communication							
Premise Telecom Equipment	4,717	5,819	7,527	7,666	7,080	7,297	9.1
Public Telecom Equipment	2,882	4,496	5,486	4,549	5,799	6,073	16.1
Radio Equipment	3,568	4,709	5,821	5,633	6,247	7,419	15.8
Broadcast and Studio	400	421	537	538	654	728	12.8
Other Telecom Equipment	851	981	1,292	1,367	1,556	1,410	10.6
Total	12,419	16,426	20,663	19,752	21,337	22,926	13.0
Industrial							
Security/Energy Management	1,797	2,270	3,330	3,283	3,729	4,921	22.3
Instrumentation	3,973	4,570	6,064	6,163	6,253	6,823	11.4
Manufacturing Systems	4,462	4,231	6,482	8,002	9,071	9,524	16.4
Medical Equipment	1,507	1,880	2,258	2,303	2,298	2,398	9.7
Other Industrial Equipment	2,794	3,307	4,679	5,111	5,061	5,053	12.6
Total	14,533	16,257	22,814	24,861	26,412	28,719	14.6
Consumer							
Audio	6,590	6,713	7,962	7,171	7,015	8,284	4.7
Video	17,286	17,772	21,307	19,516	19,876	22,375	5.3
Personal Electronics	5,440	5,537	7,042	7,485	8,700	9,242	11.2
Appliances	8,939	10,393	12,311	11,436	11,892	14,452	10.1
Other Consumer Equipment	5,223	5,971	7,117	6,866	6,956	7,421	7.3
Total	43,478	46,385	55,738	52,474	54,439	61,773	7.3
Military/Aerospace	NA	NA	2,002	1,825	1,602	1,583	NA
Transportation	5,591	7,203	8,788	9,199	9,469	9,931	12.2
Total Electronic Industry	104,827	122,455	155,648	156,052	160,031	176,275	11.0
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.2 (Continued)
Japanese Electronic Equipment Production
(Factory Revenue in Millions of Dollars)

	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Data Processing							
Computers	21,599	21,750	22,795	23,658	24,439	25,647	3.5
Data Storage	8,717	8,579	8,867	9,278	9,480	9,686	2.1
Terminals	5,971	5,747	5,937	6,165	6,437	6,786	2.6
Input/Output	7,157	7,176	7,591	8,073	8,509	9,104	4.9
Dedicated Systems	7,898	7,994	8,390	8,652	8,897	9,287	3.3
Total	51,342	51,246	53,581	55,827	57,762	60,510	3.3
Communication							
Premise Telecom Equipment	7,297	7,174	7,493	7,855	8,172	8,553	3.2
Public Telecom Equipment	6,073	6,062	6,319	6,543	6,674	6,852	2.4
Radio Equipment	7,419	7,926	8,524	9,092	9,729	10,474	7.1
Broadcast and Studio	728	741	769	785	808	858	3.3
Other Telecom Equipment	1,410	1,395	1,431	1,473	1,515	1,574	2.2
Total	22,926	23,298	24,535	25,748	26,899	28,311	4.3
Industrial							
Security/Energy Management	4,921	5,425	6,101	6,797	7,507	8,475	11.5
Instrumentation	6,823	6,411	6,737	7,073	7,324	7,609	2.2
Manufacturing Systems	9,524	8,967	9,677	10,579	11,553	12,668	5.9
Medical Equipment	2,398	2,164	2,315	2,447	2,573	2,655	2.1
Other Industrial Equipment	5,053	4,680	5,018	5,375	5,634	5,950	3.3
Total	28,719	27,646	29,848	32,270	34,591	37,357	5.4
Consumer							
Audio	8,284	7,764	8,286	8,632	8,954	9,401	2.6
Video	22,375	21,408	22,783	23,647	24,832	26,586	3.5
Personal Electronics	9,242	9,567	10,452	10,943	11,557	12,325	5.9
Appliances	14,452	14,016	15,055	15,663	16,212	16,876	3.1
Other Consumer Equipment	7,421	6,878	7,173	7,391	7,504	7,661	0.6
Total	61,773	59,633	63,750	66,275	69,059	72,849	3.4
Military/Aerospace	1,583	1,567	1,603	1,595	1,612	1,635	0.7
Transportation	9,931	9,935	10,533	11,018	11,411	11,854	3.6
Total Electronic Industry	176,275	173,325	183,849	192,732	201,334	212,516	3.8
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.3
Japanese Electronic Equipment Production Forecast
(Yen-Based Annual Growth by Percentage)

	1987	1988	1989	1990	1991
Data Processing					
Computers	14.8	21.7	21.0	1.6	10.2
Data Storage	7.0	9.0	9.5	-1.8	-1.2
Terminals	17.5	5.3	1.1	9.7	-7.9
Input/Output	12.2	18.4	-0.9	5.3	2.0
Dedicated Systems	-9.5	7.0	12.7	-2.6	3.8
Total	8.3	13.9	11.5	1.8	3.7
Communication					
Premise Telecom Equipment	6.4	16.8	8.1	-3.6	-2.7
Public Telecom Equipment	34.5	10.1	-12.0	33.0	-1.1
Radio Equipment	13.8	11.6	2.7	15.7	12.2
Broadcast and Studio	-9.1	15.0	6.3	27.0	5.2
Other Telecom Equipment	-0.6	18.9	12.3	18.8	-14.4
Total	14.1	13.6	1.5	12.7	1.5
Industrial					
Security/Energy Management	8.9	32.4	4.6	18.5	24.6
Instrumentation	-0.8	19.8	7.9	5.9	3.1
Manufacturing Systems	-18.2	38.3	31.0	18.3	-0.8
Medical Equipment	7.5	8.5	8.3	4.1	-1.4
Other Industrial Equipment	2.1	27.7	15.9	3.3	-5.7
Total	-3.5	26.7	15.7	10.9	2.7
Consumer					
Audio	-12.2	7.1	-4.4	2.1	11.5
Video	-11.3	8.2	-2.8	6.3	6.3
Personal Electronics	-12.2	14.8	12.8	21.3	0.3
Appliances	0.2	6.9	-1.4	8.5	14.8
Other Consumer Equipment	-1.4	7.6	2.4	5.7	0.8
Total	-8.0	8.5	-0.1	8.3	7.2
Military/Aerospace	NA	NA	-3.2	-8.4	-6.7
Transportation	11.1	10.1	11.1	7.4	-0.9
Total Electronic Industry	0.7	14.7	6.4	7.0	4.0

(Continued)

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Table 3.3 (Continued)
Japanese Electronic Equipment Production Forecast
(Yen-Based Annual Growth in Percentage)

	1992	1993	1994	1995	1996
Data Processing					
Computers	0.7	4.8	3.8	3.3	4.9
Data Storage	-1.6	3.4	4.6	2.2	2.2
Terminals	-3.7	3.3	3.8	4.4	5.4
Input/Output	0.3	5.8	6.3	5.4	7.0
Dedicated Systems	1.2	5.0	3.1	2.8	4.4
Total	-0.2	4.6	4.2	3.5	4.8
Communication					
Premise Telecom Equipment	-1.7	4.4	4.8	4.0	4.7
Public Telecom Equipment	-0.2	4.2	3.5	2.0	2.7
Radio Equipment	6.8	7.5	6.7	7.0	7.7
Broadcast and Studio	1.7	3.8	2.0	3.0	6.1
Other Telecom Equipment	-1.0	2.5	3.0	2.8	3.9
Total	1.6	5.3	4.9	4.5	5.2
Industrial					
Security/Energy Management	10.2	12.5	11.4	10.4	12.9
Instrumentation	-6.0	5.1	5.0	3.6	3.9
Manufacturing Systems	-5.8	7.9	9.3	9.2	9.6
Medical Equipment	-9.7	7.0	5.7	5.2	3.2
Other Industrial Equipment	-7.4	7.2	7.1	4.8	5.6
Total	-3.7	8.0	8.1	7.2	8.0
Consumer					
Audio	-6.3	6.7	4.2	3.7	5.0
Video	-4.3	6.4	3.8	5.0	7.1
Personal Electronics	3.5	9.2	4.7	5.6	6.6
Appliances	-3.0	7.4	4.0	3.5	4.1
Other Consumer Equipment	-7.3	4.3	3.0	1.5	2.1
Total	-3.5	6.9	4.0	4.2	5.5
Military/Aerospace	-1.0	2.3	-0.5	1.1	1.4
Transportation	0	6.0	4.6	3.6	3.9
Total Electronic Industry	-1.7	6.1	4.8	4.5	5.6

NA = Not applicable

Source: MITI, Dataquest (September 1992)

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Table 3.4
Japanese Electronic Equipment Production Forecast—Data Processing
(Factory Revenue in Billions of Yen)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Computers							
General Use	985	1,166	1,354	1,376	1,291	1,457	8.1
Office Use	149	176	226	329	349	419	22.9
Personal Use	364	383	488	799	907	923	20.5
Control Use	52	56	99	119	118	138	21.6
Total	1,551	1,781	2,167	2,623	2,666	2,937	13.6
Data Storage							
Rigid Disk Drives	615	655	721	811	776	793	5.2
Flexible Disk Drives	185	199	181	143	161	141	-5.2
Other Drives	156	169	213	267	262	251	10.0
Total	956	1,023	1,115	1,221	1,199	1,186	4.4
Terminal Equipment							
General Use	412	489	470	439	451	421	0.4
Special Use	186	228	290	325	405	369	14.6
Supporting System	44	37	34	40	25	22	-12.7
Total	642	754	795	804	882	812	4.8
Input-Output Unit							
Printer	483	554	660	664	694	698	7.7
Display Unit	170	183	195	189	188	211	4.4
Other Unit	35	35	58	53	71	64	12.4
Total	688	772	914	906	954	973	7.2
Dedicated Systems							
Calculators	97	74	96	118	107	117	3.8
Cash Registers	100	96	95	125	103	101	0.2
Copying Machines	503	458	482	502	523	551	1.8
Typewriters	99	61	55	49	39	28	-22.1
Word Processors	174	191	215	267	262	277	9.8
Total	973	881	942	1,062	1,034	1,074	2.0
Data Processing Total	4,811	5,210	5,934	6,616	6,735	6,983	7.7

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Table 3.4 (Continued)
Japanese Electronic Equipment Production Forecast—Data Processing
(Factory Revenue in Billions of Yen)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Computers							
General Use	1,457	1,406	1,435	1,449	1,445	1,451	-0.1
Office Use	419	429	485	517	554	598	7.4
Personal Use	923	954	988	1,046	1,106	1,204	5.5
Control Use	138	170	192	207	219	236	11.2
Total	2,937	2,958	3,100	3,218	3,324	3,488	3.5
Data Storage							
Rigid Disk Drives	793	781	801	839	850	858	1.6
Flexible Disk Drives	141	137	143	147	148	149	1.1
Other Drives	251	249	262	276	291	311	4.4
Total	1,186	1,167	1,206	1,262	1,289	1,317	2.1
Terminal Equipment							
General Use	421	411	429	445	466	491	3.1
Special Use	369	353	365	383	402	427	3.0
Supporting System	22	17	13	11	8	5	-24.9
Total	812	782	807	838	875	923	2.6
Input-Output Unit							
Printer	698	699	739	787	828	887	4.9
Display Unit	211	214	228	243	260	279	5.7
Other Unit	64	63	66	68	70	72	2.6
Total	973	976	1,032	1,098	1,157	1,238	4.9
Dedicated Systems							
Calculators	117	120	131	141	152	166	7.3
Cash Registers	101	102	106	110	112	116	2.8
Copying Machines	551	559	589	606	621	648	3.3
Typewriters	28	22	18	14	11	8	-22.1
Word Processors	277	284	297	305	314	325	3.2
Total	1,074	1,087	1,141	1,177	1,210	1,263	3.3
Data Processing Total	6,983	6,969	7,287	7,592	7,856	8,229	3.3

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.5
Japanese Electronic Equipment Production Forecast—Data Processing
(Factory Revenue in Millions of Dollars)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Computers							
General Use	5,900	8,094	10,412	9,973	8,967	10,711	12.7
Office Use	895	1,222	1,741	2,382	2,424	3,082	28.1
Personal Use	2,180	2,659	3,756	5,789	6,298	6,789	25.5
Control Use	312	389	763	866	822	1,017	26.7
Total	9,287	12,365	16,672	19,010	18,511	21,599	18.4
Data Storage							
Rigid Disk Drives	3,685	4,547	5,544	5,880	5,392	5,835	9.6
Flexible Disk Drives	1,107	1,379	1,395	1,034	1,120	1,039	-1.3
Other Drives	932	1,175	1,637	1,936	1,817	1,844	14.6
Total	5,723	7,101	8,576	8,851	8,329	8,717	8.8
Terminal Equipment							
General Use	2,467	3,397	3,616	3,179	3,132	3,094	4.6
Special Use	1,116	1,582	2,234	2,358	2,814	2,713	19.4
Supporting System	262	260	263	286	177	164	-9.0
Total	3,846	5,238	6,113	5,823	6,123	5,971	9.2
Input-Output Unit							
Printer	2,890	3,845	5,080	4,810	4,821	5,136	12.2
Display Unit	1,021	1,273	1,503	1,372	1,309	1,553	8.8
Other Unit	212	246	449	382	495	468	17.2
Total	4,123	5,364	7,033	6,563	6,625	7,157	11.7
Dedicated Systems							
Calculators	580	516	742	856	740	858	8.1
Cash Registers	600	668	728	909	714	746	4.4
Copying Machines	3,012	3,180	3,707	3,636	3,634	4,049	6.1
Typewriters	594	422	419	357	274	209	-18.9
Word Processors	1,042	1,330	1,654	1,936	1,821	2,037	14.4
Total	5,828	6,116	7,249	7,694	7,183	7,898	6.3
Data Processing Total	28,806	36,184	45,643	47,941	46,771	51,342	12.3
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	13	

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Table 3.5 (Continued)
Japanese Electronic Equipment Production Forecast—Data Processing
(Factory Revenue in Millions of Dollars)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Computers							
General Use	10,711	10,337	10,554	10,652	10,623	10,666	-0.1
Office Use	3,082	3,153	3,565	3,798	4,077	4,395	7.4
Personal Use	6,789	7,013	7,265	7,689	8,129	8,853	5.5
Control Use	1,017	1,248	1,410	1,519	1,609	1,733	11.2
Total	21,599	21,750	22,795	23,658	24,439	25,647	3.5
Data Storage							
Rigid Disk Drives	5,835	5,743	5,892	6,169	6,251	6,307	1.6
Flexible Disk Drives	1,039	1,007	1,049	1,077	1,088	1,095	1.1
Other Drives	1,844	1,829	1,926	2,032	2,140	2,284	4.4
Total	8,717	8,579	8,867	9,278	9,480	9,686	2.1
Terminal Equipment							
General Use	3,094	3,020	3,152	3,270	3,425	3,610	3.1
Special Use	2,713	2,599	2,686	2,818	2,956	3,138	3.0
Supporting System	164	129	99	78	57	39	-24.9
Total	5,971	5,747	5,937	6,165	6,437	6,786	2.6
Input-Output Unit							
Printer	5,136	5,141	5,434	5,787	6,090	6,522	4.9
Display Unit	1,553	1,572	1,674	1,788	1,908	2,049	5.7
Other Unit	468	464	483	498	511	532	2.6
Total	7,157	7,176	7,591	8,073	8,509	9,104	4.9
Dedicated Systems							
Calculators	858	883	962	1,038	1,116	1,220	7.3
Cash Registers	746	746	779	808	827	855	2.8
Copying Machines	4,049	4,113	4,331	4,457	4,565	4,762	3.3
Typewriters	209	163	134	103	81	60	-22.1
Word Processors	2,037	2,088	2,184	2,246	2,307	2,390	3.2
Total	7,898	7,994	8,390	8,652	8,897	9,287	3.3
Data Processing Total	51,342	51,246	53,581	55,827	57,762	60,510	3.3
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

Note: Columns may not add to totals because of rounding.
Source: MITI, Dataquest (September 1992)

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Table 3.6
Japanese Electronic Equipment Production Forecast—Data Processing
(Yen-Based Annual Growth by Percentage)

Equipment Type	1987	1988	1989	1990	1991
Computers					
General Use	18.3	16.1	1.7	-6.2	12.8
Office Use	17.8	28.6	45.2	6.2	20.0
Personal Use	5.2	27.5	63.6	13.5	1.8
Control Use	7.6	76.9	20.4	-0.9	16.9
Others					
Total	14.8	21.7	21.0	1.6	10.2
Data Storage					
Rigid Disk Drives	6.4	10.1	12.6	-4.3	2.2
Flexible Disk Drives	7.5	-8.7	-21.3	13.1	-12.4
Other Drives	8.8	25.8	25.5	-2.1	-4.2
Total	7.0	9.0	9.5	-1.8	-1.2
Terminal Equipment					
General Use	18.7	-3.9	-6.7	2.8	-6.7
Special Use	22.2	27.5	12.0	24.6	-9.0
Supporting System	-14.7	-8.6	15.7	-35.7	-12.4
Total	17.5	5.3	1.1	9.7	-7.9
Input-Output Unit					
Printer	14.7	19.3	0.5	4.6	0.6
Display Unit	7.5	6.6	-3.1	-0.4	12.1
Other Unit	0.0	64.8	-9.7	35.1	-10.6
Total	12.2	18.4	-0.9	5.3	2.0
Dedicated Systems					
Calculators	-23.3	29.8	22.5	-9.7	9.4
Cash Registers	-4.1	-1.7	32.7	-18.1	-1.4
Copying Machines	-9.0	5.2	4.1	4.3	5.2
Typewriters	-38.8	-10.3	-9.7	-19.9	-28.0
Word Processors	10.1	12.3	24.2	-1.8	5.7
Total	-9.5	7.0	12.7	-2.6	3.8
Data Processing Total	8.3	13.9	11.5	1.8	3.7

(Continued)

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Table 3.6 (Continued)
Japanese Electronic Equipment Production Forecast—Data Processing
(Yen-Based Annual Growth by Percentage)

Equipment Type	1992	1993	1994	1995	1996
Computers					
General Use	-3.5	2.1	0.9	-0.3	0.4
Office Use	2.3	13.1	6.5	7.3	7.8
Personal Use	3.3	3.6	5.8	5.7	8.9
Control Use	22.7	13.0	7.7	5.9	7.7
Others					
Total	0.7	4.8	3.8	3.3	4.9
Data Storage					
Rigid Disk Drives	-1.6	2.6	4.7	1.3	0.9
Flexible Disk Drives	-3.1	4.2	2.7	1.0	0.6
Other Drives	-0.8	5.3	5.5	5.3	6.7
Total	-1.6	3.4	4.6	2.2	2.2
Terminal Equipment					
General Use	-2.4	4.4	3.7	4.7	5.4
Special Use	-4.2	3.3	4.9	4.9	6.2
Supporting System	-21.5	-23.0	-21.7	-26.6	-31.4
Total	-3.7	3.3	3.8	4.4	5.4
Input-Output Unit					
Printer	0.1	5.7	6.5	5.2	7.1
Display Unit	1.2	6.5	6.8	6.7	7.4
Other Unit	-1.0	4.3	3.0	2.6	4.2
Total	0.3	5.8	6.3	5.4	7.0
Dedicated Systems					
Calculators	2.9	9.0	7.9	7.5	9.3
Cash Registers	0.1	4.3	3.8	2.3	3.4
Copying Machines	1.6	5.3	2.9	2.4	4.3
Typewriters	-21.8	-18.1	-23.0	-21.1	-26.1
Word Processors	2.5	4.6	2.8	2.7	3.6
Total	1.2	5.0	3.1	2.8	4.4
Data Processing Total	-0.2	4.6	4.2	3.5	4.8

Source: MITI, Dataquest (September 1992)

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Table 3.7
Japanese Electronic Equipment Production Forecast—Communication
(Factory Revenue in Billions of Yen)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Customer Premises							
Telephones	102	111	156	201	261	308	24.7
Standard Telephone	38	32	27	22	21	26	-7.6
Multifunction	29	39	53	58	41	36	4.2
Cordless	NA	NA	35	71	146	177	NA
Other	35	40	41	51	54	69	14.7
Applied Telephones	56	51	31	40	41	40	-6.2
Facsimiles	303	365	466	502	445	416	6.6
PBX Telephone Systems	102	104	120	115	112	96	-1.2
Key Telephone Systems	182	138	123	123	104	93	-12.6
Modems	43	69	83	76	57	39	-2.0
Total	788	838	979	1,058	1,020	992	4.7
Public Telecommunication							
Carrier Transmission	301	407	427	355	507	469	9.3
Central Office Switch	181	241	286	273	328	357	14.6
Total	481	647	713	628	835	826	11.4
Radio							
Radio Communication	386	445	500	543	695	798	15.6
Radio Base Station Equipment	207	219	219	244	289	284	6.5
Mobile Radio Equipment	156	192	238	246	337	429	22.5
Mobile Communication Equipment	22	34	44	54	69	84	30.4
Applied Radio Equipment	210	233	256	234	205	211	0.1
Total	596	678	757	777	900	1,009	11.1
Broadcast and Studio	67	61	70	74	94	99	8.2
Other Telecom Equipment	142	141	168	189	224	192	6.2
Communications Total	2,074	2,365	2,686	2,726	3,073	3,118	8.5

(Continued)

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Table 3.7 (Continued)
Japanese Electronic Equipment Production Forecast—Communication
(Factory Revenue in Billions of Yen)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Customer Premises							
Telephones	308	311	337	363	382	400	5.4
Standard Telephone	26	26	27	28	28	28	2.0
Multifunction	36	32	33	34	35	36	0.5
Cordless	177	185	207	228	244	259	7.9
Other	69	68	71	74	74	76	1.9
Applied Telephones	40	40	41	42	44	45	2.4
Facsimiles	416	411	423	438	453	473	2.6
PBX Telephone Systems	96	92	95	100	106	114	3.5
Key Telephone Systems	93	87	88	89	91	94	0.2
Modems	39	35	35	36	36	37	-1.2
Total	992	976	1,019	1,068	1,111	1,163	3.2
Public Telecommunication							
Carrier Transmission	469	463	475	489	498	510	1.7
Central Office Switch	357	362	384	401	410	422	3.4
Total	826	824	859	890	908	932	2.4
Radio							
Radio Communication	798	880	1,045	1,245	1,517	1,895	18.9
Radio Base Station Equipment	284	281	291	305	320	338	3.5
Mobile Radio Equipment	429	510	569	616	678	750	11.8
Mobile Communication Equipment	84	88	96	106	115	123	7.8
Applied Radio Equipment	211	198	203	209	210	214	0.2
Total	1,009	1,078	1,159	1,236	1,323	1,424	7.1
Broadcast and Studio	99	101	105	107	110	117	3.3
Other Telecom Equipment	192	190	195	200	206	214	2.2
Communications Total	3,118	3,169	3,337	3,502	3,658	3,850	4.3

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.8
Japanese Electronic Equipment Production Forecast—Communication
(Factory Revenue in Millions of Dollars)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Customer Premises							
Telephones	611	773	1,203	1,455	1,813	2,262	29.9
Standard Telephone	229	221	208	156	144	189	-3.7
Multifunction	174	274	409	421	285	262	8.6
Cordless	NA	NA	271	511	1,010	1,303	NA
Other	208	278	316	368	374	507	19.5
Applied Telephones	333	355	235	293	282	296	-2.3
Facsimiles	1,814	2,534	3,584	3,639	3,092	3,061	11.0
PBX Telephone Systems	611	720	925	836	776	707	3.0
Key Telephone Systems	1,091	960	945	893	720	685	-8.9
Modems	257	478	635	549	397	286	2.1
Total	4,717	5,819	7,527	7,666	7,080	7,297	9.1
Public Telecommunication							
Carrier Transmission	1,800	2,826	3,283	2,571	3,522	3,448	13.9
Central Office Switch	1,082	1,670	2,203	1,978	2,277	2,625	19.4
Total	2,882	4,496	5,486	4,549	5,799	6,073	16.1
Radio							
Radio Communication	2,309	3,088	3,849	3,938	4,827	5,865	20.5
Radio Base Station Equipment	1,242	1,518	1,682	1,765	2,006	2,091	11.0
Mobile Radio Equipment	933	1,332	1,828	1,783	2,341	3,156	27.6
Mobile Communication Equipment	134	238	339	390	479	619	35.8
Applied Radio Equipment	1,259	1,621	1,972	1,696	1,421	1,553	4.3
Total	3,568	4,709	5,821	5,633	6,247	7,419	15.8
Broadcast and Studio	400	421	537	538	654	728	12.8
Other Telecom Equipment	851	981	1,292	1,367	1,556	1,410	10.6
Communications Total	12,419	16,426	20,663	19,752	21,337	22,926	13.0
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.8 (Continued)
Japanese Electronic Equipment Production Forecast—Communication
(Factory Revenue in Millions of Dollars)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Customer Premises							
Telephones	2,262	2,289	2,480	2,670	2,808	2,940	5.4
Standard Telephone	189	189	196	203	207	209	2.0
Multifunction	262	237	242	250	258	268	0.5
Cordless	1,303	1,359	1,520	1,675	1,798	1,906	7.9
Other	507	503	522	542	546	557	1.9
Applied Telephones	296	291	301	311	321	334	2.4
Facsimiles	3,061	3,024	3,109	3,222	3,332	3,479	2.6
PBX Telephone Systems	707	676	699	733	776	840	3.5
Key Telephone Systems	685	638	644	656	670	692	0.2
Modems	286	256	260	264	265	269	-1.2
Total	7,297	7,174	7,493	7,855	8,172	8,553	3.2
Public Telecommunication							
Carrier Transmission	3,448	3,403	3,495	3,594	3,659	3,747	1.7
Central Office Switch	2,625	2,659	2,824	2,949	3,015	3,105	3.4
Total	6,073	6,062	6,319	6,543	6,674	6,852	2.4
Radio							
Radio Communication	5,865	6,468	7,682	9,152	11,157	13,933	18.9
Radio Base Station Equipment	2,091	2,070	2,140	2,246	2,354	2,488	3.5
Mobile Radio Equipment	3,156	3,749	4,184	4,527	4,985	5,513	11.8
Mobile Communication Equipment	619	648	706	781	845	901	7.8
Applied Radio Equipment	1,553	1,459	1,494	1,537	1,546	1,572	0.2
Total	7,419	7,926	8,524	9,092	9,729	10,474	7.1
Broadcast and Studio	728	741	769	785	808	858	3.3
Other Telecom Equipment	1,410	1,395	1,431	1,473	1,515	1,574	2.2
Communications Total	22,926	23,298	24,535	25,748	26,899	28,311	4.3
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.9
Japanese Electronic Equipment Production Forecast—Communication
(Yen-Based Annual Growth by Percentage)

Equipment Type	1987	1988	1989	1990	1991
Communication					
Premise Telecom Equipment	6.4	16.8	8.1	-3.6	-2.7
Public Telecom Equipment	34.5	10.1	-12.0	33.0	-1.1
Radio Equipment	13.8	11.6	2.7	15.7	12.2
Broadcast and Studio	-9.1	15.0	6.3	27.0	5.2
Other Telecom Equipment	-0.6	18.9	12.3	18.8	-14.4
Total	14.1	13.6	1.5	12.7	1.5
Customer Premises					
Telephones	9.1	40.6	28.4	30.0	17.8
Standard Telephone	-16.8	-15.1	-20.3	-3.7	24.3
Multifunction	36.0	34.6	9.3	-29.3	-13.2
Cordless	NA	NA	100.4	106.3	21.8
Other	15.1	2.8	23.4	6.1	28.2
Applied Telephones	-8.0	-40.3	32.2	0.5	-0.8
Facsimiles	20.4	27.7	7.8	-11.3	-6.5
PBX Telephone Systems	1.5	16.1	-4.1	-3.2	-13.9
Key Telephone Systems	-24.2	-11.1	0.3	-15.9	-10.2
Modems	60.3	19.8	-8.2	-24.5	-32.0
Total	6.4	16.8	8.1	-3.6	-2.7
Public Telecommunication					
Carrier Transmission	35.4	4.9	-16.9	43.0	-7.6
Central Office Switch	33.1	19.1	-4.7	20.1	8.9
Total	34.5	10.1	-12.0	33.0	-1.1
Radio					
Radio Communication	15.3	12.5	8.6	27.9	14.8
Radio Base Station Equipment	5.4	0.0	11.4	18.6	-1.6
Mobile Radio Equipment	23.0	23.9	3.6	37.0	27.3
Mobile Communication Equipment	53.4	28.7	21.9	28.1	22.1
Applied Radio Equipment	11.0	9.9	-8.7	-12.6	3.3
Total	13.8	11.6	2.7	15.7	12.2
Broadcast and Studio	-9.1	15.0	6.3	27.0	5.2
Other Telecom Equipment	-0.6	18.9	12.3	18.8	-14.4
Communications Total	14.1	13.6	1.5	12.7	1.5

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Table 3.9 (Continued)
Japanese Electronic Equipment Production Forecast—Communication
(Yen-Based Annual Growth by Percentage)

Equipment Type	1992	1993	1994	1995	1996
Communication					
Premise Telecom Equipment	-1.7	4.4	4.8	4.0	4.7
Public Telecom Equipment	-0.2	4.2	3.5	2.0	2.7
Radio Equipment	6.8	7.5	6.7	7.0	7.7
Broadcast and Studio	1.7	3.8	2.0	3.0	6.1
Other Telecom Equipment	-1.0	2.5	3.0	2.8	3.9
Total	1.6	5.3	4.9	4.5	5.2
Customer Premises					
Telephones	1.2	8.3	7.7	5.2	4.7
Standard Telephone	-0.1	3.6	3.5	1.8	1.1
Multifunction	-9.4	2.1	3.1	3.1	4.1
Cordless	4.3	11.8	10.2	7.3	6.0
Other	-0.8	3.7	3.8	0.7	2.0
Applied Telephones	-1.7	3.4	3.2	3.3	4.1
Facsimiles	-1.2	2.8	3.6	3.4	4.4
PBX Telephone Systems	-4.4	3.4	4.8	5.8	8.2
Key Telephone Systems	-6.9	1.0	1.8	2.2	3.2
Modems	-10.5	1.7	1.6	0.2	1.4
Total	-1.7	4.4	4.8	4.0	4.7
Public Telecommunication					
Carrier Transmission	-1.3	2.7	2.8	1.8	2.4
Central Office Switch	1.3	6.2	4.4	2.2	3.0
Total	-0.2	4.2	3.5	2.0	2.7
Radio					
Radio Communication	10.3	18.8	19.1	21.9	24.9
Radio Base Station Equipment	-1.0	3.4	4.9	4.8	5.7
Mobile Radio Equipment	18.8	11.6	8.2	10.1	10.6
Mobile Communication Equipment	4.8	8.8	10.7	8.1	6.7
Applied Radio Equipment	-6.1	2.4	2.9	0.5	1.7
Total	6.8	7.5	6.7	7.0	7.7
Broadcast and Studio	1.7	3.8	2.0	3.0	6.1
Other Telecom Equipment	-1.0	2.5	3.0	2.8	3.9
Communications Total	1.6	5.3	4.9	4.5	5.2

NA = Not applicable

Source: MITI, Dataquest (September 1992)

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Table 3.10
Japanese Electronic Equipment Production Forecast—Industrial
(Factory Revenue in Billions of Yen)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Security/Energy Management							
Alarm Systems	93	89	124	132	146	163	11.9
Energy Management	207	238	309	321	391	506	19.5
Total	300	327	433	453	537	669	17.4
Instrumentation							
Meter Units	38	39	45	41	45	48	4.6
Measuring Instruments	243	243	302	336	361	348	7.4
Industrial Meters	239	237	284	307	311	334	7.0
Others	144	138	158	167	185	198	6.6
Total	663	658	788	850	900	928	6.9
Manufacturing Systems							
NC Machines	611	487	660	883	1,037	989	NA
Robotics	124	110	164	204	254	289	18.4
Ultrasonic Applied Equipment	11	12	18	17	16	18	10.9
Total	745	609	843	1,104	1,306	1,295	11.7
Medical Equipment							
X-Ray Systems	139	147	161	171	167	160	2.9
Measuring Systems	48	52	53	53	59	59	4.1
Other	65	72	80	94	106	107	10.6
Total	252	271	294	318	331	326	5.3
Other Industrial Equipment							
Vending Machines	168	210	268	295	292	277	10.5
Automatic Service Equipment	10	10	16	19	22	26	22.0
Commercial-Type Washing Machinery	16	17	17	20	18	16	0.3
Electron Microscopes	32	28	30	38	37	33	0.4
Ultrasonic Equipment	50	49	67	67	82	84	10.9
Others	191	162	210	266	277	251	5.6
Total	467	476	608	705	729	687	8.0
Industrial Total	2,427	2,341	2,966	3,431	3,803	3,906	10.0

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Table 3.10 (Continued)
Japanese Electronic Equipment Production Forecast—Industrial
(Factory Revenue in Billions of Yen)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Security/Energy Management							
Alarm Systems	163	165	193	222	257	319	14.4
Energy Management	506	573	637	703	764	833	10.5
Total	669	738	830	924	1,021	1,153	11.5
Instrumentation							
Meter Units	48	45	46	47	47	49	0.3
Measuring Instruments	348	314	333	352	368	385	2.0
Industrial Meters	334	331	348	367	380	395	3.4
Others	198	181	189	196	201	206	0.8
Total	928	872	916	962	996	1,035	2.2
Manufacturing Systems							
NC Machines	989	909	971	1,057	1,152	1,263	5.0
Robotics	289	290	321	354	388	424	8.0
Ultrasonic Applied Equipment	18	21	24	28	32	36	14.7
Total	1,295	1,220	1,316	1,439	1,571	1,723	5.9
Medical Equipment							
X-Ray Systems	160	155	167	175	185	190	3.5
Measuring Systems	59	57	60	62	64	64	1.7
Other	107	82	88	95	101	107	-0.1
Total	326	294	315	333	350	361	2.1
Other Industrial Equipment							
Vending Machines	277	267	289	315	328	348	4.7
Automatic Service Equipment	26	30	36	43	52	62	18.7
Commercial-Type Washing Machinery	16	14	14	13	12	11	-6.2
Electron Microscopes	33	26	25	24	24	23	-7.1
Ultrasonic Equipment	84	86	94	102	110	118	7.1
Others	251	214	224	234	241	247	-0.4
Total	687	636	682	731	766	809	3.3
Industrial Total	3,906	3,760	4,059	4,389	4,704	5,081	5.4

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.11
Japanese Electronic Equipment Production Forecast—Industrial
(Factory Revenue in Millions of Dollars)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Security/Energy Management							
Alarm Systems	555	617	955	960	1,013	1,198	16.6
Energy Management	1,242	1,654	2,375	2,323	2,716	3,723	24.6
Total	1,797	2,270	3,330	3,283	3,729	4,921	22.3
Instrumentation							
Meter Units	228	274	344	297	311	351	9.0
Measuring Instruments	1,455	1,689	2,323	2,431	2,504	2,559	11.9
Industrial Meters	1,428	1,649	2,185	2,223	2,157	2,459	11.5
Others	861	957	1,212	1,211	1,281	1,454	11.1
Total	3,973	4,570	6,064	6,163	6,253	6,823	11.4
Manufacturing Systems							
NC Machines	3,656	3,380	5,079	6,397	7,200	7,269	14.7
Robotics	741	766	1,262	1,478	1,763	2,122	23.4
Ultrasonic Applied Equipment	65	85	141	127	109	133	15.5
Total	4,462	4,231	6,482	8,002	9,071	9,524	16.4
Medical Equipment							
X-Ray Systems	831	1,021	1,235	1,237	1,158	1,177	7.2
Measuring Systems	287	361	411	387	407	432	8.5
Other	389	498	612	679	733	789	15.2
Total	1,507	1,880	2,258	2,303	2,298	2,398	9.7
Other Industrial Equipment							
Vending Machines	1,006	1,456	2,064	2,135	2,031	2,039	15.2
Automatic Service Equipment	58	67	125	138	152	193	27.1
Commercial-Type Washing Machinery	93	119	127	143	123	116	4.5
Electron Microscopes	191	197	233	278	259	240	4.6
Ultrasonic Equipment	299	341	513	489	571	616	15.5
Others	1,147	1,126	1,617	1,929	1,925	1,849	10.0
Total	2,794	3,307	4,679	5,111	5,061	5,053	12.6
Industrial Total	14,533	16,257	22,814	24,861	26,412	28,719	14.6
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.11 (Continued)
Japanese Electronic Equipment Production Forecast—Industrial
(Factory Revenue in Millions of Dollars)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Security/Energy Management							
Alarm Systems	1,198	1,214	1,416	1,630	1,890	2,347	14.4
Energy Management	3,723	4,210	4,684	5,166	5,617	6,129	10.5
Total	4,921	5,425	6,101	6,797	7,507	8,475	11.5
Instrumentation							
Meter Units	351	333	340	345	348	357	0.3
Measuring Instruments	2,559	2,309	2,450	2,590	2,702	2,829	2.0
Industrial Meters	2,459	2,434	2,559	2,698	2,795	2,906	3.4
Others	1,454	1,334	1,388	1,441	1,478	1,517	0.8
Total	6,823	6,411	6,737	7,073	7,324	7,609	2.2
Manufacturing Systems							
NC Machines	7,269	6,686	7,141	7,769	8,470	9,284	5.0
Robotics	2,122	2,130	2,359	2,605	2,849	3,119	8.0
Ultrasonic Applied Equipment	133	151	177	205	233	265	14.7
Total	9,524	8,967	9,677	10,579	11,553	12,668	5.9
Medical Equipment							
X-Ray Systems	1,177	1,136	1,228	1,290	1,362	1,398	3.5
Measuring Systems	432	421	439	459	469	470	1.7
Other	789	607	648	697	742	787	-0.1
Total	2,398	2,164	2,315	2,447	2,573	2,655	2.1
Other Industrial Equipment							
Vending Machines	2,039	1,961	2,127	2,314	2,409	2,560	4.7
Automatic Service Equipment	193	219	263	317	380	454	18.7
Commercial-Type Washing Machinery	116	103	101	97	92	84	-6.2
Electron Microscopes	240	191	184	178	175	166	-7.1
Ultrasonic Equipment	616	631	695	751	809	870	7.1
Others	1,849	1,574	1,648	1,718	1,768	1,815	-0.4
Total	5,053	4,680	5,018	5,375	5,634	5,950	3.3
Industrial Total	28,719	27,646	29,848	32,270	34,591	37,357	5.4
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.12
Japanese Electronic Equipment Production Forecast—Industrial
(Yen-Based Annual Growth by Percentage)

Equipment Type	1987	1988	1989	1990	1991
Security/Energy Management					
Alarm Systems	-4.2	39.8	6.7	10.1	11.7
Energy Management	14.8	29.7	3.8	22.0	29.5
Total	8.9	32.4	4.6	18.5	24.6
Instrumentation					
Meter Units	3.6	13.1	-8.2	9.2	6.5
Measuring Instruments	0.1	24.2	11.1	7.4	-3.5
Industrial Meters	-0.4	19.6	8.0	1.3	7.7
Others	-4.1	14.3	6.1	10.4	7.2
Total	-0.8	19.8	7.9	5.9	3.1
Manufacturing Systems					
NC Machines	-20.3	35.7	33.7	17.5	-4.7
Robotics	-10.9	48.7	24.4	24.4	13.7
Ultrasonic Applied Equipment	13.1	50.0	-4.9	-10.4	15.8
Total	-18.2	38.3	31.0	18.3	-0.8
Medical Equipment					
X-Ray Systems	5.8	9.2	6.3	-2.3	-4.0
Measuring Systems	8.4	2.9	-0.1	9.7	0.2
Other	10.6	10.9	17.8	12.6	1.6
Total	7.5	8.5	8.3	4.1	-1.4
Other Industrial Equipment					
Vending Machines	24.9	28.0	9.8	-0.7	-5.2
Automatic Service Equipment	-0.2	67.1	17.8	14.8	19.9
Commercial-Type Washing Machinery	10.4	-3.5	18.9	-10.0	-10.8
Electron Microscopes	-11.2	6.8	26.4	-2.8	-12.5
Ultrasonic Equipment	-1.7	35.8	1.2	22.0	1.8
Others	-15.3	29.6	26.6	4.1	-9.3
Total	2.1	27.7	15.9	3.3	-5.7
Industrial Total	-3.5	26.7	15.7	10.9	2.7

(Continued)

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Table 3.12 (Continued)
Japanese Electronic Equipment Production Forecast—Industrial
(Yen-Based Annual Growth by Percentage)

Equipment Type	1992	1993	1994	1995	1996
Security/Energy Management					
Alarm Systems	1.4	16.7	15.1	15.9	24.2
Energy Management	13.1	11.3	10.3	8.7	9.1
Total	10.2	12.5	11.4	10.4	12.9
Instrumentation					
Meter Units	-5.1	2.1	1.4	0.9	2.5
Measuring Instruments	-9.8	6.1	5.7	4.4	4.7
Industrial Meters	-1.0	5.1	5.4	3.6	4.0
Others	-8.2	4.0	3.8	2.6	2.6
Total	-6.0	5.1	5.0	3.6	3.9
Manufacturing Systems					
NC Machines	-8.0	6.8	8.8	9.0	9.6
Robotics	0.4	10.8	10.4	9.4	9.5
Ultrasonic Applied Equipment	13.6	17.2	15.6	13.7	13.6
Total	-5.8	7.9	9.3	9.2	9.6
Medical Equipment					
X-Ray Systems	-3.5	8.0	5.1	5.5	2.7
Measuring Systems	-2.4	4.2	4.6	2.2	0.2
Other	-23.1	6.9	7.5	6.4	6.0
Total	-9.7	7.0	5.7	5.2	3.2
Other Industrial Equipment					
Vending Machines	-3.8	8.5	8.8	4.1	6.2
Automatic Service Equipment	13.6	20.0	20.4	20.0	19.6
Commercial-Type Washing Machinery	-11.0	-2.2	-3.9	-5.6	-8.1
Electron Microscopes	-20.3	-3.4	-3.6	-1.6	-5.1
Ultrasonic Equipment	2.5	10.0	8.2	7.7	7.5
Others	-14.9	4.7	4.3	3.0	2.7
Total	-7.4	7.2	7.1	4.8	5.6
Industrial Total	-3.7	8.0	8.1	7.2	8.0

Source: MITI, Dataquest (September 1992)

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Table 3.13
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Billions of Yen)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Audio							
Audio Amplifiers	110	111	104	104	112	115	0.9
DAD Players	200	155	176	146	171	210	1.0
Radios	32	25	25	27	29	36	2.8
Stereo Sets	133	131	141	169	167	218	10.4
Tape Recorders	326	251	281	258	228	234	-6.4
Headphone Stereos	98	81	78	88	92	103	0.8
Music Instruments	119	142	171	155	172	178	8.4
Other Audio Equipment	83	71	59	43	39	32	-17.2
Total	1,101	967	1,035	990	1,010	1,127	0.5
Video							
VCRs	1,659	1,243	1,212	1,135	1,078	1,039	-8.9
Video Cameras	417	483	645	615	736	921	17.2
Videodisk Players	50	48	79	104	144	137	22.1
Color TVs	724	765	814	819	875	911	4.7
B/W TVs	11	4	1	NA	NA	NA	NA
LCD TVs	25	16	19	21	29	35	7.2
Total	2,887	2,559	2,770	2,693	2,862	3,043	1.1
Personal Electronics							
Cameras	375	336	319	339	347	344	-1.7
Clock	99	90	95	91	92	92	-1.4
Electric Toys	155	131	231	330	509	505	26.7
Watches	280	239	270	273	306	316	2.5
Total	909	797	915	1,033	1,253	1,257	6.7
Appliances							
Air Conditioners	673	677	801	797	881	1,098	10.3
Microwave Ovens	271	241	198	169	156	150	-11.1
Refrigerators	397	424	425	423	458	485	4.1
Washers and Dryers	152	155	176	189	218	232	8.9
Total	1,493	1,497	1,600	1,578	1,712	1,965	5.7
Other Consumer Equipment	872	860	925	947	1,002	1,009	3.0
Consumer Total	7,261	6,679	7,246	7,241	7,839	8,401	3.0

(Continued)

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Table 3.13 (Continued)
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Billions of Yen)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Audio							
Audio Amplifiers	115	106	108	107	107	107	-1.4
DAD Players	210	203	221	233	245	261	4.4
Radios	36	34	35	34	34	35	-0.9
Stereo Sets	218	206	226	241	253	269	4.3
Tape Recorders	234	219	233	245	257	274	3.2
Headphone Stereos	103	95	99	102	104	107	0.9
Music Instruments	178	168	177	183	188	195	1.8
Other Audio Equipment	32	26	28	29	30	31	-1.0
Total	1,127	1,056	1,127	1,174	1,218	1,279	2.6
Video							
VCRs	1,039	934	918	891	889	913	-2.5
Video Cameras	921	930	1,059	1,136	1,215	1,311	7.3
Videodisk Players	137	138	155	172	191	216	9.6
Color TVs	911	872	921	964	1,019	1,095	3.8
B/W TVs	NA	NA	NA	NA	NA	NA	NA
LCD TVs	35	37	45	53	64	80	17.8
Total	3,043	2,911	3,099	3,216	3,377	3,616	3.5
Personal Electronics							
Cameras	344	300	305	300	301	305	-2.4
Clock	92	74	77	78	78	79	-3.1
Electric Toys	505	635	739	808	888	985	14.3
Watches	316	291	300	302	304	308	-0.5
Total	1,257	1,301	1,421	1,488	1,572	1,676	5.9
Appliances							
Microwave Ovens	150	135	133	130	122	115	-5.3
Refrigerators	485	456	481	495	506	516	1.2
Washers and Dryers	232	220	230	236	240	245	1.1
Total	1,965	1,906	2,047	2,130	2,205	2,295	3.1
Other Consumer Equipment	1,009	935	976	1,005	1,021	1,042	0.6
Consumer Total	8,401	8,110	8,670	9,013	9,392	9,907	3.4

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.14
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Millions of Dollars)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Audio							
Audio Amplifiers	657	769	802	752	778	845	5.2
DAD Players	1,196	1,076	1,352	1,057	1,188	1,546	5.3
Radios	190	176	189	198	204	267	7.1
Stereo Sets	794	907	1,083	1,227	1,160	1,601	15.1
Tape Recorders	1,952	1,741	2,162	1,867	1,585	1,723	-2.5
Headphone Stereos	589	562	601	640	638	754	5.1
Music Instruments	715	988	1,317	1,123	1,194	1,311	12.9
Other Audio Equipment	498	494	457	308	268	237	-13.8
Total	6,590	6,713	7,962	7,171	7,015	8,284	4.7
Video							
VCRs	9,937	8,630	9,323	8,221	7,490	7,640	-5.1
Video Cameras	2,498	3,354	4,961	4,453	5,113	6,773	22.1
Videodisk Players	302	335	604	750	1,002	1,007	27.3
Color TVs	4,334	5,314	6,262	5,937	6,074	6,696	9.1
B/W TVs	66	28	8	NA	NA	NA	NA
LCD TVs	149	112	149	155	198	260	11.7
Total	17,286	17,772	21,307	19,516	19,876	22,375	5.3
Personal Electronics							
Cameras	2,247	2,335	2,457	2,454	2,407	2,527	2.4
Clock	592	627	733	662	639	679	2.8
Electric Toys	926	913	1,775	2,394	3,532	3,714	32.0
Watches	1,674	1,661	2,078	1,975	2,122	2,321	6.8
Total	5,440	5,537	7,042	7,485	8,700	9,242	11.2
Appliances							
Air Conditioners	4,027	4,698	6,158	5,773	6,119	8,072	14.9
Microwave Ovens	1,625	1,676	1,527	1,225	1,081	1,105	-7.4
Refrigerators	2,378	2,945	3,269	3,069	3,178	3,566	8.4
Washers and Dryers	909	1,073	1,357	1,369	1,515	1,709	13.5
Total	8,939	10,393	12,311	11,436	11,892	14,452	10.1
Other Consumer Equipment	5,223	5,971	7,117	6,866	6,956	7,421	7.3
Consumer Total	43,478	46,385	55,738	52,474	54,439	61,773	7.3
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.14 (Continued)
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Millions of Dollars)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Audio							
Audio Amplifiers	845	776	796	787	784	788	-1.4
DAD Players	1,546	1,493	1,624	1,716	1,802	1,919	4.4
Radios	267	248	256	252	252	255	-0.9
Stereo Sets	1,601	1,514	1,662	1,772	1,860	1,977	4.3
Tape Recorders	1,723	1,609	1,711	1,800	1,887	2,014	3.2
Headphone Stereos	754	697	729	748	765	788	0.9
Music Instruments	1,311	1,233	1,303	1,345	1,386	1,435	1.8
Other Audio Equipment	237	194	205	212	218	226	-1.0
Total	8,284	7,764	8,286	8,632	8,954	9,401	2.6
Video							
VCRs	7,640	6,868	6,751	6,551	6,533	6,716	-2.5
Video Cameras	6,773	6,839	7,783	8,354	8,933	9,638	7.3
Videodisk Players	1,007	1,011	1,143	1,264	1,403	1,589	9.6
Color TVs	6,696	6,413	6,772	7,086	7,492	8,054	3.8
B/W TVs	NA	NA	NA	NA	NA	NA	NA
LCD TVs	260	276	333	392	472	588	17.8
Total	22,375	21,408	22,783	23,647	24,832	26,586	3.5
Personal Electronics							
Cameras	2,527	2,206	2,243	2,208	2,213	2,240	-2.4
Clock	679	547	566	573	576	581	-3.1
Electric Toys	3,714	4,673	5,434	5,941	6,531	7,243	14.3
Watches	2,321	2,142	2,209	2,220	2,237	2,261	-0.5
Total	9,242	9,567	10,452	10,943	11,557	12,325	5.9
Appliances							
Air Conditioners	8,072	8,054	8,843	9,332	9,830	10,439	5.3
Microwave Ovens	1,105	992	978	952	896	844	-5.3
Refrigerators	3,566	3,355	3,539	3,643	3,721	3,791	1.2
Washers and Dryers	1,709	1,615	1,694	1,735	1,765	1,802	1.1
Total	14,452	14,016	15,055	15,663	16,212	16,876	3.1
Other Consumer Equipment	7,421	6,878	7,173	7,391	7,504	7,661	0.6
Consumer Total	61,773	59,633	63,750	66,275	69,059	72,849	3.4
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

NA = Not applicable

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.15
Japanese Electronic Equipment Production Forecast—Consumer
(Yen-Based Annual Growth by Percentage)

Equipment Type	1987	1988	1989	1990	1991
Audio					
Audio Amplifiers	0.9	-5.9	-0.5	8.1	2.6
DAD Players	-22.4	13.4	-17.0	17.2	22.9
Radios	-20.1	-3.0	11.1	7.7	23.7
Stereo Sets	-1.5	7.8	20.3	-1.4	30.3
Tape Recorders	-23.1	12.1	-8.3	-11.4	2.6
Headphone Stereos	-17.7	-3.4	13.0	4.1	11.5
Music Instruments	19.2	20.3	-9.5	10.9	3.7
Other Audio Equipment	-14.3	-16.5	-28.5	-9.3	-16.3
Total	-12.2	7.1	-4.4	2.1	11.5
Video					
VCRs	-25.1	-2.5	-6.4	-4.9	-3.7
Video Cameras	15.8	33.5	-4.7	19.8	25.1
Videodisk Players	-4.1	62.5	31.8	39.4	-5.1
Color TVs	5.7	6.4	0.6	6.8	4.1
B/W TVs	-63.6	-75.0	NA	NA	NA
LCD TVs	-35.4	20.4	10.1	33.4	23.8
Total	-11.3	8.2	-2.8	6.3	6.3
Personal Electronics					
Cameras	-10.4	-5.0	6.1	2.3	-0.8
Clock	-8.6	5.4	-4.1	0.6	0.3
Electric Toys	-15.0	75.5	43.2	54.0	-0.7
Watches	-14.4	12.9	0.9	12.1	3.3
Total	-12.2	14.8	12.8	21.3	0.3
Appliances					
Air Conditioners	0.6	18.3	-0.5	10.6	24.6
Microwave Ovens	-11.1	-17.8	-14.8	-7.9	-3.4
Refrigerators	6.8	0.2	-0.3	8.1	6.0
Washers and Dryers	1.8	14.2	7.1	15.4	6.6
Total	0.2	6.9	-1.4	8.5	14.8
Other Consumer Equipment	-1.4	7.6	2.4	5.7	0.8
Consumer Total	-8.0	8.5	-0.1	8.3	7.2

(Continued)

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Table 3.15 (Continued)
Japanese Electronic Equipment Production Forecast—Consumer
(Yen-Based Annual Growth by Percentage)

Equipment Type	1992	1993	1994	1995	1996
Audio					
Audio Amplifiers	-8.2	2.6	-1.2	-0.4	0.5
DAD Players	-3.4	8.8	5.6	5.0	6.5
Radios	-7.2	3.2	-1.7	0.2	1.1
Stereo Sets	-5.4	9.8	6.6	4.9	6.3
Tape Recorders	-6.6	6.3	5.2	4.8	6.7
Headphone Stereos	-7.5	4.6	2.6	2.2	3.0
Music Instruments	-6.0	5.7	3.3	3.0	3.5
Other Audio Equipment	-18.2	5.6	3.4	2.8	3.5
Total	-6.3	6.7	4.2	3.7	5.0
Video					
VCRs	-10.1	-1.7	-3.0	-0.3	2.8
Video Cameras	1.0	13.8	7.3	6.9	7.9
Videodisk Players	0.5	13.0	10.6	10.9	13.3
Color TVs	-4.2	5.6	4.6	5.7	7.5
B/W TVs	NA	NA	NA	NA	NA
LCD TVs	6.2	21.0	17.5	20.4	24.6
Total	-4.3	6.4	3.8	5.0	7.1
Personal Electronics					
Cameras	-12.7	1.7	-1.6	0.2	1.2
Clock	-19.4	3.5	1.2	0.5	0.9
Electric Toys	25.8	16.3	9.3	9.9	10.9
Watches	-7.7	3.1	0.5	0.7	1.1
Total	3.5	9.2	4.7	5.6	6.6
Appliances					
Air Conditioners	-0.2	9.8	5.5	5.3	6.2
Microwave Ovens	-10.2	-1.4	-2.7	-5.9	-5.9
Refrigerators	-5.9	5.5	2.9	2.1	1.9
Washers and Dryers	-5.5	4.9	2.4	1.7	2.1
Total	-3.0	7.4	4.0	3.5	4.1
Other Consumer Equipment	-7.3	4.3	3.0	1.5	2.1
Consumer Total	-3.5	6.9	4.0	4.2	5.5

NA = Not applicable

Source: MITI, Dataquest (September 1992)

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Table 3.16
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Factory Revenue in Billions of Yen)

	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Military/Aerospace	NA	NA	260	252	231	215	NA

(Continued)

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Table 3.16 (Continued)
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Factory Revenue in Billions of Yen)

	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Military/Aerospace	215	213	218	217	219	222	NA

NA = Not applicable

Source: Dataquest (September 1992)

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Table 3.17
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Factory Revenue in Millions of Dollars)

	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Military/Aerospace	NA	NA	2,002	1,825	1,602	1,583	NA
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.17 (Continued)
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Factory Revenue in Millions of Dollars)

	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Military/Aerospace	1,583	1,567	1,603	1,595	1,612	1,635	0.7
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

NA = Not applicable

Source: Dataquest (September 1992)

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Table 3.18
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Yen-Based Annual Growth by Percentage)

	1987	1988	1989	1990	1991
Military/Aerospace	NA	NA	-3.2	-8.4	-6.7

(Continued)

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Table 3.18 (Continued)
Japanese Electronic Equipment Production Forecast—Military/Aerospace
(Yen-Based Annual Growth by Percentage)

	1992	1993	1994	1995	1996
Military/Aerospace	-1.0	2.3	-0.5	1.1	1.4

NA = Not applicable

Source: Dataquest (September 1992)

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Table 3.19
Japanese Electronic Equipment Production Forecast—Transportation
(Factory Revenue in Billions of Yen)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Entertainment	341	353	356	363	388	394	2.9
Control Unit	98	184	222	319	350	347	28.9
Safety and Convenience	495	500	565	588	626	610	4.3
Transportation Total	934	1,037	1,142	1,269	1,364	1,351	7.7

(Continued)

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Table 3.19 (Continued)
Japanese Electronic Equipment Production Forecast—Transportation
(Factory Revenue in Billions of Yen)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Entertainment	394	398	420	444	458	471	3.6
Control Unit	347	355	385	406	424	447	5.2
Safety and Convenience	610	598	627	649	669	695	2.6
Total	1,351	1,351	1,433	1,498	1,552	1,612	3.6

Note: Columns may not add to totals because of rounding.

Source: MITI, Dataquest (September 1992)

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Table 3.20
Japanese Electronic Equipment Production Forecast—Transportation
(Factory Revenue in Millions of Dollars)

Equipment Type	1986	1987	1988	1989	1990	1991	1986-1991 CAGR (%)
Entertainment	2,044	2,451	2,735	2,627	2,696	2,895	7.2
Control Unit	584	1,280	1,705	2,314	2,429	2,551	34.3
Safety and Convenience	2,962	3,471	4,347	4,258	4,344	4,485	8.6
Transportation Total	5,591	7,203	8,788	9,199	9,469	9,931	12.2
Exchange Rate (¥/U.S.$1)	167	144	130	138	144	136	

(Continued)

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Table 3.20 (Continued)
Japanese Electronic Equipment Production Forecast—Transportation
(Factory Revenue in Millions of Dollars)

Equipment Type	1991	1992	1993	1994	1995	1996	1991-1996 CAGR (%)
Entertainment	2,895	2,927	3,091	3,262	3,367	3,461	3.6
Control Unit	2,551	2,613	2,832	2,983	3,121	3,283	5.2
Safety and Convenience	4,485	4,395	4,610	4,773	4,923	5,110	2.6
Transportation Total	9,931	9,935	10,533	11,018	11,411	11,854	3.6
Exchange Rate (¥/U.S.$1)	136	136	136	136	136	136	

Note: Columns may not add to totals because of rounding.
Source: MITI, Dataquest (September 1992)

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Table 3.21
Japanese Electronic Equipment Production Forecast—Transportation
(Yen-Based Annual Growth by Percentage)

Equipment Type	1987	1988	1989	1990	1991
Entertainment	3.4	0.7	1.9	7.1	1.4
Control Unit	88.9	20.2	44.1	9.5	-0.8
Safety and Convenience	1.0	13.1	4.0	6.5	-2.5
Transportation Total	11.1	10.1	11.1	7.4	-0.9

(Continued)

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Table 3.21 (Continued)
Japanese Electronic Equipment Production Forecast—Transportation
(Yen-Based Annual Growth by Percentage)

Equipment Type	1992	1993	1994	1995	1996
Entertainment	1.1	5.6	5.5	3.2	2.8
Control Unit	2.4	8.4	5.3	4.6	5.2
Safety and Convenience	-2.0	4.9	3.5	3.1	3.8
Transportation Total	0.0	6.0	4.6	3.6	3.9

Source: MITI, Dataquest (September 1992)

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Final Japanese Semiconductor Market Share

June 29, 1992

Source:
Dataquest

Market Statistics

Dataquest

Semiconductors *Japan*

SCJA-SVC-MS-9201

Final Japanese Semiconductor Market Share

June 29, 1992

Source:
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Market Statistics

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File behind the *Market Statistics* tab inside the binder labeled Semiconductors *Japan*

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Final Japanese Semiconductor Market Share

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The 1991 Semiconductor Industry in Review

Worldwide Semiconductor Industry Review

Worldwide semiconductor revenue in 1991 was up only 9 percent, the result of the continuation of the protracted recession in the United States as well as the significant political turmoil in Europe. This 9 percent growth rate was an increase over the anemic 1990 rate of 0.4 percent.

The years 1990 and 1991 in the worldwide semiconductor industry have been very slow when compared with the previous 10-year trend (1980 to 1990). Significant events occurring during 1990 and 1991 negatively impacted the industry. Some of these events are as follows:

- Iraq's invasion of Kuwait took more than $40 billion out of the world electronics and semiconductor industries in 1990 and 1991.
- Defense spending declined with the end of the cold war. The U.S. Department of Defense estimates that 300,000 directly and indirectly related jobs will disappear in 1992 and at least a third of this number disappeared in 1991.
- U.S. business failures were 50 percent higher in 1991 than in 1990.
- Japan's economy slid for most of 1991 and took a large drop in the fourth quarter. Many systems and semiconductor companies have reduced staff and restructured their organizations. Most economists believe that the first half of 1992 will continue to decline, further exacerbating the Japanese electronics industry's already poor financial conditions.
- The Organization of Economic Communities and Development (OECD) posted a decline in GDP growth in 1991, relative to 1990. Current estimates are that the GDP for the OECD countries grew only 0.9 percent in 1991.

In 1991, the U.S.-based semiconductor companies lost worldwide share; however, many of these companies continued to lead the world in microprocessors and design-intensive ASIC/ASSP chips. This leadership has enabled them to depend less on manufacturing strength vis-a-vis the Japanese companies and to be less vulnerable to price attrition.

Last year, the Japanese continued their dominance of the DRAM industry but lost share to the Koreans. Samsung, largest by far of the Koreans, jumped into the No. 2 position in DRAMs behind Toshiba.

The Europe-based semiconductor companies as a group lost share in the world market as the largest European company, Philips, continued a massive restructuring started in 1990. Siemens and SGS/Thomson also lost share because their product mixes were not in tune with 1991 growth areas.

Worldwide Market Share and Product Trends

Table 1 shows Dataquest's final 1991 market share rankings. NEC still ranks No. 1, followed by Toshiba. Intel became the No. 3 supplier, overtaking Hitachi and Motorola based on its strength in microprocessors. The fourth-largest semiconductor supplier was Motorola, which passed Hitachi. Motorola's growth was fueled by its CMOS gate arrays, microprocessors, and customer-specific microcontroller products. Texas Instruments also changed ranking this year, moving up to No. 6, ahead of Fujitsu. TI's strength came from its applications-specific products and its digital signal processors.

Table 2 shows that MOS micro was the product enjoying the most growth in 1991. The explosive growth of the 386 family drove this category to a level of 23 percent growth over 1990. The category with the least growth was the digital bipolar family of devices, which declined by 13 percent. Even the discrete devices had a better year than digital bipolar, growing by 5 percent. MOS memory also had a sluggish year as a result of excess capacity and sluggish desktop PC sales.

Table 1
1991 Top 10 Rankings in the Worldwide Semiconductor Market

Company	($M)
1. NEC	4,774
2. Toshiba	4,579
3. Intel	4,019
4. Motorola	3,802
5. Hitachi	3,765
6. Texas Instruments	2,738
7. Fujitsu	2,705
8. Mitsubishi	2,303
9. Matsushita	2,037
10. Philips	2,022

Source: Dataquest (June 1992)

Table 2
1991 Worldwide Semiconductor Market Summary, Growth and Revenue

	1991 Growth (%)	($M)
ICs	10	48,855
MOS Memory	6	12,841
MOS Micro	23	11,774
MOS Logic	15	9,700
Digital Bipolar	-13	3,628
Analog	8	10,912
Discrete	5	8,035
Optoelectronic	16	2,804
Total	9	59,694

Source: Dataquest (June 1992)

North American Semiconductor Industry Review

For all but a few companies 1991 will be remembered as a year of flat revenue and little profit. Intel and AMD were the noteworthy exceptions. These companies participated in the explosive growth of the X86 products, especially the 386. Intel had an incredible year, with sales in North America rising by 14 percent to $1,952 million. AMD revenue increased 6 percent in North America to $547 million, largely because of the success of its Am386DX and Am386SX.

Although the North American market grew by 3 percent, the region lost 1.6 percentage points of worldwide market share to the other faster-growing regions of the world. This is not too surprising, because it is common knowledge that the manufacturing base in the United States is eroding. In the 1950s, 35 percent of the U.S. work force was employed in manufacturing. In the 1970s, 28 percent was in manufacturing. Today the figure is about 17 percent.

The principal applications driver in North America last year was undoubtedly portable electronics products and workstations. Networking of office PCs also had a hand in this growth. Automotive and military electronics lagged.

The past year saw several major changes in the market structure as well as changes with several major companies. These changes are as follows:

- Intel saw several favorable court rulings, including dismissal of a major portion of the antitrust suit filed by AMD, two decisions preventing patent infringers from using licensed founders to avoid infringement, and dismissal of five separate antitrust suits.
- Motorola formed a massive technology alliance with IBM and Apple to jointly design, manufacture, and market a family of RISC microprocessors called PowerPC.
- Charlie Sporck of National Semiconductor retired after 24 years of service and turned over the President and CEO roles to Gil Amelio.
- The ACE consortium lost considerable ground as several key system players chose different strategic directions than they had planned earlier. Digital Equipment Corporation announced in the first quarter of 1992 its own RISC chip called ALPHA; Compaq withdrew from the consortium in second quarter of 1992; and ACE members Convex and Group Bull left in favor of other RISC alliances.
- Memory cards saw high growth paralleling the growth of palmtop and pen-based computers.
- Three-volt devices were introduced as portable systems grew in popularity.
- Seeq joined the ranks of fabless semiconductor companies, putting its fab in mothballs.

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North American Market Share and Product Trends

The No. 1 North American semiconductor supplier in 1991 was Intel, surpassing Motorola for the first time. Intel had domestic revenue of almost $2 billion, a growth rate of 14 percent. Motorola's estimated revenue was $1,883 million, a growth rate of 4 percent.

Intel's X86 architecture is the standard for the principal desktop computing software environment. In 1991 Microsoft (Windows/NT), Sun Microsystems (SunSoft Solaris 2.0), the new Apple/IBM joint venture (Taligent's operating system), and NeXT Inc. (NeXTstep/486) announced that their operating systems will be ported to the Intel architecture. Even though Intel's U.S. business grew 14 percent, its international business exceeded its domestic sales for the first time. Another significant event was Intel's announcement, with IBM, of the formation of the Robert N. Noyce Development Center in Boca Raton, Florida that will design "highly integrated" microprocessors.

Motorola's broad spectrum of product technologies and their ability to produce highly efficient customer solutions enabled the company to expand its customer base in 1991. Motorola is still the world's largest semiconductor supplier to the automotive electronics and industrial markets. It introduced several new products that received wide market acceptance, including 10ns and 12ns, 256Kb, and 1Mb BiCMOS fast static RAMs and the 88204 cache memory management unit. Motorola's 68040 microprocessor also achieved volume production.

Table 3 shows the complete market share ranking for the top 10 companies in the North American market.

Product trends in North America in 1991 were not much different from worldwide trends. Bipolar logic continued its long-term slide, declining 16 percent. MOS microcomponents were the product leader, growing 16 percent, followed by MOS logic. Clearly the PLD growth rate of 32 percent caused MOS logic to have a 7 percent growth. In 1991 we saw a fundamental change in design methodology as electronic manufacturers switched to high-density PLDs in their systems.

MOS memory had a lackluster year because of low desktop sales and price attrition. We estimate that this category grew by only 4 percent. For many companies 1991 was a year for getting positioned for higher growth in 1992, when the United States is expected to crawl out of its recession. Flash memories received much attention because of their nonvolatile properties and the growth of memory cards using this technology. In the hotly contested fast static RAM market, Motorola became the highest-ranking North American supplier. Table 4 shows our product market growth estimates.

Table 3
1991 Top 10 Rankings in the North American Semiconductor Market

Company	($M)
1. Intel	1,952
2. Motorola	1,883
3. Texas Instruments	1,024
4. Toshiba	934
5. National Semiconductor	765
6. AT&T	607
7. Advanced Micro Devices	547
8. NEC	546
9. Hitachi	518
10. LSI Logic	453

Source: Dataquest (June 1992)

Table 4
1991 North American Semiconductor Market Summary, Growth and Revenue

	1991	
	Growth (%)	($M)
ICs	4	15,269
MOS Memory	4	4,510
MOS Micro	16	3,916
MOS Logic	7	2,870
Digital Bipolar	-16	1,331
Analog	0	2,642
Discrete	-14	1,389
Optoelectronic	6	332
Total	3	16,990

Source: Dataquest (June 1992)

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Japanese Semiconductor Industry Review

According to Dataquest's final 1991 semiconductor market share estimates, the Japanese market represented $22,496 million (¥3,059.4 billion), or 38 percent of the worldwide market. On the basis of a dollar value calculation, the Japanese market grew 11 percent over 1990 (4.9 percent based on yen calculation). The major factors affecting the semiconductor industry's growth were as follows:

- Total manufacturing and housing expenditures had negative growth.
- Capital spending that used to be the driving force maintaining high Japanese economic growth lost momentum.

Japanese Market Share and Product Trends

On the basis of a supplier's country of origin, North American companies increased their share of the Japanese market to 12.6 percent in 1991, up from 11.8 percent in 1990. This increase in market penetration was due to U.S. pressure on Japanese systems companies to purchase more devices, as called out in the Semiconductor Trade Agreement. The Japanese market decelerated dramatically in the fourth quarter; the deceleration still continues in 1992. Table 5 lists the top 10 semiconductor companies.

The principal market driver last year in Japan was consumer electronics products, especially video cameras. However, as mentioned earlier, the consumer market turned sluggish in the fourth quarter, as did the other markets.

As usual, the top 10 positions in the ranking of suppliers to the Japanese market were all occupied by Japanese companies. In spite of the many market and product dynamics, no change in the ranking was recorded in 1991.

Companies with strong consumer products such as Sony, Rohm, Sharp, and Matsushita had double-digit growth despite the sluggish fourth-quarter consumer market. Companies with strong computer and industrial products such as Hitachi and Fujitsu did not fare as well. Table 6 shows equipment growth by categories.

Consumer electronic equipment production led total Japanese electronic equipment production. In particular, video cameras, air conditioners, and DAD players were the leading products in the market. Japanese video camera production exported to Europe grew in 1991. As a whole, Japanese electronic equipment had healthy growth in the first and second quarters, but declined in the third and fourth quarters.

Switching our attention to the semiconductor markets, we saw continuation of price erosion in the memory market, which started in 1989. This resulted from the slow PC market and oversupply of 4Mb DRAMs (1Mbx1). Because many Japanese semiconductor manufacturers are heavily dependent on the memory

Table 5
1991 Top 10 Rankings in the Japanese Semiconductor Market

Company	($M)
1. NEC	3,479
2. Hitachi	2,566
3. Toshiba	2,436
4. Fujitsu	1,975
5. Matsushita	1,717
6. Mitsubishi	1,512
7. Sharp	1,070
8. Sanyo	974
9. Sony	946
10. Rohm	760

Source: Dataquest (June 1992)

Table 6
1991 Equipment Growth in Japan, by Category

Category	Growth (%)
Data Processing	3.6
Communication	1.5
Industrial	2.7
Consumer	7.0
Transportation	-0.4
Total	3.9

Source: Dataquest (June 1992)

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products for their revenue, which were very soft, several Japanese companies lost market share.

MOS memory sales of $4,228 million reflected growth of only 1.0 percent, with DRAMs and SRAMs declining by 2 percent and 3 percent, respectively. Nonvolatile memories grew 9.4 percent, in part because of the large and growing video game market. MOS microcontrollers, ASICs, and optoelectronic products also had high growth rates because of the strong consumer market in the first half.

European Semiconductor Industry Review

The European semiconductor market increased from $10,415 million in 1990 to $11,014 million in 1991, a 6 percent increase in dollars. However, strengthening European currencies meant that the actual annual growth rate when measured in European currency units (ECUs) was 8.8 percent.

European Market Share and Product Trends

While the big three Europeans continued to hold the top spots, the headlines went to Intel, which grew its European sales by 23 percent through a substantial increase in microprocessor revenue as the PC migrated from lower-priced 80286s to the more expensive 80386s, and the 80486 established itself.

Because Intel controls 60 percent of the European microprocessor market, it is easy to understand why last year microprocessor was the strongest market in Europe, and indeed worldwide. It should be noted, however, that Intel was not alone. Not surprisingly, AMD more than doubled its European microprocessors sales. Table 7 shows the top 10 semiconductor rankings.

A review of the behavior of various semiconductor product and applications markets last year provides a valuable guide to the reason behind a company's performance. With the consumer market plagued with inventory problems, and the industrial market depressed by prevailing economic conditions, the discrete, microcontroller, and analog markets achieved very little growth, as reflected in the flat sales performances of Philips, SGS-Thomson, Motorola, and National Semiconductor.

Table 7
1991 Top 10 Rankings in the European Semiconductor Market

Company	($M)
1. Philips	1,144
2. Siemens	970
3. SGS-Thomson	855
4. Motorola	776
5. Intel	765
6. Texas Instruments	632
7. Toshiba	441
8. NEC	405
9. National Semiconductor	400
10. Advanced Micro Devices	294

Source: Dataquest (June 1992)

There were a few bright spots in the EDP segment, but overall a slowing PC market and continued restructuring among the big customers in Europe led to slow demand. This resulted in continued price erosion, particularly in memories, as reflected in the sales of Siemens, Texas Instruments, Toshiba, and NEC, which rely on memories for a significant proportion of their revenue.

Major industry events in and about Europe last year included the following:

- The extension of an IBM and Siemens relationship over DRAM, as the companies agreed to cooperate over manufacturing and marketing IBM's 16Mb DRAM.
- The growing reality of how bankrupt the Eastern European states are. This led to a rapid reduction of interest from electronics and semiconductor companies in investment and marketing into the region.
- Fujitsu and TI each completed large 4Mb DRAM fabs, while NEC and Motorola upgraded existing facilities in order to increase local DRAM production. Intel began construction of a $600 million fab project in Ireland, intended to produce state-of-the-art processors by 1994.

Table 8 shows our product market growth estimates.

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Table 8
1991 European Semiconductor Market Summary, Growth and Revenue

	1991	
	Growth (%)	($M)
ICs	7	8,701
MOS Memory	4	2,129
MOS Micro	16	2,082
MOS Logic	20	1,642
Digital Bipolar	-14	486
Analog	2	2,362
Discrete	-4	1,828
Optoelectronic	20	485
Total	6	11,014

Source: Dataquest (June 1992)

Asia/Pacific-Rest of World Semiconductor Industry Review

The results of Dataquest's worldwide semiconductor vendor market share survey indicate that the Asia/Pacific-Rest of World market expanded by 25 percent in 1991 over the previous year and grew to $9,194 billion.

Asia/Pacific-ROW Market Share and Product Trends

In 1991, North American companies competed very successfully and increased market share from 36.6 percent in 1990 to 37.8 in 1991. The less numerous Asia/Pacific companies have made impressive strides in market share, growing from 15.8 percent in 1990 to 17.4 in 1991. European companies have faced severe competition and have been less successful in responding to the Asia/Pacific market forces.

The top-ranking company in the region was Intel, which grew an incredible 75 percent. This high growth was attributed to the explosive growth of microprocessor sales. The No. 2 supplier was Toshiba, which had an excellent year with growth of 31 percent. Because of its fast-growing sales of DRAMs, Samsung grew 14 percent. But this was not good enough in 1991, as it slipped to the No. 3 position. Motorola recorded sales of $651 million, which landed it in fourth place. Philips had sales of $406 million and came in fifth in this region. Table 9 shows the top 10 ranking and our revenue estimates.

During the past two years, the MOS microcomponent product family has replaced MOS memory as the key growth driver and in 1991 it was the largest revenue producer. Also, while memory growth and prices have had wild swings over the last three years, MOS micros have been holding relatively stable but at a very high level. For example, MOS memory's growth from 1987 to 1990 has been 136.2 percent, 168.4 percent, negative 1.9 percent, and 26.8 percent, respectively. MOS micros' growth was 57 percent in 1990 and 55 percent in 1991. Overall the market grew by only 26 percent. Table 10 shows our estimates for the products in this region.

Table 9
1991 Top 10 Rankings in the Asia/Pacific-ROW Semiconductor Market

Company	($M)
1. Intel	832
2. Toshiba	768
3. Samsung	713
4. Motorola	651
5. Philips	406
6. Hitachi	405
7. Texas Instruments	352
8. NEC	344
9. Sanyo	317
10. National Semiconductor	291

Source: Dataquest (June 1992)

Table 10
1991 Asia/Pacific-ROW Semiconductor Market Summary, Growth and Revenue

	1991	
	Growth (%)	($M)
ICs	28	7,608
MOS Memory	27	1,974
MOS Micro	54	2,197
MOS Logic	25	1,114
Digital Bipolar	-7	369
Analog	18	1,954
Discrete	16	1,386
Optoelectronic	0	200
Total	25	9,194

Source: Dataquest (June 1992)

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Final Japanese Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1989-1991 market share estimates

Analyses of market share by company provide insight into high-technology markets and reinforce estimates of consumption, production, and company revenue.

Japanese market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of these data is provided in the *Dataquest Perspectives* located in the binder of the same name.

Segmentation

This section outlines the market segments that are specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For a detailed explanation of Dataquest's market segmentation, refer to the *Dataquest Research and Forecast Methodology* document located in the Source: Dataquest binder. For a complete listing of all market segments tracked by Dataquest, please refer to the *Dataquest High-Technology Guide: Segmentation and Glossary.*

Dataquest defines the semiconductor industry as the group of competing firms primarily engaged in manufacturing semiconductors and related solid-state devices. Important products of the semiconductor industry include integrated circuits, discrete devices, and optoelectronic devices.

For market share purposes, Dataquest defines the semiconductor market according to the following functional segmentation scheme:

Total Semiconductor
- Total Integrated Circuit
  - Bipolar Digital IC
    - Bipolar Digital Memory
    - Bipolar Digital Microcomponent
    - Bipolar Digital Logic
  - MOS Digital IC
    - MOS Digital Memory
    - MOS Digital Microcomponent
    - MOS Digital Logic
  - Analog IC
    - Monolithic Analog
    - Hybrid Analog
- Discrete Semiconductor
- Optoelectronic Semiconductor

Definitions

This section lists the definitions that are used by Dataquest to present the data in this document. Complete definitions for all terms associated with Dataquest's segmentation of the high-technology marketplace can be found in the *Dataquest High-Technology Guide: Segmentation and Glossary.*

Product Definitions

Total Semiconductor (Total IC + Discrete + Optoelectronic). Any active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide) and reacts dynamically to an input

signal, either by modifying its shape or adding energy to it. This definition excludes stand-alone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.

Total Integrated Circuit (Bipolar Digital IC + MOS Digital IC + Monolithic Analog + Hybrid Analog). An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package. A monolithic IC is one in which discrete circuits are integrated onto a single dice, while a hybrid IC is one in which discrete circuits are integrated onto a small number of die.

Bipolar Digital IC (Bipolar Digital Memory + Bipolar Digital Microcomponent + Bipolar Digital Logic). A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data carrying signals vary in discrete values.

Bipolar Digital Memory. Defined as a bipolar digital semiconductor product in which binary data are stored and electronically retrieved. Includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, first-in/first-out (FIFO) memory.

Bipolar Digital Microcomponent. Defined as a bipolar digital semiconductor product that contains a data processing unit or serves as an interface to such a unit. Includes both complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) processor architectures. Includes bipolar digital microprocessor (MPU), bipolar digital microcontroller (MCU), and bipolar digital microperipheral (MPR), where applicable.

Bipolar Digital Logic (Bipolar Application-Specific IC + Bipolar Digital Standard Logic + Other Bipolar Logic). Defined as a bipolar digital semiconductor product in which more than 50 percent of the die area performs logic functions. Excludes bipolar digital microcomponent ICs.

MOS Digital IC (MOS Digital Memory + MOS Digital Microcomponent + MOS Digital Logic). Defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, where any portion of the die area is manufactured using metal oxide semiconductor (MOS) technology. A digital function is one in which data carrying signals vary in discrete values. Includes mixed technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.

MOS Digital Memory IC (DRAM + SRAM + EPROM + Other Nonvolatile MOS Digital Memory + Other MOS Digital Memory). Defined as a MOS digital IC in which binary data are stored and electronically retrieved.

MOS Digital Microcomponent (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral). Defined as a MOS digital IC that contains a data processing unit or serves as an interface to such a unit. Includes both CISC and RISC.

MOS Digital Logic (MOS Digital Application-Specific IC + MOS Digital Standard Logic + Other MOS Logic). Defined as a MOS digital semiconductor product in which more than 50 percent of the die area performs logic functions. Excludes MOS digital microcomponent ICs.

Analog IC (Monolithic Analog + Hybrid Analog).

Monolithic Analog. A monolithic analog IC is a semiconductor product associated with electrical signal processing, power control, or electrical drive capability. Some of its inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes all monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single dice contained in a single package.

Hybrid Analog. A hybrid analog IC is a semiconductor product that consists of more than one dice contained in a single package. A hybrid IC may perform 100 percent linear, 100 percent digital, or mixed-signal (both linear and digital) functions. Note that hybrid digital ICs are reported in this category, and not under monolithic digital ICs. Includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies. Only those hybrids

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are included that are made in the division or other organization whose primary product is semiconductors. Several major manufacturers also manufacture hybrids in other divisions; where we have identified these manufacturers, they are excluded.

Total Discrete (Transistor + Diode + Thyristor + Other Discrete). Defined as a unit building block performing a fundamental semiconductor function.

Total Optoelectronic (LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Solar Cell). Defined as a semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated into the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

Merchant versus Captive Consumption. Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data exclude completely captive suppliers where devices are manufactured solely for the company's own use. A product that is used internally is valued at market price rather than at transfer or factory price.

Regional Definitions

Japan: Japan

Line Item Definition

Factory revenue is defined as the amount of money received by a semiconductor vendor for its goods. Revenue from the sale of semiconductors sold either as finished goods, die, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.

Market Share Methodology

Dataquest utilizes both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of secondary data utilized by Dataquest include:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press
- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other suppliers.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise the numbers of a particular company, model, series, or industry. In this section, any such

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changes contained within this document are outlined for your reference.

Notes to Market Share Tables

1. AAB-HAFO was formerly known as ASEA Brown Boveri.
2. Allegro MicroSystems was formerly known as Sprague Technologies.
3. Analog Devices revenue includes Precision Monolithics revenue from 1991 forward.
4. Appian Technology was formerly known as ZyMOS.
5. In 1989, AT&T revenue previously classified as MOS Logic was reclassified as Analog.
6. Ericsson was known as Rifa prior to March 1, 1988.
7. GEC Plessey revenue includes MEDL and Plessey revenue from 1990 forward.
8. Harris revenue includes GE Solid State revenue from 1989 forward.
9. Inmos revenue is included in SGS-Thomson revenue from 1989 forward.
10. Macronix revenue is included under Asia/Pacific Companies from 1989 forward.
11. Other North American Companies and Other Asia/Pacific Companies revenue has been restated to reflect the fewer number of companies published in 1991.
12. Philips revenue includes Signetics revenue.
13. Vertex (formerly known as Integrated CMOS Systems) revenue is included in Toshiba revenue from 1991 forward.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. The following outlines these rates for 1989 through 1991.

	1989	1990	1991
Japan (Yen/U.S.$)	138	144	136
France (Franc/U.S.$)	6.39	5.44	5.64
Germany (Deutsche Mark/U.S.$)	1.88	1.62	1.66
United Kingdom (U.S.$/ Pound Sterling)	1.50	1.79	1.77

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Table 1-1
Factory Revenue from Shipments of All Products to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Semiconductor						
North American Companies	2,143	2,388	2,833	10.0	11.8	12.6
Japanese Companies	19,141	17,599	19,337	89.1	86.9	86.0
European Companies	122	152	167	.6	.8	.7
Asia/Pacific Companies	85	118	159	.4	.6	.7
Total Market	21,491	20,257	22,496	100.0	100.0	100.0
Total Integrated Circuit						
North American Companies	2,068	2,276	2,681	12.3	14.4	15.5
Japanese Companies	14,614	13,273	14,299	86.7	84.0	82.8
European Companies	104	138	151	.6	.9	.9
Asia/Pacific Companies	74	107	146	.4	.7	.8
Total Market	16,860	15,794	17,277	100.0	100.0	100.0
Bipolar Digital						
North American Companies	375	347	283	22.8	21.2	19.6
Japanese Companies	1,246	1,269	1,139	75.6	77.6	79.0
European Companies	26	18	19	1.6	1.1	1.3
Asia/Pacific Companies	1	1	1	.1	.1	.1
Total Market	1,648	1,635	1,442	100.0	100.0	100.0
Bipolar Digital Memory						
North American Companies	20	15	7	10.5	7.7	4.2
Japanese Companies	169	178	157	88.5	91.8	95.2
European Companies	2	1	1	1.0	.5	.6
Asia/Pacific Companies	0	0	0	.0	.0	.0
Total Market	191	194	165	100.0	100.0	100.0
Bipolar Digital Logic						
North American Companies	355	321	269	24.4	22.4	21.2
Japanese Companies	1,077	1,091	982	73.9	76.3	77.3
European Companies	24	17	18	1.6	1.2	1.4
Asia/Pacific Companies	1	1	1	.1	.1	.1
Total Market	1,457	1,430	1,270	100.0	100.0	100.0
MOS Digital						
North American Companies	1,180	1,400	1,780	10.1	13.1	15.0
Japanese Companies	10,339	9,119	9,909	88.9	85.5	83.4
European Companies	53	63	75	.5	.6	.6

(Continued)

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Table 1-1 (Continued)
Factory Revenue from Shipments of All Products to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Asia/Pacific Companies	64	78	117	.6	.7	1.0
Total Market	11,636	10,660	11,881	100.0	100.0	100.0
MOS Memory						
North American Companies	421	406	470	7.5	9.7	11.1
Japanese Companies	5,131	3,694	3,621	91.2	88.0	85.6
European Companies	17	23	27	.3	.5	.6
Asia/Pacific Companies	60	73	110	1.1	1.7	2.6
Total Market	5,629	4,196	4,228	100.0	100.0	100.0
MOS Microcomponents						
North American Companies	495	632	815	18.6	21.3	22.8
Japanese Companies	2,144	2,327	2,745	80.5	78.2	76.7
European Companies	23	15	19	.9	.5	.5
Asia/Pacific Companies	0	0	0	.0	.0	.0
Total Market	2,662	2,974	3,579	100.0	100.0	100.0
MOS Logic						
North American Companies	264	362	495	7.9	10.4	12.2
Japanese Companies	3,064	3,098	3,543	91.6	88.8	87.0
European Companies	13	25	29	.4	.7	.7
Asia/Pacific Companies	4	5	7	.1	.1	.2
Total Market	3,345	3,490	4,074	100.0	100.0	100.0
Analog						
North American Companies	513	529	618	14.3	15.1	15.6
Japanese Companies	3,029	2,885	3,251	84.7	82.5	82.2
European Companies	25	57	57	.7	1.6	1.4
Asia/Pacific Companies	9	28	28	.3	.8	.7
Total Market	3,576	3,499	3,954	100.0	100.0	100.0
Total Discrete						
North American Companies	57	80	103	1.9	2.7	3.0
Japanese Companies	3,001	2,870	3,305	97.4	96.7	96.3
European Companies	12	11	14	.4	.4	.4
Asia/Pacific Companies	10	8	10	.3	.3	.3
Total Market	3,080	2,969	3,432	100.0	100.0	100.0
Total Optoelectronic						
North American Companies	18	7	0	1.2	.6	.0

(Continued)

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Table 1-1 (Continued)
Factory Revenue from Shipments of All Products to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	1,525	1,250	1,702	98.4	99.0	99.9
European Companies	6	3	0	.4	.2	.0
Asia/Pacific Companies	1	3	1	.1	.2	.1
Total Market	1,550	1,263	1,703	100.0	100.0	100.0

Source: Dataquest (June 1992)

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Table 1-2
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	21,491	20,257	22,496	100.0	100.0	100.0
North American Companies	2,143	2,388	2,833	10.0	11.8	12.6
Actel	1	1	4	.0	.0	.0
Advanced Micro Devices	143	139	135	.7	.7	.6
Allegro MicroSystems	5	4	6	.0	.0	.0
Altera	7	10	21	.0	.0	.1
Analog Devices	59	42	52	.3	.2	.2
Appian Technology	0	1	1	.0	.0	.0
Applied Micro Circuits Corp.	0	0	1	.0	.0	.0
AT&T	0	7	14	.0	.0	.1
Atmel	13	7	9	.1	.0	.0
Brooktree	4	7	7	.0	.0	.0
Burr-Brown	50	49	56	.2	.2	.2
Catalyst	10	9	13	.0	.0	.1
Chips & Technologies	18	19	18	.1	.1	.1
Cirrus Logic	2	23	23	.0	.1	.1
Crystal	1	0	2	.0	.0	.0
Cypress Semiconductor	9	11	14	.0	.1	.1
Dallas Semiconductor	1	1	0	.0	.0	.0
Elantec	2	3	3	.0	.0	.0
Exar	5	19	46	.0	.1	.2
General Instrument	16	23	24	.1	.1	.1
Gennum	2	2	2	.0	.0	.0
Gould AMI	5	4	5	.0	.0	.0
Harris	36	41	25	.2	.2	.1
Hewlett Packard	20	17	23	.1	.1	.1
Honeywell	0	4	4	.0	.0	.0
Integrated Device Technology	15	20	6	.1	.1	.0
Intel	301	367	470	1.4	1.8	2.1
Int'l Microelectronic Prod.	1	0	0	.0	.0	.0
International Rectifier	5	14	20	.0	.1	.1
ITT	25	25	25	.1	.1	.1
Lattice	4	9	10	.0	.0	.0
Linear Technology	8	10	12	.0	.0	.1
LSI Logic	51	58	77	.2	.3	.3
Maxim	9	12	14	.0	.1	.1
Microchip Technology	9	4	20	.0	.0	.1
Micro Linear	1	1	0	.0	.0	.0
Micron Technology	2	2	16	.0	.0	.1

(Continued)

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Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Micro Power Systems	3	4	4	.0	.0	.0
Mitel	0	10	8	.0	.0	.0
MOSel	1	9	25	.0	.0	.1
Motorola	353	436	492	1.6	2.2	2.2
NCR	0	3	4	.0	.0	.0
National Semiconductor	140	139	146	.7	.7	.6
Optek	0	7	0	.0	.0	.0
Performance Semiconductor	1	1	1	.0	.0	.0
Precision Monolithics	5	6	0	.0	.0	.0
Raytheon	0	4	3	.0	.0	.0
Rockwell	100	80	83	.5	.4	.4
SEEQ Technology	4	5	5	.0	.0	.0
Sierra Semiconductor	0	2	3	.0	.0	.0
Siliconix	6	5	8	.0	.0	.0
Silicon Systems	15	23	26	.1	.1	.1
Sipex	1	1	1	.0	.0	.0
Standard Microsystems	1	1	1	.0	.0	.0
Supertex	8	5	10	.0	.0	.0
Teledyne	2	2	2	.0	.0	.0
Texas Instruments	608	614	730	2.8	3.0	3.2
TRW	0	2	2	.0	.0	.0
Unitrode	3	1	1	.0	.0	.0
Vitelic	3	2	5	.0	.0	.0
VLSI Technology	7	8	21	.0	.0	.1
WaferScale Integration	0	0	4	.0	.0	.0
Weitek	4	4	6	.0	.0	.0
Western Digital	11	13	23	.1	.1	.1
Xicor	8	5	13	.0	.0	.1
Xilinx	5	12	15	.0	.1	.1
Zilog	5	6	7	.0	.0	.0
Other North American Companies	9	13	6	.0	.1	.0
Japanese Companies	19,141	17,599	19,337	89.1	86.9	86.0
Fuji Electric	256	254	256	1.2	1.3	1.1
Fujitsu	1,975	1,856	1,975	9.2	9.2	8.8
Hitachi	2,475	2,441	2,566	11.5	12.1	11.4
Matsushita	1,469	1,491	1,717	6.8	7.4	7.6
Mitsubishi	1,748	1,461	1,512	8.1	7.2	6.7
NEC	3,165	3,106	3,479	14.7	15.3	15.5
New JRC	146	119	132	.7	.6	.6

(Continued)

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Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
NMB Semiconductor	24	16	8	.1	.1	.0
Oki	615	561	556	2.9	2.8	2.5
Ricoh	81	89	94	.4	.4	.4
Rohm	592	629	760	2.8	3.1	3.4
Sanken	286	300	357	1.3	1.5	1.6
Sanyo	976	885	974	4.5	4.4	4.3
Seiko Epson	277	134	143	1.3	.7	.6
Sharp	896	956	1,070	4.2	4.7	4.8
Shindengen Electric	148	144	166	.7	.7	.7
Sony	806	778	946	3.8	3.8	4.2
Toko	46	54	41	.2	.3	.2
Toshiba	2,342	2,205	2,436	10.9	10.9	10.8
Yamaha	120	120	123	.6	.6	.5
Other Japanese Companies	698	0	26	3.2	.0	.1
European Companies	122	152	167	.6	.8	.7
ABB-HAFO	2	2	0	.0	.0	.0
Ericsson	2	2	3	.0	.0	.0
Eurosil	1	1	1	.0	.0	.0
GEC Plessey	0	16	9	.0	.1	.0
Matra MHS	1	1	0	.0	.0	.0
Philips	61	67	77	.3	.3	.3
Plessey	8	0	0	.0	.0	.0
SGS-Thomson	22	38	48	.1	.2	.2
Siemens	22	21	25	.1	.1	.1
Telefunken Electronic	2	4	2	.0	.0	.0
TMS	1	0	0	.0	.0	.0
Other European Companies	0	0	2	.0	.0	.0
Asia/Pacific Companies	85	118	159	.4	.6	.7
Goldstar	5	16	21	.0	.1	.1
Hyundai	3	2	5	.0	.0	.0
Korean Electronic Co.	8	12	11	.0	.1	.0
Macronix	8	1	6	.0	.0	.0
Samsung	59	60	83	.3	.3	.4
United Microelectronics	2	1	8	.0	.0	.0
Winbond Electronics	NA	3	1	NA	.0	.0
Other Asia/Pacific Companies	0	23	24	.0	.1	.1

NA = Not available

Source: Dataquest (June 1992)

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Table 1-3
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	2,965.8	2,917.0	3,059.5	100.0	100.0	100.0
North American Companies	295.7	343.9	385.3	10.0	11.8	12.6
Actel	.1	.1	.5	.0	.0	.0
Advanced Micro Devices	19.7	20.0	18.4	.7	.7	.6
Allegro MicroSystems	.7	.6	.8	.0	.0	.0
Altera	1.0	1.4	2.9	.0	.0	.1
Analog Devices	8.1	6.0	7.1	.3	.2	.2
Appian Technology	.0	.1	.1	.0	.0	.0
Applied Micro Circuits Corp.	.0	.0	.1	.0	.0	.0
AT&T	.0	1.0	1.9	.0	.0	.1
Atmel	1.8	1.0	1.2	.1	.0	.0
Brooktree	.6	1.0	1.0	.0	.0	.0
Burr-Brown	6.9	7.1	7.6	.2	.2	.2
Catalyst	1.4	1.3	1.8	.0	.0	.1
Chips & Technologies	2.5	2.7	2.4	.1	.1	.1
Cirrus Logic	.3	3.3	3.1	.0	.1	.1
Crystal	.1	.0	.3	.0	.0	.0
Cypress Semiconductor	1.2	1.6	1.9	.0	.1	.1
Dallas Semiconductor	.1	.1	.0	.0	.0	.0
Elantec	.3	.4	.4	.0	.0	.0
Exar	.7	2.7	6.3	.0	.1	.2
General Instrument	2.2	3.3	3.3	.1	.1	.1
Gennum	.3	.3	.3	.0	.0	.0
Gould AMI	.7	.6	.7	.0	.0	.0
Harris	5.0	5.9	3.4	.2	.2	.1
Hewlett Packard	2.8	2.4	3.1	.1	.1	.1
Honeywell	.0	.6	.5	.0	.0	.0
Integrated Device Technology	2.1	2.9	.8	.1	.1	.0
Intel	41.5	52.8	63.9	1.4	1.8	2.1
Int'l Microelectronic Prod.	.1	.0	.0	.0	.0	.0
International Rectifier	.7	2.0	2.7	.0	.1	.1
ITT	3.5	3.6	3.4	.1	.1	.1
Lattice	.6	1.3	1.4	.0	.0	.0
Linear Technology	1.1	1.4	1.6	.0	.0	.1
LSI Logic	7.0	8.4	10.5	.2	.3	.3
Maxim	1.2	1.7	1.9	.0	.1	.1
Microchip Technology	1.2	.6	2.7	.0	.0	.1
Micro Linear	.1	.1	.0	.0	.0	.0

(Continued)

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Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Micron Technology	.3	.3	2.2	.0	.0	.1
Micro Power Systems	.4	.6	.5	.0	.0	.0
Mitel	.0	1.4	1.1	.0	.0	.0
MOSel	.1	1.3	3.4	.0	.0	.1
Motorola	48.7	62.8	66.9	1.6	2.2	2.2
NCR	.0	.4	.5	.0	.0	.0
National Semiconductor	19.3	20.0	19.9	.7	.7	.7
Optek	.0	1.0	.0	.0	.0	.0
Performance Semiconductor	.1	.1	.1	.0	.0	.0
Precision Monolithics	.7	.9	.0	.0	.0	.0
Raytheon	.0	.6	.4	.0	.0	.0
Rockwell	13.8	11.5	11.3	.5	.4	.4
SEEQ Technology	.6	.7	.7	.0	.0	.0
Sierra Semiconductor	.0	.3	.4	.0	.0	.0
Siliconix	.8	.7	1.1	.0	.0	.0
Silicon Systems	2.1	3.3	3.5	.1	.1	.1
Sipex	.1	.1	.1	.0	.0	.0
Standard Microsystems	.1	.1	.1	.0	.0	.0
Supertex	1.1	.7	1.4	.0	.0	.0
Teledyne	.3	.3	.3	.0	.0	.0
Texas Instruments	83.9	88.4	99.3	2.8	3.0	3.2
TRW	.0	.3	.3	.0	.0	.0
Unitrode	.4	.1	.1	.0	.0	.0
Vitelic	.4	.3	.7	.0	.0	.0
VLSI Technology	1.0	1.2	2.9	.0	.0	.1
WaferScale Integration	.0	.0	.5	.0	.0	.0
Weitek	.6	.6	.8	.0	.0	.0
Western Digital	1.5	1.9	3.1	.1	.1	.1
Xicor	1.1	.7	1.8	.0	.0	.1
Xilinx	.7	1.7	2.0	.0	.1	.1
Zilog	.7	.9	1.0	.0	.0	.0
Other North American Companies	1.2	1.9	.8	.0	.1	.0
Japanese Companies	2,641.5	2,534.3	2,629.8	89.1	86.9	86.0
Fuji Electric	35.3	36.6	34.8	1.2	1.3	1.1
Fujitsu	272.6	267.3	268.6	9.2	9.2	8.8
Hitachi	341.6	351.5	349.0	11.5	12.1	11.4
Matsushita	202.7	214.7	233.5	6.8	7.4	7.6
Mitsubishi	241.2	210.4	205.6	8.1	7.2	6.7

(Continued)

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Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
NEC	436.8	447.3	473.1	14.7	15.3	15.5
New JRC	20.1	17.1	18.0	.7	.6	.6
NMB Semiconductor	3.3	2.3	1.1	.1	.1	.0
Oki	84.9	80.8	75.6	2.9	2.8	2.5
Ricoh	11.2	12.8	12.8	.4	.4	.4
Rohm	81.7	90.6	103.4	2.8	3.1	3.4
Sanken	39.5	43.2	48.6	1.3	1.5	1.6
Sanyo	134.7	127.4	132.5	4.5	4.4	4.3
Seiko Epson	38.2	19.3	19.4	1.3	.7	.6
Sharp	123.6	137.7	145.5	4.2	4.7	4.8
Shindengen Electric	20.4	20.7	22.6	.7	.7	.7
Sony	111.2	112.0	128.7	3.7	3.8	4.2
Toko	6.3	7.8	5.6	.2	.3	.2
Toshiba	323.2	317.5	331.3	10.9	10.9	10.8
Yamaha	16.6	17.3	16.7	.6	.6	.5
Other Japanese Companies	96.3	.0	3.5	3.2	.0	.1
European Companies	16.8	21.9	22.7	.6	.8	.7
ABB-HAFO	.3	.3	.0	.0	.0	.0
Ericsson	.3	.3	.4	.0	.0	.0
Eurosil	.1	.1	.1	.0	.0	.0
GEC Plessey	.0	2.3	1.2	.0	.1	.0
Matra MHS	.1	.1	.0	.0	.0	.0
Philips	8.4	9.6	10.5	.3	.3	.3
Plessey	1.1	.0	.0	.0	.0	.0
SGS-Thomson	3.0	5.5	6.5	.1	.2	.2
Siemens	3.0	3.0	3.4	.1	.1	.1
Telefunken Electronic	.3	.6	.3	.0	.0	.0
TMS	.1	.0	.0	.0	.0	.0
Other European Companies	.0	.0	.3	.0	.0	.0
Asia/Pacific Companies	11.7	17.0	21.6	.4	.6	.7
Goldstar	.7	2.3	2.9	.0	.1	.1
Hyundai	.4	.3	.7	.0	.0	.0
Korean Electronic Co.	1.1	1.7	1.5	.0	.1	.0
Macronix	1.1	.1	.8	.0	.0	.0
Samsung	8.1	8.6	11.3	.3	.3	.4
United Microelectronics	.3	.1	1.1	.0	.0	.0

(Continued)

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Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Winbond Electronics	NA	.4	.1	NA	.0	.0
Other Asia/Pacific Companies	.0	3.3	3.3	.0	.1	.1
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-4
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	16,860	15,794	17,277	100.0	100.0	100.0
North American Companies	2,068	2,276	2,681	12.3	14.4	15.5
Actel	1	1	4	.0	.0	.0
Advanced Micro Devices	143	139	135	.8	.9	.8
Allegro MicroSystems	5	4	6	.0	.0	.0
Altera	7	10	21	.0	.1	.1
Analog Devices	59	42	52	.3	.3	.3
Appian Technology	0	1	1	.0	.0	.0
Applied Micro Circuits Corp.	0	0	1	.0	.0	.0
AT&T	0	7	14	.0	.0	.1
Atmel	13	7	9	.1	.0	.1
Brooktree	4	7	7	.0	.0	.0
Burr-Brown	50	49	56	.3	.3	.3
Catalyst	10	9	13	.1	.1	.1
Chips & Technologies	18	19	18	.1	.1	.1
Cirrus Logic	2	23	23	.0	.1	.1
Crystal	1	0	2	.0	.0	.0
Cypress Semiconductor	9	11	14	.1	.1	.1
Dallas Semiconductor	1	1	0	.0	.0	.0
Elantec	2	3	3	.0	.0	.0
Exar	5	19	46	.0	.1	.3
Gennum	2	2	2	.0	.0	.0
Gould AMI	5	4	5	.0	.0	.0
Harris	32	35	24	.2	.2	.1
Hewlett Packard	NA	2	2	NA	.0	.0
Honeywell	0	4	4	.0	.0	.0
Integrated Device Technology	15	20	6	.1	.1	.0
Intel	301	367	470	1.8	2.3	2.7
Int'l Microelectronic Prod.	1	0	0	.0	.0	.0
ITT	15	15	10	.1	.1	.1
Lattice	4	9	10	.0	.1	.1
Linear Technology	8	10	12	.0	.1	.1
LSI Logic	51	58	77	.3	.4	.4
Maxim	9	12	14	.1	.1	.1
Microchip Technology	9	4	20	.1	.0	.1
Micro Linear	1	1	0	.0	.0	.0
Micron Technology	2	2	16	.0	.0	.1
Micro Power Systems	3	4	4	.0	.0	.0
Mitel	0	10	8	.0	.1	.0

(Continued)

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Table 1-4 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
MOSel	1	9	25	.0	.1	.1
Motorola	341	413	457	2.0	2.6	2.6
NCR	0	3	4	.0	.0	.0
National Semiconductor	140	139	145	.8	.9	.8
Performance Semiconductor	1	1	1	.0	.0	.0
Precision Monolithics	5	6	0	.0	.0	.0
Raytheon	0	4	3	.0	.0	.0
Rockwell	100	80	83	.6	.5	.5
SEEQ Technology	4	5	5	.0	.0	.0
Sierra Semiconductor	0	2	3	.0	.0	.0
Siliconix	4	3	5	.0	.0	.0
Silicon Systems	15	23	26	.1	.1	.2
Sipex	1	1	1	.0	.0	.0
Standard Microsystems	1	1	1	.0	.0	.0
Supertex	7	4	8	.0	.0	.0
Teledyne	2	2	2	.0	.0	.0
Texas Instruments	606	604	701	3.6	3.8	4.1
TRW	0	2	2	.0	.0	.0
Unitrode	2	0	0	.0	.0	.0
Vitelic	3	2	5	.0	.0	.0
VLSI Technology	7	8	21	.0	.1	.1
WaferScale Integration	0	0	4	.0	.0	.0
Weitek	4	4	6	.0	.0	.0
Western Digital	11	13	23	.1	.1	.1
Xicor	8	5	13	.0	.0	.1
Xilinx	5	12	15	.0	.1	.1
Zilog	5	6	7	.0	.0	.0
Other North American Companies	7	13	6	.0	.1	.0
Japanese Companies	14,614	13,273	14,299	86.7	84.0	82.8
Fuji Electric	57	59	48	.3	.4	.3
Fujitsu	1,838	1,714	1,785	10.9	10.9	10.3
Hitachi	1,948	1,933	2,039	11.6	12.2	11.8
Matsushita	928	945	1,102	5.5	6.0	6.4
Mitsubishi	1,452	1,234	1,233	8.6	7.8	7.1
NEC	2,670	2,629	2,945	15.8	16.6	17.0
New JRC	132	105	116	.8	.7	.7
NMB Semiconductor	24	16	8	.1	.1	.0
Oki	576	524	518	3.4	3.3	3.0
Ricoh	81	89	94	.5	.6	.5

(Continued)

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Table 1-4 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Rohm	267	278	343	1.6	1.8	2.0
Sanken	116	119	131	.7	.8	.8
Sanyo	692	595	600	4.1	3.8	3.5
Seiko Epson	277	134	143	1.6	.8	.8
Sharp	648	706	766	3.8	4.5	4.4
Shindengen Electric	33	26	50	.2	.2	.3
Sony	499	486	600	3.0	3.1	3.5
Toko	42	49	24	.2	.3	.1
Toshiba	1,623	1,512	1,630	9.6	9.6	9.4
Yamaha	120	120	123	.7	.8	.7
Other Japanese Companies	591	0	1	3.5	.0	.0
European Companies	104	138	151	.6	.9	.9
Ericsson	2	2	3	.0	.0	.0
Eurosil	1	1	1	.0	.0	.0
GEC Plessey	0	16	9	.0	.1	.1
Matra MHS	1	1	0	.0	.0	.0
Philips	59	64	73	.3	.4	.4
Plessey	8	0	0	.0	.0	.0
SGS-Thomson	20	33	43	.1	.2	.2
Siemens	11	17	20	.1	.1	.1
Telefunken Electronic	2	4	2	.0	.0	.0
Asia/Pacific Companies	74	107	146	.4	.7	.8
Goldstar	5	16	21	.0	.1	.1
Hyundai	3	2	5	.0	.0	.0
Korean Electronic Co.	1	5	4	.0	.0	.0
Macronix	8	1	6	.0	.0	.0
Samsung	55	58	79	.3	.4	.5
United Microelectronics	2	1	8	.0	.0	.0
Winbond Electronics	NA	3	1	NA	.0	.0
Other Asia/Pacific Companies	0	21	22	.0	.1	.1

NA = Not available

Source: Dataquest (June 1992)

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Table 1-5
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	2,326.7	2,274.3	2,349.7	100.0	100.0	100.0
North American Companies	285.4	327.7	364.6	12.3	14.4	15.5
Actel	.1	.1	.5	.0	.0	.0
Advanced Micro Devices	19.7	20.0	18.4	.8	.9	.8
Allegro MicroSystems	.7	.6	.8	.0	.0	.0
Altera	1.0	1.4	2.9	.0	.1	.1
Analog Devices	8.1	6.0	7.1	.3	.3	.3
Appian Technology	.0	.1	.1	.0	.0	.0
Applied Micro Circuits Corp.	.0	.0	.1	.0	.0	.0
AT&T	.0	1.0	1.9	.0	.0	.1
Atmel	1.8	1.0	1.2	.1	.0	.1
Brooktree	.6	1.0	1.0	.0	.0	.0
Burr-Brown	6.9	7.1	7.6	.3	.3	.3
Catalyst	1.4	1.3	1.8	.1	.1	.1
Chips & Technologies	2.5	2.7	2.4	.1	.1	.1
Cirrus Logic	.3	3.3	3.1	.0	.1	.1
Crystal	.1	.0	.3	.0	.0	.0
Cypress Semiconductor	1.2	1.6	1.9	.1	.1	.1
Dallas Semiconductor	.1	.1	.0	.0	.0	.0
Elantec	.3	.4	.4	.0	.0	.0
Exar	.7	2.7	6.3	.0	.1	.3
Gennum	.3	.3	.3	.0	.0	.0
Gould AMI	.7	.6	.7	.0	.0	.0
Harris	4.4	5.0	3.3	.2	.2	.1
Hewlett Packard	NA	.3	.3	NA	.0	.0
Honeywell	.0	.6	.5	.0	.0	.0
Integrated Device Technology	2.1	2.9	.8	.1	.1	.0
Intel	41.5	52.8	63.9	1.8	2.3	2.7
Int'l Microelectronic Prod.	.1	.0	.0	.0	.0	.0
ITT	2.1	2.2	1.4	.1	.1	.1
Lattice	.6	1.3	1.4	.0	.1	.1
Linear Technology	1.1	1.4	1.6	.0	.1	.1
LSI Logic	7.0	8.4	10.5	.3	.4	.4
Maxim	1.2	1.7	1.9	.1	.1	.1
Microchip Technology	1.2	.6	2.7	.1	.0	.1
Micro Linear	.1	.1	.0	.0	.0	.0
Micron Technology	.3	.3	2.2	.0	.0	.1
Micro Power Systems	.4	.6	.5	.0	.0	.0
Mitel	.0	1.4	1.1	.0	.1	.0

(Continued)

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Table 1-5 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
MOSel	.1	1.3	3.4	.0	.1	.1
Motorola	47.1	59.5	62.2	2.0	2.6	2.6
NCR	.0	.4	.5	.0	.0	.0
National Semiconductor	19.3	20.0	19.7	.8	.9	.8
Performance Semiconductor	.1	.1	.1	.0	.0	.0
Precision Monolithics	.7	.9	.0	.0	.0	.0
Raytheon	.0	.6	.4	.0	.0	.0
Rockwell	13.8	11.5	11.3	.6	.5	.5
SEEQ Technology	.6	.7	.7	.0	.0	.0
Sierra Semiconductor	.0	.3	.4	.0	.0	.0
Siliconix	.6	.4	.7	.0	.0	.0
Silicon Systems	2.1	3.3	3.5	.1	.1	.1
Sipex	.1	.1	.1	.0	.0	.0
Standard Microsystems	.1	.1	.1	.0	.0	.0
Supertex	1.0	.6	1.1	.0	.0	.0
Teledyne	.3	.3	.3	.0	.0	.0
Texas Instruments	83.6	87.0	95.3	3.6	3.8	4.1
TRW	.0	.3	.3	.0	.0	.0
Unitrode	.3	.0	.0	.0	.0	.0
Vitelic	.4	.3	.7	.0	.0	.0
VLSI Technology	1.0	1.2	2.9	.0	.1	.1
WaferScale Integration	.0	.0	.5	.0	.0	.0
Weitek	.6	.6	.8	.0	.0	.0
Western Digital	1.5	1.9	3.1	.1	.1	.1
Xicor	1.1	.7	1.8	.0	.0	.1
Xilinx	.7	1.7	2.0	.0	.1	.1
Zilog	.7	.9	1.0	.0	.0	.0
Other North American Companies	1.0	1.9	.8	.0	.1	.0
Japanese Companies	2,016.7	1,911.3	1,944.7	86.7	84.0	82.8
Fuji Electric	7.9	8.5	6.5	.3	.4	.3
Fujitsu	253.6	246.8	242.8	10.9	10.9	10.3
Hitachi	268.8	278.4	277.3	11.6	12.2	11.8
Matsushita	128.1	136.1	149.9	5.5	6.0	6.4
Mitsubishi	200.4	177.7	167.7	8.6	7.8	7.1
NEC	368.5	378.6	400.5	15.8	16.6	17.0
New JRC	18.2	15.1	15.8	.8	.7	.7
NMB Semiconductor	3.3	2.3	1.1	.1	.1	.0
Oki	79.5	75.5	70.4	3.4	3.3	3.0
Ricoh	11.2	12.8	12.8	.5	.6	.5

(Continued)

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Table 1-5 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Rohm	36.8	40.0	46.6	1.6	1.8	2.0
Sanken	16.0	17.1	17.8	.7	.8	.8
Sanyo	95.5	85.7	81.6	4.1	3.8	3.5
Seiko Epson	38.2	19.3	19.4	1.6	.8	.8
Sharp	89.4	101.7	104.2	3.8	4.5	4.4
Shindengen Electric	4.6	3.7	6.8	.2	.2	.3
Sony	68.9	70.0	81.6	3.0	3.1	3.5
Toko	5.8	7.1	3.3	.2	.3	.1
Toshiba	224.0	217.7	221.7	9.6	9.6	9.4
Yamaha	16.6	17.3	16.7	.7	.8	.7
Other Japanese Companies	81.6	.0	.1	3.5	.0	.0
European Companies	14.4	19.9	20.5	.6	.9	.9
Ericsson	.3	.3	.4	.0	.0	.0
Eurosil	.1	.1	.1	.0	.0	.0
GEC Plessey	.0	2.3	1.2	.0	.1	.1
Matra MHS	.1	.1	.0	.0	.0	.0
Philips	8.1	9.2	9.9	.3	.4	.4
Plessey	1.1	.0	.0	.0	.0	.0
SGS-Thomson	2.8	4.8	5.8	.1	.2	.2
Siemens	1.5	2.4	2.7	.1	.1	.1
Telefunken Electronic	.3	.6	.3	.0	.0	.0
Asia/Pacific Companies	10.2	15.4	19.9	.4	.7	.8
Goldstar	.7	2.3	2.9	.0	.1	.1
Hyundai	.4	.3	.7	.0	.0	.0
Korean Electronic Co.	.1	.7	.5	.0	.0	.0
Macronix	1.1	.1	.8	.0	.0	.0
Samsung	7.6	8.4	10.7	.3	.4	.5
United Microelectronics	.3	.1	1.1	.0	.0	.0
Winbond Electronics	NA	.4	.1	NA	.0	.0
Other Asia/Pacific Companies	.0	3.0	3.0	.0	.1	.1
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-6
Each Company's Factory Revenue from Shipments of Bipolar Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,648	1,635	1,442	100.0	100.0	100.0
North American Companies	375	347	283	22.8	21.2	19.6
Advanced Micro Devices	59	47	31	3.6	2.9	2.1
Applied Micro Circuits Corp.	0	0	1	.0	.0	.1
Chips & Technologies	1	1	1	.1	.1	.1
Intel	1	0	0	.1	.0	.0
Motorola	56	55	53	3.4	3.4	3.7
National Semiconductor	65	59	48	3.9	3.6	3.3
Raytheon	0	1	1	.0	.1	.1
Texas Instruments	193	184	148	11.7	11.3	10.3
Japanese Companies	1,246	1,269	1,139	75.6	77.6	79.0
Fujitsu	420	456	357	25.5	27.9	24.8
Hitachi	324	342	353	19.7	20.9	24.5
Matsushita	12	11	12	.7	.7	.8
Mitsubishi	105	83	75	6.4	5.1	5.2
NEC	206	205	215	12.5	12.5	14.9
New JRC	1	1	1	.1	.1	.1
Oki	46	41	39	2.8	2.5	2.7
Rohm	1	1	0	.1	.1	.0
Sanyo	56	53	0	3.4	3.2	.0
Toshiba	75	76	87	4.6	4.6	6.0
European Companies	26	18	19	1.6	1.1	1.3
GEC Plessey	0	4	2	.0	.2	.1
Philips	22	14	17	1.3	.9	1.2
Plessey	4	0	0	.2	.0	.0
Asia/Pacific Companies	1	1	1	.1	.1	.1
Goldstar	1	1	1	.1	.1	.1

Source: Dataquest (June 1992)

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Table 1-7
Each Company's Factory Revenue from Shipments of Bipolar Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	227.4	235.4	196.1	100.0	100.0	100.0
North American Companies	51.8	50.0	38.5	22.8	21.2	19.6
Advanced Micro Devices	8.1	6.8	4.2	3.6	2.9	2.1
Applied Micro Circuits Corp.	.0	.0	.1	.0	.0	.1
Chips & Technologies	.1	.1	.1	.0	.0	.1
Intel	.1	.0	.0	.0	.0	.0
Motorola	7.7	7.9	7.2	3.4	3.4	3.7
National Semiconductor	9.0	8.5	6.5	4.0	3.6	3.3
Raytheon	.0	.1	.1	.0	.0	.1
Texas Instruments	26.6	26.5	20.1	11.7	11.3	10.2
Japanese Companies	171.9	182.7	154.9	75.6	77.6	79.0
Fujitsu	58.0	65.7	48.6	25.5	27.9	24.8
Hitachi	44.7	49.2	48.0	19.7	20.9	24.5
Matsushita	1.7	1.6	1.6	.7	.7	.8
Mitsubishi	14.5	12.0	10.2	6.4	5.1	5.2
NEC	28.4	29.5	29.2	12.5	12.5	14.9
New JRC	.1	.1	.1	.0	.0	.1
Oki	6.3	5.9	5.3	2.8	2.5	2.7
Rohm	.1	.1	.0	.0	.0	.0
Sanyo	7.7	7.6	.0	3.4	3.2	.0
Toshiba	10.4	10.9	11.8	4.6	4.6	6.0
European Companies	3.6	2.6	2.6	1.6	1.1	1.3
GEC Plessey	.0	.6	.3	.0	.3	.2
Philips	3.0	2.0	2.3	1.3	.8	1.2
Plessey	.6	.0	.0	.3	.0	.0
Asia/Pacific Companies	.1	.1	.1	.0	.0	.1
Goldstar	.1	.1	.1	.0	.0	.1
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-8
Each Company's Factory Revenue from Shipments of TTl/Other Bipolar Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,142	1,080	875	100.0	100.0	100.0
North American Companies	330	292	242	28.9	27.0	27.7
Advanced Micro Devices	49	32	30	4.3	3.0	3.4
Chips & Technologies	1	1	1	.1	.1	.1
Intel	1	0	0	.1	.0	.0
Motorola	28	22	20	2.5	2.0	2.3
National Semiconductor	58	53	43	5.1	4.9	4.9
Texas Instruments	193	184	148	16.9	17.0	16.9
Japanese Companies	788	775	616	69.0	71.8	70.4
Fujitsu	177	192	133	15.5	17.8	15.2
Hitachi	205	216	165	18.0	20.0	18.9
Matsushita	8	7	7	.7	.6	.8
Mitsubishi	105	83	75	9.2	7.7	8.6
NEC	132	131	138	11.6	12.1	15.8
New JRC	1	1	1	.1	.1	.1
Oki	41	37	35	3.6	3.4	4.0
Rohm	1	1	0	.1	.1	.0
Sanyo	56	53	0	4.9	4.9	.0
Toshiba	62	54	62	5.4	5.0	7.1
European Companies	23	12	16	2.0	1.1	1.8
Philips	21	12	16	1.8	1.1	1.8
Plessey	2	0	0	.2	.0	.0
Asia/Pacific Companies	1	1	1	.1	.1	.1
Goldstar	1	1	1	.1	.1	.1

Source: *Dataquest (June 1992)*

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Table 1-9
Each Company's Factory Revenue from Shipments of TTL/Other Bipolar Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	157.6	155.5	119.0	100.0	100.0	100.0
North American Companies	45.5	42.0	32.9	28.9	27.0	27.6
Advanced Micro Devices	6.8	4.6	4.1	4.3	3.0	3.4
Chips & Technologies	.1	.1	.1	.1	.1	.1
Intel	.1	.0	.0	.1	.0	.0
Motorola	3.9	3.2	2.7	2.5	2.1	2.3
National Semiconductor	8.0	7.6	5.8	5.1	4.9	4.9
Texas Instruments	26.6	26.5	20.1	16.9	17.0	16.9
Japanese Companies	108.7	111.6	83.8	69.0	71.8	70.4
Fujitsu	24.4	27.6	18.1	15.5	17.7	15.2
Hitachi	28.3	31.1	22.4	18.0	20.0	18.8
Matsushita	1.1	1.0	1.0	.7	.6	.8
Mitsubishi	14.5	12.0	10.2	9.2	7.7	8.6
NEC	18.2	18.9	18.8	11.5	12.2	15.8
New JRC	.1	.1	.1	.1	.1	.1
Oki	5.7	5.3	4.8	3.6	3.4	4.0
Rohm	.1	.1	.0	.1	.1	.0
Sanyo	7.7	7.6	.0	4.9	4.9	.0
Toshiba	8.6	7.8	8.4	5.5	5.0	7.1
European Companies	3.2	1.7	2.2	2.0	1.1	1.8
Philips	2.9	1.7	2.2	1.8	1.1	1.8
Plessey	.3	.0	.0	.2	.0	.0
Asia/Pacific Companies	.1	.1	.1	.1	.1	.1
Goldstar	.1	.1	.1	.1	.1	.1
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-10
Each Company's Factory Revenue from Shipments of ECL Bipolar Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	506	555	567	100.0	100.0	100.0
North American Companies	45	55	41	8.9	9.9	7.2
Advanced Micro Devices	10	15	1	2.0	2.7	.2
Applied Micro Circuits Corp.	0	0	1	.0	.0	.2
Motorola	28	33	33	5.5	5.9	5.8
National Semiconductor	7	6	5	1.4	1.1	.9
Raytheon	0	1	1	.0	.2	.2
Japanese Companies	458	494	523	90.5	89.0	92.2
Fujitsu	243	264	224	48.0	47.6	39.5
Hitachi	119	126	188	23.5	22.7	33.2
Matsushita	4	4	5	.8	.7	.9
NEC	74	74	77	14.6	13.3	13.6
Oki	5	4	4	1.0	.7	.7
Toshiba	13	22	25	2.6	4.0	4.4
European Companies	3	6	3	.6	1.1	.5
GEC Plessey	0	4	2	.0	.7	.4
Philips	1	2	1	.2	.4	.2
Plessey	2	0	0	.4	.0	.0

Source: Dataquest (June 1992)

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Table 1-11
Each Company's Factory Revenue from Shipments of ECL Bipolar Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	69.8	79.9	77.1	100.0	100.0	100.0
North American Companies	6.2	7.9	5.6	8.9	9.9	7.3
Advanced Micro Devices	1.4	2.2	.1	2.0	2.8	.1
Applied Micro Circuits Corp.	.0	.0	.1	.0	.0	.1
Motorola	3.9	4.8	4.5	5.6	6.0	5.8
National Semiconductor	1.0	.9	.7	1.4	1.1	.9
Raytheon	.0	.1	.1	.0	.1	.1
Japanese Companies	63.2	71.1	71.1	90.5	89.0	92.2
Fujitsu	33.5	38.0	30.5	48.0	47.6	39.6
Hitachi	16.4	18.1	25.6	23.5	22.7	33.2
Matsushita	.6	.6	.7	.9	.8	.9
NEC	10.2	10.7	10.5	14.6	13.4	13.6
Oki	.7	.6	.5	1.0	.8	.6
Toshiba	1.8	3.2	3.4	2.6	4.0	4.4
European Companies	.4	.9	.4	.6	1.1	.5
GEC Plessey	.0	.6	.3	.0	.8	.4
Philips	.1	.3	.1	.1	.4	.1
Plessey	.3	.0	.0	.4	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-12
Each Company's Factory Revenue from Shipments of Bipolar Memory ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	191	194	165	100.0	100.0	100.0
North American Companies	20	15	7	10.5	7.7	4.2
Advanced Micro Devices	9	5	3	4.7	2.6	1.8
Motorola	1	0	0	.5	.0	.0
National Semiconductor	6	6	3	3.1	3.1	1.8
Texas Instruments	4	4	1	2.1	2.1	.6
Japanese Companies	169	178	157	88.5	91.8	95.2
Fujitsu	87	94	71	45.5	48.5	43.0
Hitachi	68	71	73	35.6	36.6	44.2
NEC	14	13	13	7.3	6.7	7.9
European Companies	2	1	1	1.0	.5	.6
Philips	2	1	1	1.0	.5	.6

Source: Dataquest (June 1992)

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Table 1-13
Each Company's Factory Revenue from Shipments of Bipolar Memory ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	26.4	27.9	22.4	100.0	100.0	100.0
North American Companies	2.8	2.2	1.0	10.6	7.9	4.5
Advanced Micro Devices	1.2	.7	.4	4.5	2.5	1.8
Motorola	.1	.0	.0	.4	.0	.0
National Semiconductor	.8	.9	.4	3.0	3.2	1.8
Texas Instruments	.6	.6	.1	2.3	2.2	.4
Japanese Companies	23.3	25.6	21.4	88.3	91.8	95.5
Fujitsu	12.0	13.5	9.7	45.5	48.4	43.3
Hitachi	9.4	10.2	9.9	35.6	36.6	44.2
NEC	1.9	1.9	1.8	7.2	6.8	8.0
European Companies	.3	.1	.1	1.1	.4	.4
Philips	.3	.1	.1	1.1	.4	.4
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-14
Each Company's Factory Revenue from Shipments of Bipolar Logic ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,457	1,430	1,270	100.0	100.0	100.0
North American Companies	355	321	269	24.4	22.4	21.2
Advanced Micro Devices	50	38	27	3.4	2.7	2.1
Applied Micro Circuits Corp.	0	0	1	.0	.0	.1
Chips & Technologies	1	1	1	.1	.1	.1
Intel	1	0	0	.1	.0	.0
Motorola	55	55	53	3.8	3.8	4.2
National Semiconductor	59	46	39	4.0	3.2	3.1
Raytheon	0	1	1	.0	.1	.1
Texas Instruments	189	180	147	13.0	12.6	11.6
Japanese Companies	1,077	1,091	982	73.9	76.3	77.3
Fujitsu	333	362	286	22.9	25.3	22.5
Hitachi	256	271	280	17.6	19.0	22.0
Matsushita	12	11	12	.8	.8	.9
Mitsubishi	105	83	75	7.2	5.8	5.9
NEC	192	192	202	13.2	13.4	15.9
New JRC	1	1	1	.1	.1	.1
Oki	46	41	39	3.2	2.9	3.1
Rohm	1	1	0	.1	.1	.0
Sanyo	56	53	0	3.8	3.7	.0
Toshiba	75	76	87	5.1	5.3	6.9
European Companies	24	17	18	1.6	1.2	1.4
GEC Plessey	0	4	2	.0	.3	.2
Philips	20	13	16	1.4	.9	1.3
Plessey	4	0	0	.3	.0	.0
Asia/Pacific Companies	1	1	1	.1	.1	.1
Goldstar	1	1	1	.1	.1	.1

Source: Dataquest (June 1992)

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Table 1-15
Each Company's Factory Revenue from Shipments of Bipolar Logic ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	201.1	205.9	172.7	100.0	100.0	100.0
North American Companies	49.0	46.2	36.6	24.4	22.4	21.2
Advanced Micro Devices	6.9	5.5	3.7	3.4	2.7	2.1
Applied Micro Circuits Corp.	.0	.0	.1	.0	.0	.1
Chips & Technologies	.1	.1	.1	.0	.0	.1
Intel	.1	.0	.0	.0	.0	.0
Motorola	7.6	7.9	7.2	3.8	3.8	4.2
National Semiconductor	8.1	6.6	5.3	4.0	3.2	3.1
Raytheon	.0	.1	.1	.0	.0	.1
Texas Instruments	26.1	25.9	20.0	13.0	12.6	11.6
Japanese Companies	148.6	157.1	133.6	73.9	76.3	77.4
Fujitsu	46.0	52.1	38.9	22.9	25.3	22.5
Hitachi	35.3	39.0	38.1	17.6	18.9	22.1
Matsushita	1.7	1.6	1.6	.8	.8	.9
Mitsubishi	14.5	12.0	10.2	7.2	5.8	5.9
NEC	26.5	27.6	27.5	13.2	13.4	15.9
New JRC	.1	.1	.1	.0	.0	.1
Oki	6.3	5.9	5.3	3.1	2.9	3.1
Rohm	.1	.1	.0	.0	.0	.0
Sanyo	7.7	7.6	.0	3.8	3.7	.0
Toshiba	10.4	10.9	11.8	5.2	5.3	6.8
European Companies	3.3	2.4	2.4	1.6	1.2	1.4
GEC Plessey	.0	.6	.3	.0	.3	.2
Philips	2.8	1.9	2.2	1.4	.9	1.3
Plessey	.6	.0	.0	.3	.0	.0
Asia/Pacific Companies	.1	.1	.1	.0	.0	.1
Goldstar	.1	.1	.1	.0	.0	.1
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-16
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	11,636	10,660	11,881	100.0	100.0	100.0
North American Companies	1,180	1,400	1,780	10.1	13.1	15.0
Actel	1	1	4	.0	.0	.0
Advanced Micro Devices	72	80	89	.6	.8	.7
Allegro MicroSystems	0	1	1	.0	.0	.0
Altera	7	10	21	.1	.1	.2
Analog Devices	3	3	3	.0	.0	.0
Appian Technology	0	1	1	.0	.0	.0
AT&T	0	6	14	.0	.1	.1
Atmel	6	7	9	.1	.1	.1
Catalyst	10	9	13	.1	.1	.1
Chips & Technologies	17	18	17	.1	.2	.1
Cirrus Logic	2	23	23	.0	.2	.2
Cypress Semiconductor	9	11	14	.1	.1	.1
Dallas Semiconductor	1	1	0	.0	.0	.0
Gould AMI	4	3	4	.0	.0	.0
Harris	17	20	7	.1	.2	.1
Hewlett Packard	NA	2	2	NA	.0	.0
Integrated Device Technology	15	20	6	.1	.2	.1
Intel	300	367	470	2.6	3.4	4.0
ITT	13	13	10	.1	.1	.1
Lattice	4	9	10	.0	.1	.1
LSI Logic	51	58	77	.4	.5	.6
Microchip Technology	9	4	20	.1	.0	.2
Micron Technology	2	2	16	.0	.0	.1
MOSel	1	9	25	.0	.1	.2
Motorola	236	294	319	2.0	2.8	2.7
NCR	0	3	4	.0	.0	.0
National Semiconductor	49	47	58	.4	.4	.5
Performance Semiconductor	1	1	1	.0	.0	.0
Rockwell	1	0	0	.0	.0	.0
SEEQ Technology	4	5	4	.0	.0	.0
Standard Microsystems	1	1	1	.0	.0	.0
Texas Instruments	294	309	438	2.5	2.9	3.7
Vitelic	3	2	5	.0	.0	.0
VLSI Technology	7	8	21	.1	.1	.2
WaferScale Integration	0	0	4	.0	.0	.0
Weitek	4	4	6	.0	.0	.1

(Continued)

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Table 1-16 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Western Digital	11	13	23	.1	.1	.2
Xicor	8	5	13	.1	.0	.1
Xilinx	5	12	15	.0	.1	.1
Zilog	5	6	7	.0	.1	.1
Other North American Companies	7	12	5	.1	.1	.0
Japanese Companies	10,339	9,119	9,909	88.9	85.5	83.4
Fuji Electric	24	21	21	.2	.2	.2
Fujitsu	1,284	1,125	1,270	11.0	10.6	10.7
Hitachi	1,356	1,331	1,399	11.7	12.5	11.8
Matsushita	645	629	766	5.5	5.9	6.4
Mitsubishi	1,011	785	752	8.7	7.4	6.3
NEC	2,158	2,116	2,392	18.5	19.8	20.1
New JRC	30	7	10	.3	.1	.1
NMB Semiconductor	24	16	8	.2	.2	.1
Oki	498	452	447	4.3	4.2	3.8
Ricoh	81	89	89	.7	.8	.7
Rohm	52	59	73	.4	.6	.6
Sanyo	287	227	204	2.5	2.1	1.7
Seiko Epson	267	125	133	2.3	1.2	1.1
Sharp	592	645	704	5.1	6.1	5.9
Sony	253	247	340	2.2	2.3	2.9
Toshiba	1,260	1,131	1,183	10.8	10.6	10.0
Yamaha	110	114	117	.9	1.1	1.0
Other Japanese Companies	407	0	1	3.5	.0	.0
European Companies	53	63	75	.5	.6	.6
Eurosil	1	1	1	.0	.0	.0
GEC Plessey	0	1	2	.0	.0	.0
Matra MHS	1	1	0	.0	.0	.0
Philips	24	22	23	.2	.2	.2
Plessey	2	0	0	.0	.0	.0
SGS-Thomson	14	21	29	.1	.2	.2
Siemens	11	17	20	.1	.2	.2
Asia/Pacific Companies	64	78	117	.6	.7	1.0
Goldstar	4	15	20	.0	.1	.2
Hyundai	3	2	5	.0	.0	.0
Macronix	8	1	6	.1	.0	.1

(Continued)

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Table 1-16 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Samsung	47	57	77	.4	.5	.6
United Microelectronics	2	1	8	.0	.0	.1
Winbond Electronics	NA	2	1	NA	.0	.0

NA = Not available

Source: Dataquest (June 1992)

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Table 1-17
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,605.8	1,535.0	1,615.8	100.0	100.0	100.0
North American Companies	162.8	201.6	242.1	10.1	13.1	15.0
Actel	.1	.1	.5	.0	.0	.0
Advanced Micro Devices	9.9	11.5	12.1	.6	.7	.7
Allegro MicroSystems	.0	.1	.1	.0	.0	.0
Altera	1.0	1.4	2.9	.1	.1	.2
Analog Devices	.4	.4	.4	.0	.0	.0
Appian Technology	.0	.1	.1	.0	.0	.0
AT&T	.0	.9	1.9	.0	.1	.1
Atmel	.8	1.0	1.2	.0	.1	.1
Catalyst	1.4	1.3	1.8	.1	.1	.1
Chips & Technologies	2.3	2.6	2.3	.1	.2	.1
Cirrus Logic	.3	3.3	3.1	.0	.2	.2
Cypress Semiconductor	1.2	1.6	1.9	.1	.1	.1
Dallas Semiconductor	.1	.1	.0	.0	.0	.0
Gould AMI	.6	.4	.5	.0	.0	.0
Harris	2.3	2.9	1.0	.1	.2	.1
Hewlett Packard	NA	.3	.3	NA	.0	.0
Integrated Device Technology	2.1	2.9	.8	.1	.2	.0
Intel	41.4	52.8	63.9	2.6	3.4	4.0
ITT	1.8	1.9	1.4	.1	.1	.1
Lattice	.6	1.3	1.4	.0	.1	.1
LSI Logic	7.0	8.4	10.5	.4	.5	.6
Microchip Technology	1.2	.6	2.7	.1	.0	.2
Micron Technology	.3	.3	2.2	.0	.0	.1
MOSel	.1	1.3	3.4	.0	.1	.2
Motorola	32.6	42.3	43.4	2.0	2.8	2.7
NCR	.0	.4	.5	.0	.0	.0
National Semiconductor	6.8	6.8	7.9	.4	.4	.5
Performance Semiconductor	.1	.1	.1	.0	.0	.0
Rockwell	.1	.0	.0	.0	.0	.0
SEEQ Technology	.6	.7	.5	.0	.0	.0
Standard Microsystems	.1	.1	.1	.0	.0	.0
Texas Instruments	40.6	44.5	59.6	2.5	2.9	3.7
Vitelic	.4	.3	.7	.0	.0	.0
VLSI Technology	1.0	1.2	2.9	.1	.1	.2
WaferScale Integration	.0	.0	.5	.0	.0	.0
Weitek	.6	.6	.8	.0	.0	.0

(Continued)

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Table 1-17 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Western Digital	1.5	1.9	3.1	.1	.1	.2
Xicor	1.1	.7	1.8	.1	.0	.1
Xilinx	.7	1.7	2.0	.0	.1	.1
Zilog	.7	.9	1.0	.0	.1	.1
Other North American Companies	1.0	1.7	.7	.1	.1	.0
Japanese Companies	1,426.8	1,313.1	1,347.6	88.9	85.5	83.4
Fuji Electric	3.3	3.0	2.9	.2	.2	.2
Fujitsu	177.2	162.0	172.7	11.0	10.6	10.7
Hitachi	187.1	191.7	190.3	11.7	12.5	11.8
Matsushita	89.0	90.6	104.2	5.5	5.9	6.4
Mitsubishi	139.5	113.0	102.3	8.7	7.4	6.3
NEC	297.8	304.7	325.3	18.5	19.9	20.1
New JRC	4.1	1.0	1.4	.3	.1	.1
NMB Semiconductor	3.3	2.3	1.1	.2	.1	.1
Oki	68.7	65.1	60.8	4.3	4.2	3.8
Ricoh	11.2	12.8	12.1	.7	.8	.7
Rohm	7.2	8.5	9.9	.4	.6	.6
Sanyo	39.6	32.7	27.7	2.5	2.1	1.7
Seiko Epson	36.8	18.0	18.1	2.3	1.2	1.1
Sharp	81.7	92.9	95.7	5.1	6.1	5.9
Sony	34.9	35.6	46.2	2.2	2.3	2.9
Toshiba	173.9	162.9	160.9	10.8	10.6	10.0
Yamaha	15.2	16.4	15.9	.9	1.1	1.0
Other Japanese Companies	56.2	.0	.1	3.5	.0	.0
European Companies	7.3	9.1	10.2	.5	.6	.6
Eurosil	.1	.1	.1	.0	.0	.0
GEC Plessey	.0	.1	.3	.0	.0	.0
Matra MHS	.1	.1	.0	.0	.0	.0
Philips	3.3	3.2	3.1	.2	.2	.2
Plessey	.3	.0	.0	.0	.0	.0
SGS-Thomson	1.9	3.0	3.9	.1	.2	.2
Siemens	1.5	2.4	2.7	.1	.2	.2
Asia/Pacific Companies	8.8	11.2	15.9	.5	.7	1.0
Goldstar	.6	2.2	2.7	.0	.1	.2
Hyundai	.4	.3	.7	.0	.0	.0
Macronix	1.1	.1	.8	.1	.0	.0

(Continued)

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Table 1-17 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Samsung	6.5	8.2	10.5	.4	.5	.6
United Microelectronics	.3	.1	1.1	.0	.0	.1
Winbond Electronics	NA	.3	.1	NA	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-18
Each Company's Factory Revenue from Shipments of N/PMOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,472	2,574	2,345	100.0	100.0	100.0
North American Companies	492	293	215	14.2	11.4	9.2
Advanced Micro Devices	43	35	17	1.2	1.4	.7
Gould AMI	4	1	0	.1	.0	.0
Intel	148	129	134	4.3	5.0	5.7
ITT	4	4	1	.1	.2	.0
Microchip Technology	2	1	5	.1	.0	.2
Micron Technology	2	0	0	.1	.0	.0
Motorola	29	11	23	.8	.4	1.0
Rockwell	1	0	0	.0	.0	.0
SEEQ Technology	2	1	1	.1	.0	.0
Texas Instruments	246	102	26	7.1	4.0	1.1
Xicor	8	5	5	.2	.2	.2
Zilog	3	4	3	.1	.2	.1
Japanese Companies	2,945	2,266	2,114	84.8	88.0	90.1
Fujitsu	258	225	224	7.4	8.7	9.6
Hitachi	261	257	256	7.5	10.0	10.9
Matsushita	244	237	261	7.0	9.2	11.1
Mitsubishi	431	334	210	12.4	13.0	9.0
NEC	589	556	497	17.0	21.6	21.2
Oki	143	104	97	4.1	4.0	4.1
Ricoh	33	32	29	1.0	1.2	1.2
Rohm	1	1	1	.0	.0	.0
Sanyo	64	18	6	1.8	.7	.3
Sharp	178	173	195	5.1	6.7	8.3
Sony	49	37	41	1.4	1.4	1.7
Toshiba	508	292	297	14.6	11.3	12.7
Other Japanese Companies	186	0	0	5.4	.0	.0
European Companies	7	13	15	.2	.5	.6
Philips	2	6	7	.1	.2	.3
SGS-Thomson	5	7	8	.1	.3	.3
Asia/Pacific Companies	28	2	1	.8	.1	.0
Goldstar	1	0	0	.0	.0	.0
Macronix	8	1	0	.2	.0	.0
Samsung	19	1	1	.5	.0	.0

Source: Dataquest (June 1992)

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Table 1-19
Each Company's Factory Revenue from Shipments of N/PMOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	479.1	370.7	318.9	100.0	100.0	100.0
North American Companies	67.9	42.2	29.2	14.2	11.4	9.2
Advanced Micro Devices	5.9	5.0	2.3	1.2	1.3	.7
Gould AMI	.6	.1	.0	.1	.0	.0
Intel	20.4	18.6	18.2	4.3	5.0	5.7
ITT	.6	.6	.1	.1	.2	.0
Microchip Technology	.3	.1	.7	.1	.0	.2
Micron Technology	.3	.0	.0	.1	.0	.0
Motorola	4.0	1.6	3.1	.8	.4	1.0
Rockwell	.1	.0	.0	.0	.0	.0
SEEQ Technology	.3	.1	.1	.1	.0	.0
Texas Instruments	33.9	14.7	3.5	7.1	4.0	1.1
Xicor	1.1	.7	.7	.2	.2	.2
Zilog	.4	.6	.4	.1	.2	.1
Japanese Companies	406.4	326.3	287.5	84.8	88.0	90.2
Fujitsu	35.6	32.4	30.5	7.4	8.7	9.6
Hitachi	36.0	37.0	34.8	7.5	10.0	10.9
Matsushita	33.7	34.1	35.5	7.0	9.2	11.1
Mitsubishi	59.5	48.1	28.6	12.4	13.0	9.0
NEC	81.3	80.1	67.6	17.0	21.6	21.2
Oki	19.7	15.0	13.2	4.1	4.0	4.1
Ricoh	4.6	4.6	3.9	1.0	1.2	1.2
Rohm	.1	.1	.1	.0	.0	.0
Sanyo	8.8	2.6	.8	1.8	.7	.3
Sharp	24.6	24.9	26.5	5.1	6.7	8.3
Sony	6.8	5.3	5.6	1.4	1.4	1.8
Toshiba	70.1	42.0	40.4	14.6	11.3	12.7
Other Japanese Companies	25.7	. .0	.0	5.4	.0	.0
European Companies	1.0	1.9	2.0	.2	.5	.6
Philips	.3	.9	1.0	.1	.2	.3
SGS-Thomson	.7	1.0	1.1	.1	.3	.3
Asia/Pacific Companies	3.9	.3	.1	.8	.1	.0
Goldstar	.1	.0	.0	.0	.0	.0
Macronix	1.1	.1	.0	.2	.0	.0
Samsung	2.6	.1	.1	.5	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-20
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	7,773	7,795	9,189	100.0	100.0	100.0
North American Companies	674	1,091	1,543	8.7	14.0	16.8
Actel	1	1	4	.0	.0	.0
Advanced Micro Devices	29	45	72	.4	.6	.8
Allegro MicroSystems	0	1	1	.0	.0	.0
Altera	7	10	21	.1	.1	.2
Analog Devices	3	3	3	.0	.0	.0
Appian Technology	0	1	1	.0	.0	.0
AT&T	0	6	14	.0	.1	.2
Atmel	6	7	9	.1	.1	.1
Catalyst	10	9	13	.1	.1	.1
Chips & Technologies	17	18	17	.2	.2	.2
Cirrus Logic	2	23	23	.0	.3	.3
Cypress Semiconductor	9	11	13	.1	.1	.1
Dallas Semiconductor	1	1	0	.0	.0	.0
Gould AMI	0	2	4	.0	.0	.0
Harris	17	20	7	.2	.3	.1
Hewlett Packard	NA	2	2	NA	.0	.0
Integrated Device Technology	15	20	6	.2	.3	.1
Intel	152	238	336	2.0	3.1	3.7
ITT	9	9	9	.1	.1	.1
Lattice	4	9	10	.1	.1	.1
LSI Logic	49	56	75	.6	.7	.8
Microchip Technology	7	3	15	.1	.0	.2
Micron Technology	0	2	16	.0	.0	.2
MOSel	1	9	25	.0	.1	.3
Motorola	207	279	290	2.7	3.6	3.2
NCR	0	3	4	.0	.0	.0
National Semiconductor	43	42	50	.6	.5	.5
Performance Semiconductor	1	1	1	.0	.0	.0
SEEQ Technology	2	4	3	.0	.1	.0
Standard Microsystems	1	1	1	.0	.0	.0
Texas Instruments	42	202	407	.5	2.6	4.4
Vitelic	3	2	5	.0	.0	.1
VLSI Technology	7	8	21	.1	.1	.2
WaferScale Integration	0	0	4	.0	.0	.0
Weitek	4	4	6	.1	.1	.1
Western Digital	11	13	23	.1	.2	.3
Xicor	0	0	8	.0	.0	.1
Xilinx	5	12	15	.1	.2	.2

(Continued)

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Table 1-20 (Continued)
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Zilog	2	2	4	.0	.0	.0
Other North American Companies	7	12	5	.1	.2	.1
Japanese Companies	7,017	6,578	7,470	90.3	84.4	81.3
Fuji Electric	21	18	19	.3	.2	.2
Fujitsu	933	818	950	12.0	10.5	10.3
Hitachi	1,018	999	1,054	13.1	12.8	11.5
Matsushita	401	392	505	5.2	5.0	5.5
Mitsubishi	580	451	542	7.5	5.8	5.9
NEC	1,490	1,473	1,799	19.2	18.9	19.6
New JRC	30	7	10	.4	.1	.1
NMB Semiconductor	24	16	8	.3	.2	.1
Oki	293	324	326	3.8	4.2	3.5
Ricoh	47	56	59	.6	.7	.6
Rohm	51	58	72	.7	.7	.8
Sanyo	223	209	195	2.9	2.7	2.1
Seiko Epson	267	125	133	3.4	1.6	1.4
Sharp	414	472	509	5.3	6.1	5.5
Sony	204	207	295	2.6	2.7	3.2
Toshiba	690	839	876	8.9	10.8	9.5
Yamaha	110	114	117	1.4	1.5	1.3
Other Japanese Companies	221	0	1	2.8	.0	.0
European Companies	46	50	60	.6	.6	.7
Eurosil	1	1	1	.0	.0	.0
GEC Plessey	0	1	2	.0	.0	.0
Matra MHS	1	1	0	.0	.0	.0
Philips	22	16	16	.3	.2	.2
Plessey	2	0	0	.0	.0	.0
SGS-Thomson	9	14	21	.1	.2	.2
Siemens	11	17	20	.1	.2	.2
Asia/Pacific Companies	36	76	116	.5	1.0	1.3
Goldstar	3	15	20	.0	.2	.2
Hyundai	3	2	5	.0	.0	.1
Macronix	0	0	6	.0	.0	.1
Samsung	28	56	76	.4	.7	.8
United Microelectronics	2	1	8	.0	.0	.1
Winbond Electronics	NA	2	1	NA	.0	.0

NA = Not available

Source: Dataquest (June 1992)

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Table 1-21
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,072.7	1,122.5	1,250.0	100.0	100.0	100.0
North American Companies	93.0	157.1	209.8	8.7	14.0	16.8
Actel	.1	.1	.5	.0	.0	.0
Advanced Micro Devices	4.0	6.5	9.8	.4	.6	.8
Allegro MicroSystems	.0	.1	.1	.0	.0	.0
Altera	1.0	1.4	2.9	.1	.1	.2
Analog Devices	.4	.4	.4	.0	.0	.0
Appian Technology	.0	.1	.1	.0	.0	.0
AT&T	.0	.9	1.9	.0	.1	.2
Atmel	.8	1.0	1.2	.1	.1	.1
Catalyst	1.4	1.3	1.8	.1	.1	.1
Chips & Technologies	2.3	2.6	2.3	.2	.2	.2
Cirrus Logic	.3	3.3	3.1	.0	.3	.2
Cypress Semiconductor	1.2	1.6	1.8	.1	.1	.1
Dallas Semiconductor	.1	.1	.0	.0	.0	.0
Gould AMI	.0	.3	.5	.0	.0	.0
Harris	2.3	2.9	1.0	.2	.3	.1
Hewlett Packard	NA	.3	.3	NA	.0	.0
Integrated Device Technology	2.1	2.9	.8	.2	.3	.1
Intel	21.0	34.3	45.7	2.0	3.1	3.7
ITT	1.2	1.3	1.2	.1	.1	.1
Lattice	.6	1.3	1.4	.1	.1	.1
LSI Logic	6.8	8.1	10.2	.6	.7	.8
Microchip Technology	1.0	.4	2.0	.1	.0	.2
Micron Technology	.0	.3	2.2	.0	.0	.2
MOSel	.1	1.3	3.4	.0	.1	.3
Motorola	28.6	40.2	39.4	2.7	3.6	3.2
NCR	.0	.4	.5	.0	.0	.0
National Semiconductor	5.9	6.0	6.8	.6	.5	.5
Performance Semiconductor	.1	.1	.1	.0	.0	.0
SEEQ Technology	.3	.6	.4	.0	.1	.0
Standard Microsystems	.1	.1	.1	.0	.0	.0
Texas Instruments	5.8	29.1	55.4	.5	2.6	4.4
Vitelic	.4	.3	.7	.0	.0	.1
VLSI Technology	1.0	1.2	2.9	.1	.1	.2
WaferScale Integration	.0	.0	.5	.0	.0	.0
Weitek	.6	.6	.8	.1	.1	.1
Western Digital	1.5	1.9	3.1	.1	.2	.2
Xicor	.0	.0	1.1	.0	.0	.1
Xilinx	.7	1.7	2.0	.1	.2	.2
Zilog	.3	.3	.5	.0	.0	.0
Other North American Companies	1.0	1.7	.7	.1	.2	.1

(Continued)

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Table 1-21 (Continued)
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	968.3	947.2	1,015.9	90.3	84.4	81.3
Fuji Electric	2.9	2.6	2.6	.3	.2	.2
Fujitsu	128.8	117.8	129.2	12.0	10.5	10.3
Hitachi	140.5	143.9	143.3	13.1	12.8	11.5
Matsushita	55.3	56.4	68.7	5.2	5.0	5.5
Mitsubishi	80.0	64.9	73.7	7.5	5.8	5.9
NEC	205.6	212.1	244.7	19.2	18.9	19.6
New JRC	4.1	1.0	1.4	.4	.1	.1
NMB Semiconductor	3.3	2.3	1.1	.3	.2	.1
Oki	40.4	46.7	44.3	3.8	4.2	3.5
Ricoh	6.5	8.1	8.0	.6	.7	.6
Rohm	7.0	8.4	9.8	.7	.7	.8
Sanyo	30.8	30.1	26.5	2.9	2.7	2.1
Seiko Epson	36.8	18.0	18.1	3.4	1.6	1.4
Sharp	57.1	68.0	69.2	5.3	6.1	5.5
Sony	28.2	29.8	40.1	2.6	2.7	3.2
Toshiba	95.2	120.8	119.1	8.9	10.8	9.5
Yamaha	15.2	16.4	15.9	1.4	1.5	1.3
Other Japanese Companies	30.5	.0	.1	2.8	.0	.0
European Companies	6.3	7.2	8.2	.6	.6	.7
Eurosil	.1	.1	.1	.0	.0	.0
GEC Plessey	.0	.1	.3	.0	.0	.0
Matra MHS	.1	.1	.0	.0	.0	.0
Philips	3.0	2.3	2.2	.3	.2	.2
Plessey	.3	.0	.0	.0	.0	.0
SGS-Thomson	1.2	2.0	2.9	.1	.2	.2
Siemens	1.5	2.4	2.7	.1	.2	.2
Asia/Pacific Companies	5.0	10.9	15.8	.5	1.0	1.3
Goldstar	.4	2.2	2.7	.0	.2	.2
Hyundai	.4	.3	.7	.0	.0	.1
Macronix	.0	.0	.8	.0	.0	.1
Samsung	3.9	8.1	10.3	.4	.7	.8
United Microelectronics	.3	.1	1.1	.0	.0	.1
Winbond Electronics	NA	.3	.1	NA	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-22
Each Company's Factory Revenue from Shipments of BiCMOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	391	291	347	100.0	100.0	100.0
North American Companies	14	16	22	3.6	5.5	6.3
Cypress Semiconductor	0	0	1	.0	.0	.3
LSI Logic	2	2	2	.5	.7	.6
Motorola	0	4	6	.0	1.4	1.7
National Semiconductor	6	5	8	1.5	1.7	2.3
Texas Instruments	6	5	5	1.5	1.7	1.4
Japanese Companies	377	275	325	96.4	94.5	93.7
Fuji Electric	3	3	2	.8	1.0	.6
Fujitsu	93	82	96	23.8	28.2	27.7
Hitachi	77	75	89	19.7	25.8	25.6
NEC	79	87	96	20.2	29.9	27.7
Oki	62	24	24	15.9	8.2	6.9
Ricoh	1	1	1	.3	.3	.3
Sanyo	0	0	3	.0	.0	.9
Sony	0	3	4	.0	1.0	1.2
Toshiba	62	0	10	15.9	.0	2.9

Source: Dataquest (June 1992)

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Table 1-23
Each Company's Factory Revenue from Shipments of BiCMOS Digital ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	54.0	41.9	47.2	100.0	100.0	100.0
North American Companies	1.9	2.3	3.0	3.5	5.5	6.4
Cypress Semiconductor	.0	.0	.1	.0	.0	.2
LSI Logic	.3	.3	.3	.6	.7	.6
Motorola	.0	.6	.8	.0	1.4	1.7
National Semiconductor	.8	.7	1.1	1.5	1.7	2.3
Texas Instruments	.8	.7	.7	1.5	1.7	1.5
Japanese Companies	52.0	39.6	44.2	96.3	94.5	93.6
Fuji Electric	.4	.4	.3	.7	1.0	.6
Fujitsu	12.8	11.8	13.1	23.7	28.2	27.8
Hitachi	10.6	10.8	12.1	19.6	25.8	25.6
NEC	10.9	12.5	13.1	20.2	29.8	27.8
Oki	8.6	3.5	3.3	15.9	8.4	7.0
Ricoh	.1	.1	.1	.2	.2	.2
Sanyo	.0	.0	.4	.0	.0	.8
Sony	.0	.4	.5	.0	1.0	1.1
Toshiba	8.6	.0	1.4	15.9	.0	3.0
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-24
Each Company's Factory Revenue from Shipments of MOS Memory ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	5,629	4,196	4,228	100.0	100.0	100.0
North American Companies	421	406	470	7.5	9.7	11.1
Advanced Micro Devices	41	47	58	.7	1.1	1.4
Atmel	3	3	7	.1	.1	.2
Catalyst	10	9	13	.2	.2	.3
Cypress Semiconductor	7	8	8	.1	.2	.2
Dallas Semiconductor	1	1	0	.0	.0	.0
Gould AMI	1	1	1	.0	.0	.0
Harris	8	7	1	.1	.2	.0
Integrated Device Technology	10	12	3	.2	.3	.1
Intel	45	30	37	.8	.7	.9
Microchip Technology	8	3	19	.1	.1	.4
Micron Technology	2	2	16	.0	.0	.4
MOSel	1	9	25	.0	.2	.6
Motorola	98	103	91	1.7	2.5	2.2
National Semiconductor	4	3	4	.1	.1	.1
Performance Semiconductor	1	0	0	.0	.0	.0
SEEQ Technology	3	3	3	.1	.1	.1
Texas Instruments	163	152	162	2.9	3.6	3.8
Vitelic	3	2	5	.1	.0	.1
WaferScale Integration	0	0	3	.0	.0	.1
Xicor	8	5	13	.1	.1	.3
Other North American Companies	4	6	1	.1	.1	.0
Japanese Companies	5,131	3,694	3,621	91.2	88.0	85.6
Fujitsu	750	546	577	13.3	13.0	13.6
Hitachi	768	689	719	13.6	16.4	17.0
Matsushita	221	154	147	3.9	3.7	3.5
Mitsubishi	604	366	290	10.7	8.7	6.9
NEC	847	664	667	15.0	15.8	15.8
NMB Semiconductor	24	16	8	.4	.4	.2
Oki	156	126	129	2.8	3.0	3.1
Ricoh	25	26	8	.4	.6	.2
Rohm	5	11	18	.1	.3	.4
Sanyo	108	69	59	1.9	1.6	1.4
Seiko Epson	108	43	24	1.9	1.0	.6
Sharp	335	353	376	6.0	8.4	8.9
Sony	122	109	110	2.2	2.6	2.6
Toshiba	656	522	487	11.7	12.4	11.5

(Continued)

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Table 1-24 (Continued)
Each Company's Factory Revenue from Shipments of MOS Memory ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Yamaha	0	- 0	2	.0	.0	.0
Other Japanese Companies	402	0	0	7.1	.0	.0
European Companies	17	23	27	.3	.5	.6
Matra MHS	1	1	0	.0	.0	.0
Philips	13	7	5	.2	.2	.1
SGS-Thomson	3	15	22	.1	.4	.5
Asia/Pacific Companies	60	73	110	1.1	1.7	2.6
Goldstar	3	14	20	.1	.3	.5
Hyundai	3	2	5	.1	.0	.1
Macronix	8	1	6	.1	.0	.1
Samsung	46	55	73	.8	1.3	1.7
United Microelectronics	0	0	5	.0	.0	.1
Winbond Electronics	NA	1	1	NA	.0	.0

NA = Not available

Source: Dataquest (June 1992)

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Table 1-25
Each Company's Factory Revenue from Shipments of MOS Memory ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	776.8	604.2	575.0	100.0	100.0	100.0
North American Companies	58.1	58.5	63.9	7.5	9.7	11.1
Advanced Micro Devices	5.7	6.8	7.9	.7	1.1	1.4
Atmel	.4	.4	1.0	.1	.1	.2
Catalyst	1.4	1.3	1.8	.2	.2	.3
Cypress Semiconductor	1.0	1.2	1.1	.1	.2	.2
Dallas Semiconductor	.1	.1	.0	.0	.0	.0
Gould AMI	.1	.1	.1	.0	.0	.0
Harris	1.1	1.0	.1	.1	.2	.0
Integrated Device Technology	1.4	1.7	.4	.2	.3	.1
Intel	6.2	4.3	5.0	.8	.7	.9
Microchip Technology	1.1	.4	2.6	.1	.1	.5
Micron Technology	.3	.3	2.2	.0	.0	.4
MOSel	.1	1.3	3.4	.0	.2	.6
Motorola	13.5	14.8	12.4	1.7	2.4	2.2
National Semiconductor	.6	.4	.5	.1	.1	.1
Performance Semiconductor	.1	.0	.0	.0	.0	.0
SEEQ Technology	.4	.4	.4	.1	.1	.1
Texas Instruments	22.5	21.9	22.0	2.9	3.6	3.8
Vitelic	.4	.3	.7	.1	.0	.1
WaferScale Integration	.0	.0	.4	.0	.0	.1
Xicor	1.1	.7	1.8	.1	.1	.3
Other North American Companies	.6	.9	.1	.1	.1	.0
Japanese Companies	708.1	531.9	492.5	91.2	88.0	85.7
Fujitsu	103.5	78.6	78.5	13.3	13.0	13.7
Hitachi	106.0	99.2	97.8	13.6	16.4	17.0
Matsushita	30.5	22.2	20.0	3.9	3.7	3.5
Mitsubishi	83.4	52.7	39.4	10.7	8.7	6.9
NEC	116.9	95.6	90.7	15.0	15.8	15.8
NMB Semiconductor	3.3	2.3	1.1	.4	.4	.2
Oki	21.5	18.1	17.5	2.8	3.0	3.0
Ricoh	3.5	3.7	1.1	.5	.6	.2
Rohm	.7	1.6	2.4	.1	.3	.4
Sanyo	14.9	9.9	8.0	1.9	1.6	1.4
Seiko Epson	14.9	6.2	3.3	1.9	1.0	.6
Sharp	46.2	50.8	51.1	5.9	8.4	8.9
Sony	16.8	15.7	15.0	2.2	2.6	2.6
Toshiba	90.5	75.2	66.2	11.7	12.4	11.5

(Continued)

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Table 1-25 (Continued)
Each Company's Factory Revenue from Shipments of MOS Memory ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Yamaha	.0	.0	.3	.0	.0	.1
Other Japanese Companies	55.5	.0	.0	7.1	.0	.0
European Companies	2.3	3.3	3.7	.3	.5	.6
Matra MHS	.1	.1	.0	.0	.0	.0
Philips	1.8	1.0	.7	.2	.2	.1
SGS-Thomson	.4	2.2	3.0	.1	.4	.5
Asia/Pacific Companies	8.3	10.5	15.0	1.1	1.7	2.6
Goldstar	.4	2.0	2.7	.1	.3	.5
Hyundai	.4	.3	.7	.1	.0	.1
Macronix	1.1	.1	.8	.1	.0	.1
Samsung	6.3	7.9	9.9	.8	1.3	1.7
United Microelectronics	.0	.0	.7	.0	.0	.1
Winbond Electronics	NA	.1	.1	NA	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: *Dataquest (June 1992)*

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Table 1-26
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	2,662	2,974	3,579	100.0	100.0	100.0
North American Companies	495	632	815	18.6	21.3	22.8
Advanced Micro Devices	23	18	19	.9	.6	.5
Analog Devices	3	3	3	.1	.1	.1
Appian Technology	0	1	1	.0	.0	.0
Chips & Technologies	17	18	17	.6	.6	.5
Cirrus Logic	2	23	23	.1	.8	.6
Cypress Semiconductor	0	0	2	.0	.0	.1
Harris	7	9	3	.3	.3	.1
Integrated Device Technology	1	2	2	.0	.1	.1
Intel	250	332	430	9.4	11.2	12.0
ITT	0	0	2	.0	.0	.1
LSI Logic	0	2	7	.0	.1	.2
Motorola	82	124	158	3.1	4.2	4.4
National Semiconductor	27	26	30	1.0	.9	.8
Performance Semiconductor	0	1	1	.0	.0	.0
Rockwell	1	0	0	.0	.0	.0
SEEQ Technology	0	2	1	.0	.1	.0
Standard Microsystems	1	1	1	.0	.0	.0
Texas Instruments	59	45	68	2.2	1.5	1.9
VLSI Technology	2	2	7	.1	.1	.2
WaferScale Integration	0	0	1	.0	.0	.0
Weitek	4	4	6	.2	.1	.2
Western Digital	11	13	23	.4	.4	.6
Zilog	5	6	7	.2	.2	.2
Other North American Companies	0	0	3	.0	.0	.1
Japanese Companies	2,144	2,327	2,745	80.5	78.2	76.7
Fuji Electric	0	1	1	.0	.0	.0
Fujitsu	161	171	188	6.0	5.7	5.3
Hitachi	331	355	384	12.4	11.9	10.7
Matsushita	203	235	289	7.6	7.9	8.1
Mitsubishi	335	351	401	12.6	11.8	11.2
NEC	594	689	831	22.3	23.2	23.2
Oki	76	71	76	2.9	2.4	2.1
Ricoh	21	22	62	.8	.7	1.7
Rohm	17	16	20	.6	.5	.6
Sanyo	43	34	32	1.6	1.1	.9
Seiko Epson	11	10	14	.4	.3	.4

(Continued)

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Table 1-26 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Sharp	87	103	114	3.3	3.5	3.2
Sony	43	43	85	1.6	1.4	2.4
Toshiba	221	226	248	8.3	7.6	6.9
Other Japanese Companies	1	0	0	.0	.0	.0
European Companies	23	15	19	.9	.5	.5
GEC Plessey	0	0	1	.0	.0	.0
Philips	11	4	5	.4	.1	.1
SGS-Thomson	7	5	6	.3	.2	.2
Siemens	5	6	7	.2	.2	.2

Source: Dataquest (June 1992)

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Table 1-27
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	367.4	428.3	486.7	100.0	100.0	100.0
North American Companies	68.3	91.0	110.8	18.6	21.2	22.8
Advanced Micro Devices	3.2	2.6	2.6	.9	.6	.5
Analog Devices	.4	.4	.4	.1	.1	.1
Appian Technology	.0	.1	.1	.0	.0	.0
Chips & Technologies	2.3	2.6	2.3	.6	.6	.5
Cirrus Logic	.3	3.3	3.1	.1	.8	.6
Cypress Semiconductor	.0	.0	.3	.0	.0	.1
Harris	1.0	1.3	.4	.3	.3	.1
Integrated Device Technology	.1	.3	.3	.0	.1	.1
Intel	34.5	47.8	58.5	9.4	11.2	12.0
ITT	.0	.0	.3	.0	.0	.1
LSI Logic	.0	.3	1.0	.0	.1	.2
Motorola	11.3	17.9	21.5	3.1	4.2	4.4
National Semiconductor	3.7	3.7	4.1	1.0	.9	.8
Performance Semiconductor	.0	.1	.1	.0	.0	.0
Rockwell	.1	.0	.0	.0	.0	.0
SEEQ Technology	.0	.3	.1	.0	.1	.0
Standard Microsystems	.1	.1	.1	.0	.0	.0
Texas Instruments	8.1	6.5	9.2	2.2	1.5	1.9
VLSI Technology	.3	.3	1.0	.1	.1	.2
WaferScale Integration	.0	.0	.1	.0	.0	.0
Weitek	.6	.6	.8	.2	.1	.2
Western Digital	1.5	1.9	3.1	.4	.4	.6
Zilog	.7	.9	1.0	.2	.2	.2
Other North American Companies	.0	.0	.4	.0	.0	.1
Japanese Companies	295.9	335.1	373.3	80.5	78.2	76.7
Fuji Electric	.0	.1	.1	.0	.0	.0
Fujitsu	22.2	24.6	25.6	6.0	5.7	5.3
Hitachi	45.7	51.1	52.2	12.4	11.9	10.7
Matsushita	28.0	33.8	39.3	7.6	7.9	8.1
Mitsubishi	46.2	50.5	54.5	12.6	11.8	11.2
NEC	82.0	99.2	113.0	22.3	23.2	23.2
Oki	10.5	10.2	10.3	2.9	2.4	2.1
Ricoh	2.9	3.2	8.4	.8	.7	1.7
Rohm	2.3	2.3	2.7	.6	.5	.6
Sanyo	5.9	4.9	4.4	1.6	1.1	.9
Seiko Epson	1.5	1.4	1.9	.4	.3	.4

(Continued)

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Table 1-27 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Sharp	12.0	14.8	15.5	3.3	3.5	3.2
Sony	5.9	6.2	11.6	1.6	1.4	2.4
Toshiba	30.5	32.5	33.7	8.3	7.6	6.9
Other Japanese Companies	.1	.0	.0	.0	.0	.0
European Companies	3.2	2.2	2.6	.9	.5	.5
GEC Plessey	.0	.0	.1	.0	.0	.0
Philips	1.5	.6	.7	.4	.1	.1
SGS-Thomson	1.0	.7	.8	.3	.2	.2
Siemens	.7	.9	1.0	.2	.2	.2
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-28
Each Company's Factory Revenue from Shipments of MOS Logic ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,345	3,490	4,074	100.0	100.0	100.0
North American Companies	264	362	495	7.9	10.4	12.2
Actel	1	1	4	.0	.0	.1
Advanced Micro Devices	8	15	12	.2	.4	.3
Allegro MicroSystems	0	1	1	.0	.0	.0
Altera	7	10	21	.2	.3	.5
AT&T	0	6	14	.0	.2	.3
Atmel	3	4	2	.1	.1	.0
Cypress Semiconductor	2	3	4	.1	.1	.1
Gould AMI	3	2	3	.1	.1	.1
Harris	2	4	3	.1	.1	.1
Hewlett Packard	NA	2	2	NA	.1	.0
Integrated Device Technology	4	6	1	.1	.2	.0
Intel	5	5	3	.1	.1	.1
ITT	13	13	8	.4	.4	.2
Lattice	4	9	10	.1	.3	.2
LSI Logic	51	56	70	1.5	1.6	1.7
Microchip Technology	1	1	1	.0	.0	.0
Motorola	56	67	70	1.7	1.9	1.7
NCR	0	3	4	.0	.1	.1
National Semiconductor	18	18	24	.5	.5	.6
SEEQ Technology	1	0	0	.0	.0	.0
Texas Instruments	72	112	208	2.2	3.2	5.1
VLSI Technology	5	6	14	.1	.2	.3
Xilinx	5	12	15	.1	.3	.4
Other North American Companies	3	6	1	.1	.2	.0
Japanese Companies	3,064	3,098	3,543	91.6	88.8	87.0
Fuji Electric	24	20	20	.7	.6	.5
Fujitsu	373	408	505	11.2	11.7	12.4
Hitachi	257	287	296	7.7	8.2	7.3
Matsushita	221	240	330	6.6	6.9	8.1
Mitsubishi	72	68	61	2.2	1.9	1.5
NEC	717	763	894	21.4	21.9	21.9
New JRC	30	7	10	.9	.2	.2
Oki	266	255	242	8.0	7.3	5.9
Ricoh	35	41	19	1.0	1.2	.5
Rohm	30	32	35	.9	.9	.9
Sanyo	136	124	113	4.1	3.6	2.8

(Continued)

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Table 1-28 (Continued)
Each Company's Factory Revenue from Shipments of MOS Logic ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Seiko Epson	148	72	95	4.4	2.1	2.3
Sharp	170	189	214	5.1	5.4	5.3
Sony	88	95	145	2.6	2.7	3.6
Toshiba	383	383	448	11.4	11.0	11.0
Yamaha	110	114	115	3.3	3.3	2.8
Other Japanese Companies	4	0	1	.1	.0	.0
European Companies	13	25	29	.4	.7	.7
Eurosil	1	1	1	.0	.0	.0
GEC Plessey	0	1	1	.0	.0	.0
Philips	0	11	13	.0	.3	.3
Plessey	2	0	0	.1	.0	.0
SGS-Thomson	4	1	1	.1	.0	.0
Siemens	6	11	13	.2	.3	.3
Asia/Pacific Companies	4	5	7	.1	.1	.2
Goldstar	1	1	0	.0	.0	.0
Samsung	1	2	4	.0	.1	.1
United Microelectronics	2	1	3	.1	.0	.1
Winbond Electronics	NA	1	0	NA	.0	.0

NA = Not available

Source: Dataquest (June 1992)

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Table 1-29
Each Company's Factory Revenue from Shipments of MOS Logic ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	461.6	502.6	554.1	100.0	100.0	100.0
North American Companies	36.4	52.1	67.3	7.9	10.4	12.1
Actel	.1	.1	.5	.0	.0	.1
Advanced Micro Devices	1.1	2.2	1.6	.2	.4	.3
Allegro MicroSystems	.0	.1	.1	.0	.0	.0
Altera	1.0	1.4	2.9	.2	.3	.5
AT&T	.0	.9	1.9	.0	.2	.3
Atmel	.4	.6	.3	.1	.1	.1
Cypress Semiconductor	.3	.4	.5	.1	.1	.1
Gould AMI	.4	.3	.4	.1	.1	.1
Harris	.3	.6	.4	.1	.1	.1
Hewlett Packard	NA	.3	.3	NA	.1	.1
Integrated Device Technology	.6	.9	.1	.1	.2	.0
Intel	.7	.7	.4	.2	.1	.1
ITT	1.8	1.9	1.1	.4	.4	.2
Lattice	.6	1.3	1.4	.1	.3	.3
LSI Logic	7.0	8.1	9.5	1.5	1.6	1.7
Microchip Technology	.1	.1	.1	.0	.0	.0
Motorola	7.7	9.6	9.5	1.7	1.9	1.7
NCR	.0	.4	.5	.0	.1	.1
National Semiconductor	2.5	2.6	3.3	.5	.5	.6
SEEQ Technology	.1	.0	.0	.0	.0	.0
Texas Instruments	9.9	16.1	28.3	2.1	3.2	5.1
VLSI Technology	.7	.9	1.9	.2	.2	.3
Xilinx	.7	1.7	2.0	.2	.3	.4
Other North American Companies	.4	.9	.1	.1	.2	.0
Japanese Companies	422.8	446.1	481.8	91.6	88.8	87.0
Fuji Electric	3.3	2.9	2.7	.7	.6	.5
Fujitsu	51.5	58.8	68.7	11.2	11.7	12.4
Hitachi	35.5	41.3	40.3	7.7	8.2	7.3
Matsushita	30.5	34.6	44.9	6.6	6.9	8.1
Mitsubishi	9.9	9.8	8.3	2.1	1.9	1.5
NEC	98.9	109.9	121.6	21.4	21.9	21.9
New JRC	4.1	1.0	1.4	.9	.2	.3
Oki	36.7	36.7	32.9	8.0	7.3	5.9
Ricoh	4.8	5.9	2.6	1.0	1.2	.5
Rohm	4.1	4.6	4.8	.9	.9	.9
Sanyo	18.8	17.9	15.4	4.1	3.6	2.8

(Continued)

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Table 1-29 (Continued)
Each Company's Factory Revenue from Shipments of MOS Logic ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Seiko Epson	20.4	10.4	12.9	4.4	2.1	2.3
Sharp	23.5	27.2	29.1	5.1	5.4	5.3
Sony	12.1	13.7	19.7	2.6	2.7	3.6
Toshiba	52.9	55.2	60.9	11.5	11.0	11.0
Yamaha	15.2	16.4	15.6	3.3	3.3	2.8
Other Japanese Companies	.6	.0	.1	.1	.0	.0
European Companies	1.8	3.6	3.9	.4	.7	.7
Eurosil	.1	.1	.1	.0	.0	.0
GEC Plessey	.0	.1	.1	.0	.0	.0
Philips	.0	1.6	1.8	.0	.3	.3
Plessey	.3	.0	.0	.1	.0	.0
SGS-Thomson	.6	.1	.1	.1	.0	.0
Siemens	.8	1.6	1.8	.2	.3	.3
Asia/Pacific Companies	.6	.7	1.0	.1	.1	.2
Goldstar	.1	.1	.0	.0	.0	.0
Samsung	.1	.3	.5	.0	.1	.1
United Microelectronics	.3	.1	.4	.1	.0	.1
Winbond Electronics	NA	.1	.0	NA	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-30
Each Company's Factory Revenue from Shipments of Analog ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,576	3,499	3,954	100.0	100.0	100.0
North American Companies	513	529	618	14.3	15.1	15.6
Advanced Micro Devices	12	12	15	.3	.3	.4
Allegro MicroSystems	5	3	5	.1	.1	.1
Analog Devices	56	39	49	1.6	1.1	1.2
AT&T	0	1	0	.0	.0	.0
Atmel	7	0	0	.2	.0	.0
Brooktree	4	7	7	.1	.2	.2
Burr-Brown	50	49	56	1.4	1.4	1.4
Crystal	1	0	2	.0	.0	.1
Elantec	2	3	3	.1	.1	.1
Exar	5	19	46	.1	.5	1.2
Gennum	2	2	2	.1	.1	.1
Gould AMI	1	1	1	.0	.0	.0
Harris	15	15	17	.4	.4	.4
Honeywell	0	4	4	.0	.1	.1
Int'l Microelectronic Prod.	1	0	0	.0	.0	.0
ITT	2	2	0	.1	.1	.0
Linear Technology	8	10	12	.2	.3	.3
Maxim	9	12	14	.3	.3	.4
Micro Linear	1	1	0	.0	.0	.0
Micro Power Systems	3	4	4	.1	.1	.1
Mitel	0	10	8	.0	.3	.2
Motorola	49	64	85	1.4	1.8	2.1
National Semiconductor	26	33	39	.7	.9	1.0
Precision Monolithics	5	6	0	.1	.2	.0
Raytheon	0	3	2	.0	.1	.1
Rockwell	99	80	83	2.8	2.3	2.1
SEEQ Technology	0	0	1	.0	.0	.0
Sierra Semiconductor	0	2	3	.0	.1	.1
Siliconix	4	3	5	.1	.1	.1
Silicon Systems	15	23	26	.4	.7	.7
Sipex	1	1	1	.0	.0	.0
Supertex	7	4	8	.2	.1	.2
Teledyne	2	2	2	.1	.1	.1
Texas Instruments	119	111	115	3.3	3.2	2.9
TRW	0	2	2	.0	.1	.1
Unitrode	2	0	0	.1	.0	.0
Other North American Companies	0	1	1	.0	.0	.0

(Continued)

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Table 1-30 (Continued)
Each Company's Factory Revenue from Shipments of Analog ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	3,029	2,885	3,251	84.7	82.5	82.2
Fuji Electric	33	38	27	.9	1.1	.7
Fujitsu	134	133	158	3.7	3.8	4.0
Hitachi	268	260	287	7.5	7.4	7.3
Matsushita	271	305	324	7.6	8.7	8.2
Mitsubishi	336	366	406	9.4	10.5	10.3
NEC	306	308	338	8.6	8.8	8.5
New JRC	101	97	105	2.8	2.8	2.7
Oki	32	31	32	.9	.9	.8
Ricoh	0	0	5	.0	.0	.1
Rohm	214	218	270	6.0	6.2	6.8
Sanken	116	119	131	3.2	3.4	3.3
Sanyo	349	315	396	9.8	9.0	10.0
Seiko Epson	10	9	10	.3	.3	.3
Sharp	56	61	62	1.6	1.7	1.6
Shindengen Electric	33	26	50	.9	.7	1.3
Sony	246	239	260	6.9	6.8	6.6
Toko	42	49	24	1.2	1.4	.6
Toshiba	288	305	360	8.1	8.7	9.1
Yamaha	10	6	6	.3	.2	.2
Other Japanese Companies	184	0	0	5.1	.0	.0
European Companies	25	57	57	.7	1.6	1.4
Ericsson	2	2	3	.1	.1	.1
GEC Plessey	0	11	5	.0	.3	.1
Philips	13	28	33	.4	.8	.8
Plessey	2	0	0	.1	.0	.0
SGS-Thomson	6	12	14	.2	.3	.4
Telefunken Electronic	2	4	2	.1	.1	.1
Asia/Pacific Companies	9	28	28	.3	.8	.7
Korean Electronic Co.	1	5	4	.0	.1	.1
Samsung	8	1	2	.2	.0	.1
Winbond Electronics	NA	1	0	NA	.0	.0
Other Asia/Pacific Companies	0	21	22	.0	.6	.6

NA = Not available

Source: Dataquest (June 1992)

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Table 1-31
Each Company's Factory Revenue from Shipments of Analog ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	493.5	503.9	537.7	100.0	100.0	100.0
North American Companies	70.8	76.2	84.0	14.3	15.1	15.6
Advanced Micro Devices	1.7	1.7	2.0	.3	.3	.4
Allegro MicroSystems	.7	.4	.7	.1	.1	.1
Analog Devices	7.7	5.6	6.7	1.6	1.1	1.2
AT&T	.0	.1	.0	.0	.0	.0
Atmel	1.0	.0	.0	.2	.0	.0
Brooktree	.6	1.0	1.0	.1	.2	.2
Burr-Brown	6.9	7.1	7.6	1.4	1.4	1.4
Crystal	.1	.0	.3	.0	.0	.1
Elantec	.3	.4	.4	.1	.1	.1
Exar	.7	2.7	6.3	.1	.5	1.2
Gennum	.3	.3	.3	.1	.1	.1
Gould AMI	.1	.1	.1	.0	.0	.0
Harris	2.1	2.2	2.3	.4	.4	.4
Honeywell	.0	.6	.5	.0	.1	.1
Int'l Microelectronic Prod.	.1	.0	.0	.0	.0	.0
ITT	.3	.3	.0	.1	.1	.0
Linear Technology	1.1	1.4	1.6	.2	.3	.3
Maxim	1.2	1.7	1.9	.2	.3	.4
Micro Linear	.1	.1	.0	.0	.0	.0
Micro Power Systems	.4	.6	.5	.1	.1	.1
Mitel	.0	1.4	1.1	.0	.3	.2
Motorola	6.8	9.2	11.6	1.4	1.8	2.2
National Semiconductor	3.6	4.8	5.3	.7	1.0	1.0
Precision Monolithics	.7	.9	.0	.1	.2	.0
Raytheon	.0	.4	.3	.0	.1	.1
Rockwell	13.7	11.5	11.3	2.8	2.3	2.1
SEEQ Technology	.0	.0	.1	.0	.0	.0
Sierra Semiconductor	.0	.3	.4	.0	.1	.1
Siliconix	.6	.4	.7	.1	.1	.1
Silicon Systems	2.1	3.3	3.5	.4	.7	.7
Sipex	.1	.1	.1	.0	.0	.0
Supertex	1.0	.6	1.1	.2	.1	.2
Teledyne	.3	.3	.3	.1	.1	.1
Texas Instruments	16.4	16.0	15.6	3.3	3.2	2.9
TRW	.0	.3	.3	.0	.1	.1
Unitrode	.3	.0	.0	.1	.0	.0
Other North American Companies	.0	.1	.1	.0	.0	.0

(Continued)

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Table 1-31 (Continued)
Each Company's Factory Revenue from Shipments of Analog ICs to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	418.0	415.4	442.1	84.7	82.4	82.2
Fuji Electric	4.6	5.5	3.7	.9	1.1	.7
Fujitsu	18.5	19.2	21.5	3.7	3.8	4.0
Hitachi	37.0	37.4	39.0	7.5	7.4	7.3
Matsushita	37.4	43.9	44.1	7.6	8.7	8.2
Mitsubishi	46.4	52.7	55.2	9.4	10.5	10.3
NEC	42.2	44.4	46.0	8.6	8.8	8.6
New JRC	13.9	14.0	14.3	2.8	2.8	2.7
Oki	4.4	4.5	4.4	.9	.9	.8
Ricoh	.0	.0	.7	.0	.0	.1
Rohm	29.5	31.4	36.7	6.0	6.2	6.8
Sanken	16.0	17.1	17.8	3.2	3.4	3.3
Sanyo	48.2	45.4	53.9	9.8	9.0	10.0
Seiko Epson	1.4	1.3	1.4	.3	.3	.3
Sharp	7.7	8.8	8.4	1.6	1.7	1.6
Shindengen Electric	4.6	3.7	6.8	.9	.7	1.3
Sony	33.9	34.4	35.4	6.9	6.8	6.6
Toko	5.8	7.1	3.3	1.2	1.4	.6
Toshiba	39.7	43.9	49.0	8.0	8.7	9.1
Yamaha	1.4	.9	.8	.3	.2	.1
Other Japanese Companies	25.4	.0	.0	5.1	.0	.0
European Companies	3.5	8.2	7.8	.7	1.6	1.5
Ericsson	.3	.3	.4	.1	.1	.1
GEC Plessey	.0	1.6	.7	.0	.3	.1
Philips	1.8	4.0	4.5	.4	.8	.8
Plessey	.3	.0	.0	.1	.0	.0
SGS-Thomson	.8	1.7	1.9	.2	.3	.4
Telefunken Electronic	.3	.6	.3	.1	.1	.1
Asia/Pacific Companies	1.2	4.0	3.8	.2	.8	.7
Korean Electronic Co.	.1	.7	.5	.0	.1	.1
Samsung	1.1	.1	.3	.2	.0	.1
Winbond Electronics	NA	.1	.0	NA	.0	.0
Other Asia/Pacific Companies	.0	3.0	3.0	.0	.6	.6
Exchange Rate (Yen/US$)	138	144	136			

NA = Not available

Source: Dataquest (June 1992)

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Table 1-32
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,080	2,969	3,432	100.0	100.0	100.0
North American Companies	57	80	103	1.9	2.7	3.0
General Instrument	16	23	24	.5	.8	.7
Harris	3	5	1	.1	.2	.0
Hewlett Packard	3	1	1	.1	.0	.0
International Rectifier	5	14	20	.2	.5	.6
ITT	10	10	15	.3	.3	.4
Motorola	12	23	35	.4	.8	1.0
National Semiconductor	0	0	1	.0	.0	.0
Siliconix	2	2	3	.1	.1	.1
Supertex	1	1	2	.0	.0	.1
Texas Instruments	2	0	0	.1	.0	.0
Unitrode	1	1	1	.0	.0	.0
Other North American Companies	2	0	0	.1	.0	.0
Japanese Companies	3,001	2,870	3,305	97.4	96.7	96.3
Fuji Electric	198	194	207	6.4	6.5	6.0
Fujitsu	53	57	89	1.7	1.9	2.6
Hitachi	486	467	479	15.8	15.7	14.0
Matsushita	260	286	318	8.4	9.6	9.3
Mitsubishi	270	200	256	8.8	6.7	7.5
NEC	400	382	429	13.0	12.9	12.5
New JRC	3	3	3	.1	.1	.1
Oki	9	9	9	.3	.3	.3
Rohm	241	258	307	7.8	8.7	8.9
Sanken	153	162	209	5.0	5.5	6.1
Sanyo	163	155	193	5.3	5.2	5.6
Shindengen Electric	115	118	116	3.7	4.0	3.4
Sony	79	67	77	2.6	2.3	2.2
Toko	4	5	17	.1	.2	.5
Toshiba	534	507	596	17.3	17.1	17.4
Other Japanese Companies	33	0	0	1.1	.0	.0
European Companies	12	11	14	.4	.4	.4
Philips	2	3	4	.1	.1	.1
SGS-Thomson	2	5	5	.1	.2	.1
Siemens	8	3	3	.3	.1	.1
Other European Companies	0	0	2	.0	.0	.1

(Continued)

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Table 1-32 (Continued)
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Asia/Pacific Companies	10	8	10	.3	.3	.3
Korean Electronic Co.	6	5	5	.2	.2	.1
Samsung	4	2	4	.1	.1	.1
Other Asia/Pacific Companies	0	1	1	.0	.0	.0

Source: Dataquest (June 1992)

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Table 1-33
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	425.0	427.5	466.8	100.0	100.0	100.0
North American Companies	7.9	11.5	14.0	1.9	2.7	3.0
General Instrument	2.2	3.3	3.3	.5	.8	.7
Harris	.4	.7	.1	.1	.2	.0
Hewlett Packard	.4	.1	.1	.1	.0	.0
International Rectifier	.7	2.0	2.7	.2	.5	.6
ITT	1.4	1.4	2.0	.3	.3	.4
Motorola	1.7	3.3	4.8	.4	.8	1.0
National Semiconductor	.0	.0	.1	.0	.0	.0
Siliconix	.3	.3	.4	.1	.1	.1
Supertex	.1	.1	.3	.0	.0	.1
Texas Instruments	.3	.0	.0	.1	.0	.0
Unitrode	.1	.1	.1	.0	.0	.0
Other North American Companies	.3	.0	.0	.1	.0	.0
Japanese Companies	414.1	413.3	449.5	97.4	96.7	96.3
Fuji Electric	27.3	27.9	28.2	6.4	6.5	6.0
Fujitsu	7.3	8.2	12.1	1.7	1.9	2.6
Hitachi	67.1	67.2	65.1	15.8	15.7	13.9
Matsushita	35.9	41.2	43.2	8.4	9.6	9.3
Mitsubishi	37.3	28.8	34.8	8.8	6.7	7.5
NEC	55.2	55.0	58.3	13.0	12.9	12.5
New JRC	.4	.4	.4	.1	.1	.1
Oki	1.2	1.3	1.2	.3	.3	.3
Rohm	33.3	37.2	41.8	7.8	8.7	9.0
Sanken	21.1	23.3	28.4	5.0	5.5	6.1
Sanyo	22.5	22.3	26.2	5.3	5.2	5.6
Shindengen Electric	15.9	17.0	15.8	3.7	4.0	3.4
Sony	10.9	9.6	10.5	2.6	2.2	2.2
Toko	.6	.7	2.3	.1	.2	.5
Toshiba	73.7	73.0	81.1	17.3	17.1	17.4
Other Japanese Companies	4.6	.0	.0	1.1	.0	.0
European Companies	1.7	1.6	1.9	.4	.4	.4
Philips	.3	.4	.5	.1	.1	.1
SGS-Thomson	.3	.7	.7	.1	.2	.1
Siemens	1.1	.4	.4	.3	.1	.1
Other European Companies	.0	.0	.3	.0	.0	.1

(Continued)

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Table 1-33 (Continued)
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to Japan
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Asia/Pacific Companies	1.4	1.2	1.4	.3	.3	.3
Korean Electronic Co.	.8	.7	.7	.2	.2	.1
Samsung	.6	.3	.5	.1	.1	.1
Other Asia/Pacific Companies	.0	.1	.1	.0	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-34
Each Company's Factory Revenue from Shipments of Optoelectronic Semiconductors to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,551	1,494	1,787	100.0	100.0	100.0
North American Companies	18	32	49	1.2	2.1	2.7
Harris	1	1	0	.1	.1	.0
Hewlett Packard	17	14	20	1.1	.9	1.1
Optek	0	7	0	.0	.5	.0
Texas Instruments	0	10	29	.0	.7	1.6
Japanese Companies	1,526	1,456	1,733	98.4	97.5	97.0
Fuji Electric	1	1	1	.1	.1	.1
Fujitsu	84	85	101	5.4	5.7	5.7
Hitachi	41	41	48	2.6	2.7	2.7
Matsushita	281	260	297	18.1	17.4	16.6
Mitsubishi	26	27	23	1.7	1.8	1.3
NEC	95	95	105	6.1	6.4	5.9
New JRC	11	11	13	.7	.7	.7
Oki	30	28	29	1.9	1.9	1.6
Rohm	84	93	110	5.4	6.2	6.2
Sanken	17	19	17	1.1	1.3	1.0
Sanyo	121	135	181	7.8	9.0	10.1
Sharp	248	250	304	16.0	16.7	17.0
Sony	228	225	269	14.7	15.1	15.1
Toshiba	185	186	210	11.9	12.4	11.8
Other Japanese Companies	74	0	25	4.8	.0	1.4
European Companies	6	3	2	.4	.2	.1
ABB-HAFO	2	2	0	.1	.1	.0
Siemens	3	1	2	.2	.1	.1
TMS	1	0	0	.1	.0	.0
Asia/Pacific Companies	1	3	3	.1	.2	.2
Korean Electronic Co.	1	2	2	.1	.1	.1
Other Asia/Pacific Companies	0	1	1	.0	.1	.1

Source: Dataquest (June 1992)

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Table 1-35
Each Company's Factory Revenue from Shipments of Optoelectronic Semiconductors to Japan (Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	214.0	215.1	243.0	100.0	100.0	100.0
North American Companies	2.5	4.6	6.7	1.2	2.1	2.8
Harris	.1	.1	.0	.0	.0	.0
Hewlett Packard	2.3	2.0	2.7	1.1	.9	1.1
Optek	.0	1.0	.0	.0	.5	.0
Texas Instruments	.0	1.4	3.9	.0	.7	1.6
Japanese Companies	210.6	209.7	235.7	98.4	97.5	97.0
Fuji Electric	.1	.1	.1	.0	.0	.0
Fujitsu	11.6	12.2	13.7	5.4	5.7	5.6
Hitachi	5.7	5.9	6.5	2.7	2.7	2.7
Matsushita	38.8	37.4	40.4	18.1	17.4	16.6
Mitsubishi	3.6	3.9	3.1	1.7	1.8	1.3
NEC	13.1	13.7	14.3	6.1	6.4	5.9
New JRC	1.5	1.6	1.8	.7	.7	.7
Oki	4.1	4.0	3.9	1.9	1.9	1.6
Rohm	11.6	13.4	15.0	5.4	6.2	6.2
Sanken	2.3	2.7	2.3	1.1	1.3	.9
Sanyo	16.7	19.4	24.6	7.8	9.0	10.1
Sharp	34.2	36.0	41.3	16.0	16.7	17.0
Sony	31.5	32.4	36.6	14.7	15.1	15.1
Toshiba	25.5	26.8	28.6	11.9	12.5	11.8
Other Japanese Companies	10.2	.0	3.4	4.8	.0	1.4
European Companies	.8	.4	.3	.4	.2	.1
ABB-HAFO	.3	.3	.0	.1	.1	.0
Siemens	.4	.1	.3	.2	.0	.1
TMS	.1	.0	.0	.0	.0	.0
Asia/Pacific Companies	.1	.4	.4	.0	.2	.2
Korean Electronic Co.	.1	.3	.3	.0	.1	.1
Other Asia/Pacific Companies	.0	.1	.1	.0	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

Source: Dataquest (June 1992)

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Table 1-36
Japanese Company's Factory Revenue from Shipments of Semiconductors to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	54,339	54,545	59,694	100.0	100.0	100.0
Japanese Companies	27,510	25,278	27,684	50.6	46.3	46.4
Fuji Electric	310	319	319	.6	.6	.5
Fujitsu	2,770	2,599	2,705	5.1	4.8	4.5
Hitachi	3,622	3,516	3,765	6.7	6.4	6.3
Matsushita	1,804	1,826	2,037	3.3	3.3	3.4
Mitsubishi	2,500	2,108	2,303	4.6	3.9	3.9
NEC	4,489	4,322	4,774	8.3	7.9	8.0
New JRC	171	140	151	.3	.3	.3
NMB Semiconductor	127	96	60	.2	.2	.1
Oki	1,083	954	981	2.0	1.7	1.6
Ricoh	84	89	97	.2	.2	.2
Rohm	723	759	934	1.3	1.4	1.6
Sanken	381	399	451	.7	.7	.8
Sanyo	1,197	1,196	1,362	2.2	2.2	2.3
Seiko Epson	359	196	220	.7	.4	.4
Sharp	1,107	1,194	1,318	2.0	2.2	2.2
Shindengen Electric	163	159	184	.3	.3	.3
Sony	996	1,010	1,196	1.8	1.9	2.0
Toko	50	60	64	.1	.1	.1
Toshiba	4,310	4,202	4,579	7.9	7.7	7.7
Yamaha	133	134	158	.2	.2	.3
Other Japanese Companies	1,131	0	26	2.1	.0	.0

Source: Dataquest (June 1992)

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Table 1-37
Japanese Company's Factory Revenue from Shipments of Semiconductors to the World
(Billions of Yen)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	7,498.8	7,854.5	8,118.4	100.0	100.0	100.0
Japanese Companies	3,796.4	3,640.0	3,765.0	50.6	46.3	46.4
Fuji Electric	42.8	45.9	43.4	.6	.6	.5
Fujitsu	382.3	374.3	367.9	5.1	4.8	4.5
Hitachi	499.8	506.3	512.0	6.7	6.4	6.3
Matsushita	249.0	262.9	277.0	3.3	3.3	3.4
Mitsubishi	345.0	303.6	313.2	4.6	3.9	3.9
NEC	619.5	622.4	649.3	8.3	7.9	8.0
New JRC	23.6	20.2	20.5	.3	.3	.3
NMB Semiconductor	17.5	13.8	8.2	.2	.2	.1
Oki	149.5	137.4	133.4	2.0	1.7	1.6
Ricoh	11.6	12.8	13.2	.2	.2	.2
Rohm	99.8	109.3	127.0	1.3	1.4	1.6
Sanken	52.6	57.5	61.3	.7	.7	.8
Sanyo	165.2	172.2	185.2	2.2	2.2	2.3
Seiko Epson	49.5	28.2	29.9	.7	.4	.4
Sharp	152.8	171.9	179.2	2.0	2.2	2.2
Shindengen Electric	22.5	22.9	25.0	.3	.3	.3
Sony	137.4	145.4	162.7	1.8	1.9	2.0
Toko	6.9	8.6	8.7	.1	.1	.1
Toshiba	594.8	605.1	622.7	7.9	7.7	7.7
Yamaha	18.4	19.3	21.5	.2	.2	.3
Other Japanese Companies	156.1	.0	3.5	2.1	.0	.0
Exchange Rate (Yen/US$)	138	144	136			

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1991 Japanese Semiconductor Strategic Alliances

February 1992

Source:
Dataquest

Market Statistics

Dataquest

Semiconductors *Japan*

1991 Japanese Semiconductor Strategic Alliances

February 1992

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Market Statistics

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1991 Japanese Semiconductor Strategic Alliances

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Note: All tables show estimated data.

1991 Japanese Semiconductor Strategic Alliances

Semiconductor Strategic Alliances

Strategic alliances were established as an important method of doing business in the semiconductor industry during the 1980s, and their success has led to continued use of alliances in the current decade. Dataquest has been recording the evolution of alliance activities in the Japanese semiconductor industry since 1984. The information contained in this booklet summarizes the new alliances that were created during 1991 and compares this year's statistics with those of previous years.

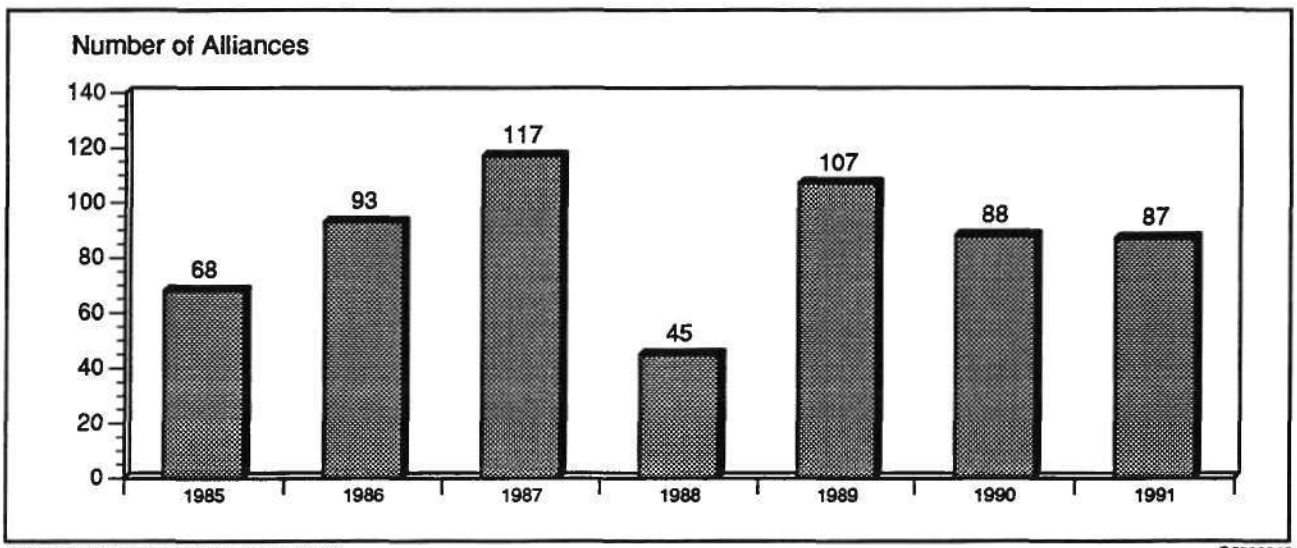
Figure 1 illustrates the alliance formation trend from 1985 through 1991. For this same period, Table 1 presents a breakdown of the alliances by product category. Table 2 lists the companies involved in publicly announced strategic alliances occurring during 1991. In addition, the individual alliance agreements are summarized in Appendix A.

Classification of Agreements

Dataquest classifies strategic alliances into the following 12 major categories:

- LA—Licensing Agreement—Japanese company receives or issues a license to partner for an up-front fee and/or royalties.
- SS—Second-Source Agreement—Both companies agree to develop consistent specifications to ensure a second source.
- SA—Sales Agency Agreement—Japanese company sells its partner's products, either as a sales representative or as a value-added reseller (VAR).
- FA—Fab Agreement—Japanese company offers fab capacity for partner's product technology.
- AT—Assembly and Testing Agreement—Japanese company sends or receives devices for assembly and/or testing.
- TE—Technology Exchange—Both companies exchange technology, which may or may not include a transfer of money.
- JV—Joint Venture—The two companies form a new joint-venture company to develop, manufacture, and market new products.
- JD—Joint Development—Both companies jointly agree to develop new products, which may or may not be marketed separately.
- IV—Investment—Japanese company invests in partner company to secure new technology or access to new markets.
- CO—Coordination of Standards—Japanese company and partner agree to device standards to ensure compatibility.
- PC—Procurement Agreement—Japanese company will buy more foreign semiconductors as part of market access program.
- OT—Other—Joint symposia and programs.

Figure 1
Japanese Semiconductor Alliances (1985-1991)



Source: Dataquest (February 1992)
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Table 1
Japanese Semiconductor Alliances by Product Type

	1985	1986	1987	1988	1989	1990	1991
Multiproducts	4	14	3	2	9	11	4
Memory	10	11	22	19	24	16	16
Micro	17	11	15	7	13	10	12
ASIC	8	17	16	7	10	8	12
Other Devices	11	15	23	9	14	23	21
CAD Tools	1	3	8	2	14	7	4
Equipment	11	12	22	3	17	10	12
Materials	6	10	8	4	1	3	3
Others	0	0	0	2	5	0	3
Total	68	93	117	45	107	88	87

Source: Dataquest (February 1992)

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Table 2
1991 Japanese Semiconductor Alliances

No.	Company 1	Company 2	Product	Agreement Type	Date
1	8 Japanese companies	LSI Logic/VLSI Technology	MUSE decoder chip set	JD	11/91
2	Asahi Kasei Microsystems	AHA	Data compression LSIs	SA, JD	6/91
3		DSP Group	Digital signal processing chips	LA, SA, JD	7/91
4		Int'l Microelectronics	Programmable filters	SA, JD	10/91
5	ASCII	Edsun	Image compression ICs	SA	3/91
6		Zilog	16-bit R800 MPUs	LA	6/91
7	Canon	TI/HP/Singapore gov't	16Mb DRAMs	JV	4/91
8		Electronics For Imaging	Color imaging ICs	LA	6/91
9	Dainippon Screen	NTN	LCD pannel repair equipment	SA	1/91
10	Fuji Electric	Siemens	Power MOSFET	FA	1/91
11	Fuji Photo Film	Altera	Programmable logic devices	JD	2/91
12	Fujitsu	Tera Microsystems	SPARC RISC chip set	FA	7/91
13		Sun Microsystems	SPARC RISC chip	LA	8/91
14		Hal Computer Systems	CMOS RISC microprocessor	JD, IV	8/91
15		Cadence	ASIC design tool	JD	10/91
16	Fujitsu/Hitachi/Sony	Texas Instruments	MUSE decoder	JD	8/91
17	Hakuto	Lattice Semiconductor	CMOS PLDs	SA	4/91
18	Hitachi	Compass Design Automation	0.8-micron ASIC cell libraries	JD	5/91
19		NMB Semiconductor	4Mb DRAMs	FA	6/91
20		Bull	IC card	LA	8/91
21		Texas Instruments	64Mb DRAM	JD	11/91
22	Hitachi Chemical	Dexter	Epoxy for semiconductors	FA, TE	3/91
23	Hoshiden	Boeing	TFT color LCDs	SA	1/91
24	Hoya	AT&T	Semiconductor photomask	SA, TE, JD	8/91
25		Munich Laser Systems	Laser manufacturing equipment	IV	9/91
26	Internix	EDI	1Mb SRAMs, 512K-8Mb SRAM modules	SA	3/91
27	Japan Macnics	Benchmark Microsystems	SRAM	SA	3/91
28	JVC	C-Cube Microsystems	Digital video compression ICs	JD	3/91
29	Kanematsu	Technique	Semiconductor plating equipment	SA	9/91
30	Kobe Steel	Texas Instruments	ASICs	SA	10/91

(Continued)

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Table 2 (Continued)
1991 Japanese Semiconductor Alliances

No.	Company 1	Company 2	Product	Agreement Type	Date
31	Kokusai Electric	BTU International	Thermal processing system	JV	12/91
32	Marubeni	Empak	Hard disk and s/c wafer case	JV	3/91
33	Marubeni Hightech	Mattson Technology	Photoresist stripping system	IV	1/91
34	Matsushita	Power Integrations	Off-line smart power ICs	LA, FA	2/91
35		Univ. of Colorado	Ferroelectric thin film technology	JD	3/91
36		Weitek	Math coprocessors	LA, FA	5/91
37		Phillps/Signetics	Consumer CMOS ICs	FA	11/91
38	Mitech	Xilinx	Programming serial ROMs	SA, FA	7/91
39	Mitsubishi	Asahi Glass	TFT LCD	JV	2/91
40		AT&T	8-bit microcontroller	FA	9/91
41		AT&T	GaAs semiconductors	FA	9/91
42		Benz Group	Bipolar analog ICs	JD	10/91
43	Mitsubishi Corp.	Tera Microsystems	Peripheral chip set for RISC	IV	8/91
44		Cymer Laser	Ultraviolet excimer laser	IV	9/91
45	Mitsui & Co.	FSI International	Surface cleaning equipment	JV	6/91
46	NEC	Cadence	ASIC design systems	JD	3/91
47		Sharp	16-bit microprocessors	SS	4/91
48		AT&T	0.35-micron process technology	TE, JD	4/91
49		Robert Bosch Automotive	microcontrollers	JD	4/91
50		Omron	Fuzzy logic microcontrollers	JD	7/91
51		CrossCreck	ASIC testing technology	LA	12/91
52	New Japan Radio	Raytheon	High-frequency semiconductors	JD	9/91
53	Nippo Sangyo	Togai Infralogic	Fuzzy logic chips	JV	4/91
54	Nippon Synthetic Rubber	Insystems	LCD AM test equipment	SA	6/91
55	Nippondenso	AT&T	IC card	JD	8/91
56	NKK	Paradigm Technology	256K, 1Mb SRAMs	JD, IV	1/91
57		Macronix International	Mask ROMs	FA, JD	4/91
58		Macronix International	1Mb, 2Mb, 4Mb flash memory	JD	9/91
59		IDT	32-bit MIPS RISC architecture	JD	9/91
60	Oki	SGS-Thomson	16Mb DRAM	JV, JD	3/91

(Continued)

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Table 2 (Continued)
1991 Japanese Semiconductor Alliances

No.	Company 1	Company 2	Product	Agreement Type	Date
61		Hewlett-Packard	HP RISC architecture	LA	9/91
62		Bull	IC card	LA	10/91
63	Olympus Optics	LSI Technology	Gate arrays	FA	8/91
64	Sanyo	LSI Logic	MUSE decoder	JD	7/91
65		Micron Technology	16-bit-wide 1Mb DRAM	LA	7/91
66	Sharp	Electrolux	Fuzzy control technology	LA, JD	1/91
67	Shibasoku	Credence Systems	Semiconductor test equipment	SA, JV, JD	11/91
68	Shin-Etsu Chemical	Herus Quotz Glass	Crucibles	JV	2/91
69	SMK	Windbond	64K, 256K SRAMs	SA	8/91
70	Sony	AMD	IC process technology	LA	4/91
71	Sumitomo Chemical	Oriental Chemical	Semiconductor cleaning material	JV	9/91
72	Sumitomo Corp.	Synopsis	CAD tools	IV	1/91
73	Sumitomo Metal Mining	N Chip	Multichip modules	SA, JD, IV	5/91
74	TDK/Silicon Systems	Level One Communications	LAN chips	IV	5/91
75		Philips	BiCMOS process technology	LA	5/91
76	Tokyo Electronic Design	Intel Japan	In-circuit emulators	JD	4/91
77	Tomen Electronics	VLSI Technology Japan	ASICs, SRAMs	SA	6/91
78	Toshiba	Synergy	Industrial bipolar ICs	LA, JD, IV	1/91
79		Bull America	MCA bus chip set	JD	1/91
80		Kubota	Image processing ICs	SA	8/91
81		Motorola	Semiconductors	SA	9/91
82		IDT/Siemens	RISC MPUs	SA, JD	10/91
83		MIPS Computer	MIPS RISC MPUs	LA, IV, CO	10/91
84		Siemens	MIPS RISC MPUs	JD	11/91
85		3 U.S. companies	LCD process equipment	JD	11/91
86	Toyota Motor	6 U.S. companies	Automotive ICs	JD	9/91
87	Yokogawa HP	Cadence	ASIC design systems	FA	2/91

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Appendix A

Eight Japanese Companies

1. **LSI Logic/VLSI Technology (U.S.)** (November 1991)

Two U.S. companies, LSI Logic and VLSI Technology, will participate in an alliance to develop an HDTV MUSE decoder chip set in Japan. The eight Japanese participants are Matsushita Electric Industrial, Matsushita Electronics, Mitsubishi Electric, NEC, NEC Home Electronics, Pioneer, Sharp, and Victor Company of Japan (JVC).

LSI Logic will work on audio chips, and VLSI Technology will handle color-processing ICs. Matsushita Electric Industrial will develop frame memory and motion-detection circuitry with its affiliate Matsushita Electronics. Mitsubishi will design and produce input/output processing chips. NEC and its sister organization, NEC HE, will create other signal-processing circuits. Pioneer, Sharp, and JVC will work on the chips governing digital signals and picture quality.

Asahi Kasei Microsystems

2. **Advanced Hardware Architecture (U.S.)** (June 1991)

Asahi Kasei Microsystems teamed up with Advanced Hardware Architecture (AHA) of Idaho in error-correction/data-compression LSI sales and magneto-optic disc (MOD) drive controller LSI development. Asahi will exclusively market AHA chips in the Asia/Pacific region including Japan.

3. **DSP Group (U.S.)** (July 1991)

DSP Group of San Jose, California, has agreed to supply a digital-signal-processing chip to Asahi Kasei Microsystems on an OEM basis for worldwide sales. The two also will work together to develop a digital communications chip set for the Japanese market using DSP's technology. Asahi Kasei will have rights to market the resulting product as well as certain other DSP chip sets worldwide.

4. **International Microelectronics Products (U.S.)** (October 1991)

Asahi Kasei Microsystems has signed a programmable filter sales and development agreement with International Microelectronics Products (IMP) of California. Asahi will import and market IMP programmable filters in Japan and send its research staff to IMP to jointly develop a signal-processing LSI chip that will integrate filters and peripheral circuits.

ASCII

5. **Edsun (U.S.)** (March 1991)

ASCII signed an image-processing semiconductor distribution contract with Edsun, a Massachusetts-based semiconductor design company. Under the terms of agreement, ASCII will start sample-shipping of the CEG/DAC graphics LSI device in April. When used with a Chips & Technologies VGA controller LSI, the CEG/DAC chip can clear notches of slanted lines and curves.

6. **Zilog (U.S.)** (June 1991)

Under a 10-year pact, ASCII will give Zilog rights to manufacture and sell its 16-bit R800 microprocessor. ASCII hopes to boost monthly sales of the MPUs by tapping Zilog's worldwide sales network. The two companies also will work together on ASICs and next-generation MPUs.

Canon

7. **TI/HP/Singapore Government** (April 1991)

Texas Instruments (TI) has teamed up with Hewlett-Packard (HP), Canon, and the Singapore Economic Development Board to build a fab in Singapore. The aim of the joint venture is to produce 4Mb and 16Mb DRAMs based on TI's submicron CMOS process and 8-inch wafer technologies by mid-1993. To join the enterprise, each partner provided an initial $73 million investment.

8. **Electronics For Imaging (U.S.)** (June 1991)

Canon and Electronics For Imaging (EFI) signed a cross-license pact involving color imaging ICs. The San Francisco company will use a Canon chip set in its Fiery controller. EFI will license its software expertise to Canon to develop new color imaging applications for Canon's copiers.

Dainippon Screen

9. **NTN (Japan)** (January 1991)

Dainippon and NTN, a Japanese electronic equipment company, signed an agreement regarding the technology for NTN's LCD panel-repair equipment. NTN will design and manufacture new LCD panel-repair machinery, and both companies will market the equipment through Dainippon's distribution channels.

Fuji Electric

10. **Siemens (Germany)** (January 1991)

Under this agreement, Siemens will double its semiconductor assembly contract with Fuji Electric by 1995. Fuji Electric currently produces about ¥3.5 billion worth of Siemens chips. Both companies plan to increase production by a 15 percent growth rate per year.

Fuji Photo Film

11. **Altera (U.S.)** (February 1991)

Fuji Photo Film will work with Altera on programmable logic devices for use in electronic image-processing equipment. Fuji will provide its image-processing and video technologies; Altera will design, produce, and market the chips. Fuji plans to incorporate the PLDs into its camcorders and electronic still cameras.

Fujitsu

12. **Tera Microsystems (U.S.)** (July 1991)

Tera Microsystems, a start-up company in Santa Clara, California, will take on Fujitsu and LSI Logic in the business of core-logic chip sets for SPARC-based computers. Fujitsu will be a foundry for Tera's chip set.

13. **Sun Microsystems (U.S.)** (August 1991)

Fujitsu Microelectronics (FMI), a subsidiary of Fujitsu in California, signed a RISC chip licensing agreement with Sun Microsystems. The chip integrates an MB86903 RISC chip core and a floating-point processor on a single chip. The agreement also covers the licensing of Sun's GX graphics chip. FMI will market the RISC chip to Sun-compatible workstation manufacturers.

14. **HaL Computer Systems (U.S.)** (August 1991)

Fujitsu has invested $40 million for a 44 percent stake in HaL Computer Systems Inc., a commercial computer start-up company, to jointly develop UNIX-based CMOS RISC microprocessors.

15. **Cadence (U.S.)** (October 1991)

Fujitsu agreed to develop ASIC design systems with Cadence Design Systems. Fujitsu and Cadence will integrate design software so that customers of both companies will be able to use either company's software. The two vendors will also expand their CAD tool product lines and develop design systems capable of handling systems-on-chip by working together closely. This is the first time Fujitsu has cooperated in the ASIC business with a third-party CAE vendor.

Fujitsu/Hitachi/Sony

16. **Texas Instruments (U.S.)** (August 1991)

Fujitsu, Hitachi, Sony, and TI Japan have agreed to jointly develop HDTV decoder LSIs by the spring of 1992 to meet the "MUSE" Japanese standard specifications. Sony will be

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in charge of developing an analog input/output processing unit; TI Japan will develop frame memory; and Fujitsu and Hitachi will work on digital and voice processing units, respectively. A decoder to be developed by the four chipmakers will consist of about 30 chips.

Hakuto

17. **Lattice Semiconductor (U.S.)** (April 1991)

Hakuto obtained the distribution rights for Lattice's CMOS PLDs. Hakuto will market 26 kinds of products in Japan, including Lattice's PLD—the world's fastest PLD.

Hitachi

18. **Compass Design Automation (U.S.)** (May 1991)

Hitachi will jointly develop 0.8-micron CMOS ASIC cell libraries with Compass Design Automation of the United States. Hitachi, which has already teamed up with VLSI Technology, now has decided to join hands with this VLSI Technology subsidiary to meet demand for faster and denser ASIC devices.

19. **NMB Semiconductor (Japan)** (June 1991)

Hitachi will commission 4Mb DRAM production by NMBS in an effort to help NMBS overcome its current management crisis. Hitachi will provide NMBS with 4Mb DRAM production technology, and NMBS will produce 4Mb DRAMs at its headquarters' second facility. Hitachi will procure chips from NMBS and market them under its own name.

20. **Bull (France)** (August 1991)

Hitachi has signed a license agreement with Bull CP8—the Bull group's IC card operating company—and is expected to pay approximately 6 percent of sales to Bull. Bull's patent is essential in manufacturing reliable IC cards at low costs. Using the patent, Hitachi will produce IC card chips; supply them to SPOM Japan, a joint venture established in Japan by Bull CP8 and Dainippon Printings; and distribute them abroad using its own channel.

21. **Texas Instruments (U.S.)** (November 1991)

Hitachi and TI have signed a 64Mb DRAM development agreement. The two companies have also agreed to extend their contract for 16Mb DRAM development until the end of 1994. Hitachi and TI will jointly design 64Mb DRAMs by setting up a design team at TI Japan's Miho plant. They will also develop a design automation environment, 0.35-micron processing technology, reliability and evaluation standards, and packages.

Hitachi Chemical

22. **Dexter (U.S.)** (March 1991)

Hitachi Chemical teamed up with Dexter of Connecticut in the semiconductor sealing material business. The two companies will join forces in R&D and manufacturing of epoxy sealing materials. Initially, Dexter will produce epoxy sealing materials to be marketed in Asia at Hitachi Chemical's plants in Japan and Malaysia. Dexter will also produce the materials at its plants in the United States and Germany for sale in those countries. Hitachi and Dexter will exchange engineers to engage in joint research for 16Mb DRAM sealing materials as well.

Hoshiden

23. **Boeing (U.S.)** (January 1991)

Hoshiden obtained a sales and codevelopment contract with Boeing Company for production of color TFT LCDs for Boeing's B777 cockpit. The 6.7-inch LCD panel is the world's largest display installed in a commercial aircraft. Hoshiden has been working with Honeywell since 1984 to develop LCDs for aircraft and is geared up for mass production of 5,000 panels per month.

Hoya

24. **AT&T (U.S.)** (August 1991)

AT&T Microelectronics, Hoya Micro Mask Inc., and Hoya Corporation have agreed to

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exchange mask-making technology and to market AT&T's captive mask-making capacity to U.S. chip vendors. Under the three-pronged agreement, Hoya will market AT&T's mask capacity in the United States and will purchase computer-integrated manufacturing software and an automated mask production line from AT&T.

25. **Munich Laser Systems (Germany)** (September 1991)

Hoya has acquired a 38.9 percent equity stake in Munich Laser Systems GmbH, a German laser device manufacturer, to expand its laser equipment business overseas. Hoya, a leading Japanese maker of optical glass and glass for semiconductor manufacturing, plans to produce optoelectronics overseas, including laser equipment. In addition, Hoya also recently acquired a 90 percent equity in a U.S. laser equipment company.

Internix

26. **EDI (U.S.)** (March 1991)

Internix has started marketing EDI semiconductor products in Japan. EDI is a Massachusetts chipmaker specializing in large-capacity memory products. Internix will market EDI's DRAMs, SRAMs, and SRAM modules.

Japan Macnics

27. **Benchmark Microsystems** (March 1991)

Japan Macnics has started marketing Benchmark Microsystems' semiconductor products. Benchmark's products include processor management units (PMUs) for monitoring microprocessor power supplies, nonvolatile SRAMs, and energy-management units.

Victor Company of Japan (JVC)

28. **C-Cube Microsystems (U.S.)** (March 1991)

JVC teamed up with C-Cube Microsystems of California to jointly develop MPEG-standard video decoder ICs. Motion Picture Expert Group (MPEG) is a video signal compression format that can transfer data at 1 to 1.5 Mbps, which is not fast enough to send video pictures as in broadcasting transmissions. JVC has been working with C-Cube to improve data transfer speed to between 4 Mbps and 6 Mbps.

Kanematsu

29. **Technique (U.S.)** (September 1991)

Kanematsu has teamed up with Technique of Rhode Island in semiconductor plating equipment production and sales. Kanematsu modifies Technique's products sold in the United States to meet the Japanese standards and markets them in Japan. The two companies plan to set up a joint sales/maintenance company in Japan.

Kobe Steel

30. **Texas Instruments (U.S.)** (October 1991)

Kobe Steel signed a distribution contract with TI Japan and opened the Kobe Steel IC Design Center in Kobe. The center will be staffed by 21 people initially and will employ 80 people by 1995. Kobe Steel and TI established KTI Semiconductor in May 1990, and this joint venture is building a production plant in Nishiwaki City, Hyogo Prefecture. Production is slated to start in the fall of 1992.

Kokusai Electric

31. **BTU International (U.S.)** (December 1991)

BTU International has agreed in principle with Kokusai Electric to transfer its Bruce Systems Division to a joint venture corporation. Kokusai will hold a majority stock of the joint venture, which has its headquarters in Billerica, Massachusetts, and manufactures thermal processing systems.

Marubeni

32. **Empak (U.S.)** (March 1991)

Marubeni will set up a joint venture with U.S plastics manufacturer Empak of Minnesota to market hard disk and semiconductor wafer

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cases. The joint venture will invest $10 million to build production facilities in either Japan or Malaysia for the Asian region and in either Germany or Great Britain for the European region.

Marubeni Hightech

33. **Mattson Technology (U.S.)** (January 1991)

Marubeni Hightech has acquired a 20 percent stake in Mattson Technology, a maker of plasma-based photoresist stripping systems. As part of the deal, Marubeni will distribute the Mattson Technology systems in Japan.

Matsushita

34. **Power Integrations (U.S.)** (February 1991)

Matsushita teamed up with Power Integrations (PI) of California in high-volume intelligent power MOS IC production and sales. Using PI's technology, Matsushita will supply processed wafers to PI and will market the finished PI products through its own distribution channel. Matsushita also plans to develop its proprietary products using PI techniques.

35. **University of Colorado (U.S.)** (March 1991)

Matsushita will make a three-year, $1 million investment in a ferroelectric research effort with the University of Colorado and privately held Symetric Corporation. Matsushita is interested in incorporating ferroelectric thin films in consumer electronic devices, either as part of a thin film semiconductor layer or as a substrate material in a module.

36. **Weitek (U.S.)** (May 1991)

Matsushita and Weitek, a California-based start-up, concluded an alliance relationship in the math coprocessor production area. Matsushita will produce wafers based on Weitek's design technology.

37. **Matsushita/Philips/Signetics (U.S.)** (November 1991)

Signetics, a subsidiary of Philips Electronics NV, will manufacture and assemble significant quantities of ICs for Matsushita. Under the agreement, Signetics will build consumer-oriented CMOS digital ICs for Matsushita in its New Mexico fab and assemble the parts in its plant in Thailand. With the linkup, the Matsushita group aims to give a lift to the microchip operations of Philips, the Dutch electronics giant that has been in a slump. Signetics will produce 9,000 wafers per month for Matsushita.

Mitech

38. **Xilinx (U.S.)** (July 1991)

Mitech will manufacture and market Xilinx's logic circuit for programming serial ROMs in Japan. The chip is capable of programming eight serial ROMs at a time. Mitech also will make and sell Xilinx's serial emulators.

Mitsubishi

39. **Asahi Glass (Japan)** (February 1991)

Mitsubishi and Asahi Glass will form a joint venture to focus on TFT AM LCD modules using amorphous silicon. The new venture will be owned 80 percent by Mitsubishi and 20 percent by Asahi Glass. Headquarters initially will be in Kyoto, Japan. The venture is expected to start producing 8,000 to 10,000 10-inch TFT AM LCDs per month.

40. **AT&T (U.S.)** (September 1991)

Mitsubishi will commission 8-bit microcontroller production at AT&T's Singapore plant. Mitsubishi will supply AT&T-made MCUs to mainly Japanese companies with operations in Malaysia and other Southeast Asian countries. Mitsubishi has been commissioning bipolar IC production by AT&T's Singapore and Thailand plants since 1990 and plans to expand to 16-bit MCU production.

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41. **AT&T (U.S.)** (September 1991)

Mitsubishi and AT&T will jointly develop a GaAs semiconductor production technique. AT&T will manufacture GaAs ICs customized for Mitsubishi at its Reading, Pennsylvania, plant using that technique and will supply them to Mitsubishi on an OEM basis. Mitsubishi hopes to increase foreign semiconductor procurement through its link with AT&T.

42. **Benz Group (Germany)** (October 1991)

Mitsubishi and Benz Group have agreed to cooperate in the semiconductor business in 1992. Mitsubishi will commission AEG, a Benz company, to manufacture consumer semiconductors on an OEM basis. The two companies plan to start with production of bipolar analog ICs.

Mitsubishi Corporation

43. **Tera Microsystems (U.S.)** (August 1991)

Mitsubishi Corporation invested $750,000 for a 6.7 percent stake in Tera Microsystems Inc., which specializes in peripheral chip sets for Sun Microsystems' SPARC chip set. The Japanese trading company will help Tera find a Japanese chipmaker to produce SPARC chip sets on a commission basis and market the chip set to Japanese workstation manufacturers.

44. **Cymer Laser (U.S.)** (September 1991)

Mitsubishi has invested $2 million in Cymer Laser Technologies of San Diego, California, to fund ongoing excimer laser technology development. The investment gives Mitsubishi a 4 percent ownership in Cymer. Canon and Nikon have a combined 4 percent ownership position in Cymer. Cymer was founded in 1986 to develop, manufacture, and support ultraviolet excimer lasers for use in the manufacturing of semiconductor devices.

Mitsui & Co.

45. **FSI International (U.S.)** (June 1991)

Mitsui & Co. and FSI International have agreed to set up a company for the manufacturing and sales of semiconductor surface processing equipment in Japan early in August. M-FSI, as the company will be called, will be capitalized at ¥450 million. FSI, Mitsui, and a Mitsui subsidiary will own 49 percent, 25 percent, and 26 percent, respectively, of the joint venture. Production in Japan will start in the third year of operations.

NEC

46. **Cadence (U.S.)** (March 1991)

NEC and Cadence will jointly develop an ASIC EDA environment that will support NEC's plans to offer high-level system-design capability in both gate array and standard cell technologies. Cadence's Japanese subsidiary was to port Cadence CAE software programs on NEC engineering workstations by the end of 1991. The "Open CAD Design System" will reach the Japanese market sometime in 1992.

47. **Sharp (Japan)** (April 1991)

NEC and Sharp have signed a 16-bit microprocessor second-sourcing agreement. Sharp is licensed to manufacture the V20HL and V30HL MPUs under the five-year contract.

48. **AT&T (U.S.)** (April 1991)

NEC and AT&T Microelectronics will jointly develop a semiconductor fab process to build next-generation LSI chips. Under the new agreement, the two companies will develop a 0.35-micron CMOS process applicable to building 64Mb DRAM and 16Mb SRAM chips. The agreement is valid until January 1, 1993.

49. **Robert Bosch (Germany)** (April 1991)

NEC and Robert Bosch will develop automotive network microcontrollers. Under the terms of the five-year contract, NEC will develop MCUs based on the CAN—an automotive communications protocol developed by Robert Bosch—and put them on the market starting in fiscal 1992.

50. **Omron (Japan)** (July 1991)

NEC has joined forces with Omron, which holds many of the basic patents in the fuzzy

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microprocessor field, to work on the software-development tools and microprocessors needed to make fuzzy inference systems more widely available. NEC will develop and manufacture 4-, 8-, and 16-bit microprocessors based on technical information and patents from Omron covering fuzzy inference modules and development tools.

51. **CrossCheck (U.S.)** (December 1992)

NEC obtained a nonexclusive license from CrossCheck Technology Inc. for the San Jose, California, company's design-in testing know-how for ASICs. CrossCheck's technology incorporates a testing framework in the chips. Other rights obtained by NEC include use of CrossCheck's fault simulation, automatic test pattern generation, and diagnostic software.

New Japan Radio

52. **Raytheon (U.S.)** (September 1991)

New Japan Radio (NJR) has agreed to develop high-frequency semiconductors with Raytheon of Massachusetts. The two companies will develop 10-GHz or higher frequency devices for use in broadcasting satellite converters by the end of 1992. An expert in bipolar IC production, NJR will develop the high-frequency devices by either modifying bipolar ICs or developing GaAs devices. The prototype will be developed at NJR's Kawagoe plant; once volume production becomes feasible, each company will start production at its own plants.

Nippo Sangyo

53. **Togai Infralogic (U.S.)** (April 1991)

Nippo Sangyo has established a new joint venture with Togai Infralogic, a California-based start-up company. The two companies plan to develop fuzzy logic chips that will apply to consumer products.

Nippon Synthetic Rubber

54. **Insystems (U.S.)** (June 1991)

Nippon Synthetic Rubber will market Insystems' LCD active matrix (AM) test equipment. The two companies plan to jointly develop test equipment by the beginning of 1992 and start marketing products in Japan.

Nippondenso

55. **AT&T (U.S.)** (August 1991)

Nippondenso reached a cooperative agreement to take AT&T's smart card systems to Japan. Under the agreement, AT&T and Nippondenso will jointly develop applications for use with AT&T's smart card. Nippondenso will have exclusive rights to manufacture AT&T's reader/writer and to market the jointly developed applications in Japan. AT&T will supply smart cards for applications and provide technical services and training.

NKK

56. **Paradigm Technology (U.S.)** (January 1991)

NKK made an $11 million equity and technology investment in Paradigm Technology Inc., a four-year-old specialty SRAM company. The investment consists of a $5 million cash infusion that gives NKK a 10 percent equity stake in Paradigm and a $6 million payment in exchange for rights to Paradigm's submicron process technology. NKK also gains the right to produce and sell Paradigm's SRAMs in the Far East.

57. **Macronix International (Taiwan)** (April 1991)

NKK will work with Macronix International of Taiwan to develop mask ROMs. The pact calls for mask-ROM development ranging from 4Mb to 16Mb densities. NKK will build an R&D center at Ayase that will include an 8-inch wafer fab capable of processing 6,000 to 8,000 wafers per month. The R&D center will employ approximately 500 people after construction is completed in the fall of 1992.

58. **Macronix International (Taiwan)** (September 1991)

NKK will jointly develop 1Mb to 4Mb flash memory chips with Macronix International. The

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two companies plan to develop 1Mb, 2Mb, and 4Mb flash memory chips using 6-inch wafers in Taiwan by the spring of 1992 and start volume production at the new NKK Electronics Lab, which will be completed by 1993. Sample chips will be shipped in the Japanese market in 1992.

59. **Integrated Device Technology (IDT) (U.S.)** (September 1991)

NKK and IDT have established a design agreement whereby IDT will assist NKK in developing its design expertise in preparation for NKK's volume manufacturing. NKK is constructing an 8-inch wafer fabrication facility in Japan. NKK is planning to sample-ship the IDT R3051/3052 controllers by the summer of 1992 and to start manufacturing and marketing the MIPS R3000 RISC chip using IDT's technology by the fall of 1992.

Oki

60. **SGS-Thomson (France)** (March 1991)

Oki and SGS-Thomson will build a 16Mb DRAM production plant in Europe in about two years. It will be the first semiconductor plant built by a Japanese and European chipmaker collaboration, and construction is expected to cost from ¥70 billion to ¥80 billion. Oki will contribute production technology to the joint endeavor.

61. **Hewlett-Packard (HP) (U.S.)** (September 1991)

Oki has signed a RISC license agreement with HP. The second Japanese company after Hitachi to license the Precision Architecture (PA) RISC from HP, Oki will commercialize the RISC chip in fiscal 1993 and incorporate the chip into its products, including communications systems, automotive electronics equipment, and printers.

62. **Bull (France)** (October 1991)

Bull will license to Oki its IC card SPOM patent, which will lower the manufacturing cost by allowing both CPU and memory to be integrated on the same chip. Oki will pay 6 percent of its sales royalty to Bull.

Olympus Optics

63. **LSI Technology (Japan)** (August 1991)

Olympus Optics has teamed up with LSI Technology in prototype AISC production. LSI will take orders for the LS Board gate arrays, and Olympus will produce LSI-designed gate arrays using a 1.2-micron CMOS double-metal process. Olympus will utilize a method for fabricating multiple types of products on a wafer to cut the production costs in half.

Sanyo

64. **LSI Logic (U.S.)** (July 1991)

Sanyo and the Japanese subsidiary of LSI Logic will codevelop a single-chip decoder for the MUSE HDTV system. The decoder, which will replace about 40 devices used in the current-generation part, will be used in HDTV systems that also can display normal NTSC television.

65. **Micron Technology (U.S.)** (July 1991)

Sanyo has licensed the design of a 1Mb DRAM, and the process to fabricate it, from Micron Technology Inc. Micron will receive royalties in return for its year-old 16-bit-wide device. The DRAM is used primarily in high-resolution VGA graphics and main memory in laptop computers.

Sharp

66. **Electrolux (Sweden)** (January 1991)

Sharp signed a cross-license contract with Electrolux of Sweden for joint development of fuzzy control technology and consumer ICs. Sharp will provide Electrolux with consumer IC production technologies, while Electrolux will introduce techniques for controlling vibration and noise of large electric appliances in the home.

Shibasoku

67. **Credence Systems (U.S.)** (November 1991)

Credence has tapped Shibasoku, a maker of instrumentation for electronics applications, to

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market and support its complete line of digital and mixed-signal testers. The two companies will jointly develop an HDTV semiconductor tester using Shibasoku's analog technology and Credence's logic testing technology and will establish a joint venture in Japan to strengthen their ties.

Shin-Etsu Chemical

68. **Herus Quotz Glass (Germany)** (February 1991)

Shin-Etsu Chemical reached an agreement with Herus-Amecile, a subsidiary of Herus Quotz Glass of Germany, to establish a joint venture in the United States.

SMK

69. **Windbond (Taiwan)** (August 1991)

SMK reached a semiconductor sales agreement with Windbond Electronics of Taiwan. SMK will distribute Windbond's 2ns versions of 64K and 256K CMOS SRAMs in the Japanese market. Other Windbond products will be marketed in Japan, including a 12ns version of 64K BiCMOS SRAMs, peripheral ICs, and mask ROMs.

Sony

70. **Advanced Micro Devices (AMD) (U.S.)** (April 1991)

Sony and AMD signed a five-year cross-licensing pact covering a broad range of chip patents and copyrights. The agreement enhances the companies' cooperative efforts to jointly develop process technologies for 0.5-micron circuitry. Much of this work is being done at a former AMD plant in San Antonio, Texas, now owned by Sony.

Sumitomo Chemical

71. **Oriental Chemical (Korea)** (September 1991)

Sumitomo Chemical and Oriental Chemical of Korea agreed to establish a joint venture in Korea. The two companies will start manufacturing and marketing semiconductor wet station materials in the fall of 1992 and will cooperate in the photoresist business.

Sumitomo Corporation

72. **Synopsys (U.S.)** (January 1991)

Sumitomo Corp. has added $5 million to its earlier $9.5 million investment in Synopsys Inc., which develops software to design computer chips. In the past 18 months, Synopsys has placed 50 software packages with 40 Japanese semiconductor manufacturers through a Sumitomo subsidiary.

Sumitomo Metal Mining

73. **N Chip (U.S.)** (May 1991)

Sumitomo Metal Mining made a multimillion-dollar investment in N Chip Inc. of California as part of a broad collaboration that includes joint development of packaging and processing technologies for multichip modules. The affiliate company of Sumitomo also agreed to handle sales of the module in Japan.

TDK/Silicon Systems

74. **Level One Communications (U.S.)** (May 1991)

Silicon Systems Inc. (SSI) and Level One Communications will combine design, process, CAD, and manufacturing resources in a wide-ranging strategic alliance to target the telecommunications and LAN IC markets. Under the pact, SSI will make an undisclosed equity investment in Level One, which has struggled to penetrate the communications IC market since the company's inception in 1985.

75. **Philips (Germany)** (May 1991)

Philips and Silicon Systems Inc. (SSI) reached an agreement whereby Philips would license its BiCMOS process technology to SSI. SSI agreed to produce ASICs for disk drive and communications chips using Philips technology by the end of 1991.

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Tokyo Electronic Design

76. **Intel Japan (U.S.)** (April 1991)

Computer peripheral equipment manufacturer Tokyo Electronic Design and Intel Japan have jointly developed an image-processing in-circuit emulator (ICE), which checks Intel's RISC microprocessor used for a laser printer CPU.

Tomen Electronics

77. **VLSI Technology Japan (U.S.)** (June 1991)

Tomen Electronics signed a distribution contract with VLSI Technology Japan. Under the agreement, the trading firm will market gate arrays, standard cells, and IBM PC chip sets developed by VLSI Technology, the parent company of the Japanese partner. Tomen also opened a design center where engineers will work on VLSI's ASICs in Tokyo.

Toshiba

78. **Synergy (U.S.)** (June 1991)

Toshiba has signed an agreement with Synergy Semiconductor Corp. that includes joint development of high-speed ASICs, a foundry relationship, and the purchase of a 10 percent stake in Synergy. The two companies will use Synergy's bipolar and BiCMOS processes to produce gate arrays and standard cells, and the products will be marketed by both companies.

79. **Bull America (France)** (January 1991)

Toshiba and Bull America, a U.S. subsidiary of Bull, jointly entered the chip set business. Toshiba America will produce and market a chip set designed by Bull Micral of America to support the Intel 80486 on the Micro Channel Architecture (MCA) bus.

80. **Kubota (Japan)** (August 1991)

Toshiba will produce a still-picture compression/depression IC developed by C-Cube Microsystems, a California-based venture in which Kubota invests on a commissioned production basis. Kubota and Kubota C-Cube, a joint venture set up by Kubota, will be in charge of marketing. Kubota and Toshiba also plan to cooperate in the production of a video-picture compression/decompression IC being developed by C-Cube and Philips.

81. **Motorola (U.S.)** (September 1991)

Toshiba and Motorola will team up in semiconductor sales. The two companies will recommend each other when their customers seek a second-source supplier for general-use semiconductor products. Toshiba decided that expanding its cooperative relationship with Motorola to the sales area would be a positive measure, as Motorola has been picking up the pace of its move into the Japanese market with the new semiconductor production base.

82. **IDT (U.S.)/Siemens (Germany)** (October 1991)

Toshiba, Integrated Device Technology (IDT), and Siemens will link up in the development, production, and sales of semiconductors. The three companies cited the need to reduce their investment burdens and avoid trade friction. Under the agreement, IDT will begin supplying a new microprocessing unit with RISC to Toshiba and Siemens on an OEM basis in early 1992. The three manufacturers will jointly develop products by using IDT's microprocessor technology and will share the production work.

83. **MIPS Computer Systems (U.S.)** (October 1991)

Toshiba entered the merchant RISC MPU market with products based on the architecture developed by MIPS Computer Systems. The move significantly broadens the scope of Toshiba's participation in the RISC MPU business. Toshiba has acquired the right to manufacture and market MIPS' R3000 and R4000 series MPUs.

84. **Siemens (Germany)** (November 1991)

Toshiba agreed with Siemens to cooperate in RISC microprocessor development. The two companies will jointly design and manufacture RISC MPUs based on the MIPS' R3000 and

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R4000 MPUs and peripheral LSIs and will mutually supply the MPUs on an OEM basis. Both companies have R3000/R4000 manufacturing and sales contracts with MIPS.

85. **Applied Materials/InSystems/Photon Dynamics (U.S.)** (November 1991)

Toshiba will cooperate with three U.S. companies to jointly develop diagnostic and manufacturing equipment for TFT LCD production.

Toyota Motor

86. **Six Companies (U.S.)** (September 1991)

Toyota Motor has agreed to jointly develop 28 automotive semiconductors with 6 U.S. chipmakers. Toyota will develop 16 devices with Texas Instruments, 4 with Motorola, and 2 each with National Semiconductor, General Instrument, International Rectifier, and Exar.

Yokogawa HP

87. **Cadence (U.S.)** (February 1991)

Yokogawa HP (YHP) will team up with a Japanese subsidiary of Cadence Design Systems to cultivate the semiconductor CAE system market in both Japan and the United States. YHP System Technology Lab will be in charge of developing an integrated system based on a YHP large-scale ASIC design system, which consists of logic synthesis software and a logic simulator and can be used to design ASICs with more than 100,000 gates.

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Facsimile: 66-2-275-7005

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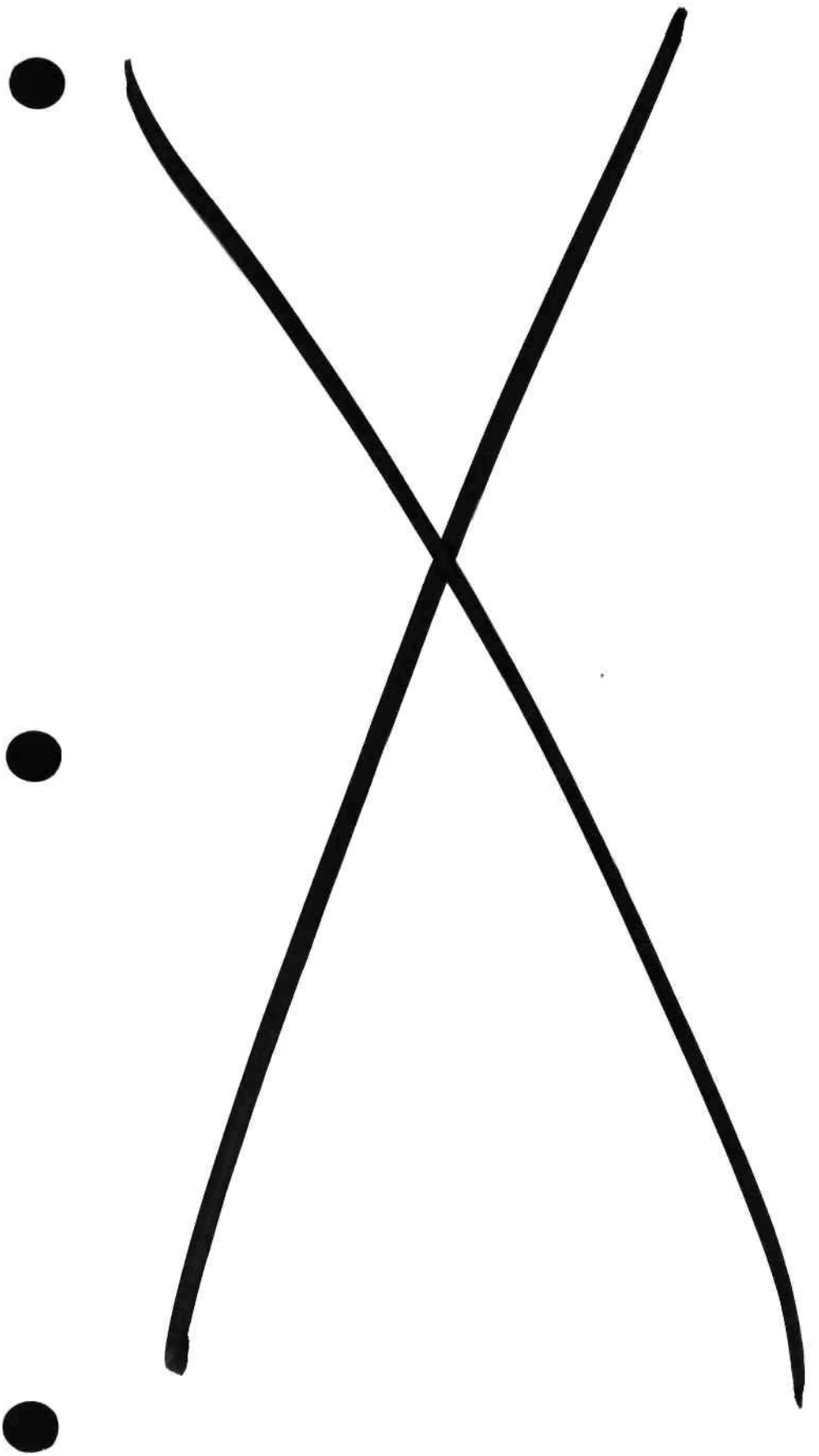

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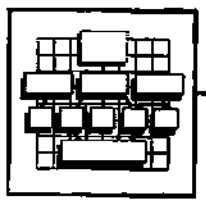

Dataquest Vendor Profile

Semiconductors *Japan*

December 28, 1992

Fujitsu Limited

Corporate Statistics

Address	Fujitsu Limited 6-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100
Telephone	81-3-3216-3211
Facsimile	81-3-3213-7174
Chairman of the Board	Takuma Yamamoto
President and CEO	Tadashi Sekizawa
Established	1935
Number of Employees	155,779 (as of March 31, 1992)
Total Sales	¥3,442 billion (FY1991)
Net Income	¥12 billion (FY1991)
Total Assets	¥3,992 billion (FY1991)
Main Product Area	Computers and Information Processing Systems Communications Systems Electronic Devices Other Operation

Corporate Overview

Fujitsu was originally established as Fuji-Tsushinki K.K. in 1935. As a spin-off from Fuji Electric, the initial charter of the company was to market telephone products, including set-and-exchange equipment, through sales and manufacturing arrangements with other companies. In 1951, Fujitsu began producing data processing equipment—which subsequently led, three years later, to the company's entry into the business of fabricating semiconductor devices. In 1967, the company was renamed Fujitsu Limited.

Fujitsu is associated with the Furukawa group of companies, which itself is one of three subdivisions of the Dai-ichi Kangyo Bank (DKB) group. As a member of the DKB keiretsu, Fujitsu has close ties to

For more information on Fujitsu Limited or the semiconductor industry, call Junko Matsubara at (408) 437-8572.

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financial institutions that can provide the company with banking services, business advice, and introductions to other keiretsu manufacturers.

Fujitsu has 367 consolidated subsidiaries worldwide and 248 subsidiaries operating outside of Japan.

Corporate Business: Trends and Climate

Fujitsu's consolidated revenue recorded ¥3,442 billion in fiscal year (FY) 1991 (see Table 1). This translated to a 15.8 percent growth rate over the previous year's revenue and gave Fujitsu the highest expansion rate among the top 10 Japanese electronics companies during FY1991. Fujitsu's historical revenue trend is plotted in Figure 1. Although total sales reached a peak in FY1991, net income declined by 85.2 percent to ¥12 billion, marking the lowest net gain in a decade of the company's most recent history. The company attributed the drop in profits to the slowdown in demand for both semiconductor and telecommunications products worldwide.

Fujitsu, like nearly all Japanese industries, began suffering the effects of the collapse of Japan's bubble economy in the second half of 1991. Sustaining gross revenue and market share at the expense of net income has become a hallmark of the Japanese business methodology.

In Fujitsu's implementation of this strategy, rapid adjustments to trends that most affected the company's core systems businesses have allowed the company to remain in the black for the fiscal year. The impending trends that are perceived as most important to Fujitsu's

Table 1
Fujitsu Limited Sales, by Product Segment and Market (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Computers and Information Processing Systems	1,372	1,579	1,690	2,056	2,511
Communications Systems	325	375	394	442	445
Electronic Devices	256	334	357	349	349
Other Operations	94	99	109	125	138
Total	2,047	2,387	2,550	2,971	3,442
Domestic Market	1,594	1,859	1,941	2,233	2,415
Percentage of Total Revenue	77.9	77.9	76.1	75.2	70.2
Overseas Market	453	528	609	738	1,027
Percentage of Total Revenue	22.1	22.1	23.9	24.8	29.8
Fiscal Year Exchange Rate (¥=U.S.$1)	138	128	142	141	133

Note: Some columns do not add to totals shown because of rounding.
Source: Company Literature, Dataquest (December 1992)

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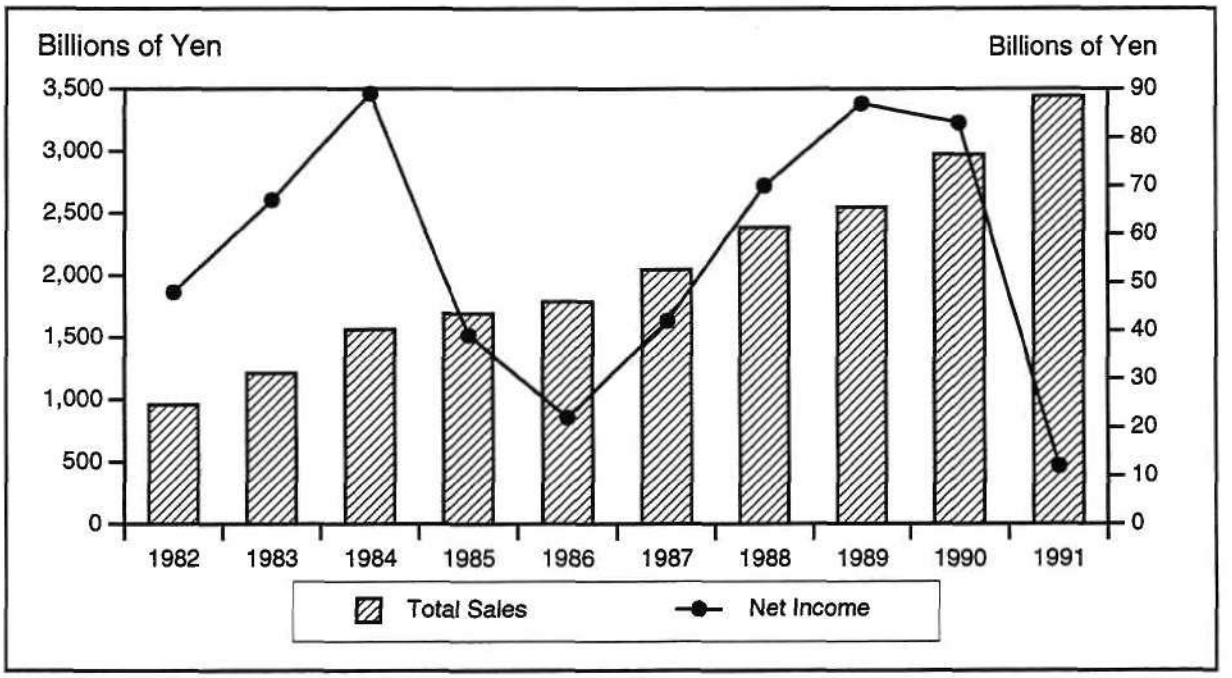
Figure 1
Fujitsu Limited Total Revenue and Net Income



Source: Company Literature, Dataquest (December 1992) G2002667

primary businesses are the move toward downsized-networked systems based on open hardware and software platforms.

To cope with these trends, Fujitsu has instituted new policies and businesses strategies. Some of the aspects of these new policies that may have helped Fujitsu in 1991 were the emphasis on providing new software and service products. The integration of these software and service solutions, while promoting open architectures, may have contributed to the strong domestic sales of Fujitsu's line of large-scale general-purpose mainframe computers during the year. These computer systems have embraced an open UNIX environment as well as Fujitsu's existing operating system, which is becoming an increasingly "open" or user-influenced platform. The continued application of partnerships has also helped in the overseas market performance of Fujitsu systems.

Business Structure

Fujitsu divides its operation into four major sectors: Computers and Information Processing Systems, Communications Systems, Electronic Devices, and Other Operations. Among the four divisions, the Computers and Information Processing Systems grew 22.1 percent and accounted for 73 percent of FY1991 revenue. This heavy emphasis on systems has given Fujitsu the distinction, among horizontally diversified Japanese competitors, of being primarily a business machine

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supplier, along the lines of an IBM. Unlike other major Japanese companies, Fujitsu does not produce a significant amount of consumer electronics products. Instead, Fujitsu has elected to focus on premium electronics markets for such items as supercomputers, telecommunications equipment, and semiconductors.

While the Information Processing arm of its business grew substantially, Fujitsu's Communications, Electronic Devices, and all other operations saw negligible growth. The Electronic Devices part of Fujitsu's business actually contracted slightly during the year. Although this segment accounts for only 10.1 percent of Fujitsu's corporate revenue, the company's primary products, such as its extensive lines of computers and communications equipment, are heavily dependent on the in-house semiconductor manufacturing technology provided by the Electronic Devices group. Thus, the welfare of its Electronics Devices division has critical impact on the company's ability to leverage technical competitive advantage and obscures the group's immediate contribution to the company's revenue stream.

Multinational Profile

In FY1991, 29.8 percent of Fujitsu revenue was generated in overseas markets. Over the past five years, Fujitsu has gradually increased its revenue from overseas markets, with 1991 recording the highest levels of foreign market sales during the five-year period.

Fujitsu's major overseas growth is occurring in the European markets. This growth can be traced to the company's increased investments in that part of the world. In particular, the high-visibility acquisition and merger with ICL in November 1990 immediately increased Fujitsu's systems customer base and visibility in Europe. This relationship between ICL and Fujitsu has since yielded several new products, including some SPARC-based systems, ranging from mainframe computers to small network servers. In addition, extensive sales and marketing ventures have been jointly financed by Fujitsu and ICL in North America, Australia, and Europe. These efforts have resulted in improvements to Fujitsu's retail market shares in North America and to its business segment performance in Europe and Australia.

Fujitsu has also invested in semiconductor manufacturing capacity in Europe. Its latest venture involved a ¥90 billion investment to its Durham plant in England, which began producing 4Mb DRAM parts in September 1991 for consumption in the European Community (EC).

Although overall corporate sales to the Asia/Pacific region have increased only slightly during the last few years, this region is a stable consumer of Fujitsu's telecommunications products. During 1991, orders for switching systems continued to arrive from the People's Republic of China, Singapore, and Hong Kong; and optical transmission hardware has been purchased to link Japan, Taiwan, Hong Kong, Malaysia, and Singapore. Fujitsu has also just begun marketing its ultracompact cellular telephone units—which have sold well in both Japan and the United States—in Asian markets. With renewed

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awareness of the need to establish software products on open platforms, Fujitsu has recently established a joint venture in the People's Republic of China to develop software applications to run under UNIX.

The recession in the United States has been the main cause of Fujitsu's slow decline in annual sales to North America since FY1989. This has occurred in spite of the numerous alliances Fujitsu has formed with U.S. companies and the substantial presence of its subsidiaries located in the United States.

Corporate Investment

During FY1991, Fujitsu invested ¥392 billion, or about 11.4 percent of its total corporate sales, in R&D activities (see Table 2). This yen-based expenditure approached the 1991 R&D investment of Matsushita, a company with revenue more than double that of Fujitsu. The steady increase in Fujitsu's R&D costs over the past several years has caused its corporate-level R&D-to-sales ratios to far surpass the ratios exhibited by the other top 10 Japanese electronics companies. These high levels of R&D have allowed Fujitsu to produce leading-edge semiconductor components, as well as field high-performance computer and telecommunications systems. Fujitsu conducts R&D activities at two facilities that are part of the Fujitsu Laboratory, which became an independent subsidiary of Fujitsu in 1968.

Fujitsu's capital spending levels have also exceeded the levels of most of its competitors. Although Toshiba spent roughly the same percentage of its total revenue on capital spending during 1991, Fujitsu has maintained these higher, double-digit capital spending and R&D levels for the past four years. Furthermore, most competitors, such as NEC and Hitachi, actually reduced the magnitude of their capital spending during 1991. Like Toshiba, Fujitsu continues to invest heavily in semiconductor technology with most of FY1991 capital spending being applied toward ramp-up of the Durham facility, increased production capacity at the Yamanashi GaAs LSI plant, and expansion of a semiconductor research facility.

Table 2
Fujitsu Limited Investment: Capital Spending and R&D (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Revenue	2,047	2,387	2,550	2,971	3,442
Capital Spending	167	254	301	315	351
Percentage of Total Revenue	8.2	10.6	11.8	10.6	10.2
R&D Spending	190	247	299	330	392
Percentage of Total Revenue	9.3	10.3	11.7	11.1	11.4

Source: Company Literature, Dataquest (December 1992)

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Financial Condition and Analysis in FY1991

Tables 3 and 4 show a cross section of Fujitsu's consolidated balance sheet and income statements, respectively. Total sales in FY1991 reached a record high of ¥3,442 billion, a 15.8 percent increase over the previous year's figure. However, net income declined by a steep 85.2 percent to a mere ¥12 billion.

The decline of net income and profitability occurring during 1986 and 1991 are common dips in the revenue histories of all major electronics firms in Japan. For most Japanese electronics companies, FY1991

Table 3
Fujitsu Limited Consolidated Balance Sheet (Billions of Yen)

Japanese Fiscal Year	1987	1988	1989	1990	1991
Total Current Assets	1,355	1,458	1,647	2,080	2,155
Cash	119	156	134	188	251
Marketable Securities	214	173	160	245	176
Receivables	503	592	737	866	897
Inventory	463	479	586	711	750
Other Current Assets	56	58	30	69	81
Long-Term Receivables and Investment	366	460	495	554	573
Net Property, Plant, and Equipment	592	703	826	981	1,086
Other Assets	4	4	4	123	177
Total Assets	2,317	2,625	2,971	3,737	3,992
Total Current Liabilities	974	1,101	1,283	1,686	1,653
Long-Term Debt	445	485	513	778	1,027
Minority Interest	70	78	90	114	146
Total Liabilities	1,490	1,664	1,886	2,578	2,826
Total Shareholders' Equity	827	961	1,085	1,159	1,165
Common Stock	169	194	216	221	222
Additional Paid-In Capital	296	352	387	393	395
Retained Earnings	350	402	466	528	529
Other Equity	13	14	16	17	19
Total Liabilities and Shareholders' Equity	2,317	2,625	2,971	3,737	3,992
Fiscal Year Exchange Rate (¥ = U.S.$1)	138	128	142	141	133

Note: Some columns do not add to totals shown because of rounding.
Source: Company Literature, Dataquest (December 1992)

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Table 4
Fujitsu Limited Consolidated Income Statement
(Billions of Yen)

Japanese Fiscal Year	1987	1988	1989	1990	1991
Net Sales	2,047	2,387	2,550	2,971	3,442
Domestic Sales	1,594	1,859	1,941	2,233	2,415
Overseas Sales	453	528	609	738	1,027
Cost of Goods Sold	1,339	1,528	1,578	1,821	2,120
Selling, General, and Administrative Expense	588	674	776	937	1,185
Operating Income	120	186	195	214	137
Operating Income Margin	5.8	7.8	7.7	7.2	4.0
Other Income	15	16	18	28	29
Interest	9	14	16	26	27
Others	6	2	2	2	2
Other Expenses	29	47	43	88	125
Interest	29	32	39	66	91
Others	0	14	4	22	34
Income before Income Taxes	106	155	170	154	42
Effective Tax Rate (%)	56	56	54	52	52
Income Taxes	73	97	99	91	32
Income after Income Taxes	33	58	71	62	10
Equity in Income of Unconsolidated subsidiaries	13	19	21	24	9
Minority Interests and Others	3	6	6	3	7
Net Income	42	70	87	83	12
Fiscal Year Exchange Rate (¥ = U.S.$1)	138	128	142	141	133

Note: Some columns do not add to totals shown because of rounding.
Source: Company Literature, Dataquest (December 1992)

yielded lower profitability, which is equivalent to net income divided by total sales, than achieved in FY1986. This occurred despite the fact that net income magnitudes were generally higher in FY1991 than in FY1986.

In Fujitsu's case, however, both profitability and net income were lower in FY1991 than in FY1986. This gave Fujitsu the appearance of a lower financial performance than most of its Japanese competitors. In reality, the source of the sag in performance was the higher semiconductor capital spending and R&D levels that reflect Fujitsu's apparent confidence in the recovery of those markets. Although other Japanese companies may or may not share this confidence, they have followed

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more conservative budgeting schedules for the year. Thus, Fujitsu's lower income rate appears to be more attributable to a conscious decision to invest, perhaps based on optimistic forecasts for a semiconductor market recovery, than to falling sales or a lack of cost control.

Several Japanese electronics companies, such as Hitachi and Matsushita, have a return on sales ratio, which is equal to earnings before taxes divided by net sales, that regularly exceeds their corresponding operating income margin, which is equal to gross operating income divided by net sales. This effect is usually attributable to a company's having surplus income, such as from stock dividends and funds generated from ventures outside of its primary businesses, that have offset its annual debt payments. Fujitsu's external income is relatively insignificant compared with Japanese electronics firms of roughly the same size, such as NEC. Hence, Fujitsu's debt payments typically exceed its supplementary income by a factor of 2. Although Fujitsu's capital-intensive semiconductor operations and 1990 acquisition of a majority stake in ICL required increasing its debt level, Fujitsu has still managed to have reasonable financial ratios by Japanese standards.

Table 5 summarizes some key figures, which represent Fujitsu's financial status, and compares them with those of NEC and Toshiba's for the FY1991 period. From this table, it is clear that Fujitsu's solvency displayed a discrete discontinuity, as measured by its elevated debt-to-equity ratio, following the 1990 investment in ICL. Yet, even with this higher level of insolvency, Fujitsu remained less debt-laden than either NEC or Toshiba, again measured by their respective debt-to-equity ratios. Although Japanese accounting practices have often been viewed with skepticism by U.S. companies, the long-term safety—or debt-to-equity figure—would seem to be a relatively standard calculation that should facilitate comparisons among companies in different countries.

Japanese electronics companies typically can remain stable and liquid with smaller current and quick ratios than their U.S. counterparts can. Although not as conservative as Hitachi, Fujitsu maintains liquidity ratios that are generally higher than either NEC or Toshiba—which are companies of comparable size that also invest heavily in semiconductor manufacturing, particularly in commodity DRAM capacity.

Many large corporations in Japan have large blocks of their stocks owned by financial institutions that belong to a particular family of companies, otherwise known as a keiretsu group. A paradox of such groupings, however, is that often a company will have members of competing keiretsu as major stockholders. To illustrate this point Dataquest notes that Hitachi, Toshiba, and NEC have major stockholders that are members of the Mitsubishi, Mitsui, Sumitomo, and Dai-ichi keiretsu. And Fujitsu is no exception to the multiple-keiretsu influence, where, as shown in Table 6, 13.5 percent of Fujitsu's stock remains in the hands of its original parent company, Fuji Electric. Although this may seem to be a large voting block, the Sumitomo group's influence over NEC is substantially higher. Nearly one-quarter (24.3 percent) of Fujitsu's stock is owned by individual investors, and foreigners own 9.3 percent of the company.

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Table 5
Fujitsu Limited Financial Ratios Compared with NEC and Toshiba

	1987	1988	1989	1990	1991	NEC	Toshiba
Total Sales (¥B)	2,047	2,387	2,550	2,971	3,442	3,774	4,722
Net Income (¥B)	42	70	87	83	12	15	39
Total Assets (¥B)	2,317	2,625	2,971	3,737	3,992	4,081	5,724
Operating Income Margin (%)	5.9	7.8	7.7	7.2	4.0	3.2	2.5
Net Income/Total Sales (%)	2.1	2.9	3.4	2.8	0.4	0.4	0.8
Foreign Sales/Total Sales (%)	22.1	22.1	23.9	24.8	29.8	21.0	29.1
Corporate R&D/Total Sales (%)	9.3	10.3	11.7	11.1	11.7	8.0	6.7
Semiconductor Sales* (¥B)	259	339	382	374	368	649	623
Semiconductor Sales/Total Sales (%)	12.7	14.2	15.0	12.6	10.7	17.2	13.2
Sales/Employee (¥M)	21.585	22.846	22.170	20.370	22.095	29.410	28.109
Net Income/Employee (¥M)	0.444	0.669	0.754	0.567	0.078	0.119	0.235
Growth Rate							
Total Sales (%)	14.4	16.6	6.8	16.5	15.8	2.0	0.6
Net Income (%)	94.9	66.1	24.0	-4.7	-85.2	-71.9	-67.3
Financial Ratios							
Current Ratio	1.39	1.32	1.28	1.23	1.30	1.19	1.23
Quick Ratio	0.94	0.89	0.83	0.81	0.85	0.76	0.81
Sales/Net Working Capital	5.37	6.69	7.01	7.54	6.86	9.88	7.04
Net Working Capital/Total Assets	0.16	0.14	0.12	0.11	0.13	0.09	0.12
Debt-Equity Ratio	0.54	0.50	0.47	0.67	0.88	1.30	1.24
Total Asset Turnover	0.88	0.91	0.86	0.80	0.86	0.92	0.82
Return on Sales (%)	5.2	6.5	6.7	5.2	1.2	1.4	2.4
Return on Asset (%)	4.6	5.9	5.7	4.1	1.0	1.3	2.0
Return on Equity (%)	5.1	7.3	8.0	7.2	1.1	1.7	3.3
Earning per Share (¥)	19.38	29.53	37.08	45.17	18.81	25.17	13.22
Payout Ratio	0.41	0.30	0.24	0.22	0.53	0.40	0.76

*Semiconductor sales estimated for a calendar year.
Source: Dataquest (December 1992)

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Table 6
Fujitsu Limited Top 10 Shareholders

Shareholders	Share (%)
Fuji Electric	13.5
Asahi Life Insurance	6.5
Dai-ichi Kangyo Bank	4.6
Sumitomo Trust & Banking	2.8
Industrial Bank of Japan	2.3
Mitsubishi Trust & Banking	2.3
Toyo Trust & Banking	1.8
Nippon Life Insurance	1.8
Asahi Bank	1.6
Sakura Bank	1.5

Source: Company Literature, Dataquest (December 1992)

Semiconductor Climate of 1991

Worldwide semiconductor sales totaled $59.7 billion in 1991, which exceeded the previous year's sales by 9.4 percent. The Japanese market comprised 37.7 percent of the global 1991 market, with $22.5 billion in sales, and continued to make Japan the single largest region for chip consumption. Japanese semiconductor consumption has grown 11.1 percent during the past year. The Japanese market expanded by a slight 0.6 percent, relative to the world market, during a one-year period.

In terms of suppliers, Japan's 46.4 percent share of the 1991 global market nearly matched the 1990 figure of 46.3 percent. Asia/Pacific ROW suppliers made market share gains at the expense of North American and European companies.

The Japanese companies continued their dominance of the DRAM market, led by Toshiba, but lost some market share to Korean companies. Samsung moved to the No. 2 position, trailing only Toshiba, in terms of volume of commodity DRAMs products shipped. Fujitsu was the No. 7 leading supplier of DRAMs to world markets. U.S.-based semiconductor companies lost worldwide share; however, many of these companies continued to lead the world in microprocessors and design-intensive ASIC/ASSP chips.

Fujitsu Semiconductor Overview

According to Dataquest's semiconductor market share estimates for 1991, Fujitsu recorded $2,705 million in semiconductor revenue, qualifying the company as the seventh largest in the worldwide semiconductor business. In Japan's domestic market, Fujitsu captured the No. 4 position trailing NEC, Hitachi, and Toshiba. Total annual semiconductor sales declined by a small amount as compared with the previous year's totals.

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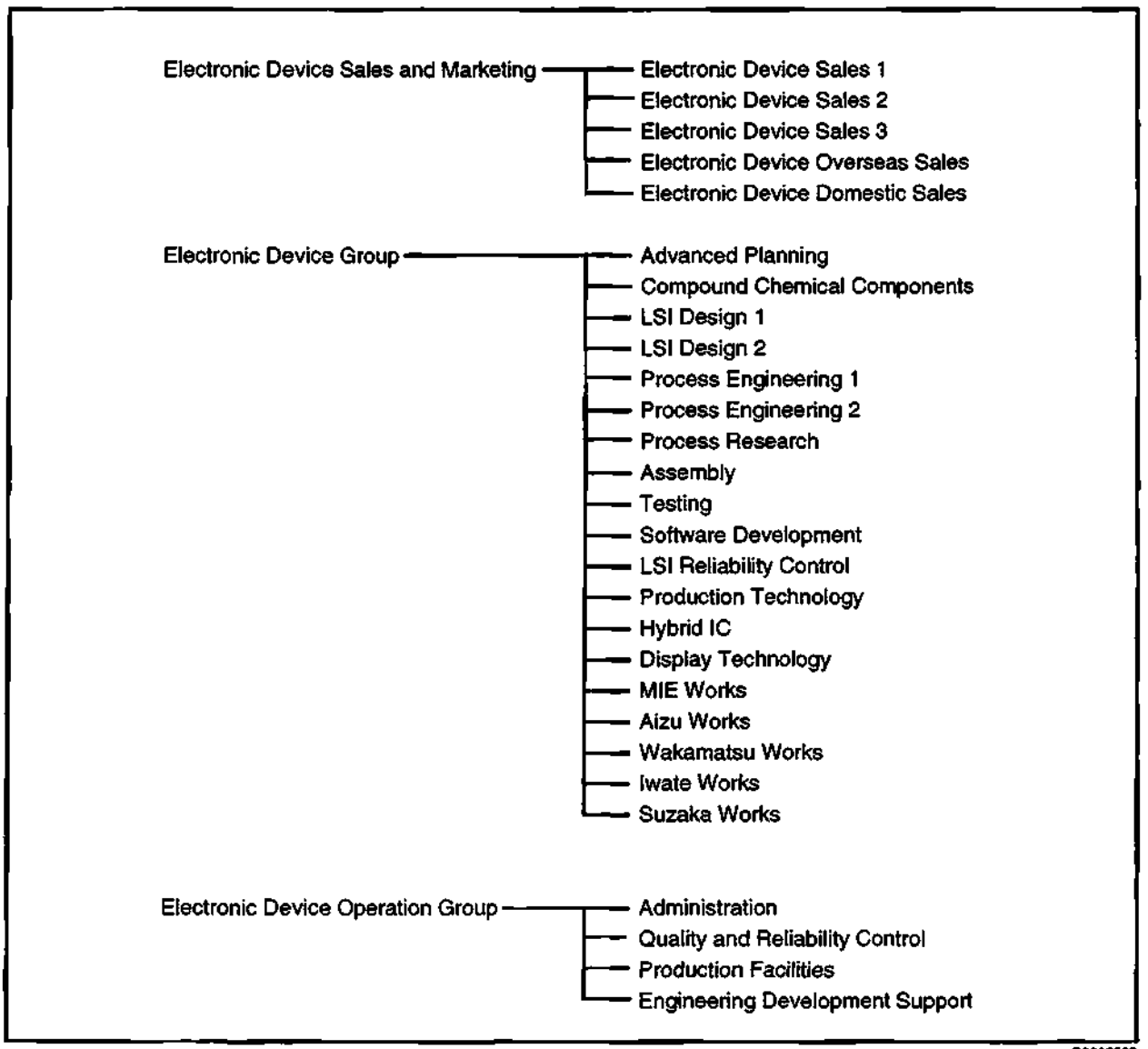
Figure 2 is an organization chart of Fujitsu's semiconductor-related operations.

Fujitsu is a substantial supplier of all types of silicon-based semiconductors, including commodity memories and microcomponents, as summarized in Table 7 and charted in Figure 3. However, the feature that most differentiates Fujitsu from its chip-producing Japanese competitors is the degree of investment in compound semiconductor technology. Although revenue from GaAs components is modest relative to that from silicon devices, Fujitsu's commitment to the development of GaAs components at all levels of integration is remarkable. Given the company's strength in systems-level, high-frequency

Figure 2
Fujitsu Semiconductor Organization



Source: Fujitsu Limited

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Table 7
Estimated 1991 Fujitsu Ranking, by Product Segment

	Worldwide Market	Japanese Market
Total Semiconductor	7	4
Total Integrated Circuit	7	3
Bipolar Digital	2	1
MOS	6	3
MOS Memory	5	3
MOS Microcomponents	11	7
MOS Logic	3	2
Analog	20	9
Total Discrete	16	8
Total Optoelectronics	8	8

Source: Dataquest (December 1992)

telecommunications products and high-end computers, GaAs technology development has been a logical, if somewhat risky, addition to Fujitsu's technology base.

However, Fujitsu seems to have already proven to itself the feasibility of the various GaAs-device technologies that it intends to use. These technologies include high-electron-mobility transistors (HEMT), heterojunction bipolar transistors, and field-effect transistors (FET). The HEMT devices have already been employed in various telecommunications applications including satellite broadcasting receivers and a prototype of an ultrahigh-speed asynchronous transfer mode switching module capable of switching 640 Gbps.

Product Strategy

Figure 3 illustrates the Fujitsu semiconductor product mix revenue and the worldwide product mix revenue recorded in 1991. Fujitsu is a healthy contender in MOS memories, MOS logic, and bipolar markets. In contrast, although Fujitsu captured about 27.7 percent of the market for SPARC RISC microprocessors in 1991, this market was so small that Fujitsu managed only a 0.4 percent share of the world microprocessor market, which translated to a world ranking of No. 17 among microprocessor suppliers. Fujitsu received more than seven times more revenue from selling microcontrollers than it did from sales of its microprocessors in 1991.

As a broad-line computer and telecommunications supplier, Fujitsu has excelled in memory and logic markets both to supply its own internal needs and to further develop competitive advantage for its own system-level products. Strong silicon ECL, CMOS, and BiCMOS—as well as GaAs FET, HEMT, and bipolar—fabrication capabilities have been grown to maturity at Fujitsu.

And the degree to which Fujitsu leverages these technologies in its own computer and telecommunications products appears to be

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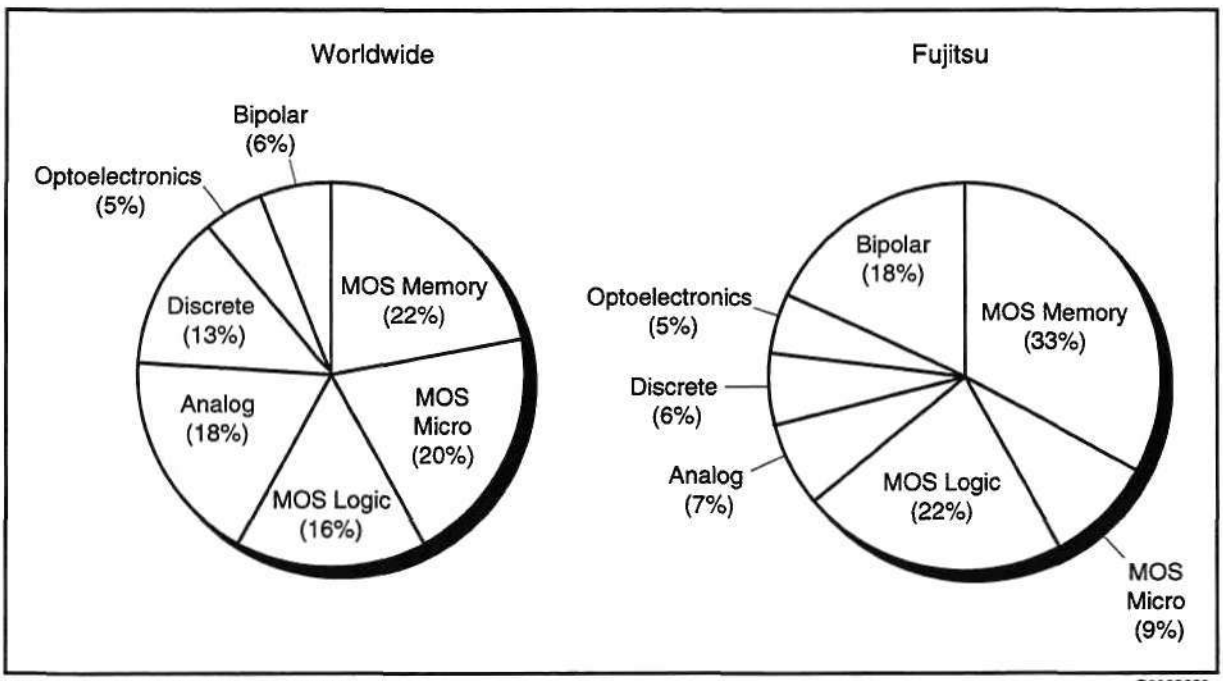
Figure 3
1991 Semiconductor Market Share Product Mix: Worldwide versus Fujitsu



Source: Dataquest (December 1992)

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increasing relative to its competitors. The high R&D investment levels sustained by Fujitsu for a number of years have made several experimental technologies positioned to make major returns on investments. Although the company's research in superconducting electronics may not yield commercial products in the foreseeable future, its GaAs efforts have resulted in the world's largest GaAs LSI manufacturing plant, built at Fujitsu's Yamanashi site.

The high-performance devices built at Yamanashi will include FET, HEMT, and heterojunction bipolar LSI circuits. Gate arrays with densities of 45K gates and 64Kb SRAM have been constructed in the GaAs HEMT technology. Optoelectronic and experimental quantum-well device structures will also be fabricated at Yamanashi. Circuits from Yamanashi have already been delivered to workstation and supercomputer manufacturers, with Cray Computer Corporation having been a past GaAs customer of Fujitsu.

Although the anticipated potential of GaAs technology has not yet been realized, primarily because of the unexpected difficulties of working with compound semiconductors, Yamanashi does seem to have the potential to give Fujitsu a real advantage in telecommunications and high-end computer systems. Furthermore, GaAs technology at-large does appear to be reaching a commercially competitive stage as evident from the growing number of sockets that GaAs IC products are filling. Many GaAs vendors have found success by "tuning" their products into a competitive speed-power dissipation

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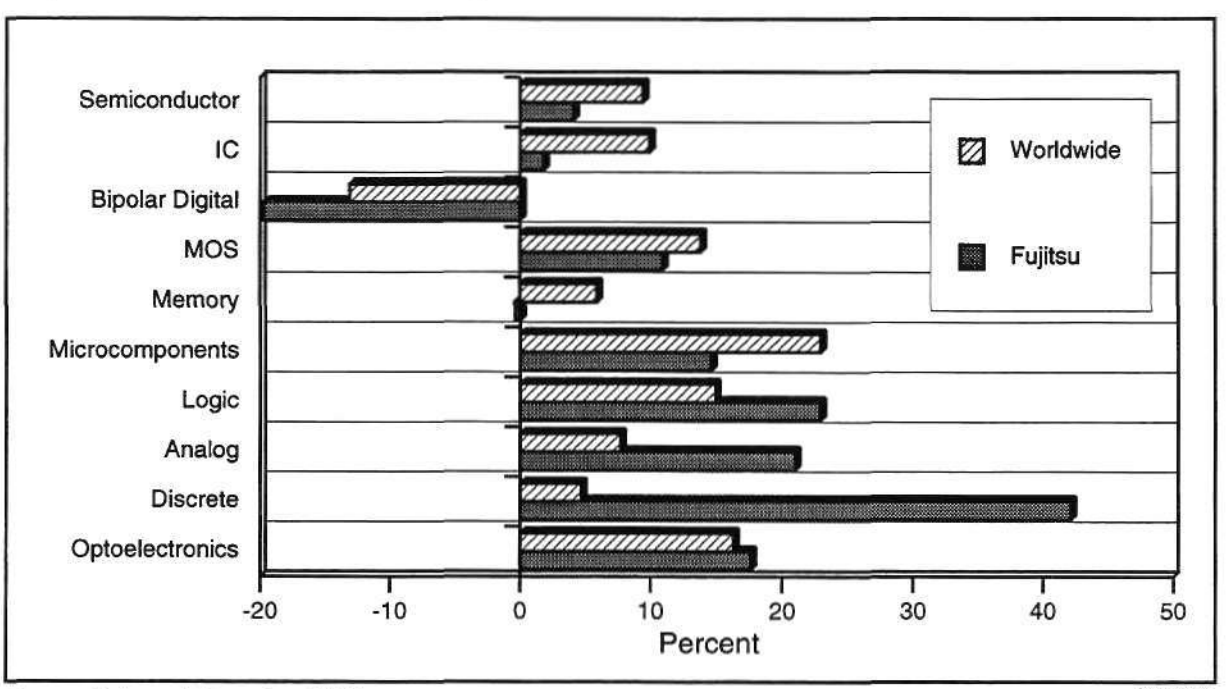
combination to match the needs of various niche applications as opposed to marketing GaAs products purely on the basis of optimum speed.

Figure 4 compares Fujitsu's semiconductor growth rates, by product category, against corresponding product growth rates on the world market for FY1991. Fujitsu captured market share in global markets for logic, analog, discrete, and optoelectronic devices. Brisk sales of a line of discrete and analog GaAs devices for applications in cellular telephones and broadcasting receivers have helped advance Fujitsu's revenue in these market segments. Sales of logic devices were also helped by the introduction of several new high-performance CMOS and BiCMOS gate arrays, as well as ASICs built around a microcontroller.

Fujitsu's 4Mb DRAM facility in Durham came online too late in the year to have had an impact on the 4Mb market, which is beginning to expand. This facility is poised to take advantage of the expected rise in demand for 4Mb parts as memory-intensive graphical interface operating systems continue to gain in popularity in the EC, as they already have in the United States. The Durham plant will complement a Fujitsu Telecommunications VLSI Laboratory in London, which was established in June 1990. Researchers at the London facility will develop semiconductors to meet local demand in telecommunications applications throughout the EC.

Table 8 provides Fujitsu's semiconductor revenue by product segment for the past five years.

Figure 4
Fujitsu's 1991 Growth Rate Compared with Worldwide Market



Source: Dataquest (December 1992)

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Table 8
Estimated Worldwide Semiconductor Revenue, by Product
(Billions of Yen)

Calendar Year	1987	1988	1989	1990	1991	1991 Market Share (%)
Total Semiconductor	259.3	338.9	382.3	374.3	367.9	4.5
Total Integrated Circuit	239.0	314.6	353.7	343.3	329.9	5.0
Bipolar Digital	71.3	84.9	81.4	91.3	69.2	14.0
TTL/Others	33.6	41.2	34.8	39.2	27.3	7.9
ECL	37.7	43.7	46.6	52.1	41.9	28.4
Bipolar Digital	71.3	84.9	81.4	91.3	69.2	14.0
Bipolar Digital Memory	25.6	33.0	18.6	20.7	15.4	31.7
Bipolar Digital Logic	45.6	51.9	62.8	70.6	53.9	12.5
MOS (Technology)	146.0	210.1	251.4	230.7	236.4	5.1
N/PMOS	105.8	69.6	52.0	47.5	43.5	5.3
CMOS	40.2	140.5	185.2	170.2	178.3	4.7
BiCMOS	0	0	14.2	13.0	14.6	19.1
MOS (Function)	146.0	210.1	251.4	230.7	236.4	5.1
MOS Memory	91.3	138.7	163.9	131.5	123.6	7.1
MOS Microcomponents	21.0	26.3	27.2	30.7	33.2	2.1
MOS Logic	33.7	45.1	60.3	68.5	79.6	6.0
Analog	21.7	19.6	20.8	21.3	24.3	1.6
Total Discrete	10.1	10.7	13.8	15.4	20.7	1.9
Total Optoelectronics	10.2	13.7	14.8	15.6	17.3	4.5
Exchange Rate (¥ = U.S.$)	144	130	138	144	136	

Note: Some columns do not add to totals because of rounding.
Source: Dataquest (December 1992)

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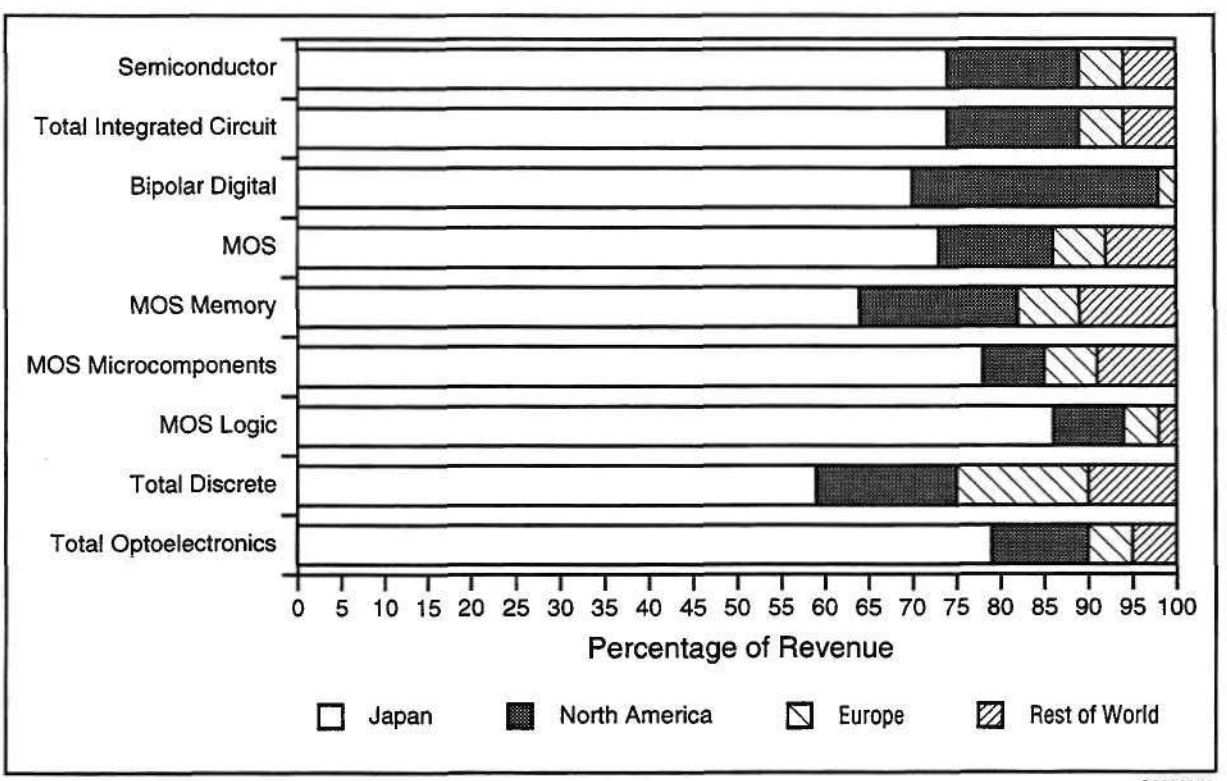
Regional Market

Figure 5 illustrates Fujitsu's semiconductor revenue broken down into four major regional markets: Japan, North America, Europe and the rest of the world (ROW). With 29.8 percent of total corporate revenue derived from overseas markets, Fujitsu's overseas semiconductor sales, as a percentage of its total semiconductor revenue, roughly matched the market share of the company's systems-level products in foreign markets.

On a percentage basis of semiconductors sold in foreign markets, Fujitsu trailed Toshiba by a wide margin but nearly matched both Hitachi and NEC's foreign semiconductor market share. Since both Hitachi and NEC are much larger merchant semiconductor suppliers, based on sales volume, Fujitsu's share of foreign semiconductor markets is not a particular disappointment.

Furthermore, the company's large emphasis in GaAs IC production, particularly at its Yamanashi site, has yet to develop significant sales volumes overseas, although GaAs IC products have begun to ship to engineering workstation and supercomputer manufacturers with high expectations for overseas GaAs consumption.

Figure 5
Fujitsu's Semiconductor Revenue, by Region



Source: Dataquest (December 1992)

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Semiconductor Investment

Table 9 and Figure 6 represent Fujitsu's semiconductor capital spending and R&D expense trends against overall semiconductor revenue for the past five years. The escalation of Fujitsu's investments during the last three years has made Fujitsu the clear semiconductor capital and R&D spending leader in Japan.

However, even by Fujitsu's standards, FY1991 was a record year for capital spending. The ¥154.4 billion spent on semiconductor capacity exceeded the levels spent by all other manufacturers by a wide margin both as a percentage of revenue and in absolute yen. Fujitsu's semiconductor capital-spending-to-revenue ratio came to an unusually high 42 percent, a number that obviously cannot be sustained for long without subsidies from Fujitsu's other business divisions. Falling semiconductor revenue since 1989 is partly to blame for the high ratio of capital spending to revenue; however, it does not explain how a company with semiconductor revenue nearly half that of NEC's can have 50 percent higher capital spending levels.

During the past three years, Fujitsu conducted major expansion of its domestic Wakamatsu ASIC plant, its Iwate memory facility, and one of its subsidiaries at the Yamanashi GaAs LSI facilities. A new 16Mb DRAM production plant at Mie is also scheduled for construction and completion before the end of 1992. Offshore, Fujitsu spent another ¥90 billion at Durham to complete that DRAM facility.

Fujitsu's R&D spending levels are more congruent with its competitors as a percentage of revenue. Fujitsu's 1992 semiconductor R&D costs are expected to rise by 7 percent above the 1991 R&D level.

In 1992, worldwide semiconductor capital spending is expected to contract by 9.5 percent. Japan is expected to make the largest cuts in capital spending, with current projections calling for a decline of

Table 9
Fujitsu Semiconductor Investment: Capital Spending and R&D
(Billions of Yen)

	1987	1988	1989	1990	1991
Semiconductor Revenue	259.3	338.9	382.3	374.3	367.9
Capital Spending	35.0	58.7	82.1	125.5	154.4
Percentage of Revenue	13.5	17.3	21.5	33.5	42.0
R&D Expense	40.0	45.0	49.5	55.0	60.5
Percentage of Revenue	15.4	13.3	12.9	14.7	16.4
Total Investment to Revenue Percentage	28.9	30.6	34.4	48.2	58.4

Note: Semiconductor revenue and capital spending are calculated for calendar year periods, while R&D expense is stated for a Japanese fiscal year.
Source: Dataquest (December 1992)

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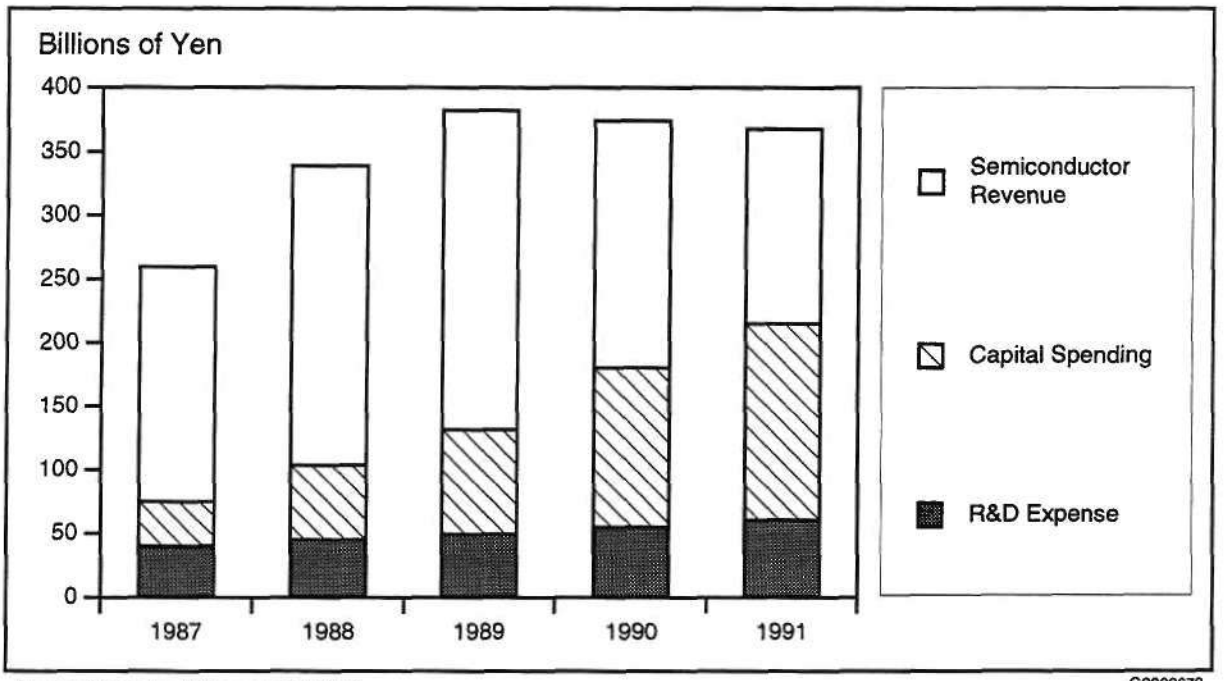
Figure 6
Fujitsu Semiconductor Investment: Capital Spending and R&D



Source: Dataquest (December 1992)

23.5 percent. Many Japanese semiconductor companies have already announced intentions to make major investment cuts in their 1992 budgets. Although Fujitsu has closed a memory assembly plant in San Diego, and downsized its work force at Fujitsu Microelectronics Inc., in San Jose, California, Fujitsu still appears to be in an expansion mode globally.

Manufacturing Facilities

Fujitsu owns five front-end fab facilities in Japan including its GaAs plant in Yamanashi. Fujitsu's two remaining front-end facilities are located overseas at Gresham, Oregon—which produces ASICs and 1Mb DRAMs—and Durham. The location, size of the work force, and semiconductor products made at Fujitsu's primary manufacturing sites are shown in Table 10. Figure 7 shows the relationship between various semiconductor manufacturing sites and possible chip production steps performed at the various Fujitsu plants.

The EC body that governs semiconductor trade policy has already begun imposing import regulations, including procedures for defining, calculating, and establishing limits on foreign chips imported into the EC semiconductor markets. An EC committee has also made rulings defining a domestic semiconductor product as one that has its front-end wafer fabrication steps performed on European territory.

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Table 10
Fujitsu Semiconductor Manufacturing Facilities

Plant Name	Location	Type	Product	Number of Employees	Year Opened
Domestic Facilities					
Aizu Works	Fukushima	F	Arrays, micro, EPROM	3,000	1984
Wakamatsu Works	Fukushima	F	ASIC	900	1985
Fujitsu VLSI	Gifu	R	R&D	1,020	1985
Iwate Works	Iwate	F	DRAM, SRAM, ROM	2,600	1984
Atsugi Laboratory	Kanagawa	R	R&D	NA	1987
Kawasaki	Kanagawa	PF	DRAM, HEMT, 3-D ICs	12,000	1938
Mie Works	Mie	PR	Memory, logic	1,500	1984
Quantum Device	Yamanashi	RF	Optoelectronics, GaAs, HEMT	450	1984
Fujitsu Miyagi Electronics	Miyagi	AT	Micro, gate array	670	1989
Fujitsu Tohoku Electronics	Fukushima	AT	Gate array	663	1981
Kyushu Fujitsu Electronics	Miyazaki	AT	Memory, micro, custom LSI	1,486	1985
Sakashita Microelectronics	Fukushima	AT	Discrete	150	1983
Aizu Denshi Device	Fukushima	AT	Micro, ASIC	75	1984
Okano Electronics	Kagoshima	AT	MOS memory	100	1987
Overseas Facilities					
Fujitsu Microelectronics	Gresham, Oregon	F	1Mb DRAM, gate array		1988
Fujitsu Microelectronics	Durham, United Kingdom	F	4Mb DRAM, ASIC		1988
Fujitsu Microelectronics Ireland	Dublin, Ireland	AT	Memory		1981
Fujitsu Microelectronics Asia	Singapore	AT	DRAM		1986
Fujitsu Component	Penang, Malaysia	AT	DRAM, TTL		1988

F: Fab
P: Pilot Line
R: Semiconductor R&D
A: Assembly
T: Test
NA = Not available
Source: Dataquest (December 1992)

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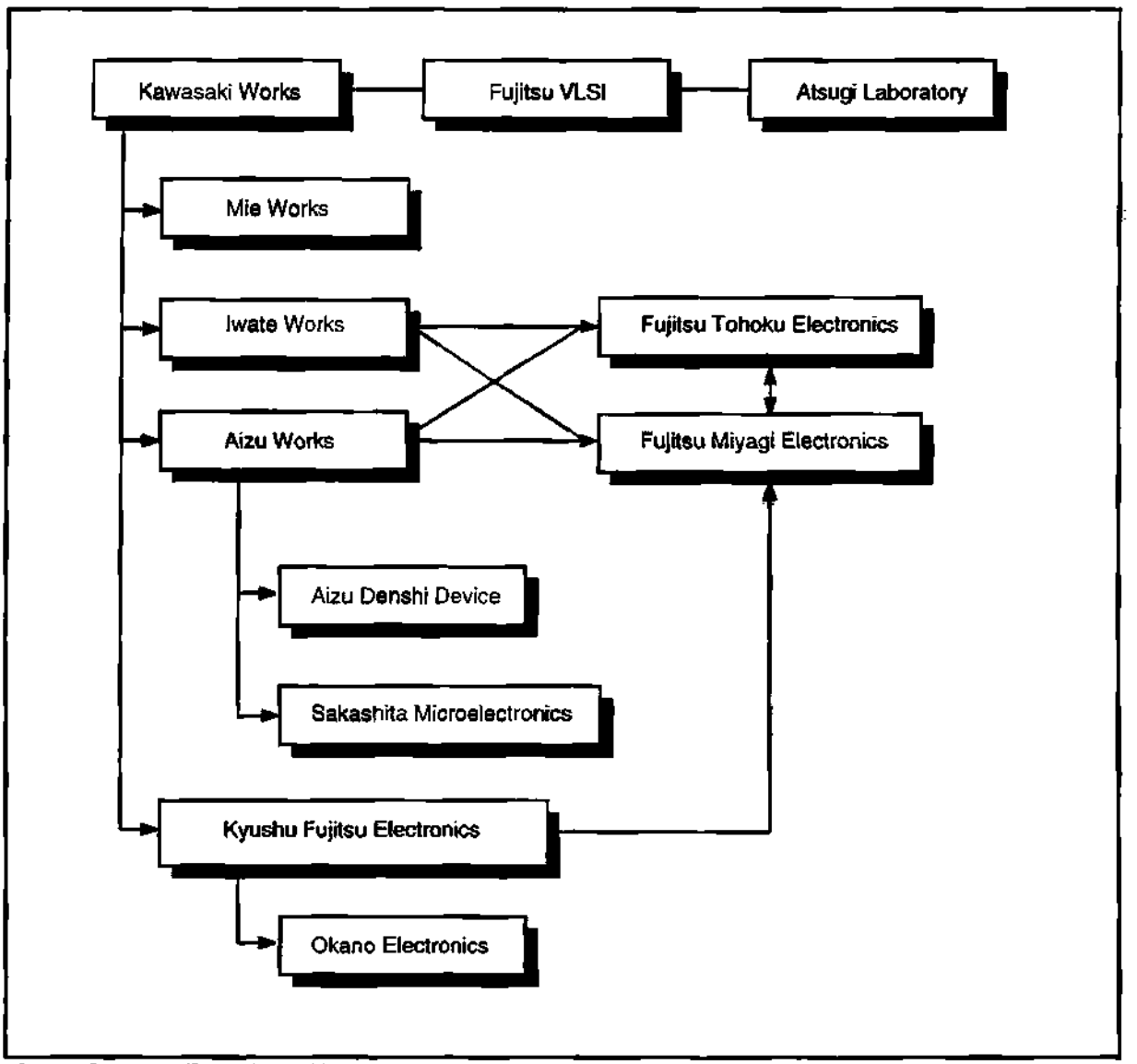
Figure 7
Fujitsu Semiconductor Manufacturing Shift



Source: Dataquest (December 1992) G2002673

These mandates have induced major Japanese chip makers—such as Hitachi, NEC, and Toshiba—to construct or upgrade existing fabs in Europe in anticipation of unification of the European markets. Fujitsu's Durham plant is a complete front-end facility for manufacturing 4Mb DRAM and will supply the EC's current memory market. In addition, the company's VLSI Laboratory in London will design telecommunications chips for the EC, and an older facility in Ireland will test and assemble Fujitsu semiconductor products destined for EC markets.

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Semiconductor Alliances

Fujitsu has long been a proponent of strategic alliances and joint ventures as a business strategy to leverage resources and to enter new markets. Table 11 lists Fujitsu's publicly announced alliances involving semiconductor-related projects formed during the past five years.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 11.

- LA—Licensing agreement
- SS—Second source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

Fujitsu Microelectronics Inc. (FMI), located in San Jose, has pioneered international alliances and is still actively seeking partnerships to assist in its immediate goal of entering the field-programmable gate array business after its April reorganization. This business is believed to be complementary to Fujitsu's existing ASIC product lines and manufacturing capabilities. ASIC development and related design automation software are two likely areas that FMI will investigate as possible targets for alliances. Fujitsu has several ongoing joint ventures with software vendors in various countries. The exploration of further alliances involving software development has become a corporate mandate at Fujitsu. Fujitsu has already established an alliance with Cadence Design Systems Inc. to jointly develop design tools and has created an R&D company in the United States to further develop UNIX software.

Fujitsu has licensed the Rambus technology for implementing high-speed DRAM architectures. In addition, Fujitsu established links with the U.S. company HaL Computer Systems Inc. for the purpose of collectively developing next-generation UNIX systems for use in business environments.

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Table 11
Fujitsu's Semiconductor Strategic Alliances

Date	Partner	Agreement Type	Product
5/88	NEC	JD	Military-use infrared seeker
6/88	Mizer/Wind River	JD	SPARC RISC MPU
1/89	Ikos Systems	TE	ASIC libraries
3/89	VIA Technologies	IV	SPARC peripherals
4/89	Sun Microsystems	SS, FA	SPARC RISC MPU
11/89	Vitesse Semiconductor	SS	GaAs material
11/89	Tandem Computers	SA	Wafer-scale memory
11/89	Texas Instrument Japan	LA, JD	ASIC software
1/90	Isuzu Motor	JV	Automotive electronics
1/90	Samsung	SS	Printer-control gate array
1/90	ASCII	JD, IV	16-, 32-bit MPUs
6/90	CrossCheck Technology	LA	ASIC testing technology
7/90	Signetics	SS, JD	Communications ICs
8/90	Toyota Motor	JV	CAE design for automobiles
8/90	Cray Computer	SS	GaAs ICs
10/90	Level One Communications	SS, JD	Communications ICs
11/90	Flash memory cards	FA	Flash memory cards
7/91	Tera Microsystems	FA	SPARC RISC chip set
8/91	SPARC RISC chip	LA	SPARC RISC MPU
8/91	HaL Computer Systems	JD, IV	CMOS RISC microprocessor
10/91	Cadence	JD	ASIC design tool
3/92	Rambus	LA	Memory interface technology
4/92	Wang Laboratories	LA	SIMM license
4/92	Samsung	LA	Cross-licensing
5/92	Mosel	FA	Memory
7/92	AMD	JV, JD	Flash memory

Source: Dataquest (December 1992)

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Dataquest Perspective

Fujitsu has a character quite distinct from other Japanese electronics companies. In many ways, Fujitsu is an innovative trendsetter. By being an early advocate of strategic global alliances, the company pioneered this now pervasive business strategy as a means of entering new markets. Although its finances are generally conservative by Japanese standards, Fujitsu is equally willing to risk heavy investments in new technologies such as GaAs HEMT devices. The company established a high level of synergy among its various enterprises because of a focus that appears to be by design; Fujitsu does not make rice cookers, just all types of semiconductors that go into every telecommunications and computer system the company makes. Fujitsu has also adopted the concept that complete systems integration, involving both hardware and software, is the solution it needs to provide in order to effectively compete in future markets.

Fujitsu's semiconductor business appears to be struggling to maintain revenue levels while the company continues to add capacity. For Fujitsu to continue to maintain semiconductor capital spending levels that are more than 40 percent of semiconductor revenue, the semiconductors it produces must be tailored to give its system-level products a higher degree of competitive advantage.

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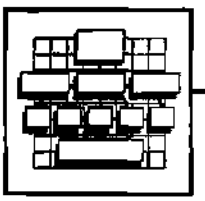

Dataquest Vendor Profile

Semiconductors *Japan*

December 21, 1992

Toshiba Corporation

Corporate Statistics

Address	Toshiba Corporation 1-1, Shibaura 1-chome, Minato-ku, Tokyo 105
Telephone	81-3-3457-4511
Facsimile	81-3-3456-1631
Chairman of the Board	Joichi Aoi
President and CEO	Fumio Sato
Established	1875 (Incorporated in 1939)
Number of Employees	168,000 (as of March 31, 1992)
Total Sales	¥4,722 Billion (FY1991)
Net Income	¥39 Billion (FY1991)
Total Assets	¥5,724 Billion (FY1991)
Main Product Divisions	Information/Communications Systems and Electronic Devices Heavy Electrical Apparatus Consumer Products and Others

Corporate Overview

Toshiba Corporation was founded as Tanaka Seizo-sho in 1875 and was renamed Shibaura Engineering Works in 1893. In 1939, the company merged with Tokyo Electrical Company (founded in 1880 as Hakunetsu-sha) and became Tokyo Shibaura Electric Co. Ltd. In 1978, the company's English name was changed to Toshiba Corporation.

Toshiba is one of two leaders of the Toshiba-IHI Group; the other is Ishikawajima-Harima Heavy Industries (IHI). These parent companies have close capital and business connections. Their subsidiaries are engaged in electrical and electronics production, construction, trading and finance, and shipbuilding.

The company has based its activities on the synergistic business concept of "E&E," the integration of energy and electronics. Toshiba has

For more information on Toshiba Corporation or the semiconductor industry, call Junko Matsubara at (408) 437-8572.

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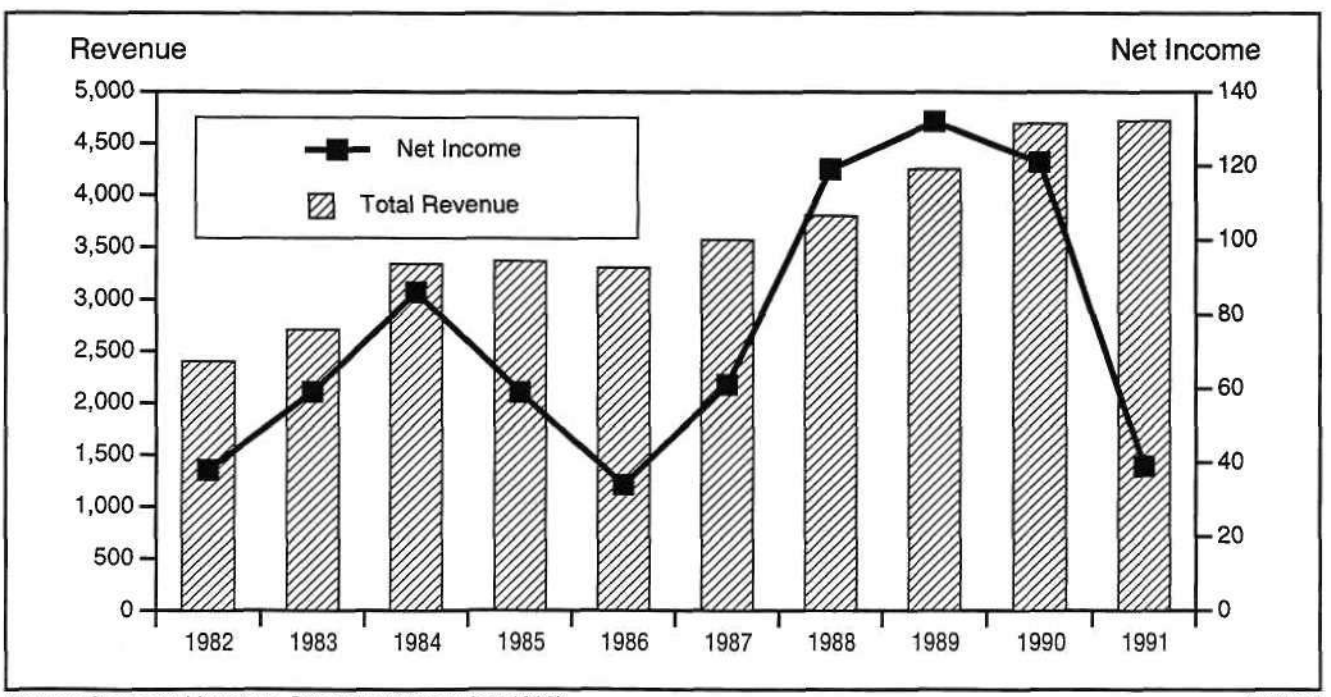
132 consolidated subsidiaries worldwide and 45 subsidiaries operating outside of Japan.

Corporate Business

Japanese industries experienced two distinct economic phases during fiscal year 1991. For the first half, Japan remained in the tail end of the record-long Heisei Boom, a historically periodic bubble economy. Although many economic forecasts predicted an earlier end of the boom in Japan, it lasted until the third quarter of the 1991 calendar year. Although product sales in all business sectors were buoyed by the extended duration of the bubble, the ensuing burst was quickly followed by a steep decline into a recession that few anticipated. The climate at the close of 1991 could not have been more dissimilar to the forecasts of the early part of the year.

Toshiba's consolidated revenue recorded ¥4,722 billion in fiscal year (FY) 1991, a slight 0.6 percent increase over the previous year's showing (see Table 1). Toshiba's historical revenue trend is plotted in Figure 1. Although total sales reached a historical peak in 1991, net income tumbled 67.3 percent, to ¥39 billion, a level nearly matching its 10-year low achieved in 1986. The company attributed the drop in profits to the slowdown in demand for both semiconductor and computer products worldwide.

Figure 1
Toshiba Corporation Total Revenue and Net Income
(Billions of Yen)



Source: Company Literature, Dataquest (December 1992)

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Table 1
Toshiba Corporation Sales, by Product Segment and Market (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Information/Communications Systems and Electronic Devices	1,528	1,867	2,304	2,523	2,501
Heavy Electrical Apparatus	874	727	880	1,001	1,053
Consumer Products and Others	1,170	1,207	1,384	1,507	1,548
Intersegment	-	-	-316	-335	-379
Total	3,572	3,801	4,252	4,695	4,722
Domestic Market	2,466	2,582	2,908	3,241	3,350
Percentage of Total Market	69.0	67.9	68.4	69.0	70.9
Overseas Market	1,106	1,219	1,344	1,454.8	1,372.5
Percentage of Total Market	31.0	32.1	31.6	31.0	29.1
Fiscal Year Exchange Rate (¥/U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding. Toshiba changed its account segment method in 1989.
Source: Company Literature, Dataquest (December 1992)

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Business Segments

Toshiba divides its operation into three major divisions: Information/Communications Systems and Electronic Devices, Heavy Electrical Apparatus, and Consumer Products and Others. Among the three divisions, Information/Communications Systems and Electronic Devices was the only one to show negative growth during the 1991 fiscal year. However, this segment accounts for almost one-half of Toshiba's corporate revenue; hence, even small fluctuations in its performance can have a major impact on Toshiba's overall performance. Although the remaining two divisions showed positive growth, these rates were modest and resulted in a continuation of a steady leveling trend in the company's overall sales.

In the short history of portable computers, Toshiba has consistently been a dominant supplier of both laptop and notebook computers. Sales volume of Toshiba laptop and notebook computers is about evenly distributed between the Japanese domestic and North American markets. Sluggish personal consumption and corporate capital spending brought on by a recession in Japan, coupled with the slow recovery of the U.S. economy, has adversely affected Toshiba's financial performance. Toshiba has much of its vested interests in interrelated semiconductor and computer businesses that all suffered when corporate capital expenditure sagged and purchases of luxury items such as laptop computers were delayed or canceled from 1991 budgets. Although most Japanese companies still refrain from layoffs in Japan, by the first quarter of 1992, Toshiba followed the lead of many U.S. companies in downsizing its work force by 350 employees at Toshiba America. Layoffs occurred mainly at laptop and notebook computer assembly plants in the United States.

Although Toshiba was founded as a heavy machinery enterprise, the Information/Communications Systems and Electronic Devices group has become its primary emphasis. Among Japan's largest electronics conglomerates, Toshiba has maintained a rather aggressive approach toward managing its semiconductor and computer businesses. Toshiba is highly regarded as a dominant supplier of latest-generation commodity DRAMs and a traditional leader in portable computers. However, both have also proven to be highly volatile, risk-laden markets that have witnessed extremes of high growth and profitability as well as price wars and oversupply. While the synergistic relationship between the various businesses within Toshiba's Information/Communications Systems and Electronic Devices group has created a measure of competitive advantage, its 1991 financial performance may indicate an overdependence on interrelated chip and computer markets and, to some degree, a lack of diversification for a company the size of Toshiba. The Information/Communications Systems and Electronic Devices Division now accounts for 49 percent of the company's revenue. Toshiba plans for computers and semiconductors to continue to play key roles in its long-term business strategies.

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International Business

In FY1991, 29 percent of Toshiba revenue were generated in overseas markets. Over the past five years Toshiba has garnered an average of about 31 percent of total revenue from overseas markets, with 1991 recording the lowest foreign market sales figures during the five-year period.

Most Japanese electronic companies' foreign trade has suffered from the combined effects of an appreciating yen on worldwide currency markets and escalating trade friction, particularly with the United States and the European Community (EC). International semiconductor trade management adversely affected exports of Japanese semiconductor parts beginning in 1986 and severely altered the revenue levels for most of the largest electronic business companies in Japan. All indications are that the EC will continue to construct trade barriers designed to protect and nurture its domestic semiconductor industries to a far greater extent than either the U.S. or Japanese governments currently institute.

Toshiba will necessarily continue to strengthen its global presence by moving plants to offshore sites closer to their respective markets. The company has achieved a strong manufacturing presence in several Asian countries, and will continue to invest in facilities in such Southeast Asian countries as Thailand and Malaysia as the regional demand for semiconductors and other electronic components scale with the high-growth economies of these countries.

Corporate Investment

During FY1991, Toshiba invested ¥318 billion, or about 6.7 percent of its total sales, in research and development (R&D) activities (see Table 2). Toshiba's R&D expenditure has consistently been among the highest levels invested by a leading Japanese company and has allowed Toshiba to stay at the forefront of high-technology manufacturing. Toshiba's capital spending levels have also surprised many competitors because it traditionally has maintained high investment in

Table 2
Toshiba Corporation Investment: Capital Spending and R&D (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Revenue	3,572	3,801	4,252	4,695	4,722
Capital Spending	212	268	324	441	485
Percentage of Total Sales	5.9	7.1	7.6	9.4	10.3
R&D Spending	217	230	266	299	318
Percentage of Total Sales	6.1	6.1	6.3	6.4	6.7

Source: Company Literature, Dataquest (December 1992)

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capacity even as competitors have scaled down their operations during market turndowns. Toshiba has dedicated about half its semiconductor fab lines to DRAM production, which lately has proven to be a costly strategy. While pursuing basic research projects, Toshiba has attempted to give its research endeavors a sense of purpose by constantly targeting potential commercial applications. In keeping with these policies, Toshiba has asserted tight control over its intellectual property portfolio by maintaining a high rate of patent filings. During the past few years, Toshiba has consistently ranked amongst the top three institutions based on the number of U.S. patents granted to it; furthermore, in 1991 Toshiba filed more U.S. patents than any other institution.

Financial Condition in FY1991

Tables 3 and 4 show a cross section of Toshiba's consolidated balance sheet and income statements, respectively. Although total sales in FY1991 reached a record high of ¥4,722 billion, net income was a mere ¥39 billion, a steep 68 percent decline over the previous year's figure.

While FY1991 did not hit the low-income mark set in FY1986, the profitability ratio, equal to net income divided by total sales, for FY1991 was actually below that achieved in FY1986. The profitability minimums occurring during 1986 and 1991 are a trait prevalent in the histories of virtually all major electronics companies in Japan. The 1991 minimums, however, were particularly severe for companies such as Toshiba and NEC that had invested heavily in semiconductor manufacturing capacity, particularly DRAM production. Toshiba itself attributes its poor FY1991 performance to soft demand for both semiconductors and computer systems.

Several Japanese electronics companies, including Hitachi, have a return on sales ratio (equal to earnings before taxes divided by net sales) that regularly exceeds their corresponding operating income margin (equal to gross operating income divided by net sales). While this effect is usually attributable to a company having surplus income—such as from stock dividends and funds generated from ventures outside of primary businesses—that has offset annual debt payments, added income in Toshiba's aggressive capital-intensive mode of operation has been leveraged for expansion with the consequent debt, canceling out any surplus gains from external dealings. Toshiba typically rates within the top 10 Japanese corporations that generate supplemental income from financial activities outside their primary business ventures. During FY1991, however, Toshiba consumed about half of this surplus income on debt payments. Furthermore, Japan's slow economy and recent financial scandals have significantly depreciated its stock's value. Toshiba recently has been required to make large payments from its cash reserves in order to retire convertible bonds, to gear up for next-generation memory production, and to establish a multimedia joint venture involving Time Warner and C. Ito.

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Table 3
Toshiba Corporation Consolidated Balance Sheet
(Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Current Assets	2,351	2,723	3,442	3,580	3,609
Cash	508	637	1,019	847	791
Marketable Securities	195	171	189	194	180
Receivables	721	883	1,019	1,170	1,170
Inventory	743	825	960	1,103	1,224
Other Current Assets	184	207	255	266	245
Long-Term Receivables and Investments	448	521	622	599	591
Net Property, Plant, and Equipment	738	790	906	1,118	1,287
Other Assets	159	172	212	234	238
Total Assets	3,696	4,206	5,181	5,530	5,724
Total Current Liabilities	2,073	2,437	2,757	2,925	2,940
Long-Term Debt	779	770	1,205	1,287	1,461
Minority Interest	126	118	134	140	142
Total Liabilities	2,978	3,325	4,096	4,352	4,543
Total Shareholders' Equity	718	880	1,086	1,179	1,182
Common Stock	197	230	262	272	273
Additional Paid-In Capital	192	225	273	283	283
Retained Earnings	316	408	505	606	609
Other Equity	14	18	47	19	17
Total Liabilities and Shareholders' Equity	3,696	4,206	5,181	5,530	5,725
Fiscal Year Exchange Rate	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company Literature, Dataquest (December 1992)

Financial Analysis

Table 5 summarizes some key figures representing Toshiba's financial status and compares them with those of Hitachi and NEC for FY1991. Japanese electronics companies typically can maintain stability and company value with smaller current and quick ratios than can their U.S. counterparts. However, even by these financial indicators, Toshiba recorded weak performance for the year. Commensurate with its highly leveraged approach to semiconductor manufacturing, the company's debt-equity ratio stood at 1.24 for FY1991. This ratio, not surprisingly, was close to the ratio achieved in the same year by NEC,

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Table 4
Toshiba Corporation: Consolidated Income Statement (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Net Sales	3,572	3,801	4,252	4,695	4,722
Domestic Sales	2,466	2,582	2,908	3,241	3,350
Overseas Sales	1,106	1,219	1,344	1,455	1,373
Cost of Goods Sold	2,573	2,584	2,864	3,179	3,311
Selling, General, and Administrative	889	969	1,072	1,255	1,293
Gross Income	110	248	316	262	118
Gross Profit (%)	3.1	6.5	7.4	5.6	2.5
Operating Income (Loss)	132	117	155	190	181
Operating Expenses					
Interest	66	70	95	126	124
Other Expense	51	60	106	67	61
Income before Income Taxes	126	235	270	259	115
Effective Tax Rate (%)	56	56	54	52	52
Income Taxes	65	123	146	140	79
Income after Income Taxes	61	111	124	119	36
Minority Interest in Income (Loss)	0	8	8	2	3
Net Income	61	119	132	121	39
Fiscal Year Exchange Rate	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company Literature, Dataquest (December 1992)

another company that gambled heavily on semiconductor DRAM manufacturing.

Although Toshiba appears to have done poorly in FY1991, with falling liquidity and a reduced stock value, it appears to be no more subject to instability than most of its Japanese competitors. Some of Toshiba's strength in gaining the confidence of the financial community stems from its affiliation and membership, as a key manufacturer, in the Mitsui Group. Although Mitsui's holdings in Toshiba are not as extensive as the Sumitomo Group's interests in NEC, Toshiba has the distinction of having a diverse set of investors, often with conflicting interests, as major shareholders—11 banks and financial institutions, including members of both the Mitsubishi and Sumitomo Groups, comprise the list of Toshiba's major shareholders (see Table 6).

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Table 5
Toshiba Corporation Financial Ratios

	Toshiba					Hitachi	NEC
	1987	1988	1989	1990	1991	1991	1991
Total Sales (¥B)	3,572	3,801	4,252	4,695	4,722	7,766	3,774
Net Income (¥B)	61	119	132	121	39	128	15
Total Assets (¥B)	3,696	4,206	5,181	5,530	5,724	8,858	4,081
Operating Income Margin (%)	3.1	6.5	7.4	5.6	2.5	4.5	3.2
Net Income/Total Sales (%)	1.7	3.1	3.1	2.6	0.8	1.6	0.4
Foreign Sales/Total Sales (%)	31.0	32.1	31.6	31.0	29.1	23.8	21.0
Corporate R&D/Total Sales (%)	6.1	6.1	6.3	6.4	6.7	6.7	8.0
Semiconductor Sales* (¥B)	436	571	595	605	623	542	649
S/C Sales/Total Sales (%)	12.2	15.0	14.0	12.9	13.2	7.0	17.2
Sales/Employee (¥M)	29.282	30.407	29.943	28.984	28.109	23.946	29.410
Net Income/Employee (¥M)	0.498	0.955	0.928	0.746	0.235	0.394	0.119
Growth Rate							
Total Sales (%)	8.0	6.4	11.9	10.4	0.6	0.4	2.0
Net Income (%)	77.6	96.7	10.4	-8.3	-67.3	-44.6	-71.9
Financial Ratios							
Current Ratio	1.15	1.12	1.25	1.22	1.23	1.56	1.19
Quick Ratio	0.74	0.78	0.90	0.85	0.81	1.10	0.76
Sales/Net Working Capital (NWC)	11.65	13.29	6.20	7.17	7.04	3.68	9.88
NWC/Total Assets	0.08	0.07	0.13	0.12	0.12	0.24	0.09
Debt-Equity Ratio	0.75	0.88	1.11	1.09	1.24	0.33	1.30
Total Asset Turnover	0.97	0.90	0.82	0.85	0.82	0.88	0.92
Return on Sales (%)	3.5	6.2	6.3	5.5	2.4	4.8	1.4
Return on Asset (%)	3.4	5.6	5.2	4.7	2.0	4.2	1.3
Return on Equity (%)	8.5	13.6	12.1	10.3	3.3	4.4	1.7
Earning per Share (¥)	12.90	20.19	30.80	29.32	13.22	25.12	25.17
Payout Ratio	0.62	0.40	0.32	0.34	0.76	0.44	0.40

*Semiconductor sales estimated for a calendar year.
Source: Company Literature, Dataquest (December 1992)

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Table 6
Toshiba Corporation Top 10 Shareholders

Shareholders	Share (%)
Dai-ichi Mutual Life Insurance	4.0
Sakura Bank	3.7
Nippon Life Insurance	3.5
Mitsui Murual Life Insurance	2.5
Sumitomo Trust & Banking	2.2
Mitsubishi Trust & Banking	2.2
Mitsui Trust & Banking	2.2
Nippon Fire & Marine Insurance	1.9
Tokai Bank	1.8
Long-Term Credit Bank	1.8

Source: Company Literature (December 1992)

Large blocks of corporate stock are commonly owned by financial institutions in Japan. This has often led to or been the result of actions designed to expand or promote a particular keiretsu. In Toshiba's case, Mitsui was the founding keiretsu. However, Toshiba has developed into a surprisingly less keiretsu-dominated organization—32 percent of its stock has found its way into the hands of individual investors, and no single financial institution owns more than a small percentage stake in Toshiba. In contrast, foreigners possess a minor stake in Toshiba, with a total of less then 8 percent ownership of the company. This percentage is the lowest among Japan's top five electronics companies, and may indicate that Toshiba's aggressive and heavily leveraged style is rather unappealing to the international investment community.

Semiconductor Climate of 1991

Worldwide semiconductor sales totaled $59.7 billion in 1991, which exceeded the previous year's sales by 9.4 percent. The Japanese market comprised 37.7 percent of the global 1991 market, with $22.5 billion in sales, and continued to make Japan the single largest region for chip consumption. Japanese semiconductor consumption has grown 11.1 percent during the past year. The Japanese market expanded by a slight 0.6 percent, relative to the world market, during a one-year period.

In terms of suppliers, Japan's 46.4 percent share of the 1991 global market nearly matched the 1990 figure of 46.3 percent. Asia/Pacific-Rest of World (ROW) suppliers made market share gains at the expense of North American and European companies.

The Japanese companies continued their dominance of the DRAM market, led by Toshiba, but lost some market share to Korean companies. Samsung moved to the number 2 position, trailing only Toshiba

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in terms of volume of commodity DRAMs products shipped. U.S.-based semiconductor companies lost worldwide share; however, many of these companies continued to lead the world in microprocessors and design-intensive ASIC/ASSP chips.

Toshiba Semiconductor Overview

According to Dataquest's semiconductor market share estimates for 1991, Toshiba recorded $4.6 billion in semiconductor revenue, qualifying it as the second largest in the world following NEC. In Japan's domestic market, Toshiba ranked third behind the top supplier NEC, and Hitachi, the second largest domestic supplier.

Toshiba has long been a major supplier of commodity DRAMs but has suffered lately from an overdependence on the high revenue streams required to maintain dominance in this market segment. Nevertheless, Toshiba appears as resolute as any other Japanese semiconductor supplier in its conviction that its future prosperity lies in dominating commodity DRAM markets. Although many Japanese suppliers have resigned themselves to sharing markets with aggressively priced Korean products, Toshiba has been persistent in pursuing high-end markets with density and performance specifications to differentiate its products from those of its competitors in an increasingly crowded market. High-performance memories have been achieved through innovation in both fabrication processes and circuit designs, such as those licensed from the U.S. startup Rambus Inc. or Toshiba's own NAND-type circuit technology. Although the Rambus approach has yet to gain widespread popularity in system designs, partly because it requires a customized DRAM and hence a larger die, acceptance of the architecture as a standard would necessarily promote the Rambus DRAM to commodity status.

Toshiba is an active supplier of MIPS-compliant RISC microprocessors and is part of several joint efforts involving MIPS CPU development. Toshiba also is positioning itself to compete in the EEPROM and flash markets, which are expected to grow as these products begin to replace hard disk drives in notebook and smaller systems. Toshiba's internally developed NAND gate technology is promoted by Toshiba as a competitive advantage and apparently is applicable to its various RISC CPU implementations as well as to its nonvolatile MOS memory products.

In the area of semiconductors, Toshiba and IBM are now beginning to reap the rewards of their joint venture to produce thin film transistor (TFT) LCD panels. Color panels as large as 13.8 diagonal inches and possessing a megapixel of resolution represent state-of-the-art flat panel technology that has been produced by the joint venture. A commercially viable production yield of such panels would give Toshiba and IBM a clear competitive advantage in high-end laptop and notebook computer systems.

Table 7 summarizes Toshiba's semiconductor ranking by product segment in 1991. Figure 2 is an organization chart of Toshiba's semiconductor-related operation.

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Table 7
Estimated 1991 Toshiba Semiconductor Ranking, by Product Segment

	Worldwide Market	Japanese Market
Total Semiconductor	2	3
Total Integrated Circuit	3	4
Bipolar Digital	9	4
MOS	3	4
MOS Memory	1	4
MOS Microcomponents	6	6
MOS Logic	2	3
Analog	3	3
Total Discrete	1	1
Total Optoelectronics	3	4

Source: Dataquest (December 1992)

Product Strategy

Figure 3 shows Toshiba's semiconductor product mix revenue and the worldwide product mix revenue recorded in 1991. Toshiba's strengths reside in its MOS capabilities, particularly in the area of MOS memories. Total MOS production, including memories, microcomponents, and logic, roughly matches world demand for MOS products. Like most Japanese semiconductor manufacturers, Toshiba's semiconductor revenue is heavily dependent on commodity MOS memories, which accounted for about 31 percent of its total semiconductor business. DRAMs contributed about 21 percent to total semiconductor revenue, which translated to about 67 percent of Toshiba's MOS memory sales. About 45 percent of all DRAMs sold by Toshiba in 1991 were of the 4Mb variety. Toshiba's 1Mb DRAMs and VRAMs also continued to contribute to memory revenue during 1991, as the company took advantage of the slow ramp-up and soft demand for 4Mb DRAM products. For 1992, 4Mb DRAM demand is expected to quickly diminish demand for 1Mb parts with Hitachi, NEC, Toshiba, and Samsung in a tight race to recover their development costs for the 4Mb generation of DRAM products.

The rapid deterioration of DRAM markets, coupled with the determination of Korean manufactures to establish a dominant role in these markets, caused most Japanese DRAM manufactures to suspend or delay their advanced DRAM manufacturing schedules early in 1992. However, price wars in the U.S. PC markets, coupled with the growing adoption of graphical user interfaces (GUIs) and 32-bit operating systems, have revitalized the markets for nearly all types of memories. In addition, the U.S. Department of Commerce, after having determined that Korean manufacturers were dumping

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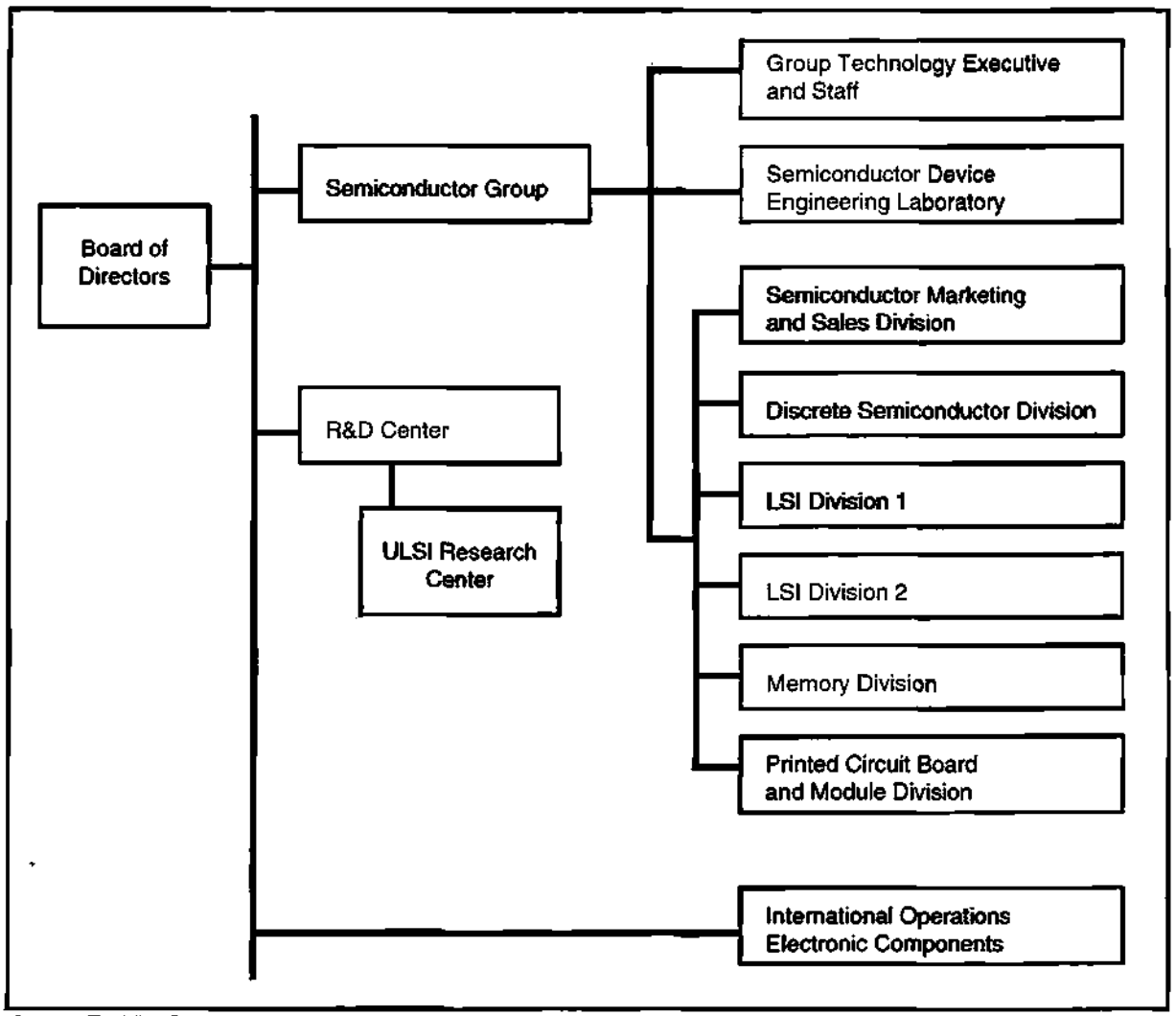
Figure 2
Toshiba Semiconductor Organization



Source: Toshiba Corporation G2001951

DRAMs in the United States, levied tariffs on those products. All these factors created a climate suddenly more conducive for Japanese memory manufacturers to begin reimplementing their long-delayed manufacturing plans. Toshiba has announced that it will construct a new building at its Yokkaichi Plant. It also plans to establish a new R&D center to develop next-generation 64Mb DRAM parts at its Oita Plant, which houses Toshiba's main 4Mb DRAM fabrication lines. Although the Oita Plant eventually will mass-produce 64Mb parts, the plant at Yokkaichi is scheduled for production of 16Mb devices in the more immediate future. Toshiba's intended investment of ¥130 billion at Yokkaichi demonstrates a clear commitment to the memory business that has become a virtual hallmark of the Toshiba semiconductor business methodology.

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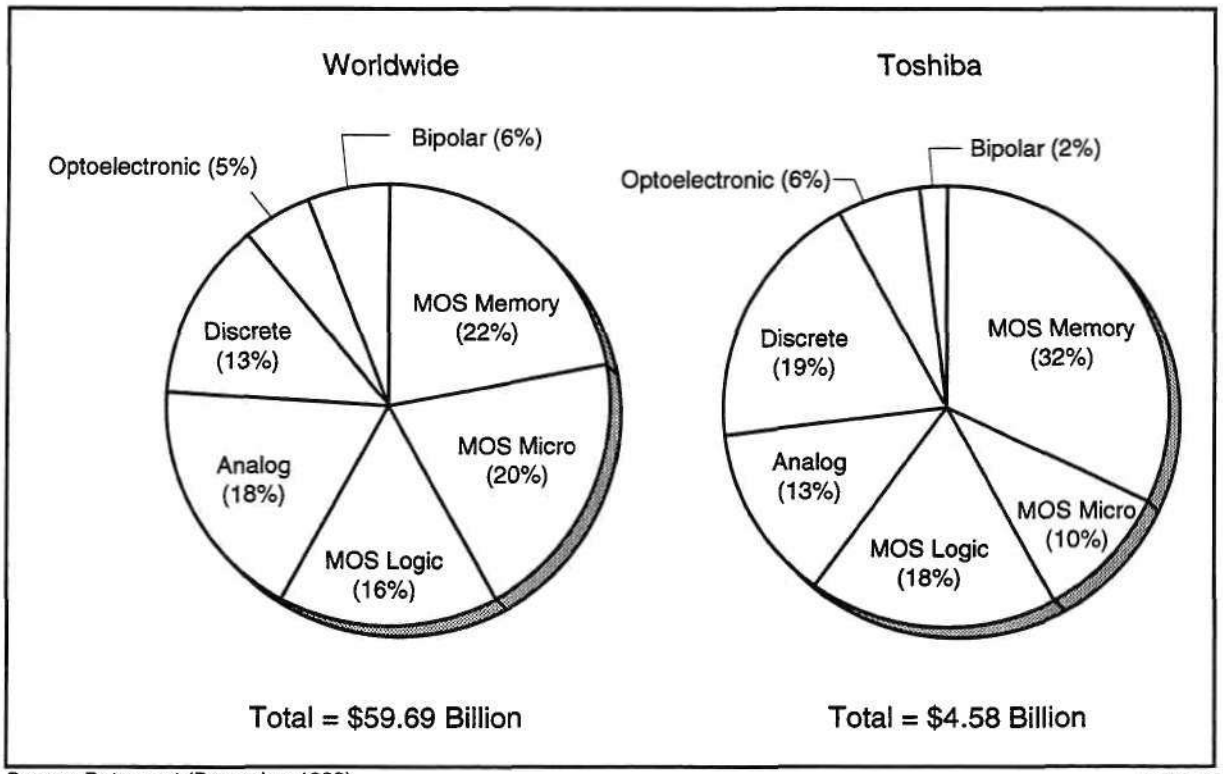
Figure 3
1991 Semiconductor Market Share Product Mix: Worldwide versus Toshiba



Source: Dataquest (December 1992) G2001952

Figure 4 compares Toshiba's semiconductor growth rates, broken down by product category, against corresponding product growth rates on the worldwide market for FY1991. Although products fabricated in MOS technology accounted for about 60 percent of Toshiba's annual semiconductor business, its MOS product lines failed to match the 14 percent growth in the world's MOS markets during 1991. In particular, Toshiba's MOS memory market share actually shrank, with a negative growth rate for the year. Because MOS memories constitute 53 percent of its MOS product revenue, it is surprising that Toshiba has not maintained market share; however, in the last five years Toshiba has begun to reduce its levels of capital spending to amounts more closely approaching those of other major Japanese companies. Heavy 4Mb investment by Japanese competitors and market incursions by Korean manufacturers resulted in a loss of dominance by Toshiba in DRAM markets during the standardization transition from 1Mb to 4Mb. Because this transition was slow in developing, Toshiba's overall DRAM memory strategy appears to have been justified as the added cost of gaining market share in today's 4Mb market may not have proven to be a sound return on investment. The diminishing returns of dominating the memory business, particularly in the

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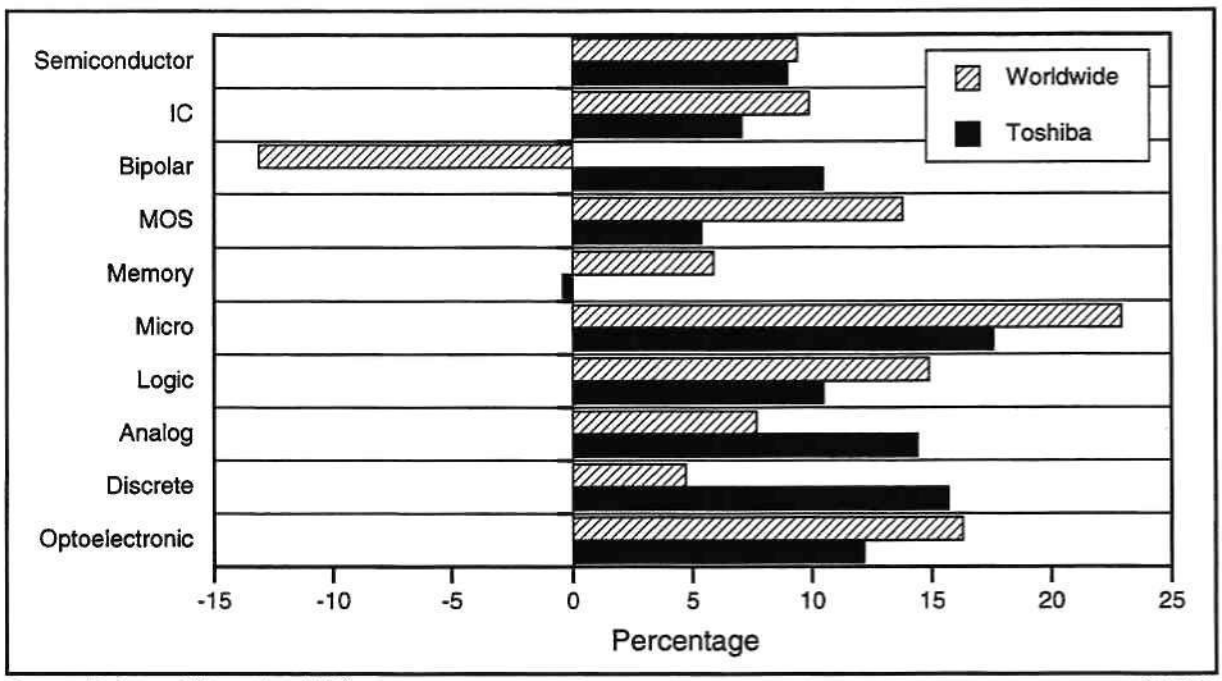
Figure 4
Toshiba's 1991 Growth Rate Compared with Worldwide Market



Source: Dataquest (December 1992)

G2001953

capital-intensive DRAM businesses, no longer appear cost-effective unless one clings to the now unrealistic expectations of driving competitors completely out of the business.

In the year's major growth areas of microcomponents and logic, Toshiba performed better than it did in memories, with growth rates that approached the growth of global markets for these product categories. Although more than half of Toshiba's microcomponent sales consisted of microcontroller (MCU) products, Toshiba's microprocessor (MPU) endeavors stem from its role as the largest second source of Motorola's 680X0 CISC family and from its support as a merchant developer and supplier of MPUs based on the MIPS RISC platform. For Toshiba, the commercial viability of the MIPS platform still remains to be proven, however, particularly as the issue of the platform's continued "openness" has again been raised with the recent purchase of MIPS by Silicon Graphics. Should Toshiba decide to seek other RISC platforms to support, a likely candidate would seem to be IBM's PowerPC architecture, which is being codeveloped with Motorola. Because Toshiba is not a dominant MIPS supplier and has ongoing joint ventures with both IBM and Motorola, the IBM PowerPC RISC design is a logical choice for Toshiba to endorse.

A slow consumer electronics market in Japan, which began in the latter half of 1991, resulted in reduced consumption of MCU devices for the year.

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Toshiba recently announced its intention to invest in DSP chip development for mobile telecommunications applications.

Table 8 provides Toshiba's semiconductor revenue, by product segment, for the past five years.

Regional Market

Figure 5 shows Toshiba's semiconductor revenue broken down into four major regional markets. Nearly half of Toshiba's total revenue was generated in overseas markets during 1991. Despite Toshiba's small number of foreign stock holders, its foreign sales as a percentage of overall revenue is the largest among the top 10 Japanese semiconductor manufacturers. With such a large global market share and extensive offshore operations, Toshiba qualifies as much as any Japanese company to be a true multinational business. The diversity of regional markets to which Toshiba supplies should enable it to insulate itself from the negative effects of a particular region's adverse economic adjustments. The two-thirds of MOS memory sales that came from foreign markets helped offset the weak domestic memory markets of Japan during the same year.

Semiconductor Investment

Table 9 and Figure 6 represent Toshiba's semiconductor capital spending and R&D expense trends against overall semiconductor revenue for the past five years. Toshiba has been a traditional capital spending leader in Japan. Even during market lulls, Toshiba continued to invest heavily in capacity and invested more in semiconductor production than any other competitor during the 1980s. This assertive posture contributed to its dominance in the 1Mb DRAM contest and strong contention in all DRAM markets. For the past 10 years, Toshiba's average investment-to-revenue ratio has been greater than those of its two closest semiconductor competitors, NEC and Hitachi.

Toshiba, along with many other Japanese semiconductor producers, invested substantial amounts in preparation for the arrival of the much-anticipated 4Mb DRAM markets. Unfortunately, the 4Mb race never developed the way most had anticipated, as peak demand refused to reach the levels once forecast and may ultimately be delayed indefinitely by the combined effects of a worldwide recession and the inevitable arrival of 16Mb technology. In this departure from expectations, the competitor that quickly scaled back its 4Mb production and possessed the right blend of marketing and production could possibly have recovered its 4Mb technology investment. However, for most competitors that participated in the 4Mb DRAM markets, the result will be minimal return on investment and an expensive lesson in DRAM risk management.

During the period from 1987 to 1991, Toshiba reinvested about 13.5 percent of semiconductor revenue into semiconductor R&D efforts. While absolute R&D costs continue to escalate, revenue increases have not kept pace with the cost of advanced R&D projects and thus R&D expenditure as a percentage of revenue tends to exaggerate R&D investment trends, even though the burden is real and

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Table 8
Estimated Worldwide Semiconductor Revenue, by Product (Billions of Yen)

	1987	1988	1989	1990	1991	1991 Market Share (%)
Total Semiconductor	436.2	571.4	594.8	605.1	622.7	6.3
Total Integrated Circuit	315.9	431.1	459.4	458.4	463.6	6.3
Bipolar Digital	18.0	14.0	12.6	13.7	14.3	12.7
TTL/Others	18.0	13.7	10.4	9.6	10.2	9.8
ECL	0	0.4	2.2	4.0	4.1	19.5
Bipolar Digital	18.0	14.0	12.6	13.7	14.3	12.7
Bipolar Digital Memory	0	0	0	0	0	27.8
Bipolar Digital Logic	18.0	14.0	12.6	13.7	14.3	11.4
MOS (Technology)	229.4	340.7	376.6	367.6	366.1	6.6
N/PMOS	75.2	111.4	111.9	85.0	80.5	7.3
CMOS	154.2	229.3	255.9	282.7	284.2	6.2
BiCMOS	0	0	8.8	0	1.4	20.5
MOS (Function)	229.4	343.1	376.6	367.6	366.1	66.4
MOS Memory	97.8	197.1	232.0	206.1	193.8	10.4
MOS Microcomponents	40.8	45.0	49.8	55.6	61.7	5.0
MOS Logic	90.9	101.0	94.8	106.0	110.6	3.8
Analog	68.5	74.0	70.2	77.0	83.2	3.3
Total Discrete	101.2	112.3	99.9	110.0	120.2	7.4
Total Optoelectronics	19.0	28.0	35.5	36.7	38.9	2.4
Exchange Rate (¥/U.S.$)	144	130	138	144	136	

Note: Columns may not add to totals because of rounding.
Source: Dataquest (December 1992)

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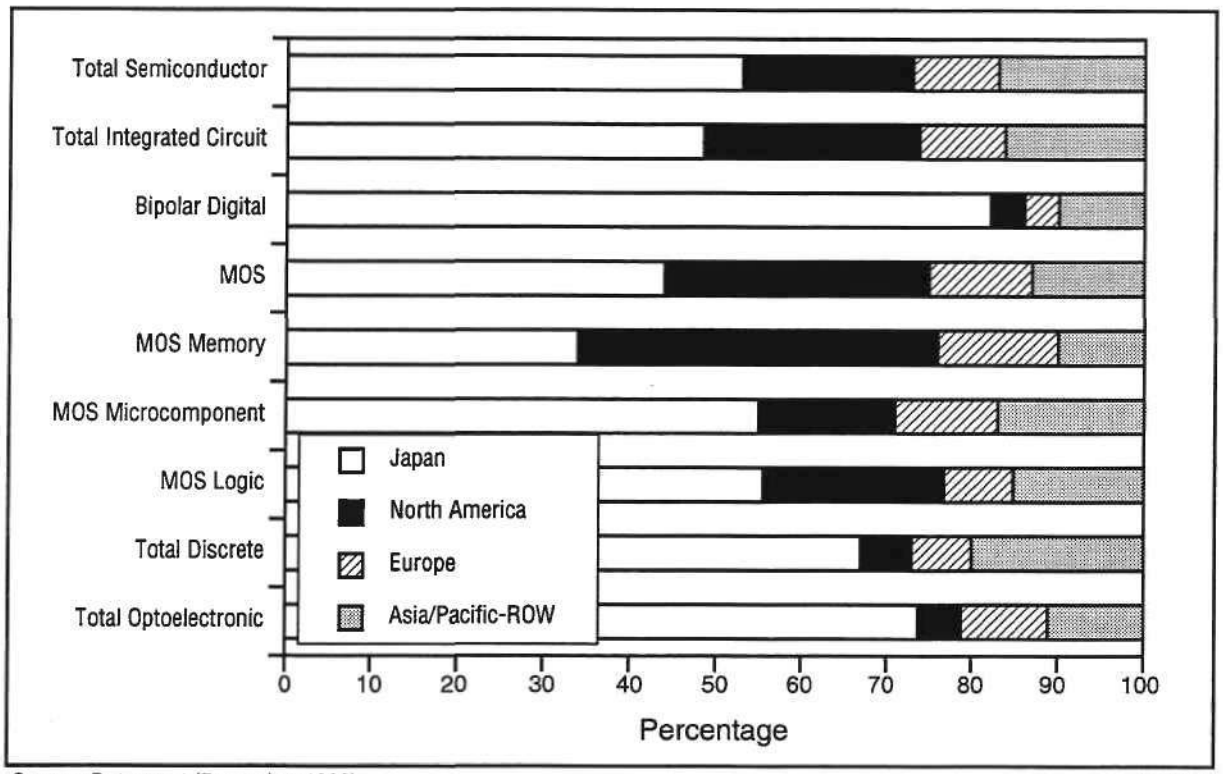
Figure 5
Toshiba's 1991 Semiconductor Revenue, by Region



Source: Dataquest (December 1992)

G2001954

Table 9
Toshiba Semiconductor Investment: Capital Spending and R&D (Billions of Yen)

	1987	1988	1989	1990	1991
Semiconductor Revenue	436.2	571.4	594.8	605.1	622.7
Capital Spending	68.0	83.0	93.8	117.5	106.3
Percentage of Revenue	15.6	14.5	15.8	19.4	17.1
R&D Expense	61.5	65.5	75.0	85.0	94.0
Percentage of Revenue	14.1	11.5	12.6	14.0	15.1
Total Investment to Revenue	29.7	26.0	28.4	33.5	32.2

Note: Semiconductor revenue and capital spending are calculated for a calendar year, while R&D expense is stated for a Japnese fiscal year.
Source: Dataquest (December 1992)

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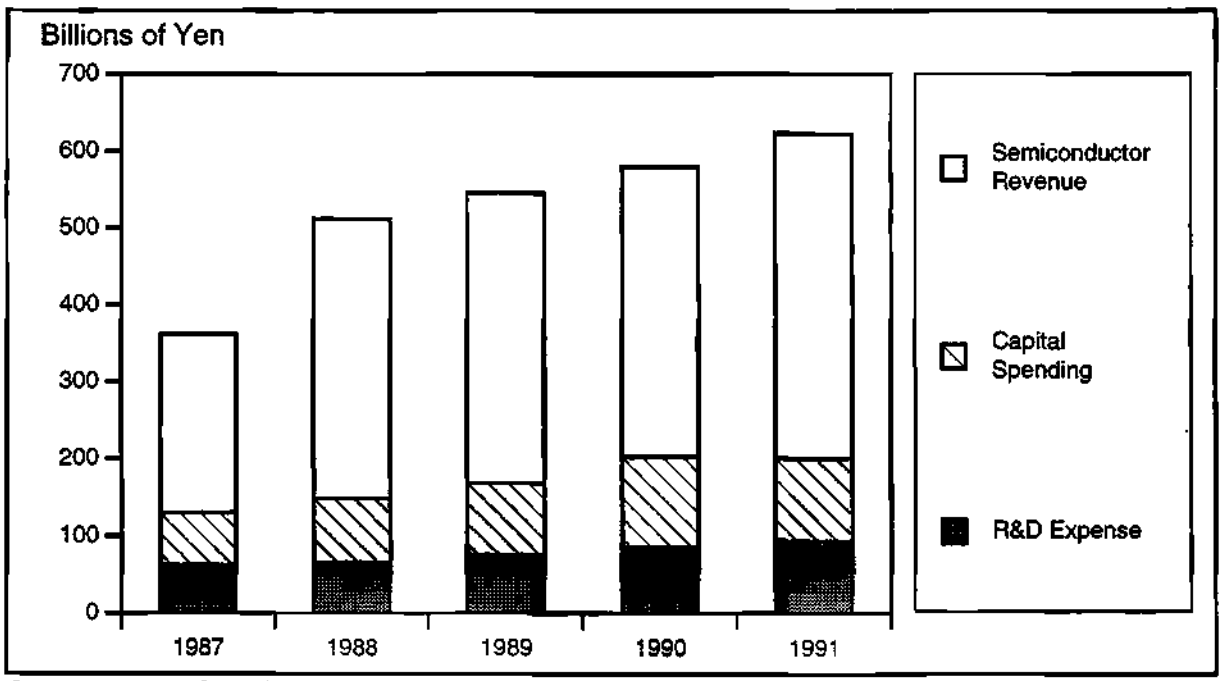
Figure 6
Toshiba Semiconductor Investment: Capital Spending and R&D



Source: Dataquest (December 1992) G2001955

must be sustained by Toshiba's nearly flat revenue levels. Toshiba's 1992 semiconductor R&D costs are expected to be within a few percentages of its 1991 R&D expenditure.

Worldwide semiconductor capital spending is expected to decline 9.5 percent in 1992. Japan is expected to take the largest cuts in capital spending, with current projections calling for a 23.5 percent decline in semiconductor capital spending during 1992. Many Japanese semiconductor companies already have announced their intentions for major investment cuts in their 1992 budgets. In contrast, Toshiba's activities at its plants and at its various joint ventures do not give any indications that the company is downsizing its ambitious capital spending plans. Both Oita and Yokkaichi recently underwent major upgrades costing more than ¥100 billion, each in preparation for production of 4Mb and 16Mb parts. These investment levels suggest that Toshiba's 1992 capital spending rates may match 1991 levels, as predicted by Toshiba's own internal estimates.

Manufacturing Facilities

Toshiba owns 25 front-end fab lines in 8 Japanese facilities. Two other lines at Tohoku Semiconductor also are jointly owned and operated with Motorola. Table 10 shows the location, work force size, and semiconductor products made at Toshiba's primary manufacturing sites. Figure 7 shows the relationship between various semiconductor

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Table 10
Toshiba Semiconductor Manufacturing Facilities

Plant Name	Location	Type	Product	Number of Employees	Year Opened
Domestic Facilities					
Tamagawa Works	Kanagawa	PR	Next-generation memory	1,887	1958
Toshiba Components	Kanagawa	F	Discrete	1,250	1979
Kitakyushu Works	Fukuoka	F	Bipolar, optoelectronics	1,782	1970
Himeji Works	Hyogo	F	Discrete	1,230	1963
Kaga Toshiba Electronics	Ishikawa	FAT	Discrete	860	1984
Toshiba Iwate	Iwate	F	ASIC, micro, CCD	2,500	1973
ULSI Laboratory	Kanagawa	PR	Submicron process technology	NA	1988
Yokkaichi Works	Mie	F	4Mb DRAM	700	1992
Oita Works	Oita	FAT	MOS memory, logic, micro	2,900	1970
Tohoku Semiconductor	Miyagi	F	DRAM, micro	800	1987
Usuki Toshiba Electronics	Oita	AT	MOS memory	630	1983
Takeda Toshiba Electronics	Oita	AT	ASIC	174	1982
Oita Denshi	Oita	AT	MOS ICs	200	1970
Nakaya Denshi	Oita	AT	MOS ICs	350	1970
Hozen Toshiba Electronics	Fukuoka	AT	Discrete, bipolar	950	1973
Nohkata Toshiba Electronics	Fukuoka	AT	Discrete	900	1970
Kunimi Denshi	Fukushima	AT	Hybrid IC, LCD	415	1986
Mizusawa Semiconductor	Iwate	AT	ASIC, logic	345	1976
Mihara Metal	Fukuoka	AT	Bipolar	950	1964
Overseas Facilities					
Toshiba America	Sunnyvale, California	AT	1Mb, 4Mb DRAMs, prototye array		1980
Toshiba Semiconductor	Braunsweig, Germany	FAT	DRAM		1982
Toshiba Semiconductor Thailand	Bangkok, Thailand	AT	Bipolar discrete		1992
Toshiba Electronics Malaysia	Malaysia	AT	Memory, discrete, bipolar		1973

F: Fab
P: Pilot line
R: Semiconductor R&D
A: Assembly
T: Test
NA= Not available
Source: Dataquest (December 1992)

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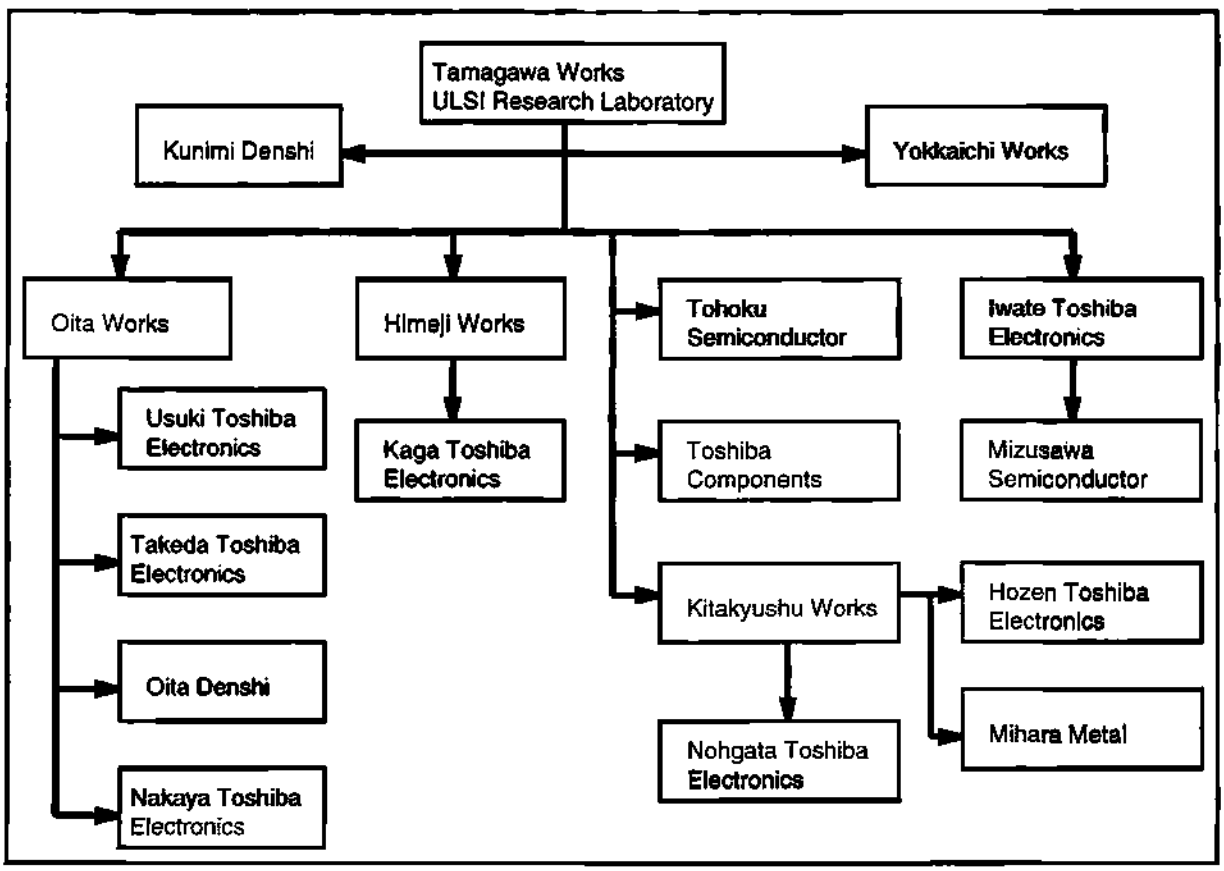
Figure 7
Toshiba Semiconductor Manufacturing Shift



Source: Dataquest (December 1992) G2001856

manufacturing sites and possible chip production steps performed at the various Toshiba plants.

Toshiba has semiconductor production facilities in Germany, the United States, Malaysia, and Thailand. The plant in Germany is a front-end facility producing 256K and 1Mb DRAMs. The EC body that governs semiconductor trade policy has already begun imposing import regulations, including procedures for defining, calculating, and establishing limits on foreign chips imported into the EC semiconductor markets. An EC committee has also made rulings defining a domestic semiconductor product as one that has its front-end wafer fabrication steps performed on European territory. These mandates have induced major Japanese chip makers such as Hitachi, NEC, and Toshiba to construct or upgrade existing fabs in Europe in anticipation of unification of the European markets. Toshiba's facility in Germany, together with collaborative efforts with Siemens, should help in creating a strong platform for Toshiba's semiconductor products in the EC's markets.

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Toshiba has also acquired property in Hillsboro, Oregon, and plans to build a wafer fabrication facility that is slated to begin producing ASICs in mid-1993. This front-end facility will provide a major boost to Toshiba's presence in the United States. Its current representation consists of a back-end plant in Sunnyvale, California, where ASICs and 1Mb and 4Mb DRAMs are packaged.

Semiconductor Alliances

Table 11 lists Toshiba's publicly announced alliances formed during the past five years. Toshiba has cultivated a long-term strategic alliance with Motorola to codevelop, fabricate, and market a wide variety of semiconductors. Both companies jointly own a manufacturing facility, Tohoku Semiconductor, where they produce 1Mb and 4Mb DRAMs and microcomponents.

Toshiba has also collaborated with IBM and continues to have ongoing projects to codevelop both TFT LCDs and flash memories. To further demonstrate their willingness to work together, Toshiba and IBM, together with Siemens, have begun a high-profile alliance to jointly develop technologies to be employed in 256Mb DRAM production.

In addition to semiconductor-related alliances, Toshiba entered into a partnership with Time Warner Inc. and C. Ito & Co. during FY1991 to conduct forward-looking multimedia projects. In this venture, Toshiba's hardware technology will be integrated with Time Warner's software resources and knowledge base, utilizing C. Ito's networking expertise. Furthermore, in June 1992, Toshiba entered into an agreement with Apple Computer Inc. that also involved development and licensing of multimedia technology. Although these alliances do not approach the magnitude of Sony's acquisition of Columbia Pictures or Matsushita's purchase of MCA, all this activity signifies that major media and electronics companies recognize the significance of the impeding multimedia markets that will further unite media to their electronic carriers and processors.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 11.

- LA—Licensing agreement
- SS—Second source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard

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Table 11
Toshiba's Semiconductor Strategic Alliances

Date	Partner	Agreement Type	Product
April 1988	Zoran	FA, JD	DSP
May 1988	Advanced Silicon Corporation	FA, JD	6-inch CMOS wafer
March 1989	Fuji Film	JD	IC card memory
May 1989	Siemens	SS, TE	Gate array
June 1989	Motorola	LA, SS	Bipolar CMOS logic IC
July 1989	Motorola	TE, JD	4Mb DRAM, RISC
July 1989	Sun Microsystems	LA	RISC, SPARC chip
November 1989	IBM	JV	Large color LCD
December 1989	Integrated CMOS Systems	IV	Scan-test methodology
January 1990	Integrated CMOS Systems	TE, JD	Gate array, CAD tools
January 1990	Nikon	JD	Next-generation steppers
January 1990	Motorola	FA	Motorola's 68020 MPU
February 1990	MIPS Computer	FA	MIPS RISC MPUs
February 1990	Rockwell International	LA	Metalorganic CVDs
February 1990	Echelon Systems	LA, JD	LON MPUs
September 1990	Motorola	JV	4Mb DRAMs
November 1990	Hopkin	LA	CAD software
December 1990	Motorola	JD	HDTV semiconductors
December 1990	Motorola	JD	16-bit MCUs for automobiles
January 1991	Synergy	LA, JD, IV	Industrial bipolar ICs
January 1991	Bull America	JD	MCA bus chip set
August 1991	Kubota	SA	Image processing ICs
September 1991	Motorola	SA	Semiconductors
October 1991	IDT 19Siemens	SA, JD	RISC MPUs
October 1991	MIPS Computer	LA, IV, CO	MIPS RISC MPUs
November 1991	Siemens	JD	MIPS RISC MPUs
November 1991	3 U.S. companies	JD	LCD process equipment
January 1992	Intel	LA	8-year patent cross-license
March 1992	Rambus	LA	Memory interface technology
May 1992	National Semiconductor	FA, JD	CMOS logic ICs
June 1992	IBM	SA, JD	Flash memory
July 1992	IBM 19Siemens	JD	256Mb DRAM

Source: Dataquest (December 1992)

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- PC—Procurement agreement
- OT—Other

Dataquest Perspective

Toshiba is one of Japan's large vertically integrated companies and has established itself as an aggressive supplier of commodity semiconductors and computer systems. Although the company supplies a variety of heavy electrical equipment, such as power plant systems, there is a perception that it has banked its future on its Information/Communications Systems and Electronic Devices Division. Long-term investment in semiconductor production capacity and the frequency and character of its major new joint ventures and alliances support this perception. Capital investment in the Information/Communications Systems and Electronic Devices Division has caused the division to grow relative to the remaining parts of Toshiba to where it now generates 49 percent of the company's revenue.

Joint ventures provided Toshiba with the opportunity to diversify and to more effectively utilize its resources during the past year, which was a particularly lean period for major DRAM suppliers. Toshiba's semiconductor business shows some similarities to the semiconductor operations of NEC: Both are aggressive commodity DRAM suppliers with nearly equivalent semiconductor revenue streams. NEC, however, appears to have a more well-rounded product mix, while Toshiba has become a bit too heavily dependent on commodity DRAMs. NEC, with its larger market share of MPUs, has also benefited from the growth in microcomponents to a greater degree than has Toshiba.

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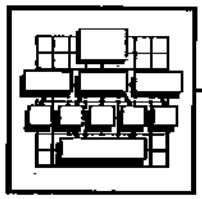

Dataquest Vendor Profile

Semiconductors *Japan*

October 26, 1992

NEC Corporation

Corporate Statistics

Address	NEC Corporation 7-1 Shiba 5-chome, Minato-ku, Tokyo 108-01
Telephone	81-3-3454-1111
Facsimile	81-3-3798-1510
Chairman	Kenzo Nakamura
President	Tadahiro Sekimoto
Established	July 1899
Number of Employees	128,320 (as of March 31, 1992)
Total Sales	¥3,774 billion (FY1991)
Net Income	¥15.3 billion (FY1991)
Total Assets	¥4,081 billion (FY1991)
Main Product Area	Communications systems and equipment Computers and industrial electronic systems Electron devices Consumer electronics and other operations

Corporate Overview

NEC Corporation was founded in 1899 as a manufacturer of telephone sets and switchboards. Initial seed funding was received from Western Electric Company, at the time called International Standard Electric Corporation, of the United States, and subsequently the company was transferred to a part of the Sumitomo Corporation. NEC is a leading global supplier of electronic products that comprise primarily communications systems and equipment, computers and industrial electronic systems, and electron devices. In its domestic enterprise, NEC has 66 consolidated subsidiaries, 63 plants, and about 400 sales offices. NEC operates 70 affiliates or subsidiaries in 28 other countries, with plants in 15 of them and marketing, service, and/or research and development facilities in 25.

In mid-1991, NEC adopted a market-oriented business concept dubbed "C&C," or computers and communications, which symbolizes the

For more information on NEC Corporation or the Japanese semiconductor industry, call Junko Matsubara at (408) 437-8572.

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synergistic relationship between various electronic components and the integrated systems using these components. Crucial to the realization of this synergy is the role of semiconductors as the fundamental building block for all the C&C endeavors. In mid-1992, NEC modified its corporate logo.

Corporate Business

During fiscal year 1991, Japanese industries experienced two distinct economic phases. For the first half of the year, Japan remained in the tail end of a record-long "Heisei Boom," a bubble economy that has historically affected the Japanese economy in a periodic cycle. Although many economic forecasts predicted an earlier end of the boom in Japan, it lasted until the third quarter of the 1991 calendar year. And although product sales in all business sectors were buoyed by the extended duration of the bubble, the ensuing burst was quickly followed by steep decline into a recession that few anticipated. The climate at the close of 1991 could not have been more dissimilar to the optimistic growth climate witnessed earlier in the year.

NEC's consolidated revenue reached ¥3,774 billion in FY1991, a moderate 2 percent increase over the previous fiscal year's showing (see Table 1). NEC's revenue history is plotted in Figure 1. Although total sales recorded the highest in NEC's history, net income declined 72 percent to ¥15.3 billion. The company attributed the drop in profits

Table 1
NEC Corporation Sales, by Product Segment and Market (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
C&C Operations					
Communications Systems and Equipment	803	852	932	1,040	1,002
Computers and Industrial Electronic Systems	1,193	1,370	1,590	1,757	1,949
Electron Devices	499	610	664	649	617
Consumer Electronics and Other Operations	220	250	258	253	206
Total	2,715	3,083	3,444	3,699	3,774
Fiscal Year	**1987**	**1988**	**1989**	**1990**	**1991**
Domestic Market	1,969	2,306	2,552	2,833	2,980
Percentage of Total Market	72.5	74.8	74.1	76.6	79.0
Overseas Market	746	777	892	866	794
Percentage of Total Market	27.5	25.2	25.9	23.4	21.0
Fiscal Year Exchange Rate (¥/U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company Literature, Dataquest (October 1992)

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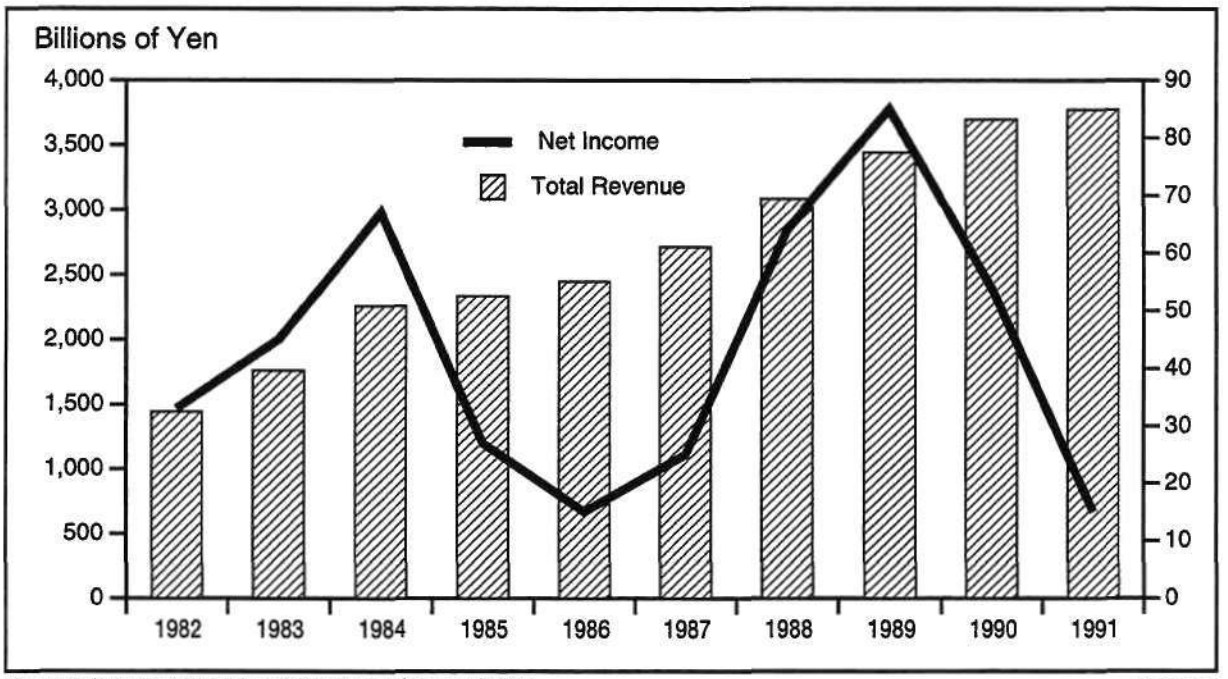
Figure 1
NEC Corporation Total Revenue and Net Income (Billions of Yen)



Source: Company Literature, Dataquest (October 1992) G2001777

to the slowdown in the world semiconductor business, which typically accounts for about one-fifth of NEC's total revenue.

NEC divides its operations into two principal areas: Computers and Communications (C&C) Operations, and Consumer Electronics and Other Operations. C&C Operations accounts for 95 percent of NEC's sales and comprises three subdivisions: Communications Systems and Equipment, Computers and Industrial Electronic Systems, and Electron Devices. Of the four separate business units, only the Computers and Industrial Electronics Systems entity increased revenue during the past year, primarily because of strong domestic computer sales. The increased computer sales caused NEC's largest revenue-generating business unit to grow by 10.9 percent during FY1991 and account for 52 percent of total corporate net sales.

In addition to holding the largest share of the Japanese domestic PC market, NEC is a vertical computer manufacturer with offerings in the workstation, fault-tolerant server, minicomputer, mainframe, and supercomputer categories. As an international competitor, NEC is a growing factor in the world supercomputer market with its competitive SX-3 series and is a solid performer in the notebook class with new models including internally developed color TFT LCD panels.

NEC's three remaining divisions experienced revenue declines during the year, reflecting weak consumer spending and soft demand for its

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semiconductor products. Sales of consumer electronic products, particularly audio-visual (AV) products, were stagnant during this period and suffered from a lack of new application products and severe competition from direct broadcast satellite products. Among all of NEC's subsidiaries, NEC Home Electronics' particularly poor performance adversely affected the parent company's bottom line during the accounting period.

In FY1991, 21.0 percent of NEC revenue was generated by overseas markets. This figure is the lowest among the top 10 Japanese electronics companies and the ratio of overseas revenue to total sales has been generally flat or falling since the mid-1980s. Although the Japanese economy showed some growth in FY1991, sustained by increased personal consumption in the first half of the year, overseas economies were generally poor performers because of delays in the recovery of the U.S. economy and either static or declining European economies. The only positive regional growth was found in other Asian electronics markets. Some NEC products, such as a revamped MultiSync line of color CRT monitors and cellular mobile telephone products, also did well in foreign markets despite the slow economies, which hindered consumption of other product lines.

During FY1991, NEC invested ¥302 billion, or about 8 percent of net sales, in research and development (R&D) activities (see Table 2). This percentage of sales spent on R&D nearly matched the figure spent the previous year. However, with net revenue down, the cost of R&D has been a greater burden. Although NEC is traditionally a big investor in R&D, sustaining high R&D levels will necessarily come at the expense of other investment, such as capital spending on new facilities.

Table 2
NEC Corporation Investment: R&D and Capital Spending (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Revenue	2,715	3,083	3,444	3,699	3,774
Capital Spending	250	286	344	357	322
Percentage of Total Revenue	9.2	9.3	10.0	9.6	8.5
R&D Spending	208	222	247	279	302
Percentage of Total Revenue	7.7	7.2	7.2	7.6	8.0

Source: Company Literature, Dataquest (October 1992)

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Financial Condition in FY1991

Tables 3 and 4 show NEC's consolidated financial statements. NEC has constantly increased its total revenue for the past five years. Total sales in FY1991 reached ¥3,774 billion, a record high for the company. Nevertheless, net income was only ¥15.3 billion, a serious 71.9 percent decline over the previous year's net revenue. This drop in net income nearly matched the record set in FY1986, when NEC recorded a net income of just ¥15.0 billion, the lowest figure for the past 12 years. However, although FY1991 did not hit the low income mark set in FY1986, the profitability ratio, or net income divided by total sales, for FY1991 was actually below that achieved in FY1986. This makes FY1991 a poor performance year for NEC and reveals some of NEC's business weaknesses.

NEC wholly owns 20 foreign consolidated subsidiaries. For the past two fiscal years, NEC's foreign consolidated net revenue, including losses, was smaller than that of the parent company, which effectively diminished the profitability of NEC. The subsidiary companies' lack of performance had a negative impact on the parent's financial bottom line. NEC's home electronics and semiconductor subsidiaries were especially poor performers during FY1991. NEC subsidized the losses incurred by the subsidiaries during FY1991 and in so doing increased its own interest payment burden.

Financial Analysis

Table 5 summarizes key figures that characterize NEC's financial profile during FY1991 and compares them to similar figures for Hitachi and Toshiba. Japanese electronics companies typically maintain both financial stability and stock value with smaller current and quick ratios than that of their U.S. counterparts. However, even by Japanese standards, NEC has established itself as a nontraditional company by leveraging all of its financial resources to their respective limits. NEC's liquidity ratios are possibly the lowest in the industry. Commensurate with these liquidity ratios, the company's leverage debt-equity ratio stands at 0.94 for FY1991.

Although NEC appears to have an impaired capacity to service its debt, the confidence of banks and shareholders has not sufficiently declined to lead to measurable instability. This may be a manifestation of NEC's close keiretsu ties to the Sumitomo Group of banks, which has helped to reinforce trust in NEC's ability to determine and maintain a reasonable and effective balance sheet. However, confidence in financial institutions collectively declined following scandals involving Japanese banks and security firms during early 1990. These scandals contributed to the subsequent Japanese stock market crash, as Japanese consumers and shareholders lost confidence in Japanese financial management. Following this stock declining trend, NEC's stock price dropped to a low of ¥710 in August 1992, a 73 percent decline from its high point of ¥2,640 attained in October 1987.

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Table 3
NEC Corporation: Consolidated Balance Sheet (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Current Assets	1,830.0	2,124.2	2,237.1	2,344.7	2,392.8
Cash	209.0	389.8	352.5	384.5	397.7
Marketable Securities	50.2	58.9	67.0	68.8	76.9
Receivables	742.4	873.6	1,000.1	1,025.6	997.6
Inventory	650.1	683.6	735.9	798.2	863.9
Other Current Assets	178.1	118.3	81.6	67.6	56.8
Long-Term Receivables and Investments	260.5	298.9	311.3	337.0	347.7
Net Property, Plant, and Equipment	680.8	769.8	957.7	1,055.8	1,117.2
Other Assets	133.6	153.6	177.8	192.0	223.6
Total Assets	2,904.9	3,346.4	3,684.0	3,929.5	4,081.2
Total Current Liabilities	1,596.9	1,760.2	1,960.6	1,992.8	2,010.7
Long-Term Debt	679.6	855.3	865.7	1,002.1	1,139.7
Minority Interest	35.2	41.5	52.6	53.7	52.5
Total Liabilities	2,311.7	2,657.0	2,878.9	3,048.6	3,202.9
Total Shareholders' Equity	593.2	689.4	805.2	880.9	878.4
Common Stock	147.0	160.0	175.4	187.7	188.3
Additional Paid-In Capital	212.9	245.1	268.7	296.7	297.4
Retained Earnings	225.5	275.2	343.6	381.0	379.2
Other Equity	7.9	10.0	17.5	15.6	13.7
Treasury Stock	0	1.0	0	0	0
Total Liabilities and Shareholders' Equity	2,904.9	3,346.4	3,684.1	3,929.5	4,081.2
Fiscal Year Exchange Rate (¥/U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company Literature, Dataquest (October 1992)

October 26, 1992

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Table 4
NEC Corporation: Consolidated Income Statement (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Net Sales	2,714.7	3,082.8	3,444.2	3,698.8	3,773.9
Domestic Sales	1,969.2	2,305.5	2,552.1	2,832.6	2,979.9
Overseas Sales	745.5	777.3	892.1	866.2	794.0
Cost of Goods Sold	1,874.9	2,098.5	2,283.4	2,416.9	2,520.8
Gross Income	839.8	984.3	1,160.8	1,281.9	1,253.1
Gross Profit (%)	31	32	34	35	33
Operating Income (Loss)	40.5	44.0	60.1	70.1	77.7
Operating Expenses	808.2	896.1	1,047.1	1,217.9	1,279.4
SG & A Expense	727.0	799.5	927.4	1,067.4	1,131.6
Interest	68.8	72.3	90.5	107.6	108.1
Other Expense	12.4	24.3	29.2	42.9	39.6
Income before Income Taxes	72.1	132.2	173.8	134.2	51.4
Effective Tax Rate (%)	56	56	54	52	52
Income Taxes	50.8	87.3	105.6	87.2	45.6
Income after Income Taxes	21.3	44.9	68.2	47.0	5.8
Extraordinary Income (Loss)	4.2	19.6	17.0	7.4	9.4
Net Income	25.5	64.5	85.2	54.4	15.3
Fiscal Year Exchange Rate (¥/U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company Literature, Dataquest (October 1992)

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Table 5
NEC Corporation Financial Ratios (Billions of Yen)

	1987	1988	1989	1990	1991	Hitachi	Toshiba
Total Sales (Billions of Yen)	2,715	3,083	3,444	3,699	3,774	7,766	4,722
Net Income (Billions of Yen)	25	64	85	54	15	128	39
Total Assets (Billions of Yen)	2,905	3,346	3,684	3,930	4,081	8,858	5,724
Operating Income Margin (%)	4.2	6.0	6.8	5.8	3.2	4.5	2.5
Net Income/Total Sales (%)	0.9	2.1	2.5	1.5	0.4	1.6	0.8
Foreign Sales/Total Sales (%)	27.5	25.2	25.9	23.4	21.0	23.8	29.1
Corporate R&D/Total Sales (%)	7.7	7.2	7.2	7.6	8.0	6.7	6.7
Semiconductor Sales* (Billions of Yen)	485	589	620	622	649	542	623
Semiconductor Sales/Total Sales (%)	17.9	19.1	18.0	16.8	17.2	7.0	13.2
Sales/Employee (Millions of Yen)	26.498	29.636	30.054	31.361	29.410	23.946	28,107
Net Income/Employee (Millions of Yen)	0.248	0.620	0.744	0.461	0.119	0.394	0.232
Growth Rate							
Total Sales (%)	10.8	13.6	11.7	7.4	2.0	0.4	0.6
Net Income (%)	68.7	154.2	32.2	-36.2	-71.9	-44.6	-5.7
Financial Ratios							
Current Ratio	1.15	1.21	1.14	1.18	1.19	1.56	1.23
Quick Ratio	0.74	0.82	0.77	0.78	0.76	1.10	0.81
Sales/Net Working Capital (NWC)	11.65	8.47	12.46	10.51	9.88	3.68	7.04
NWC/Total Assets	0.08	0.11	0.08	0.09	0.09	0.24	0.12
Debt-Equity Ratio	0.75	0.86	0.73	0.79	0.94	0.33	1.24
Total Asset Turnover	0.93	0.92	0.93	0.94	0.92	0.88	0.83
Return on Sales (%)	2.7	4.3	5.0	3.6	1.4	4.8	2.4
Return on Asset (%)	2.5	4.0	4.7	3.4	1.3	4.2	2.0
Return on Equity (%)	2.5	9.4	10.6	6.2	1.7	4.4	3.3
Earning per Share	26.00	37.29	49.62	37.87	25.17	25.12	13.22
Payout Ratio	0.35	0.24	0.20	0.26	0.40	0.44	0.76

*Semiconductor sales are estimated for calendar-year periods.
Source: Company Literature, Dataquest (October 1992)

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Financial institutions historically have frequently been the largest shareholders of major corporations' stocks. These institutional investors have contributed to the stability of stock prices. Only 19.0 percent of NEC's stock is owned by private investors, which makes NEC the least likely investment choice by individuals among Japan's top 10 electronics companies. Again, NEC's close affiliation with the Sumitomo group explains the major ownership of NEC by bank investors. Table 6 shows NEC's top 10 shareholders and their holdings volume. Foreigners currently retain about 12.7 percent of NEC's stock.

Table 6
NEC Corporation Top 10 Shareholders

Shareholders	Percentage of Share
Sumitomo Life Insurance	6.8
Sumitomo Trust & Banking	5.6
Sumitomo Bank	5.0
Nippon Life Insurance	3.6
Dai-ichi Mutual Life Insurance	3.3
Sumitomo Marine & Fire Insurance	2.6
Mitsubishi Trust & Banking	2.2
Sumitomo Electric Industries	2.2
Sumitomo Corporation	2.2
Toyo Trust & Banking	1.6

Source: Company Literature (October 1992)

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Semiconductor Climate of 1991

Worldwide semiconductor sales totaled $59.7 billion, a 9.4 percent increase over 1990. The Japanese market grew 11.1 percent, comprising 37.7 percent of the global 1991 market, with $22.5 billion in sales, and continues to make Japan the single largest region for chip consumption.

In terms of suppliers, Japan's 46.4 percent share of the 1991 global market nearly matched the 1990 figure of 46.3 percent. Asia/Pacific-Rest of World suppliers made market share gains at the expense of North American and European companies.

The Japanese companies continued their dominance of the DRAM market but lost market share to Korean companies. Samsung became the No. 2 supplier of commodity DRAMs products, trailing only Toshiba. U.S.-based semiconductor companies lost worldwide share; however, many of these companies continued to lead the world in microprocessors and design-intensive ASIC and custom application chips.

NEC Semiconductor Organization

NEC's chip business is divided into two major groups: the Semiconductor Group and the Electronics Component Group. These two groups employ about 40,000 workers and account for about one-third of NEC's total worldwide employee population. Figure 2 is an organizational chart of NEC's semiconductor groups.

On July 1, 1992, NEC announced a companywide organizational restructuring. The major changes that affected the semiconductor segments of the business were establishment of two R&D divisions within the Semiconductor Group and the integration and restructuring of three sales divisions.

NEC's Research and Development Group, which had been directly supervised by upper management, has been traditionally an in-house think tank where most of NEC's basic and advanced research projects had been conducted. Following the restructuring, the new R&D groups will address a greater number of product-related issues, maintain closer ties to manufacturing functions, and generally pursue the application of R&D discoveries toward products.

Several sales divisions have also been reorganized in an attempt to more readily adapt to the current demands of semiconductor clients. Several sales groups, which were previously organized by product type (that is, memories, micros, and ASICs), are now geared toward system-level integration by the formation of sales groups based on an application category, such as a consumer or an industrial system application. By equipping its sales force with a sufficient technical dimension to deal with complete solutions, NEC is attempting—as are others in the crowded merchant chip business—to distinguish itself from competitors and to deal with the accelerating rate at which new

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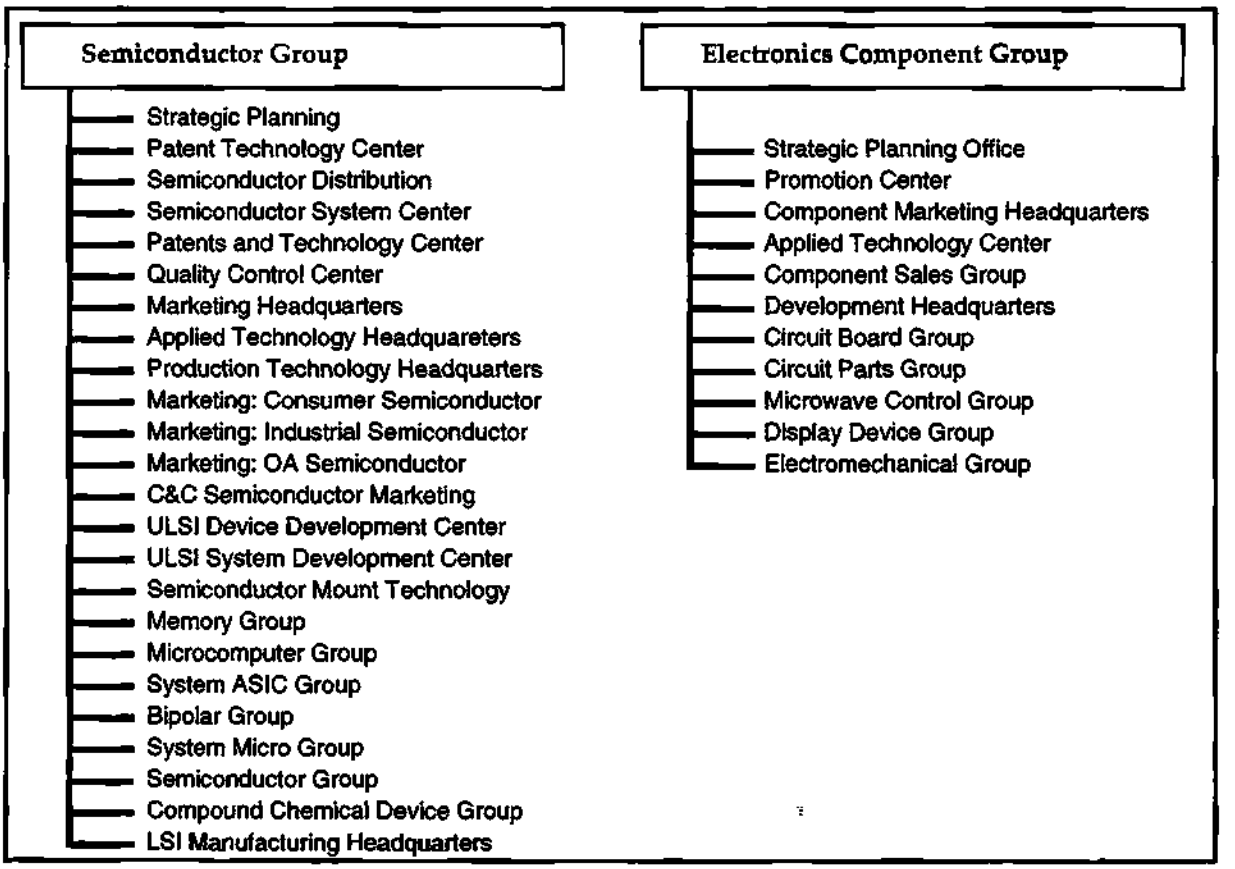
Figure 2
NEC Semiconductor Organization



Source: NEC Corporation G2001778

products are being transformed into commodities. NEC plans to stress its rapid IC customization capacity and "system-on-silicon" solutions.

NEC Semiconductor Overview

According to Dataquest's semiconductor market share estimates, NEC has ranked as a top semiconductor manufacturer in the world market since 1985. NEC was first among global competitors in worldwide market share in calendar year 1991, a status the company achieved by scoring a top-five ranking in four major product categories: MOS memories, MOS microcomponents, MOS logic, and discrete devices. Table 7 summarizes NEC's semiconductor ranking by product segment in 1991.

Product Strategy

Figure 3 shows both NEC's semiconductor product mix revenue and worldwide product mix revenue recorded in 1991. NEC's most productive product lines, MOS memories, MOS microcomponents, and MOS logic, each contributed about one-fourth of NEC's total

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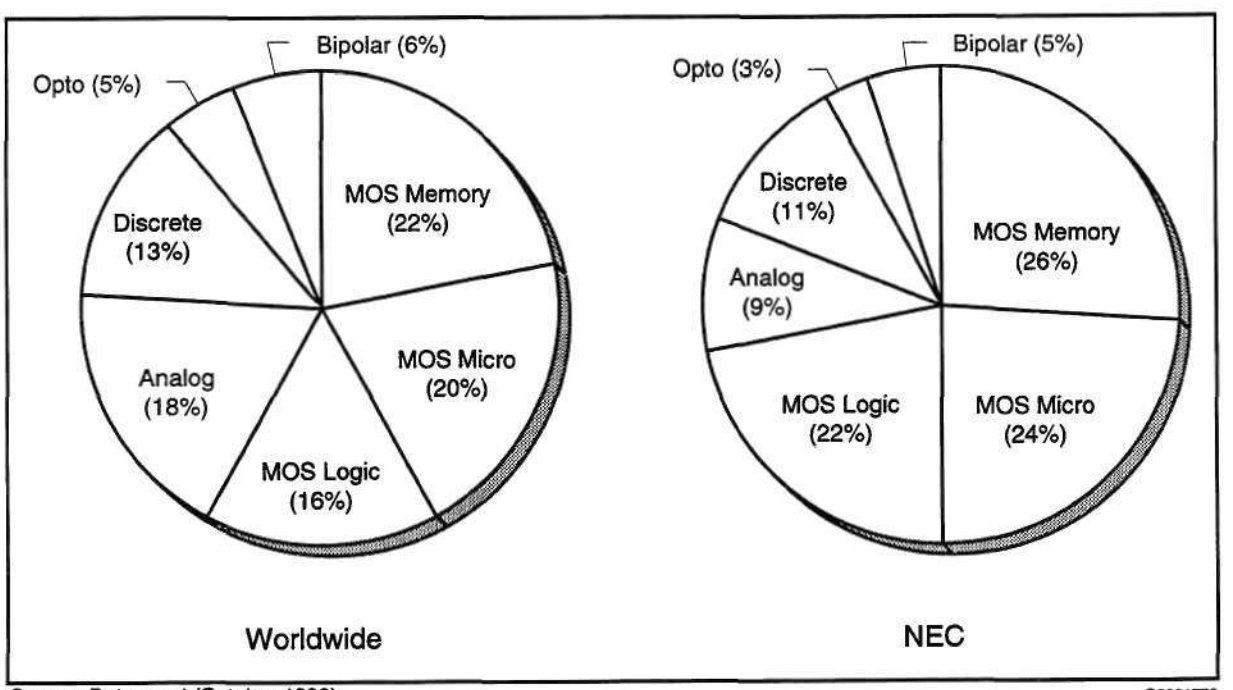
Table 7
Estimated 1991 NEC Ranking, by Product Segment

	Worldwide Market	Japanese Market
Total Semiconductor	1	1
Total Integrated Circuit	1	1
Bipolar Digital	8	3
MOS	2	1
MOS Memory	3	2
MOS Microcomponents	3	1
MOS Logic	1	1
Analog	10	4
Total Discrete	4	3
Total Optoelectronics	10	7

Source: Dataquest (October 1992)

Figure 3
1991 Semiconductor Market Share Product Mix: Worldwide versus NEC



Source: Dataquest (October 1992)

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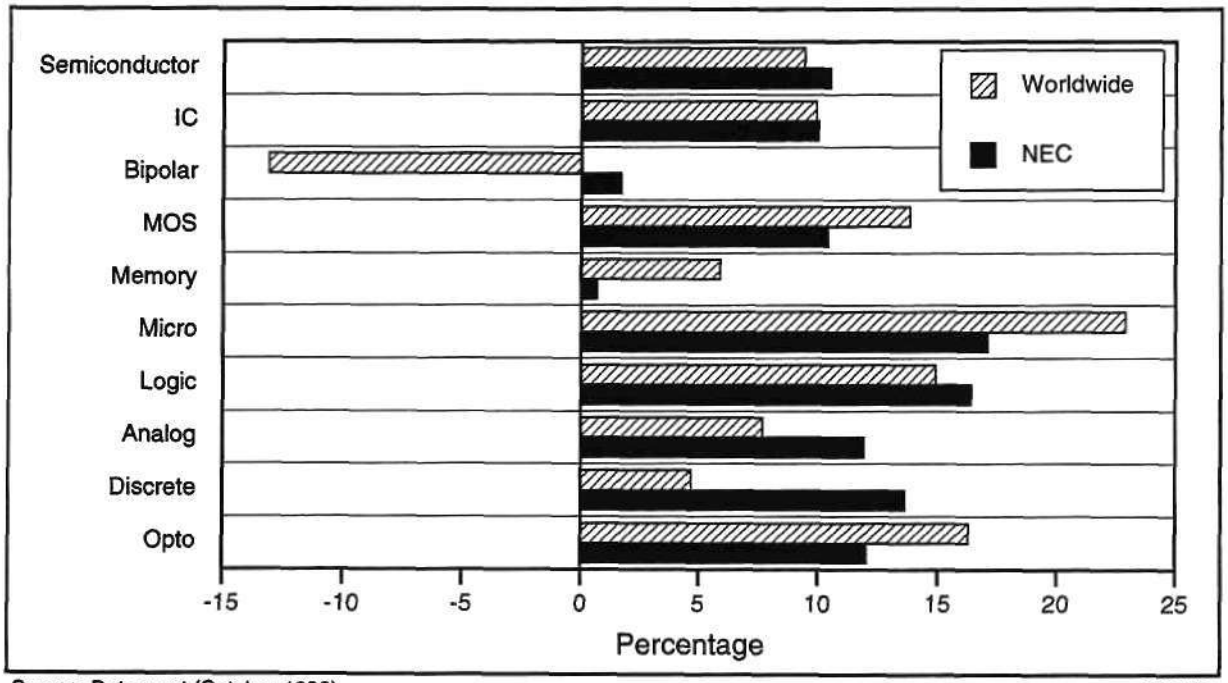
semiconductor sales. NEC's semiconductor product portfolio remains particularly well balanced, with good market presence in a diverse number of product categories. This is no small feat, as many of the larger commodity markets such as DRAMs and microprocessors are unpredictably volatile.

The rapid deterioration of DRAM markets coupled with the determination of Korean manufactures to establish a dominant role in these markets has caused most Japanese DRAM manufacturers to suspend or delay their advanced DRAM manufacturing plans. NEC's recent postponement of full scale-up of its 8-inch 16Mb line at NEC Kyushu is a clear reflection of steep declines in DRAM revenue and dismal near-term forecasts for recovery of these memory markets. NEC has stated that full scale-up of production at the Kyushu facility will not begin until demand forecasts for 16Mb memories improve.

With more than 20 percent worldwide annual growth (see Figure 4), MOS microcomponents maintained its place as the highest growth area of the chip industry during 1991. Microprocessors are an important element in NEC's C&C vision of establishing a synergistic relationship between its technological strengths. NEC ranked third among suppliers to this segment of the industry, behind Intel and Motorola.

Figure 4
NEC's 1991 Growth Rate Compared with Worldwide Market



Source: Dataquest (October 1992)

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As with most major microprocessor players, NEC is involved in both RISC and CISC development and manufacturing. However, in contrast to both Intel and Motorola, NEC is also a major end user of microprocessors in the production of desktop systems. And although Intel has produced supercomputers based on massively parallel gangs of its microprocessors, NEC is a more entrenched supercomputer supplier with a greater installed based of supercomputer products.

Although RISC-based CPUs are expected to exceed half of the worldwide 32-bit microprocessor market by 1995, and have resulted in the formation of numerous alliances and consortia, CISC sales remain the largest single market for microcomponents. NEC has elected to align itself with the MIPS Computer architecture and has developed both 32- and 64-bit versions based on the MIPS architecture, which are already available as merchant product. NEC also is perhaps the earliest and one of the most successful clones of Intel 80x86 CISC designs. This makes the company well equipped to emerge as a supplier of the potentially lucrative i80486-compatible parts. NEC is a uniquely vertical supplier of CPUs, with established expertise in many supporting technologies.

Efforts to stimulate sales of NEC's ASIC and cell-based products by restructuring the product engineering and sales teams were to be implemented by July 1992. By eliminating redundancies in team efforts and other inefficient methods of the previous structure, NEC hopes to streamline the process and cut the time from a client's concept to working silicon.

Table 8 shows NEC semiconductor revenue by product segment for the past five years.

Regional Market

Figure 5 shows NEC's semiconductor revenue generated by the four major market regions. Because of NEC's heavy dependence on domestic semiconductor markets—with 72.9 percent of NEC's revenue being generated by the Japanese market in 1991—its semiconductor sales slowed when Japan's economy stumbled. Of NEC's best selling semiconductor product categories—memories, microprocessors, and logic—only the memory class sold internationally at close to the same rate as it sold in Japan. Microprocessors and logic were disproportionately dependent on the Japanese market, given the size of the international markets for these products. The positive aspect of these sales figures is that NEC has strong market share in its domestic markets. But the negative aspect is that, when that domestic market slows, NEC's sales will track with consumption in Japan.

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Table 8
Estimated Semiconductor Revenue, by Product, in Worldwide Market (Billions of Yen)

Calendar Year	1987	1988	1989	1990	1991	1991 Market Share (%)
Total Semiconductor	485.0	590.6	619.5	622.4	649.3	8.0
Total Integrated Circuit	402.5	504.9	537.2	537.8	558.8	8.4
Bipolar Digital	35.6	38.0	33.8	34.6	33.2	6.7
TTL/Other	23.0	23.9	22.5	23.0	21.9	6.3
ECL	12.5	14.0	11.3	11.5	11.3	7.7
Bipolar Digital	35.6	38.0	33.8	34.6	33.2	6.7
Bipolar Digital Memory	4.8	5.7	2.9	2.9	2.6	5.3
Bipolar Digital Logic	30.8	32.2	30.9	31.7	30.6	7.1
MOS (Technology)	275.9	406.0	451.4	449.0	468.2	10.0
N/PMOS	178.1	148.2	130.8	121.1	99.1	12.1
CMOS	97.8	255.5	309.4	315.1	353.6	9.4
BiCMOS	0	2.3	11.2	12.8	15.5	20.3
MOS (Function)	288.9	406.0	451.4	449.0	468.2	10.0
MOS Memory	120.7	193.7	220.0	177.6	168.9	9.7
MOS Microcomponents	81.5	102.7	116.1	141.3	156.3	9.8
MOS Logic	86.7	109.6	115.4	130.2	143.1	10.8
Analog	78.0	61.0	52.0	54.3	57.4	3.9
Total Discrete	74.6	74.2	67.5	69.0	74.0	6.8
Total Optoelectronics	7.9	11.4	14.8	15.6	16.5	4.3
Exchange Rate (¥/U.S.$1)	144	130	138	144	136	

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (October 1992)

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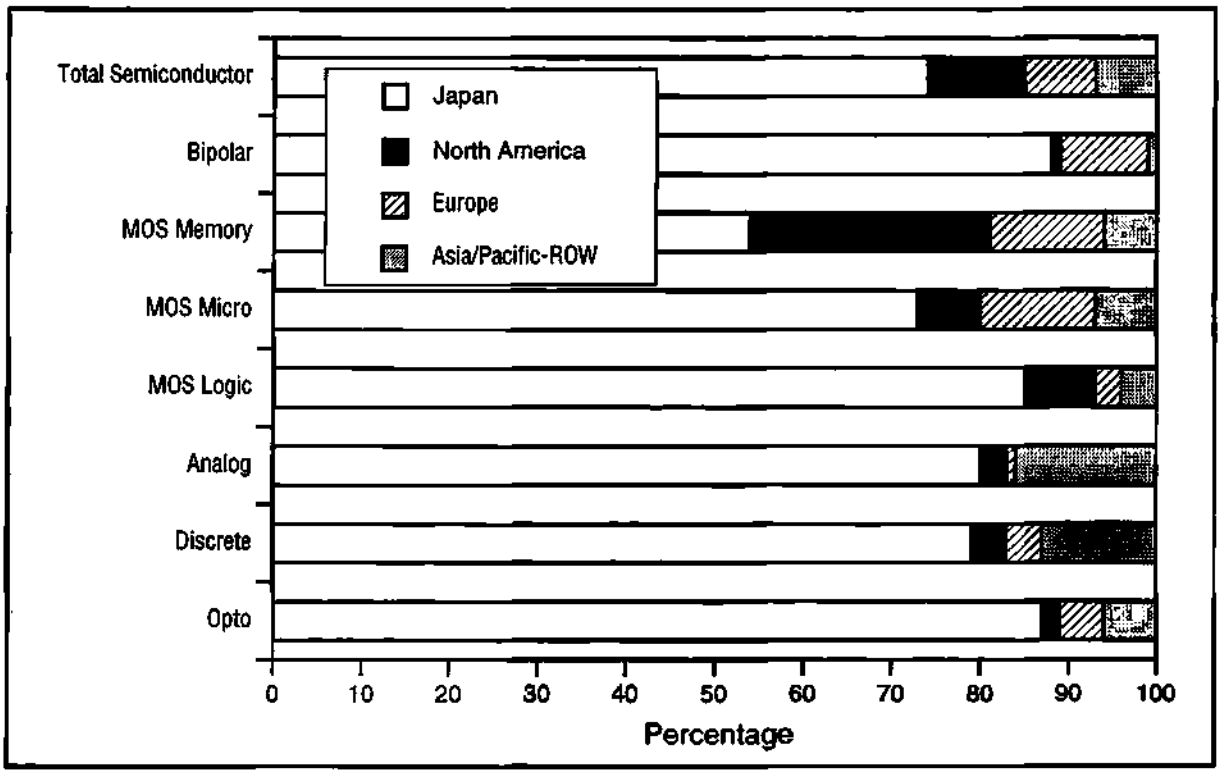
Figure 5
NEC's Semiconductor Revenue, by Region



Source: Dataquest (October 1992) G2001781

Semiconductor Investment

Table 9 and Figure 6 show NEC's industry-leading semiconductor capital spending and R&D expense trends against overall semiconductor revenue for the past five years. Capital spending and R&D costs have been steadily increasing to the point where NEC has reinvested more than one-fourth of its semiconductor revenue during the past two years. NEC took an early lead in the 256K DRAM race, but because of the semiconductor downturn of 1986 and 1987 it reduced its capital spending to ¥30 billion, which was equivalent to about 6.2 percent of revenue. This action resulted in a loss of its market leading position to Toshiba and Hitachi in the 1Mb DRAM race. NEC has subsequently invested heavily to re-establish itself as a leading supplier of 4Mb DRAM parts. Unfortunately, the 4Mb DRAM race has virtually stalled as of the end of calendar 1991, with little or no return on investment.

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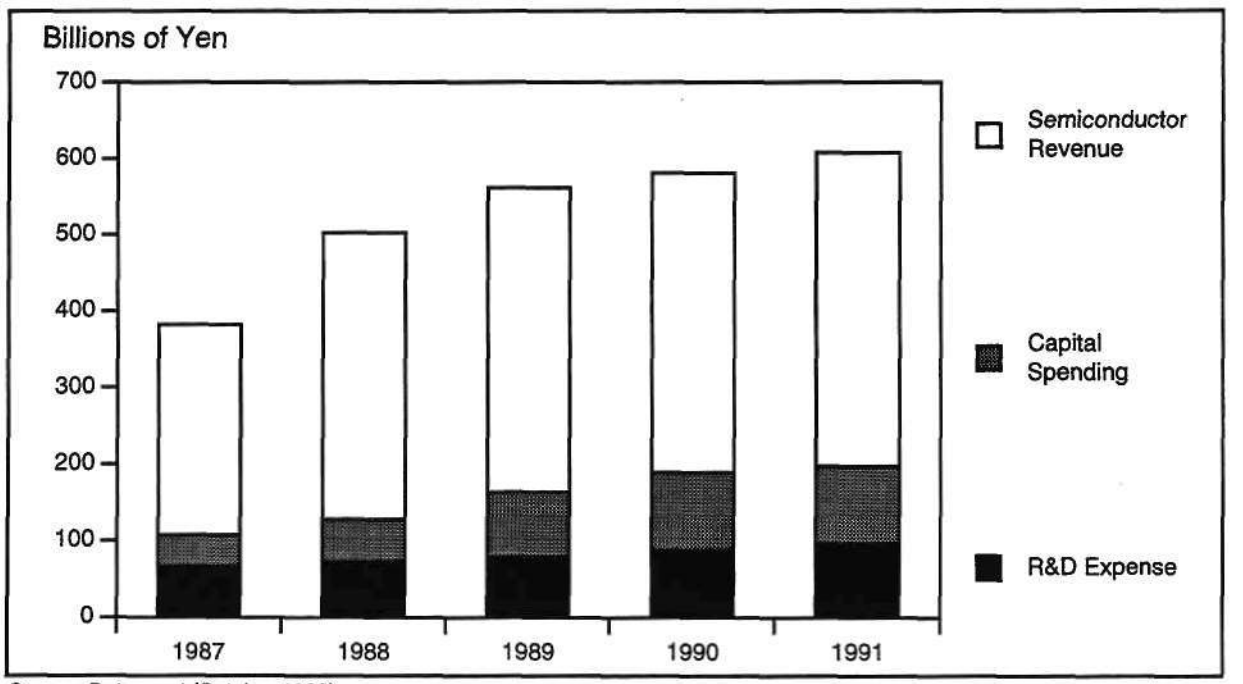
Table 9
Semiconductor Investment: Capital Spending and R&D (Billions of Yen)

	1987	1988	1989	1990	1991
Semiconductor Revenue	485.0	590.6	619.5	622.4	649.3
Capital Spending	40.0	55.0	85.0	101.3	101.3
Percentage of Revenue	8.2	9.3	13.7	16.3	15.6
R&D Expense	67.5	73.0	79.0	88.0	96.0
Percentage of Revenue	13.9	12.4	12.8	14.1	14.8
Investment to Revenue	22.2	21.7	26.5	30.4	30.4

Note: Semiconductor revenue and capital spending are calculated for calendar-year periods, while R&D expense is stated for a Japanese fiscal year.
Source: Dataquest (October 1992)

Figure 6
NEC Semiconductor Investment: Capital Spending and R&D



Source: Dataquest (October 1992)
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Manufacturing Facilities

NEC owns and manages facilities both directly and through its subsidiaries. The location, work force size, and semiconductor products made at NEC's primary manufacturing sites are shown in Table 10. Figure 7 shows the relationship between various semiconductor manufacturing sites and possible chip production steps performed at various NEC plants.

NEC is highly globalized for a Japanese semiconductor manufacturer. It began overseas production in the late 1970s. It owns state-of-the-art front-end facilities in both Europe (Livingston, Scotland) and the United States (Roseville, California). The Roseville plant investment has reached $600 million, which endowed the new fab line with the capacity to produce 4Mb DRAMs as of January 1991, with follow-on 16Mb DRAM production slated for the future.

Semiconductor Alliances

NEC has cultivated a long-term strategic alliance with ATT to codevelop chip manufacturing technology involving the development of a 0.35-micron CMOS process, a 0.5-micron SRAM process, and manufacturing technologies related to fabrication of 256Mb DRAMs (see Table 11). NEC has also nurtured alliances with NTT as a supplier for some of its more sophisticated communications products.

As a member and licensee of the MIPS RISC architecture, NEC has designed and begun marketing both 32- and 64-bit RISC chips in its VR3000, VR3010, and VR4000 products based on the R3000 and R4000 designs originally created by MIPS. MIPS merged with Silicon Graphics Inc. (SGI) in June 1992, so it remains to be seen if NEC will continue to support the MIPS architecture. This will probably depend, as with other licensees of the MIPS designs, on whether SGI maintains the MIPS designs as a true open architecture. Because SGI and NEC are potential systems-level competitors in workstation markets, NEC and other users of the MIPS architecture will continue to monitor the direction that SGI charts for the MIPS platform before renewing their commitment to support the architecture. A major consideration that favors NEC remaining with the MIPS camp is simply that other standards such as SPARC and Hewlett-Packard's PRISM are also basically under the control of potential competitors. This is true of all open RISC architectures because they are based on the same premise that cooperation and the production of a sufficiently large installed base of compatible hardware is a prerequisite to establishing a standard from which to stimulate software development.

NEC has an alliance with Control Data Corporation to market the SX-3 supercomputer. As an investor in Compagnie des Machines Bull, NEC has worked cooperatively in areas related to mainframe computer technology.

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Table 10
NEC Semiconductor Manufacturing Facilities

Plant Name	Location		Product	Number of Employees	Year Opened
Domestic Facilities					
NEC Hiroshima	Hiroshima	FAT	DRAM, micro, ROM	580	1988
Tsukuba R&D Center	Ibaragi	R	ULSI, material	300	1989
NEC Kagoshima	Kagoshima	FAT	Optoelectronics	1,600	1969
Tamagawa Works	Kanagawa	PR	Semiconductor headquarters	NA	1936
Sagamihara	Kanagawa	P	MOS ASIC	4,700	1962
Semiconductor Technology Center	Kanagawa	PR	Memory, ASIC, micro	700	1989
NEC Kyushu	Kumamoto	F	MOS ICs, micro, ASIC	2,900	1974
Kyushu LSI Development Center	Kumamoto	R	ULSI design, micro, CAD soft	300	1991
NEC Kansai	Shiga	F	Memory, logic, discrete, bipolar	4,200	1983
NEC Yamagata	Yamagata	FAT	Logic ICs	3,100	1982
NEC Yamaguchi	Yamaguchi	FAT	DRAM, micro	1,400	1983
Otsuki Works	Yamanashi	F	Optoelectronics	300	1986
NEC Fukushima	Fukushima	AT	Hybrid ICs	605	1973
NEC Oita	Oita	AT	Memory, MCU	400	1983
NEC Kumamoto	Kumamoto	AT	MOS memory, MCU	700	1980
NEC Fukuoka	Fukuoka	AT	MCU, gate array	600	1979
Hara Seiki	Kumamoto	AT	MOS ICs	550	1974
Kyushu Denshi	Kumamoto	AT	MOS ICs, LED	700	1973
Urabe	Yamagishi	AT	1Mb DRAM	270	1988
Kouyama Denki	Akita	AT	Hybrid ICs	750	1946
NEC Fukui	Fukui	AT	MOS ICs, discrete	1,050	1979
NEC Akita	Akita	AT	Consumer ICs	520	1981
Naito Densei	Niigata	AT	Memory, discrete	1,300	1970

(Continued)

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Table 10 (Continued)
NEC Semiconductor Manufacturing Facilities

Plant Name	Location		Product	Number of Employees	Year Opened
Kitanihon Denshi	Toyama	AT	Memory, micro, bipolar	600	1969
Nisseri Denki	Kumamoto	AT	MOS memory, micro	350	1980
Semiconductors Niino	Yamagata	AT	Discrete	530	1968
Overseas Facilities					
NEC Electronics	Roseville, California	F	1Mb, 4Mb DRAMs, ASIC, micro		1984
NEC Semiconductors	Livingston, Scotland	F	Memory, SRAM, MPU		NA
NEC Semiconductors Ireland	Meath, Ireland	AT	Memory, ASIC, MPU		1976
Shougang NEC Electronics	Beijing,China	FAT	Linear ICs		1993
NEC Electronics Singapore	Singapore	AT	1Mb, 4Mb DRAMs, linear		1976
NEC Semiconductors Malaysia	Kuala Langot, Malaysia	AT	1Mb DRAM, linear, discrete		1976

F: Fab
P: Pilot line
R: Semiconductor R&D
A: Assembly
T: Test
NA = Not available
Source: Dataquest (October 1992)

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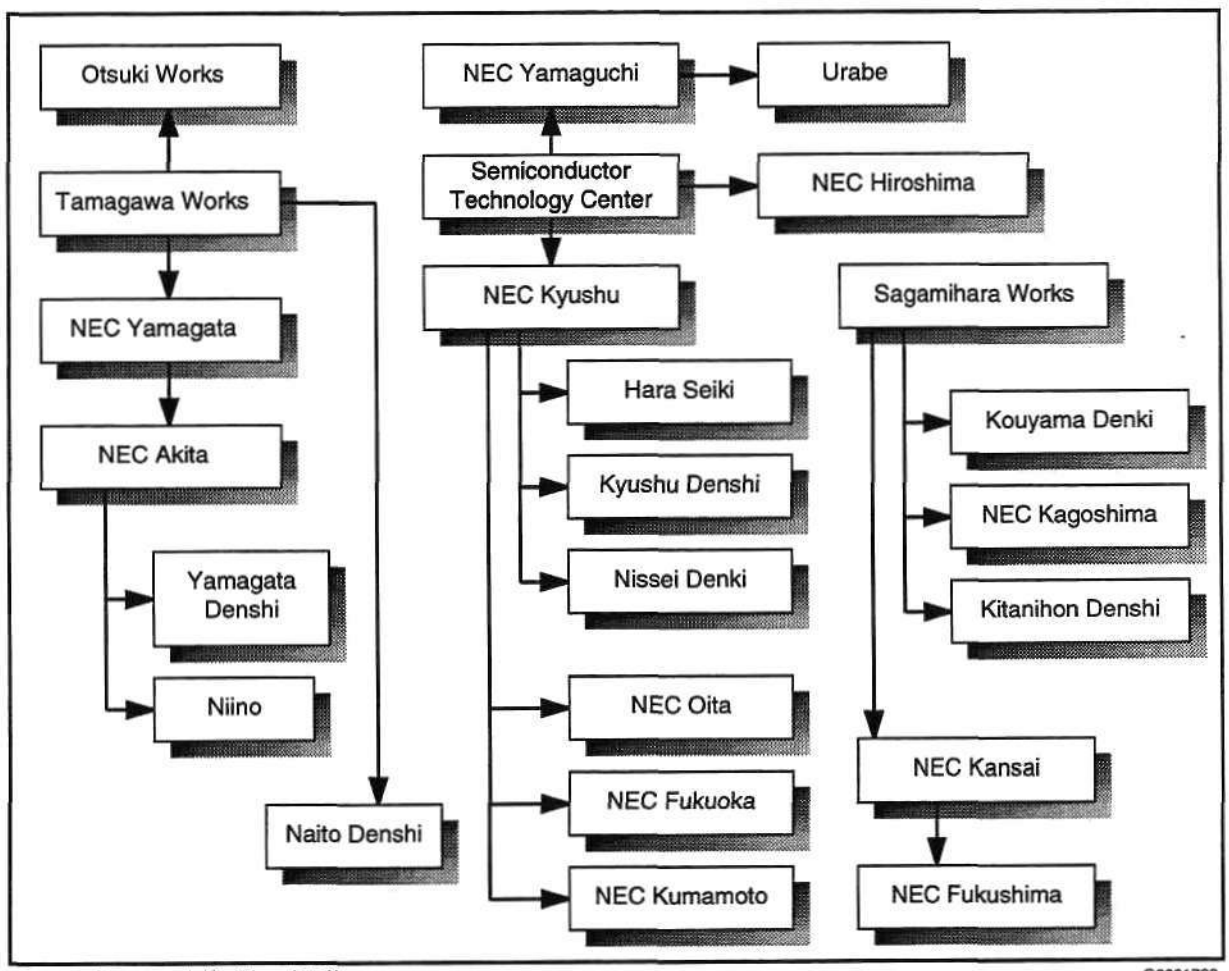
Figure 7
NEC Semiconductor Manufacturing Shift



Source: Dataquest (October 1992)

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Dataquest classifies strategic alliances into the following major categories, as applied in Table 11:

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

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Table 11
NEC's Semiconductor Strategic Alliances

Date	Partner	Agreement Type	Product
11/88	Summit Microcircuit	JD	64K, 256K SRAMs
1/89	Texas Instruments	PC	256Kb, 1Mb DRAMs
1/89	Kanematsu Electric	SA	Simulation systems
2/89	MIPS Computer	LA, SA, JD	RISC MPU, CMOS
4/89	Vadem	JD	IBM clone chip
5/89	Matra-Harris	LA	16-bit MPU
10/89	Honeywell	IV	Supercomputer
11/89	Four companies	CO	MIPS RISC MPU
11/89	Yokogawa Hewlett-Packard	SA, JD	32-bit MPU
12/89	Silicon Compiler	JD	ASIC, gate array
1/90	Chinese government	JV	ICs
3/90	AT&T	LA, FA, TE	ASIC, CAD tools, 4-bit MPU
5/90	National Semiconductor	FA	256K SRAM
9/90	Chinese company	JV	LSIs
3/91	Cadence	JD	ASIC design systems
4/91	Sharp	SS	16-bit microprocessors
4/91	AT&T	TE, JD	0.35-micron process technology
4/91	Robert Bosch Automotive	JD	Microcontrollers
7/91	Omron	JD	Fuzzy logic microcontrollers
12/91	CrossCheck	LA	ASIC testing technology
1/92	AT&T	JD	4Mb SRAMs
1/92	Seiko Instruments	JD	CAD system
1/92	Mentor Graphics	SA	Logic circuit design system
2/92	MIPS Computer	LA	MIPS RISC MPU
3/92	Schlumberger	JD	LSI defect analyzer

(Continued)

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Table 11 (Continued)
NEC's Semiconductor Strategic Alliances

Date	Partner	Agreement Type	Product
4/92	MIPS Computer	JD	R4000 RISC MPU
4/92	Mitsubishi	SS	DRAM disk
5/92	AT&T	SA	Memory, logic ICs
5/92	Micron Technology	SA	256, 1Mb DRAMs
6/92	CrossPoint Solutions	SA	FPGA, development systems
7/92	AT&T	JD	256Mb DRAM
9/92	Oak Technology	LA	MCU for hard disk controller
9/92	Micron Technology	FA	Memories

Source: Dataquest (October 1992)

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Dataquest Perspective

Although NEC is clearly a multinational entity as defined by its manufacturing presence in foreign countries, its income is heavily dependent on the Japanese domestic market. This dependence on Japanese markets was to NEC's advantage when the economy was booming in Japan, but it rapidly became a deficiency when the economy slowed. This will continue to be a weakness if the Japanese economy fails to recover before other nations begin to rebound from their own economic downturns. In global semiconductor markets in particular, NEC's microprocessors and logic products derive a disproportionate amount of their revenue from the Japanese markets. Even if internal consumption by NEC systems divisions is responsible for the excessive consumption within Japan, NEC's products should demonstrate their competitiveness in international merchant markets the way that the DRAM products have.

Within the Japanese domestic markets, NEC has enjoyed a dominant role as the market leader of desktop PCs based on a proprietary platform originally derived from the IBM PC. The NEC platform is almost certain to be vulnerable to market share loss when the open hardware systems, based on either Microsoft's Windows or IBM's OS/2, begin to displace the older DOS-based systems. For NEC, the growth of an open-32-bit operating system in Japan would be a mixed blessing because it would bring increased competition, particularly in the form of clones from other Asian countries, to its PC markets. But it would also stimulate demand for NEC's high-density DRAM and microprocessor products. To maintain profitability in this scenario, NEC must prepare itself to compete in a market that is destined to be saturated with low-cost commodity clones. NEC has the technology base to leverage its current market share dominance into a commanding position when the PCs based on 32-bit operating systems begin to flood the market.

NEC appears committed to using both creative financing and strategic global alliances to capitalize on opportunity. Alliances involving all types of semiconductor products are probably in NEC's future, and even a renewed program to develop x86-compatible parts is conceivable. Other potential likely alliance areas for NEC are in software development, particularly in CAD tool development, and in TFT LCD manufacturing, where a partner could share in the high cost of building these parts. We might also expect to see NEC engaged in development of massively parallel supercomputer systems using an alliance.

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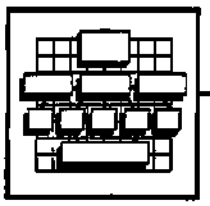

Dataquest Vendor Profile

Semiconductors *Japan*

November 30, 1992

Hitachi Ltd.

Corporate Statistics

Address	Hitachi Ltd. 6, Kanda-Surugadai 4-chome, Chiyoda-ku, Tokyo 101
Phone	81-3-3258-1111
Facsimile	81-3-3253-2186
Chairman	Katsushige Mita
President	Tsutomu Kanai
Established	1910 (Incorporated in 1920)
Number of Employees	324,292 (as of March 31, 1992)
Total Sales	¥7,766 billion (FY1991)
Net Income	¥128 billion (FY1991)
Total Assets	¥8,858 billion (FY1991)
Main Product Area	Information systems and electronics Power and industrial systems Consumer products Materials and others

Corporate Overview

Hitachi Ltd. was founded in 1910 and initially emphasized the development of heavy electrical equipment and industrial machinery. After World War II, the company expanded into the consumer product area. In the 1950s, it entered into several electronics markets that eventually led to the production of semiconductors, computers, and various other consumer electronics devices. Over the years, Hitachi has continued to expand and diversify the scope of its business activities. Its growth has propelled it into the ranks of giant multinational corporate entities with highly leveraged competitive strengths, allowing it to excel in many high-technology fields.

Hitachi has 799 consolidated subsidiaries worldwide and 209 subsidiaries operating outside Japan.

For more information on Hitachi Ltd. or the semiconductor industry, call Junko Matsubara at (408) 437-8572.

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Corporate Business

Japanese industries experienced two distinct economic phases during fiscal year 1991. For the first half of the year, Japan remained in the tail end of the record-long "Heisei Boom," a historically periodic bubble economy. Although many economic forecasts predicted an earlier end of the boom in Japan, it lasted until the third quarter of the 1991 calendar year. While product sales in all business sectors were buoyed by the extended duration of the bubble, the ensuing burst was quickly followed by a steep decline into a recession that few anticipated. The climate at the close of 1991 could not have been more dissimilar to forecasts of the early part of the year.

Hitachi's consolidated revenue was ¥7,766 billion in fiscal year (FY) 1991, a slight 0.4 percent increase over the previous year's showing (see Table 1). Hitachi's historical revenue trend is plotted in Figure 1. Although total sales were the highest in Hitachi's history, and the highest among Japan's electronics companies, net income fell 44.4 percent to ¥128 billion. The company attributed the drop in profits to the slowdown of consumer spending and corporate investment because of the unstable economy.

Table 1
Hitachi Ltd. Sales, by Product Segment and Market (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Information Systems and Electronics	-	2,202	2,473	2,781	2,921
Power and Industrial Systems	-	1,959	2,243	2,358	2,459
Consumer Products	-	1,041	1,009	1,107	1,067
Materials and Others	-	1,686	1,884	2,101	2,105
Eliminations	-	-486	-530	-611	-787
Total	5,717	6,401	7,078	7,737	7,766
Fiscal Year	**1987**	**1988**	**1989**	**1990**	**1991**
Domestic Market	4,527	4,933	5,420	5,882	5,922
Percentage of Total Revenue	79.2	77.1	76.6	76.0	76.3
Overseas Market	1,190	1,469	1,658	1,855	1,844
Percentage of Total Revenue	20.8	22.9	23.4	24.0	23.7
Fiscal Year Exchange Rate (¥=U.S.$1)	138	128	142	141	133

Notes: Columns may not add to totals shown because of rounding.
The company has reorganized its industry segmentation from FY1988.
The figures for FY1987 were restated.
Source: Company literature, Dataquest (November 1992)

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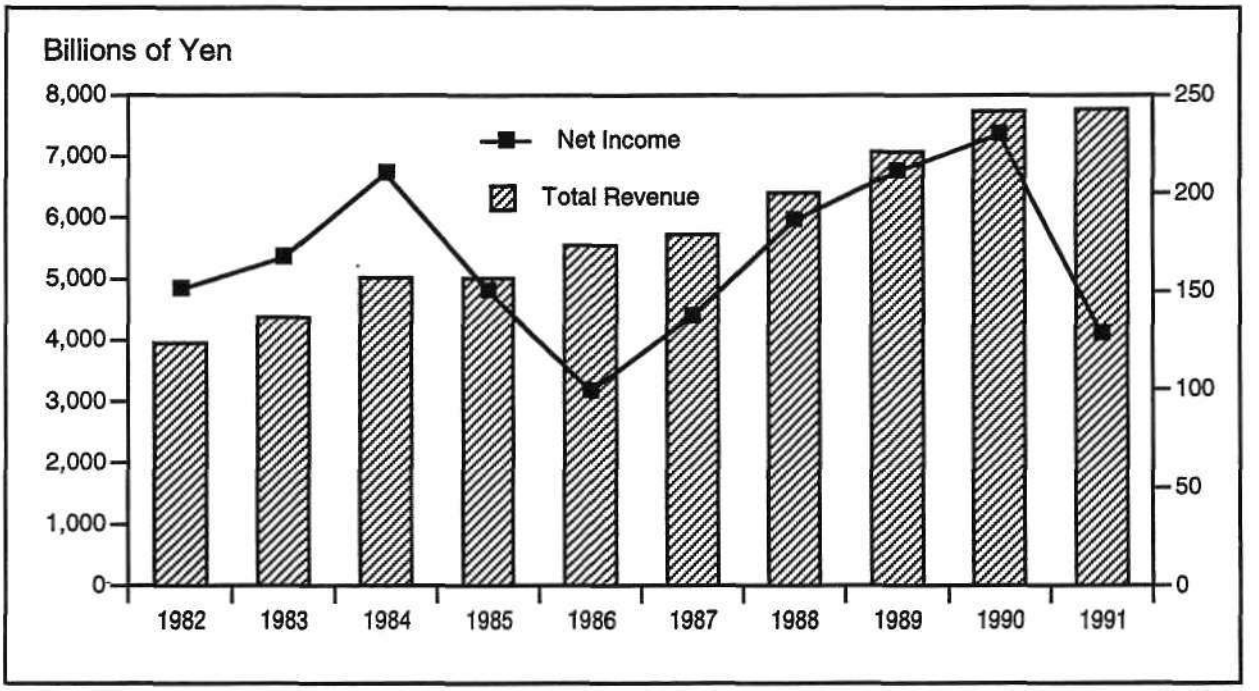
Figure 1
Hitachi Ltd. Total Revenue and Net Income (Billions of Yen)



Source: Company Literature, Dataquest (November 1992)

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Business Segments

Hitachi divides its operation into four major sectors: Information Systems and Electronics, Power Industrial Systems, Consumer Products, and Materials and Others. Consumer Products was the only area to show a negative growth during the year. This drop in performance was attributed to weak sales of consumer electronic products in Japan, in particular audio-visual (AV) related items, combined with a lack of new products and applications. Although the remaining divisions showed growth, the rates were modest, leading to a continuation of a steady leveling trend in the company's overall sales. Since FY1987, when Hitachi experienced a near 12.0 percent increase in revenue over the previous year's totals, the growth rate has dropped continuously to reach under 0.4 percent for 1991. The latest reduction in revenue has been associated with the decline in computer and semiconductor sales brought on by the poor economy in Japan.

Although not historically where Hitachi has its roots, the Information Systems and Electronics group has become the company's primary emphasis and now accounts for 34.2 percent of its revenue. Hitachi plans for computers and semiconductors to continue to play keys roles in its long-term business strategies.

In August 1992, Hitachi announced plans for consolidation of its various operations. For some time, Hitachi had followed a system of independent oversight at each of its plants, intended to encourage

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plants to be individually accountable. However, the system is now credited with having produced an overly conservative corporate culture that is somewhat lacking in direction and purpose. In the consolidation effort, Hitachi implemented a divisional control system to govern consumer products, computers, and semiconductors product areas. In about February 1989, the company began shifting control from each chip fabrication plant to a specialized division within its semiconductor operations. In contrast, Hitachi elected to retain its previous management structure within the heavy electric machinery product areas, thus resulting in the coexistence of two management systems within Hitachi.

International Business

In FY1991, 23.8 percent of Hitachi revenue was generated in overseas markets. As a percentage of total sales, overseas revenue peaked at 32.6 percent in 1985 and has since fallen steadily to its current level of between 23 and 24 percent. Most Japanese electronic companies' foreign trade has suffered from the combined effects of an appreciating yen on world currency markets and escalating trade friction, particularly with the United States and the European Community (EC). International semiconductor trade management adversely affected exports of Japanese semiconductor parts beginning in 1986 and severely altered revenue levels for most of the largest electronic businesses in Japan.

As were most of these large Japanese-based multinational companies, Hitachi was continuing to expand its overseas production capabilities. Currently 15.1 percent of the company's products are made outside of Japan, compared with a 5 percent offshore production level in 1987. Hitachi undoubtedly will continue to strengthen its overseas production capacity to increase its global presence and to insulate its revenue stream from the effects of domestic or localized foreign market fluctuations.

Corporate Investment

During FY1991, Hitachi invested ¥520 billion, or about 6.7 percent of its total sales, in research and development (R&D) activities (see Table 2). Hitachi's R&D has consistently ranked among the highest R&D investors among Japanese electronics companies. Although many Japanese companies have been criticized for overemphasizing applications and not contributing sufficiently to fundamental advances through basic research, Hitachi's corporate charter mandates that at least 1 percent of the corporate R&D expense be dedicated to funding basic research. In FY1991, basic research accounted for more than ¥5 billion of Hitachi's annual budget. As an indication of the effectiveness of these policies regarding R&D investment, Hitachi filed more U.S. patents than any other institution during two of the past three years. Although patent filings admittedly are a less-than-perfect measure of creativity or talent, they can act as a gauge of the intent and dedication a particular company has toward the creation of competitive advantage through development of intellectual property.

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Table 2
Hitachi Ltd. Investment: Capital Spending and R&D (Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Revenue	5,717	6,401	7,078	7,737	7,766
Capital Spending	371	532	658	781	757
Percentage of Total Revenue	6.5	8.3	9.3	10.1	9.8
R&D Spending	332	374	429	491	520
Percentage of Total Revenue	5.8	5.8	6.1	6.3	6.7

Source: Company literature, Dataquest (November 1992)

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Financial Condition in FY1991

Tables 3 and 4 depict the essence of Hitachi's consolidated financial statements. Although total sales in FY1991 reached a record high of ¥7,766 billion, net income was a mere ¥128 billion, representing a 44 percent decline in net revenue over the previous year's figure. However, while FY1991 did not hit the low income mark set in FY1986, the profitability ratio (net income divided by total sales) for FY1991 was actually below that achieved in FY1986. These low profitability totals during 1986 and 1991 are a trait prevalent in the financial history of virtually all major electronics companies in Japan. Even

Table 3
Hitachi Ltd. Consolidated Balance Sheet
(Billions of Yen)

Fiscal Year	1987	1988	1989	1990	1991
Total Current Assets	4,303	4,869	5,390	5,751	5,849
Cash	1,404	1,638	1,853	1,648	1,495
Marketable Securities	350	385	324	384	487
Receivables	1,219	1,372	1,594	1,833	1,820
Inventory	1,135	1,250	1,355	1,597	1,750
Other Current Assets	193	224	263	286	295
Long-Term Receivables and Investments	396	445	493	575	608
Net Property, Plant, and Equipment	1,353	1,473	1,708	1,985	2,169
Other Assets	134	148	211	213	230
Total Assets	6,187	6,937	7,805	8,526	8,857
Total Current Liabilities	2,851	3,183	3,314	3,694	3,741
Long-Term Debt	907	1,002	1,380	1,411	1,540
Minority Interest	410	470	548	609	657
Total Liabilities	4,169	4,656	5,244	5,715	5,940
Total Shareholders' Equity	2,018	2,281	2,560	2,811	2,918
Common Stock	180	219	246	269	270
Additional Paid-In Capital	232	302	357	410	436
Retained Earnings	1,591	1,740	1,911	2,093	2,174
Other Equity	14	19	45	37	36
Total Liabilities and Shareholders' Equity	6,188	6,937	7,805	8,526	8,857
Fiscal Year Exchange Rate (¥=U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Company literature, Dataquest (November 1992)

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Table 4
Hitachi Ltd. Consolidated Income Statement (Billions of Yen)

Japanese Fiscal Year	1987	1988	1989	1990	1991
Net Sales	5,717	6,401	7,077	7,737	7,765
Domestic Sales	4,286	4,932	5,420	5,881	5,921
Overseas Sales	1,431	1,468	1,657	1,855	1,844
Cost of Goods Sold	4,122	4,552	5,023	5,417	5,488
SG & A Expense	1,275	1,416	1,553	1,813	1,924
Operating Income	319	433	501	506	352
Operating Income Margin (%)	5.6	6.8	7.1	6.5	4.5
Other Income (Loss)	141	143	177	204	187
Other Expenses	80	85	148	149	164
Interest	72	71	97	129	140
Others	8	13	51	19	24
Income before Income Taxes	380	491	530	562	374
Effective Tax Rate (%)	56	56	54	52	52
Income Taxes	218	272	281	290	219
Income after Income Taxes	161	218	248	271	155
Minority Interests and Others	24	32	37	41	27
Net Income	136	185	211	230	127
Fiscal Year Exchange Rate (¥=U.S.$1)	138	128	142	141	133

Note: Columns may not add to totals shown because of rounding.
Source: Source: Company literature, Dataquest (November 1992)

though Hitachi's profitability still exceeds those of major competitors such as NEC and Toshiba, the 1.6 percent net has left the company just as concerned with market forecasts as competitors that did not fare as well during the year. As with most Japanese electronics giants, Hitachi was strongly affected by soft demand for both computer systems and semiconductor components.

Hitachi has an uncommonly high return on sales ratio, equal to earnings before taxes divided by net sales, than its corresponding operating income margin, equal to operating income divided by net sales, would normally suggest. This irregularity seems to indicate that Hitachi has a surplus of extra income, such as from stock dividends and funds generated from ventures outside of its primary businesses, relative to its interest payments. Hitachi frequently is among the Japanese corporations that generate the most supplemental

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income from financial activities outside of their primary business ventures. These ventures have contributed significantly to Hitachi's overall financial performance during lean periods such as FY1991. However, even this source of income dwindled for Hitachi during 1991; having peaked in 1990, the supplement fell by 8.4 percent to a total ¥187.8 billion for 1991. Japan's slow economy and recent financial scandals all have contributed to a climate in which investors have lesser confidence in stocks as a secondary investment strategy. This lack of confidence has resulted in severe stock price declines since October 1991. Japanese electronics companies often generate funds for large capital investment by equity financing. The reduction of stock values has made it more difficult for most Japanese electronics companies, including Hitachi, to finance new investment via equity financing. During FY1991, however, Hitachi still maintained a supplemental income that ranked third in Japan behind Toyota and Matsushita.

Financial Analysis

Table 5 summarizes key figures, which represent Hitachi's financial status, and compares them with those of Matsushita and NEC in FY1991. Japanese electronics companies typically can maintain stable stock values with financial ratios and low liquidity figures that would normally precipitate stock devaluation in the United States. By Japanese standards, however, Hitachi maintains relatively high liquidity and leverage ratios in its distinctly conservative approach to corporate finances. This conservatism is shown in Table 5, where Hitachi's financial ratios are in stark contrast to the aggressive business style of the smaller NEC. Despite annual profitability that fell steeply in FY1991, Hitachi maintains a greater profitability than NEC.

Traditionally, many large corporations' have large blocks of their stocks owned by financial institutions in Japan. This has often led to or been the result of actions designed to expand or promote a particular keiretsu. In a surprising divergence from this norm, 29.4 percent of Hitachi's stock is owned by individual investors, including its own employees, making Hitachi one of Japan's most publicly owned companies. Hence Hitachi's shareholder profile has perhaps secured Hitachi from the dominant influence of any single keiretsu. While Hitachi has created its own internal league, known as the Hitachi Group, this label is more indicative of a conventional business grouping that associates a collection of businesses that all belong to a parent organization.

Hitachi's ownership profile also includes a significant number of foreign shareholders comprising a 15.3 percent interest in the company. This ratio is the second highest in Japan, behind Sony, and is indicative of Hitachi's global status as a good stock investment with tolerable risk. Furthermore, the international appeal of Hitachi's stock might also help to explain the rather conservative approach to its finances. Table 6 lists the company's top 10 shareholders and the size of their holdings. Of particular interest to foreigners may be the high representation of competing keiretsu interests in the form of such organizations as Mitsubishi and the Sumitomo group, the keiretsu with heavy influence at NEC.

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Table 5
Hitachi Ltd. Financial Ratios

	1987	1988	1989	1990	1991	Matsushita	NEC
Total Sales	5,717	6,401	7,078	7,737	7,766	7,449	3,774
Net Income	137	186	211	230	128	133	15
Total Asset	5,621	6,938	7,805	8,526	8,858	9,020	4,081
Operating Income Margin (%)	5.6	6.8	7.1	6.6	4.5	5.2	3.2
Net Income/Total Sales (%)	2.4	2.9	3.0	3.0	1.6	1.8	0.4
Foreign Sales/Total Sales (%)	20.8	22.9	23.4	24.0	23.7	48.2	21.0
Corporate R&D/Total Sales (%)	5.8	5.8	6.1	6.3	6.7	6.1	8.0
Semiconductor Sales (¥B)	377	456	500	506	512	277	649
Semiconductor Sales/Total Sales (%)	6.6	7.1	7.1	6.5	6.6	3.7	17.2
Sales/Employee (¥M)	21.655	23.320	24.338	24.978	23.946	30.750	29.410
Net Income/Employee (¥M)	0.518	0.676	0.725	0.743	0.394	0.549	0.119
Growth Rate							
Total Sales (%)	10.8	12.0	10.6	9.3	0.4	12.9	-49.3
Net Income (%)	68.7	35.7	13.7	9.1	-44.6	-48.7	-88.5
Financial Ratios							
Current Ratio	1.51	1.53	1.63	1.56	1.56	1.36	1.19
Quick Ratio	1.11	1.14	1.22	1.12	1.10	1.03	0.76
Sales/Net Working Capital (NWC)	3.94	3.80	3.41	3.76	3.68	6.33	9.88
NWC/Total Assets	0.23	0.24	0.27	0.24	0.24	0.13	0.09
Debt-Equity Ratio	0.45	0.44	0.54	0.50	0.53	0.45	1.30
Total Asset Turnover	0.92	0.92	0.91	0.91	0.88	0.83	0.92
Return on Sales (%)	6.7	7.7	7.5	7.3	4.8	4.9	1.4
Return on Assets (%)	6.1	7.1	6.8	6.6	4.2	4.0	1.3
Return on Equity (%)	6.8	8.1	8.2	8.2	4.4	3.8	1.7
Earning per Share	22.74	33.62	37.71	37.92	25.12	52.28	25.17
Payout Ratio	0.40	0.27	0.29	0.29	0.44	0.24	0.40

Source: Company literature, Dataquest (November 1992)

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Table 6
Hitachi Ltd. Top 10 Shareholders

Shareholders	Percentage Share
Nippon Life Insurance	3.9
Mitsubishi Trust & Banking	2.6
Dai-ichi Life Insurance	2.5
Hitachi Group Employee Own	2.4
Industrial Bank of Japan	2.3
Sanwa Bank	2.3
Toyo Trust & Banking	2.1
Sumitomo Trust & Banking	2.1
Meiji Life Insurance	2.0
Dai-ichi Kangyo Bank	2.0

Source: Company literature (November 1992)

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Semiconductor Climate of 1991

Worldwide semiconductor sales totaled $59.7 billion in 1991, which exceeded the previous year's sales by 9.4 percent. The Japanese market comprised 37.7 percent of the global 1991 market with $22.5 billion in sales and continued to make Japan the single largest region for chip consumption. Japanese semiconductor consumption has grown 11.1 percent during the past year. The Japanese market expanded by a slight 0.6 percent, relative to the world market, during a one-year period.

In terms of suppliers, Japan's 46.4 percent share of the 1991 global market nearly matched the 1990 figure of 46.3 percent. Asia/Pacific-Rest of World suppliers made market share gains at the expense of North American and European companies.

The Japanese companies continued their dominance of the DRAM market but lost market share to Korean companies. Samsung became the No. 2 supplier of commodity DRAMs products, trailing only Toshiba. U.S.-based semiconductor companies lost worldwide share; however, many of these companies continued to lead the world in microprocessors and design-intensive ASIC/ASSP chips.

Hitachi Semiconductor Overview

According to Dataquest's semiconductor market share estimates, Hitachi had $3.77 billion in semiconductor revenue during 1991, ranking the company fifth among global competitors. In Japan's domestic market, Hitachi captured the No. 2 position. Hitachi has consistently performed well as a semiconductor supplier but has never fully realized its potential to dominate as a chip supplier. If this has been by strategic design, then the Hitachi business strategy has been vindicated during the recent semiconductor recession because many of Hitachi's major competitors, more heavily dependent on semiconductor revenue, sustained greater losses in the chip markets during FY1991. Nevertheless, Hitachi placed first among Japanese suppliers to the domestic MOS memory markets in 1991. Hitachi's early lead in 4Mb DRAM technology is at least partially responsible for its strength in domestic memory markets. Table 7 summarizes Hitachi's semiconductor ranking by product segment in 1991.

Product Strategy

Figure 2 shows both Hitachi's semiconductor product mix revenue and the worldwide product mix revenue recorded in 1991. Hitachi's strengths reside in its MOS capabilities. Total MOS production, including memories, microcomponents, and logic, nearly match world demand for MOS products. Like most Japanese semiconductor manufacturers, Hitachi's semiconductor revenue is heavily dependent on commodity MOS memories, which accounted for more than one-third of its total semiconductor business. DRAMs contributed about 18 percent to total semiconductor revenue, which translates to about 50 percent of Hitachi's MOS memory sales. About 70 percent of all DRAMs sold by Hitachi in 1991 were of the 4Mb variety. Although

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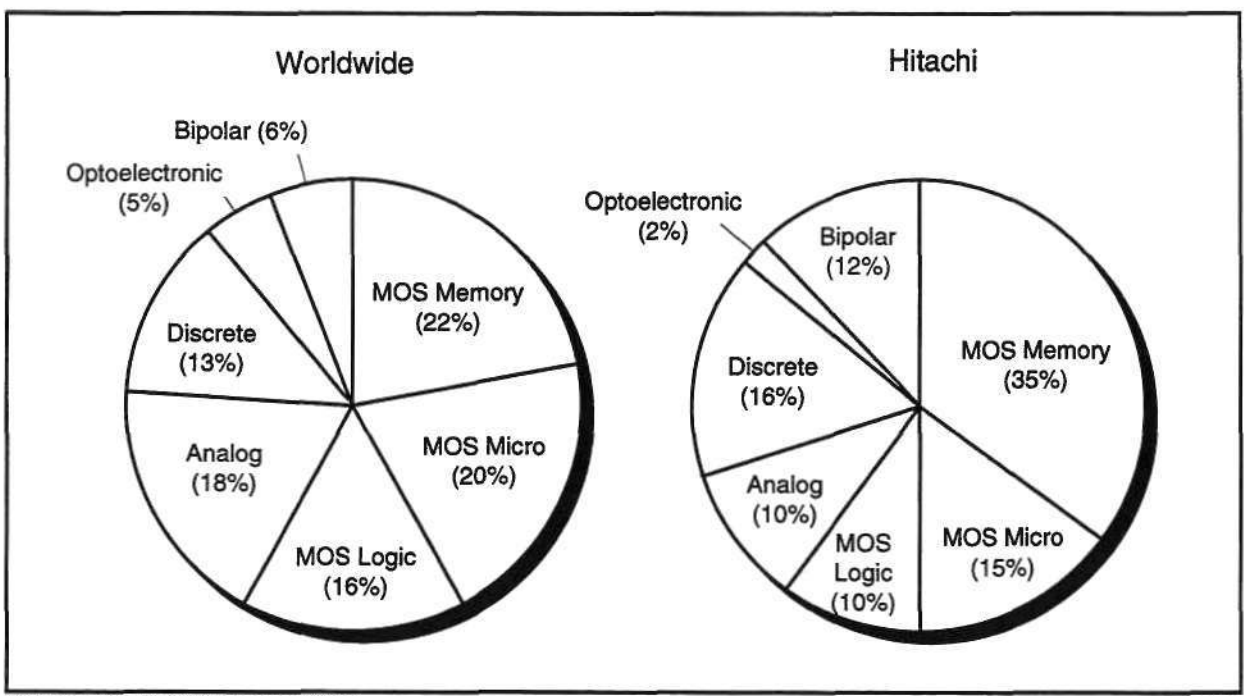
Table 7
Estimated 1991 Hitachi Ranking, by Product Segment

	Worldwide Market	Japanese Market
Total Semiconductor	5	2
Total Integrated Circuit	4	2
Bipolar Digital	3	2
MOS	4	2
MOS Memory	2	1
MOS Microcomponents	4	4
MOS Logic	8	5
Analog	13	6
Total Discrete	3	2
Total Optoelectronic	12	9

Source: Dataquest (November 1992)

Figure 2
1991 Semiconductor Market Share Product Mix: Worldwide versus Hitachi



Source: Dataquest (November 1992)

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this figure was sufficient to propel Hitachi into the position of leading market supplier of 4Mb parts, 1990 saw a rapid erosion of 4Mb DRAM prices as demand fell short of both supply and booking projections. The repercussions of these events were that, while Hitachi's market share held firm, the DRAM business was not profitable during 1991.

The rapid deterioration of DRAM markets, coupled with the determination of Korean manufacturers to establish a dominant role in these markets, has caused most Japanese DRAM manufacturers to suspend or delay their advanced DRAM manufacturing plans. Hitachi completed construction of a new building at Naka Plant, and the company planned to install equipment for 16Mb DRAM mass production by the end of 1992. However, Hitachi recently decided to freeze this additional equipment investment because of uncertain 16Mb DRAM demand. Hitachi has also made the strategic decision to reduce memory revenue as percentage of total semiconductor sales from its current value of more than 35 percent to a goal of about 30 percent.

Figure 3 compares Hitachi's semiconductor growth rates, by product category, against corresponding product growth rates on the world market for 1991. Hitachi clearly has been a dominant supplier of MOS memory and has outpaced world growth in this area. Yet the cost of gaining this market share at a rate surpassing the growth of the market itself may have been too high and directly related to Hitachi's subsequent decision to scale back memory emphasis relative to other semiconductor endeavors. The diminishing returns of dominating the memory business, particularly in the capital-intensive DRAM businesses, no longer appear cost-effective unless one clings to expectations of driving competitors completely out of the business by thorough market domination. Such a strategy is clearly unrealistic given today's proliferation of technology alliances and the determination of many nations' governments to subsidize development of leading-edge memory fabrication technologies. In the year's major growth areas of microcomponents and logic, Hitachi failed to capitalize on its MOS expertise. This inability to grow with the increased demand for microcomponents and logic possibly is because of its overemphasis on memory production. Hitachi's absence as a significant producer of a main stream CISC or RISC microprocessor may be another reason for its minor role in these markets.

Based on its actions to date, it would appear that Hitachi, as a vertically integrated player, prefers to manufacture microprocessors primarily for internal use in its own systems products. Open RISC architectures, such as the SPARC and MIPS standards, offer the most readily accessible platforms for foundries and second-source manufacturers to gain microprocessor market share as RISC architectures expand their acceptance. Rather than adopt this strategy to become another commodity RISC vendor, Hitachi elected to align with the Hewlett-Packard Precision RISC Architecture. Although this architecture is also rapidly becoming another viable open platform, it trails both SPARC and MIPS in the number of different companies supporting its designs. It is therefore possible that Hitachi's role as a

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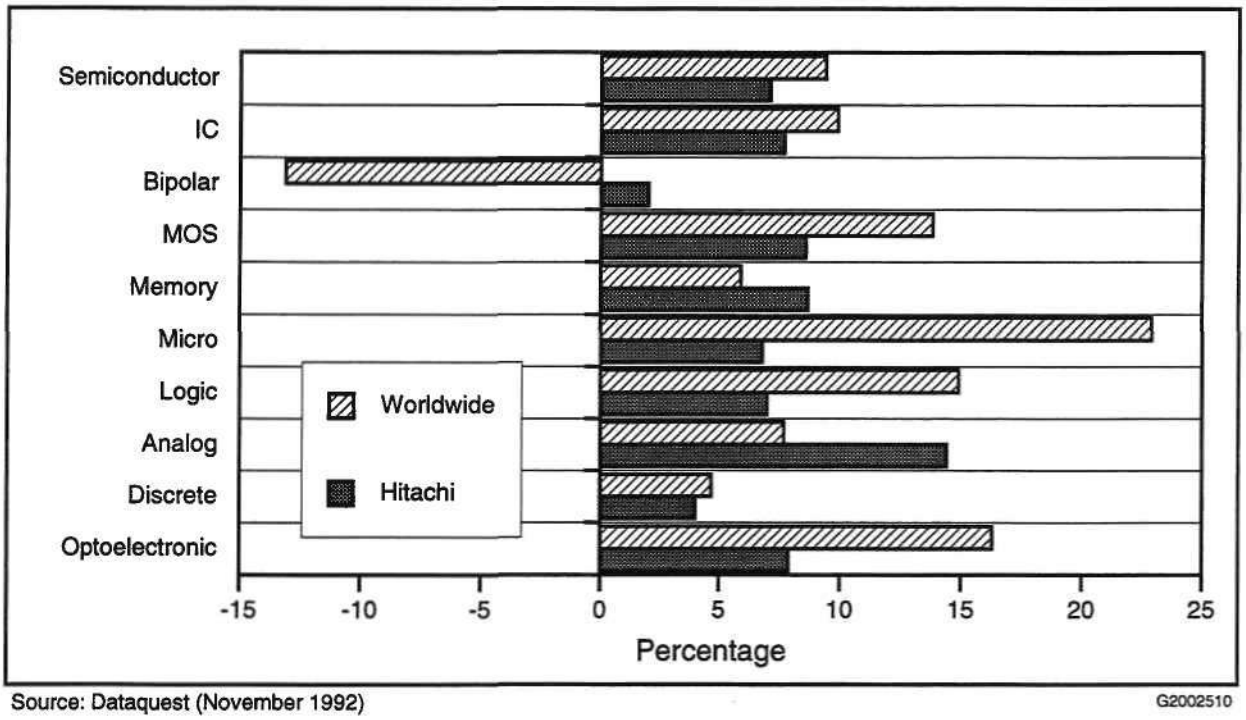
Figure 3
Hitachi's 1991 Growth Rate, Compared with the Worldwide Market



Source: Dataquest (November 1992)

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less-than-dominant supplier of microprocessors is more of a business decision than an inability to position itself within the market. While it may seem to be a conservative approach to an important market, the HP/Hitachi lead efforts probably have as much of an opportunity to establish a standard as the IBM-Apple-Motorola Power RISC chip designs. Furthermore, the cause of these RISC designs in trying to make a transition from proprietary to open architectures has perhaps not been hurt by the merger between Silicon Graphics Inc. and MIPS. This is because many may regard the SGI-MIPS merger as an obstruction to a truly open architecture based on the MIPS designs. In any case, at this point an SGI/MIPS lead consortium would seem to be no more viable than an HP/Hitachi lead consortium in creating a successful open platform.

Hitachi's lack of performance in the logic/ASIC markets could also be linked to conscious decisions to focus on providing for its own internal requirements and to maintain a competitive advantage for systems produced higher in the vertical structure of the company.

Bipolar products accounted for 12.7 percent of Hitachi's semiconductor revenue. Pure bipolar product lines are shrinking categorically because of the widespread success of BiCMOS, which generally offer more control of speed, power, and integration density trade-offs than do pure bipolar devices. Unfortunately, categorization of parts has not yet expanded to include this class of devices. Hitachi is considered a

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leading producer of components made in BiCMOS, which is often used as an indicator of the technical sophistication of a company's semiconductor fabrication technology.

Table 8 provides Hitachi' semiconductor revenue, by product segment, for the past five years.

Regional Market

Figure 4 shows Hitachi's semiconductor revenue, broken into four major regional markets. About one-third of Hitachi's total revenue was generated in overseas markets during 1991. Foreign sales of MOS memories captured about half of Hitachi's memory revenue, and helped offset the weak domestic memory markets during the same year.

Semiconductor Investment

Table 9 and Figure 5 present Hitachi's semiconductor capital spending and R&D expense trends against overall semiconductor revenue for the past five years. Capital spending and R&D costs have steadily increased to where Hitachi reinvested about one-third of its semiconductor revenue in 1991. Hitachi achieved a high revenue-to-investment efficiency in semiconductor sales during the past decade, not an uncommon trait for a dominant memory supplier during that time frame. In 1987, because of a semiconductor business downturn, Hitachi cut its capital spending to ¥38 billion, or about 10 percent of revenue. This action is believed to have resulted in Toshiba's forging ahead in the 1Mb DRAM race, and Hitachi has subsequently been spending heavily to regain and maintain a lead in 4Mb that never fully developed as expected. In terms of R&D, Hitachi had been investing about 14 to 15 percent of semiconductor revenue up until 1989, when it began increasing that rate to reach 18.4 percent by 1991.

Although absolute R&D costs continue to escalate, revenue increases have not kept pace with the cost of advanced R&D projects and thus R&D expenditure as a percentage of revenue tends to exaggerate R&D investment trends, even though the burden is real and must be sustained by flat revenue. Hitachi enjoys the luxury of having sufficient capital to indulge in many long-term basic research projects that have uncertain commercial value. Nevertheless, the rate at which patents are generated by Hitachi guarantees that the company will not be at a disadvantage when intellectual licensing exchanges are made.

Hitachi has been devoting more than 30 percent of its total corporate investment, which includes both capital spending and R&D expenditure, on semiconductor-related activities. Since Hitachi's merchant semiconductor sales accounted for only 6.6 percent of total corporate revenue during 1991, a relatively modest figure compared with figures from competitors such as NEC and Toshiba, Hitachi's commitment toward establishing a competitive advantage through the development of semiconductor technologies remains clear. The application of technology toward merchant chip products or systems further up the manufacturing tree is what separates Hitachi from those that place a greater emphasis on their merchant semiconductor sales.

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Table 8
Estimated Semiconductor Revenue, by Product in Worldwide Market
(Billions of Yen)

Calendar Year	1987	1988	1989	1990	1991	1991 Market Share (%)
Total Semiconductor	377.0	455.8	499.8	506.3	512.0	6.3
Total Integrated Circuit	280.2	354.8	409.3	414.4	421.5	6.3
Bipolar Digital	66.7	65.1	61.7	65.1	62.7	12.7
TTL/Other	51.3	48.9	42.5	44.4	34.0	9.8
ECL	15.4	16.3	19.2	20.7	28.7	19.5
Bipolar Digital	66.7	65.1	61.7	65.1	62.7	12.7
Bipolar Digital Memory	13.7	15.5	13.4	13.7	13.5	27.8
Bipolar Digital Logic	53.0	49.7	48.3	51.4	49.2	11.4
MOS (Technology)	168.9	245.1	305.0	304.3	310.1	6.6
N/PMOS	67.8	93.7	61.5	61.3	59.4	7.3
CMOS	100.7	150.4	229.8	229.1	235.0	6.2
BiCMOS	0.4	0.9	13.7	13.8	15.6	20.5
MOS (Function)	168.9	245.1	305.0	304.3	310.1	66.4
MOS Memory	82.9	144.8	192.6	176.3	180.9	10.4
MOS Microcomponent	57.9	68.3	69.7	78.6	79.3	5.0
MOS Logic	28.1	32.0	42.6	49.4	49.9	3.8
Analog	44.6	44.6	42.6	45.1	48.7	3.3
Total Discrete	90.0	91.9	82.0	82.8	81.3	7.4
Total Optoelectronics	6.8	9.1	8.6	9.1	9.2	2.4
Exchange Rate (¥=U.S.$1)	144	130	138	144	136	

Note: Columns may not add to totals because of rounding.
Source: Dataquest (November 1992)

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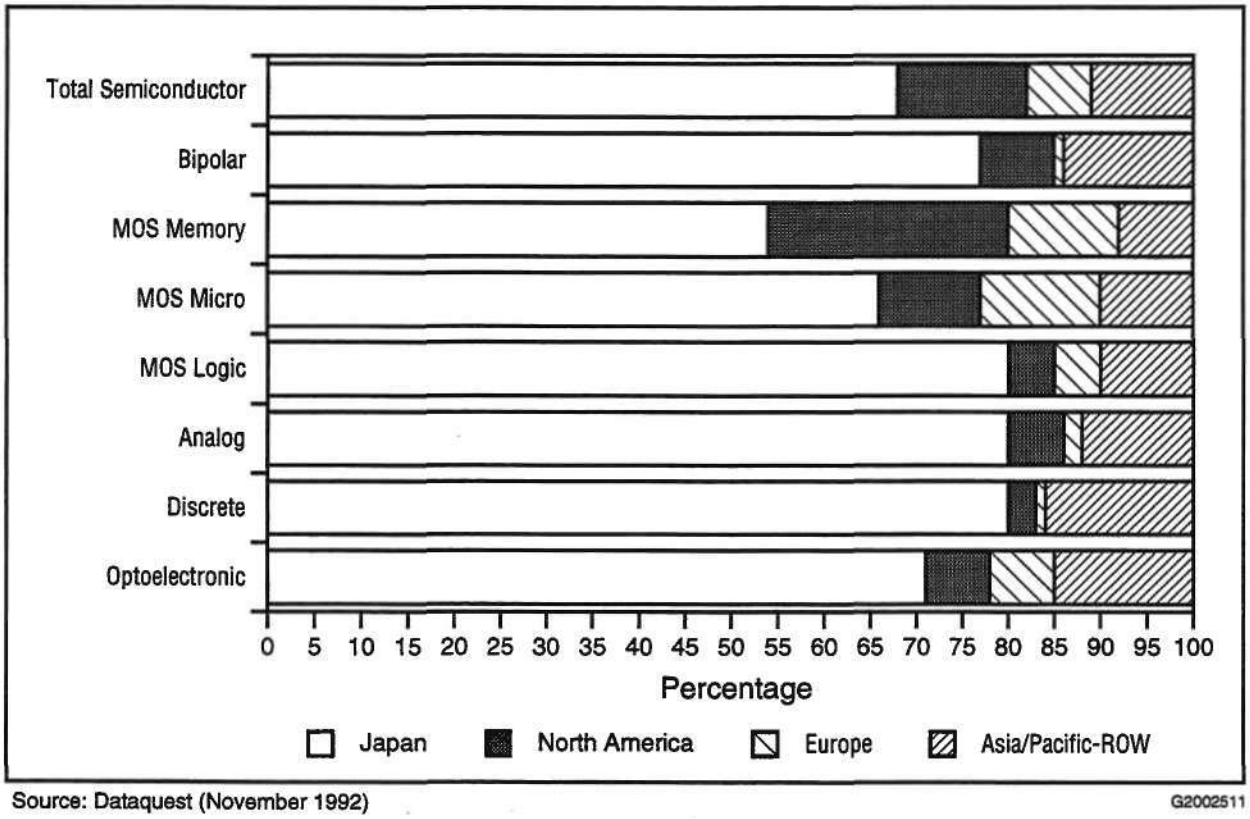
Figure 4
Hitachi's Semiconductor Revenue, by Region



Source: Dataquest (November 1992)

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Table 9
Semiconductor Investment: Capital Spending and R&D (Billions of Yen)

	1987	1988	1989	1990	1991
Semiconductor Revenue	377.0	455.8	499.8	506.3	512.0
Capital Spending	37.5	65.0	88.8	106.3	87.5
Percentage of Revenue	9.9	14.3	17.8	21.0	17.1
R&D Expense	58.0	64.0	73.5	84.5	94.0
Percentage of Revenue	15.4	14.0	14.7	16.7	18.4
Total Investment to Revenue	25.3	28.3	32.5	37.7	35.4

Note: Semiconductor revenue and capital spending are calculated for calendar year periods, while R&D expense is stated for a Japanese fiscal year.
Source: Dataquest (November 1992)

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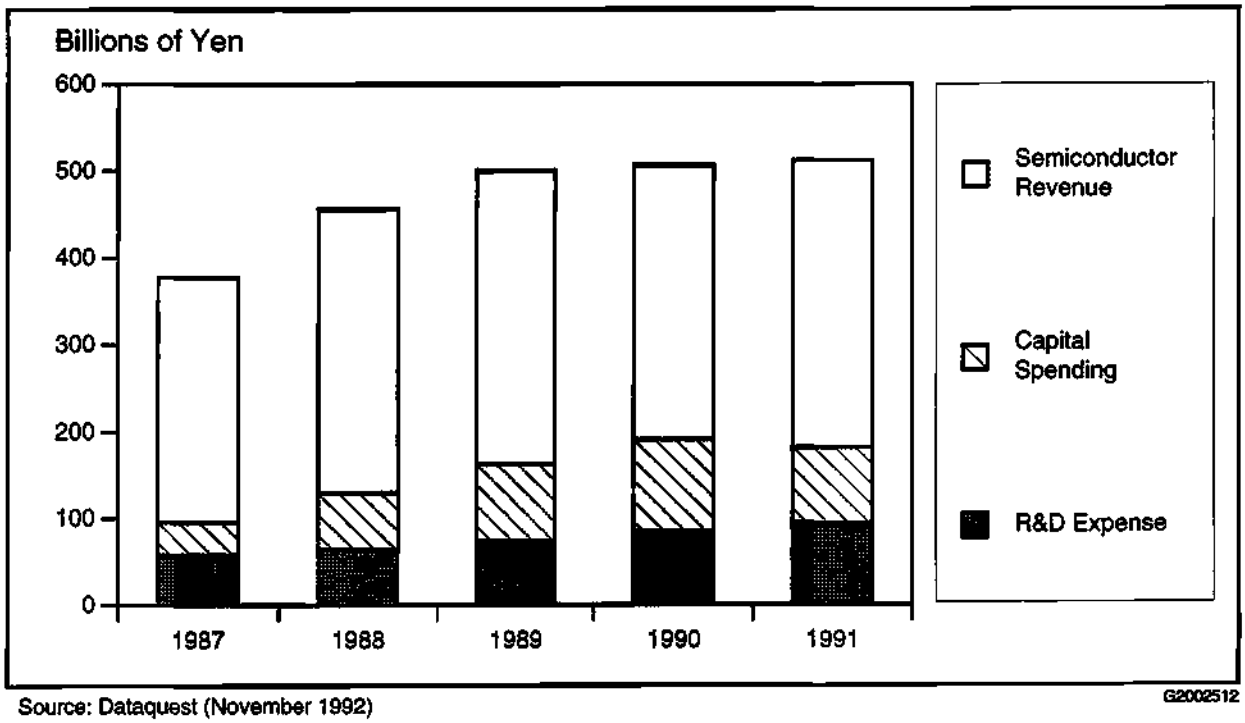
Figure 5
Hitachi Semiconductor Investment: Capital Spending and R&D



Source: Dataquest (November 1992)

Manufacturing Facilities

Hitachi generally manages front-end production in its own plants and channels end production and assembly/testing to subsidiaries or affiliated companies. Table 10 shows the location, work force size, and semiconductor products made at Hitachi's primary manufacturing sites. Figure 6 shows the relationship between various semiconductor manufacturing sites and possible chip production steps performed at the various Hitachi plants.

Hitachi completed a new front-end fab facility in Germany at the close of 1991. The EC body that governs semiconductor trade policy has already begun defensive moves, including procedures for defining, calculating, and establishing limits on foreign chips imported into the EC semiconductor markets. An EC committee has also made rulings on semiconductors that require front-end wafer fabrication to be performed on European territory to qualify as "made in EC." These mandates have induced major Japanese chip makers such as Hitachi and NEC to construct or upgrade existing fabs in Europe in anticipation of unification of the European markets. Hitachi's total investment at its Germany fab line is estimated to be more than $450 million. Current schedules call for the plant in Germany to produce 4Mb DRAM and logic chips; fab line qualification testing is now under way.

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Table 10
Hitachi Semiconductor Manufacturing Facilities

Plant Name	Location	Facility	Product	Number of Employees	Year Opened
Domestic Facilities					
Mobara Works	Chiba	F	Memory, logic, TFT	400	1943
Komoro Works	Nagano	F	Optoelectonics	900	1969
Takasaki Works	Gunma	F	Bipolar, logic, ROM	2,000	1988
Hokkai Semiconductor	Hokkaido	F	DRAM, SRAM	750	1982
Hitachi Works	Ibaragi	F	Discrete	200	1910
Naka Works	Ibaragi	F	DRAM, equipment	300	1961
Musashi Works	Tokyo	PR	MOS IC, VLSI	2,600	1958
Central Research Lab	Tokyo	R	R&D	NA	NA
Device Development Center	Tokyo	R	Micro, semi custom ICs	1,000	1983
Kofu Works	Yamanashi	F	Memory, micro, logic	1,300	1969
Hitachi Tokyo Electronics	Yamanashi	AT	MOS ICs, discrete	50	NA
Tobu Semiconductor	Aomori	FAT	Linear, logic, SRAM	600	1974
Tsuruta Electric	Aomori	AT	Discrete, GaAs	450	1981
Yonezawa Electric	Yamagata	AT	MOS ICs	700	1969
Haguro Denshi	Yamagata	AT	MOS ICs	240	1984
Shinsho Elemex	Yamagata	AT	Bipolar	185	1983
Akita Electric Tenno	Akita	AT	MOS, bipolar	550	1969
Akita Electric Yuwa	Akita	AT	MOS ICs	650	1982
Toyo Electric	Niigata	AT	Bipolar digital	260	1973
Haramachi Electric	Ibaragi	AT	Discrete	500	1973
Otaki Electric	Chiba	F	LCD module	160	NA
Overseas Facilities					
Hitachi America	Irving, Texas	F	Micro, DRAM, SRAM		1988
Hitachi Denshi	Landshut, Germany	FAT	DRAM, micro, bipolar		1980
Hitachi Semiconductor	Taiwan	AT	Transistor		1967
Hitachi Semiconductor	Penang, Malaysia	AT	DRAM, micro, bipolar		1972

NA = Not available
F: Fab
P: Pilot line
R: Semiconductor R&D
A: Assembly
T: Test
Source: Dataquest (November 1992)

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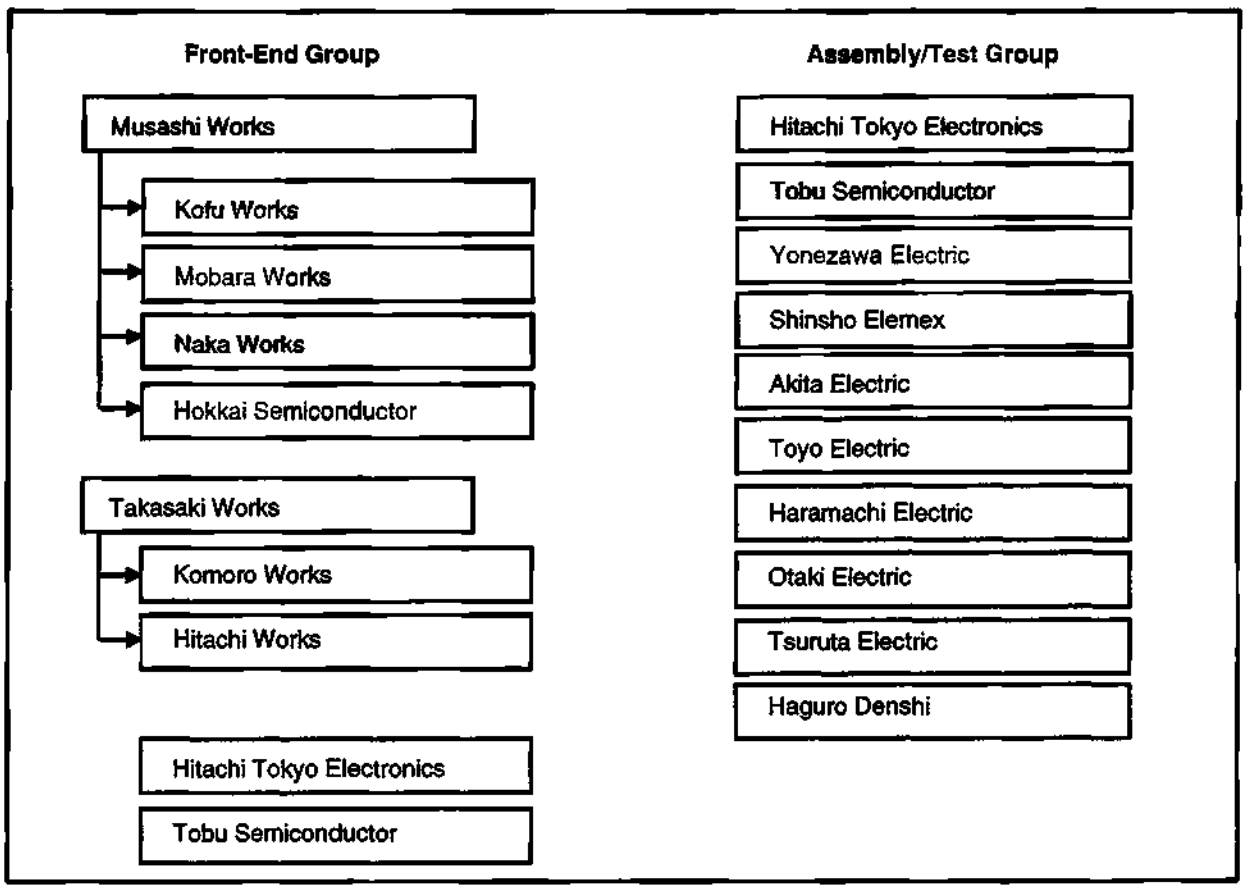
Figure 6
Hitachi Semiconductor Manufacturing Shift



Source: Dataquest (November 1992)

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Semiconductor Alliances

Table 11 lists Hitachi's publicly announced alliances formed during the past five years. Hitachi was, and continues to be, an early ally to HP in efforts to transform HP's RISC architecture into an open platform. In addition, Hitachi has often been linked to Texas Instruments in various ambitious technology codevelopment agreements. In fact the close ties between TI and Hitachi were cause for concern by Sematech members as a potential source of a technology leak. Having had a peak number of alliances in 1989, Hitachi continues to embrace alliances as a business methodology; its rate of entering new alliance agreements leveled at about four per year for the past several years.

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Dataquest classifies strategic alliances into the following major categories, as applied in Table 11:

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

Dataquest Perspective

Hitachi, a leading supplier of everything from home appliances to heavy machinery and from semiconductors to supercomputers, is both vertically and horizontally diversified. During FY1991, Hitachi's Information & Communication Systems and Electronic Devices Division generated 34.2 percent of Hitachi's total revenue, a percentage that has been steadily increasing during the past few years. Key to the continued success of this division is development of leading-edge semiconductor technology in which Hitachi is investing heavily. Although Hitachi possesses the capacity to be a more aggressive merchant semiconductor supplier, there is evidence to suggest that Hitachi has chosen to utilize much of its technology to gain competitive advantage in systems-level products rather than as a dominant merchant.

Collectively, HP and Hitachi lead a RISC consortium that is a formidable threat to the SPARC, MIPS, or Power designs. As a systems supplier in the fast-growing workstation and PC markets, Hitachi has yet to make an impact. Hitachi's strategy of designing systems around the HP PA RISC is consistent with its role as a sophisticated supplier of systems. By combining its expertise in semiconductor manufacturing of MOS logic, memories, and microprocessors with its established systems manufacturing capabilities, the workstation and PC products it fields should prove both competitive and interesting.

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Table 11
Hitachi's Semiconductor Strategic Alliances

Date	Partner	Agreement Type	Product
1/87	Chinese government	LA	Linear IC assembly and test
4/87	VLSI Technology	FA	1Mb mask ROM
8/87	Oklahoma University	JD	Product and material
9/89	Nanometrics	LA	Equipment
10/87	International Rectifier	LA	Power MOS-FETs
7/89	Mitsubishi	CO	EDTV chip sets
9/88	Intel Japan	PC	Consumer MPUs
12/88	Texas Instruments	JD	16Mb DRAM
1/89	VLSI Technology	FA	High-speed SRAM
6/89	National Semiconductor	LA, JD	Logic IC
7/89	Texas Instruments	SS	256Kb SRAM
7/89	Kimsung (Goldstar)	SS, TE	1Mb DRAM
7/89	Hewlett-Packard	TE	RISC MPU
7/89	Cray Computer	LA	Supercomputer
9/89	National Semiconductor	SS	CMOS logic ICs
10/89	Goldstar	LA, SS	1Mb DRAM
6/90	Hewlett-Packard	LA	RISC MPU
6/90	Goldstar	LA	4Mb DRAM
8/90	Nissan Motor	JV	Automotive electronics
5/91	Compass Design Automation	JD	0.8-micron ASIC cell libraries
6/91	NMB Semiconductors	FA	4Mb DRAMs
8/91	Bull	LA	IC card
11/91	Texas Instruments	JD	64Mb DRAM
3/92	Wang Laboratories	LA	SIMM
4/92	Oki	JD, CO	HP PA-RISC MPU
4/92	Texas Instruments	SA, FA, CO	BiCMOS bus interface
7/92	National Semiconductor	FA	CMOS logic devices

Source: Dataquest (November 1992)

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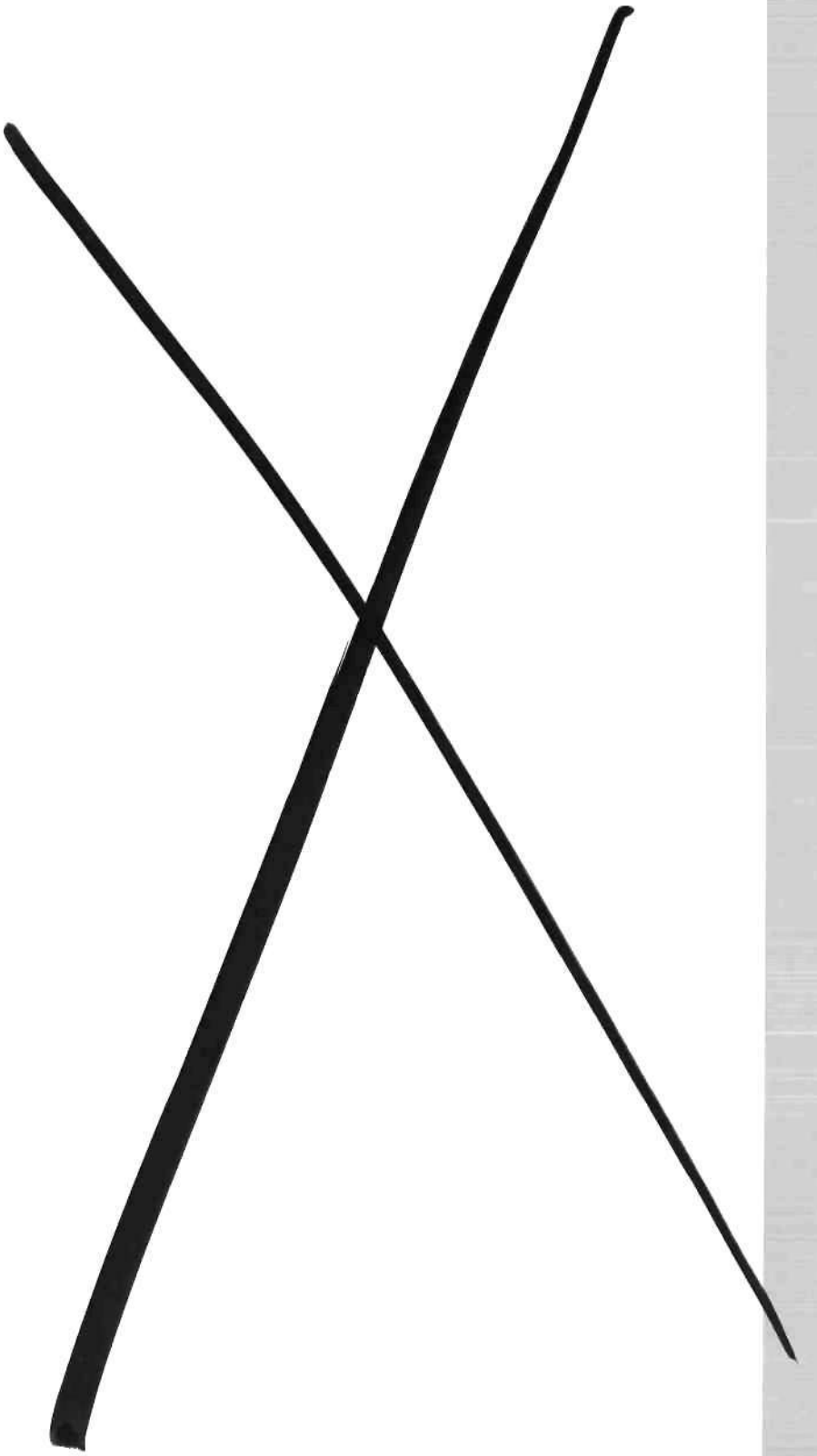

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Semiconductors *Japan*

SCJA-SVC-DP-9214 December 28, 1992

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the differences in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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Market Analysis

Japanese Electronics Companies: FY1991 Financial Analysis

This article updates previous articles with a more detailed financial profile of five of Japan's top electronics companies—Fujitsu, Hitachi, Matsushita, NEC, and Toshiba—and examines their financial reports.

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The Sound Effect of Karaoke on Videodisk Players

This article sheds light on the present and future markets of VDPs and analyzes their impact on the semiconductor industry.

By Kun Soo Lee *Page 8*

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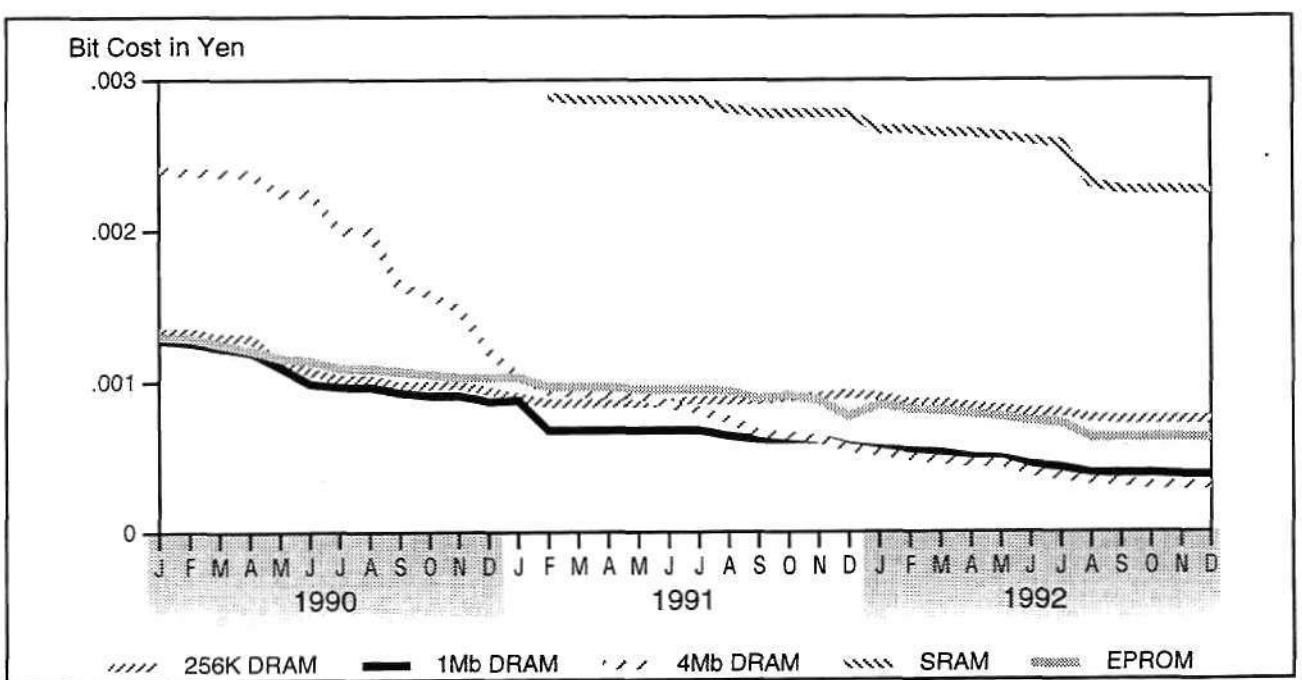
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Korea
DRAM 1Mbx1NA8	3.23	2.98	3.50	3.45	2.80
DRAM 4Mbx1NA8	11.00	9.66	10.60	11.50	9.90
EPROM 2Mb, 170ns	6.25	6.20	5.00	NA	4.10
FLASH 1Mb	8.35	7.26	7.45	6.50	NA
FLASH 2Mb	13.78	13.69	15.90	NA	NA
SRAM 128Kx8NA70	10.16	10.07	7.50	NA	7.60
SRAM 32Kx8NA70	3.70	3.14	3.00	3.23	2.90
SRAM 64Kx4NA25	5.25	5.23	4.50	4.75	4.30
VRAM 128Kx8NA8	6.83	6.60	7.00	NA	6.95
68040NA25	382.50	450.99	370.00	NA	NA
80386DXNA40	46.50	92.61	85.00	60.50	73.00
80386SXNA20	49.50	37.85	38.00	47.00	32.00
80486DXNA33	325.00	322.14	350.00	345.00	340.00
R3000NA25	91.70	96.64	80.00	NA	NA

Note: These figures correspond with the DQ Monday Report dated December 14, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (December 1992)

Memory Bit Price in Japan



Source: Dataquest (December 1992)
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Market Analysis

Japanese Electronics Companies: FY1991 Financial Analysis

The Semiconductors Japan service in the past has provided newsletters each year dealing specifically with the annual financial performance of some of Japan's top electronics companies. In June 1992, our *Dataquest Perspective* concerned the FY1991 financial performance of the top 10 Japanese electronics companies.

The purpose of this article is to update the previous article with a more detailed financial profile of some of Japan's top electronics companies. This article examines the financial reports of five Japanese electronics companies: Fujitsu, Hitachi, Matsushita, NEC, and Toshiba. Their financial figures will be compared with the 1991 financial results of AT&T and Intel to yield some insight into some differences in business operating modes both in Japan and the United States.

FY1991 Summary: Grim Weather Continues

Japan's economy experienced a steep decline following the midyear point when the bubble or "Heisei" economy enjoyed by Japan for several years rapidly collapsed and brought the country to the threshold of recession. Although in 1991 some analysts still believed that Japan could avoid the difficulties experienced by other world economies, its dependence on foreign markets, particularly that of the United States, eventually undermined domestic consumer confidence and failed to keep Japan from its own recession.

Table 1 shows the financial performance of five Japanese and two U.S. companies. In FY1991, all five Japanese companies listed here recorded their highest revenue in terms of total corporate sales. Although Hitachi, NEC, and Toshiba all grew by slim margins, Fujitsu and Matsushita showed impressive double-digit growth. In terms of net income, however, all five sustained significant negative growth. For most of the companies, continued investment in semiconductor manufacturing capacity in the face of leveling sales was the immediate cause of diminished net revenue. Fujitsu, with one of the most ambitious semiconductor expansion schedules of the five Japanese companies during FY1991, relative its size, saw its net income declined by 85.2 percent. This figure marked both the biggest decline in the company's history, as well as the low figure for change in net income recorded by the five companies under study.

With regard to semiconductor sales, forecasts based on a historical trend (often referred to as the Silicon Cycle) called for an upward swing following a bottom that supposedly occurred in 1990. This cycle was broken in 1991, however, as the Japanese semiconductor sales grew only a modest 3.4 percent on a yen basis.

Four of the five Japanese companies, with the notable exception of Fujitsu, had absolute semiconductor revenue that increased over the previous year. For these companies, semiconductors also increased as a percentage of total corporate revenue, as compared with the previous year's percentages. For NEC and Toshiba, in particular, increases in semiconductor revenue, despite the slowdown in chip markets worldwide, accounted for a major portion of overall corporate revenue growth. In contrast, Fujitsu's semiconductor sales declined even though its total corporate revenue was up. Because Fujitsu's corporate revenue more than offset the drop in semiconductor sales, it was able to maintain a high capital investment level and a positive net income for the year. Fujitsu's overall growth behavior suggests that the company may have effectively utilized its semiconductor technology to increase the competitive advantage, and hence market share, of some of its more profitable system level products.

Heavy semiconductor capital investment coupled with price erosion of commodity DRAMs contributed to the low margins shown by all the companies. However, for the three smallest companies—NEC, Toshiba, and Fujitsu—the burden was particularly harsh as their profit margins for the year shrank to less than 1 percent.

While Japanese semiconductor sales grew 3.4 percent, the semiconductor applications market grew 4.4 percent in calendar year 1991. Broad-line computer manufacturers such as Hitachi, NEC, and Fujitsu all had computer systems divisions that grew during FY1991 at a faster rate than the applications market as a whole. Fujitsu showed the most growth; its Computers and Information Processing Systems Division expanded by a respectable 22.1 percent. This growth was derived mostly from sales

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Table 1
Electronics Companies Financial Results—Fiscal Year 1991 (Billions of Yen)

	Fujitsu	Hitachi	Matsushita	NEC	Toshiba	AT&T[1]	Intel[2]
Total Sales	3,442	7,766	7,449	3,774	4,722	8,580	651
Change of Total Sales (%)	15.8	0.4	12.9	2.0	0.6	1.4	15.2
Net Income	12	128	133	15	39	71	111
Change of Net Income (%)	-85.2	-44.6	-48.7	-71.9	-67.3	-83.2	18.1
Total Assets	3,992	8,858	9,020	4,081	5,724	7,256	856
Operating Income Margin (%)	4.0	4.5	5.2	3.2	2.5	2.2	22.6
Net Income/Total Sales (%)	0.4	1.6	1.8	0.4	0.8	0.8	17.1
Foreign Sales/Total Sales (%)	29.8	23.7	48.2	21.0	29.1	24.0	51.3
Corporate R&D/Sales (%)	11.7	6.7	6.1	8.0	6.7	4.9	12.9
Semiconductor Sales[3]	368	512	277	649	623	97	547
Semiconductor Sales/Total Sales (%)	10.7	6.6	3.7	17.2	13.2	1.1	84.1
Sales/Employee (¥M)	22.095	23.946	30.750	29.410	28.107	27.058	26.418
Net Income/Employee (¥M)	0.078	0.394	0.549	0.119	0.232	0.224	4.526
5-Year CAGR							
Sales (%)	13.9	8.0	10.1	6.2	7.2	1.0	25.8
Net Income (%)	-26.9	-1.7	-5.3	-12.0	-10.6	-32.2	34.8

[1] AT&T's fiscal year ended December 31, 1991.
[2] Intel's fiscal year ended December 28, 1991.
[3] Semiconductor sales are estimated for calendar year.
Source: Dataquest (December 1992)

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involving mainframe-class computer systems. Similarly, NEC's Computer and Industrial Electronic Systems Division grew by 10.9 percent and Hitachi's Information Systems segment grew by 4.8 percent.

The consumer equipment segment also showed a positive 7.4 percent growth. However, most of this gain occurred during the first half of FY1991. Hitachi and Matsushita, both diversified suppliers of consumer electronics equipment, would have been expected to benefit more than others in the group from growth in this segment. Nevertheless, only Matsushita appeared able to capitalize on the opportunity, with substantial revenue increases from its sale of consumer items.

Hitachi and Matsushita for some time prior to FY1991 have been able to maintain stable net income margins. Some indications suggest that both companies have had substantial income from external business transactions, relative to their interest payments, that afforded them the luxury of being able to effectively manipulate their net income. This is about equivalent to suggesting that a large company will, in profitable periods, simply spend surplus income on R&D or capital spending. During FY1991, however, both Hitachi and Matsushita disclosed in their balance sheets that their external incomes fell and that their net income margins were cut in half, compared with the previous year's results. Japan's slow economy and recent financial scandals all have contributed to widespread stock devaluation, higher capital costs, and reduced investor confidence in traditional stocks with low dividend returns on investment. For Matsushita, the interest payments on its loan to acquire MCA has dampened its capacity to service its debt and placed constraints on its cash flow. However, despite the prevailing financial conditions, both Matsushita and Hitachi maintained a supplemental income that ranked second and third, respectively, in Japan behind Toyota Motors during FY1991.

In terms of productivity, all five Japanese companies have sales-per-employee figures equivalent to those from both AT&T and Intel. Intel's net income per employee, however, eclipsed AT&T's as well as all of the other Japanese companies. Intel's double-digit growth in net income during FY1991 contributed to a profit-per-employee figure 58 times larger than the level attained by Fujitsu, which had the lowest net income per employee of all companies. Low net income per employee has become a fixture of Japanese corporate balance sheets and appears to be a deliberate target for many Japanese companies. The absence of pressure to produce profits at Japanese corporations allows these companies to sustain higher levels of capital spending and debt while their business is flourishing, and to bear even lower net income during lean business periods, with less stock depreciation.

Financial Ratios

Table 2 compares selected financial ratios of the five sample Japanese companies with the corresponding approximate U.S. electronics industry average figures. The U.S. average ratios and formulas are from both the Dun & Bradstreet Business Credit Service and Robert Morris Associates.

The Japanese companies have much smaller current ratios and quick ratios than those of the average U.S. company. These smaller ratios imply that these companies generally have less capacity, or liquidity, to meet their short-term liabilities, compared with their U.S. counterparts. Furthermore, all five Japanese companies reported little change in their FY1991 current and quick ratios from the previous year's calculations. In fact, current and quick ratios have been relatively static at these companies for the past five years. It can, therefore, be inferred that Hitachi is the most liquid, and hence conservative, of the Japanese companies, followed by Matsushita, Fujitsu, Toshiba, and NEC. Moreover, there appears to be some correlation between liquidity levels and the percentage of corporate revenue derived from semiconductor sales (see Table 1). Lower liquidity seems prevalent among those companies most reliant on the semiconductor segment for revenue. NEC, with the lowest liquidity of the five companies, derives the largest percentage of total corporate income from the sale of semiconductors. Although these high debt levels may be related to semiconductor manufacturing, it may also be just specific to commodity DRAM manufacturing, an activity engaged in by all five of the Japanese companies. Intel, by comparison, achieved a current ratio of 2.94 in FY1991, well

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Table 2
Five Japanese Companies' Financial Ratios—Fiscal Year 1991

	Fujitsu	Hitachi	Matsushita	NEC	Toshiba	U.S. Industry Average
Liquidity Ratio						
Current Ratio	1.30	1.56	1.36	1.19	1.23	2.30
Quick Ratio	0.85	1.10	1.03	0.76	0.81	1.20
Sales/NWC	6.86	3.68	6.33	9.88	7.04	3.20
NWC/Total Assets	0.13	0.24	0.13	0.09	0.12	NA
Leverage Ratio						
Debt-Equity Ratio	0.88	0.53	0.45	1.30	1.24	0.80*
Fixed/Worth	0.93	0.74	0.43	1.27	1.09	0.50
Efficiency Ratio						
Total Asset Turnover	0.86	0.88	0.83	0.92	0.82	1.10
Net Profit Margin (%)	0.3	2.0	2.2	0.2	0.8	NA
Profitability Ratio						
Return on Sales (%)	1.2	4.8	4.9	1.4	2.4	2.5
Return on Assets (%)	1.0	4.2	4.0	1.3	2.0	3.2
Return on Equity (%)	1.1	4.4	3.8	1.7	3.3	6.8
Market Value Ratio						
Earnings per Share	18.81	25.12	52.28	25.17	13.22	54.40*
Payout Ratio	0.53	0.44	0.24	0.40	0.76	3.30*

*AT&T's FY1991 figures
NA=Not available
Source: Dataquest (December 1992)

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above the U.S. industry average, and derived 84 percent of corporate revenue from semiconductor sales.

Differences in Japanese and U.S. accounting practices may be the cause of substantial discrepancies between financial ratios produced in the two countries. However, it remains a possibility that liquidity is a rather arbitrary and relative figure basically determined by stockholder tolerance. In Japan, less importance is placed on a company's liquidity because there exists so much confidence in large companies that they are essentially never expected to fail because of insufficient capacity to service short-term liabilities. This is perhaps a fringe benefit of the common ownership profile of Japan's major electronics companies, which frequently includes many institutional investors and banks that have diversified portfolios containing holdings that may even encompass competing companies. For these stockholders, a company's long-term solvency, as often measured by the debt-equity ratio of Table 2, is a more significant gauge of its viability. In contrast, a U.S. company's immediate health, regardless of its size or stature, is quantified by its financial ratios, and stock instability is usually a direct response of those ratios falling below a given threshold. Unfortunately, this instability and ensuing feedback tends to further destabilize a company in the United States.

As shown in Table 2, the debt-equity ratios for the five Japanese companies are more consistent with their U.S. counterparts. This long-term safety or solvency calculation appears to be less susceptible to accounting distortions and is probably a more reliable figure of comparison between companies of the United States and Japan. Here too the debt-equity ratio for the five Japanese companies appears to correlate with the degree of involvement in semiconductor markets. A higher debt-equity ratio seems to be incurred upon those with a greater percentage of their sales from semiconductor sales.

Fiscal Year 1992: Driving Forces

Declines in stock prices on the Tokyo Stock Exchange, which began in FY1990, remained depressed throughout FY1991. A weak stock market, combined with the selective investor kickback scandals occurring during the past few years, has resulted in limited investment capital availability, higher capital costs, and some reassessment of dividend yield and payout ratio expectations of Japanese stocks. Furthermore, recent market research suggests that stockholders' priorities are shifting from capital-gain-oriented toward investment with more reliable yields. In response to investor complaints, particularly those coming from abroad, Japan's Ministry of Finance has induced many publicly traded Japanese corporations to change their business practices with regard to profit sharing. New restrictions have been imposed on public businesses to make their accounting practices more detailed and to conform to more rigid guidelines. For the larger electronics companies this has meant that, as of 1990, their balance sheets have been required to disclose a more detailed breakdown of income from various business segments.

To combat the recession, the Bank of Japan has steadily lowered the official discount rate to 3.25 percent, now at the lowest level since the beginning of the 1990s. Japan's economy has not, however, shown much reaction to these measures; economic indicators such as capital investment activity remain low. A lower Japanese central bank rate and a stable yen/dollar exchange rate are considered key ingredients toward promoting capital investment in manufacturing capacity.

The continuation of the global downturn in the semiconductor industry through the end of FY1991 (March 1992) had caused many Japanese companies initially to downsize their capital spending budget plans for FY1992. However, because of the rapid fluctuations in market demand for commodity products and the minimum delay periods needed to ramp up production facilities, it is likely that all Japanese electronics companies revised their capital spending projections more than once during FY1992. Demand for commodity DRAMs is a strong driving force for all the Japanese companies in this study and a key indicator for the Japanese electronics industry as a whole. Although most major Japanese DRAM suppliers were prepared to ramp up 4Mb DRAM production facilities long ago, reduced demand for these parts stalled or delayed this expansion for most of FY1992. As of the close of calendar year 1992, promising signs of recovery in the 4Mb DRAM markets have suppliers now pondering whether they

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should add capacity to meet possible 4Mb DRAMs demand or move directly to manufacturing the next-generation 16Mb parts. Workstation manufacturers in the United States already are beginning to spur demand for the higher-density components, in accordance with extrapolated historical demand trends.

Dataquest Perspective

With regard to their capital-intensive DRAM businesses, Japanese companies are beginning to see the light at the end of the tunnel. Indicators show that the U.S. economy is recovering from its recession. Although all five Japanese companies are expected to register higher R&D spending levels in FY1992 as compared with FY1991 amounts, thus far Fujitsu is the only company to project an increase in its level of capital spending for FY1992. Capital spending will likely remain a dynamic figure that is successively modified as fluctuating market demands dictate investment levels throughout a given year.

Japanese companies in the past have been able to manage short-term liabilities with smaller current assets than their American counterparts. NEC and Toshiba are the traditional leaders in leveraging their resources to develop their semiconductor enterprises. These two companies appear determined to test the limits of financial performance while still fulfilling the expectations of stockholders.

Even though Fujitsu has the smallest total revenue stream of the five Japanese companies, it possesses the financial makeup of a moderate, with liquidity and leverage ratios more in line with Hitachi and Matsushita than with those of NEC or Toshiba. Nevertheless, Fujitsu has established itself as an aggressive investor with disproportionate levels of capital spending, R&D, and external investment, such as its majority stake in ICL of Great Britain.

Although Japanese accounting practices still differ from those found in other parts of the world, it appears that these differences are receding. With the exception of liquidity and dividend yield, which may be because of fundamental differences in the Japanese stockholders' outlook, U.S. companies such as AT&T and Intel have financial profiles comparable to those of the five Japanese companies described in Tables 1 and 2. As companies achieve higher degrees of true multinational status, normalized accounting practices within a multinational company will both facilitate internal bookkeeping efforts and foster the ability of a company to successfully engage foreign companies in joint ventures, alliances, or mergers.

By Junko Matsubara

The Sound Effect of Karaoke on Videodisk Players

Some believe that the 1990s will pass without any "star product" application to drive the semiconductor market because of the changing face of the silicon cycle and the electronic equipment market bottoming in deep waters. Yet there is a continuous expansion of semiconductor application markets, even into personal entertainment segments such as computer-controlled "pachinko" (a popular arcade pinball game) and laser disk-based "karaoke," both of which have grown into sizable markets. Karaoke in particular is rapidly emerging as a major driving force for the videodisk player (VDP) market, which is expected to become a core system in the multimedia age as CD-I players are commercialized.

This article analyzes the present VDP market and its future, as well as its impact on the semiconductor industry.

The VDP Market and Karaoke

VDP production in Japan increased 35.5 percent from 720,000 units in 1988 to 975,000 in 1989 as a result of low-end products introduced by Pioneer Electronic and the promotion of karaoke applications by Nippon Columbia, among others. It further grew by 52.2 percent to 1.48 million units in 1990, driven by healthy growth of domestic demand. Growth dropped 13.1 percent to 1.29 million units in 1991 as the Japanese economy went into the "bubble crash." In 1992, production picked up again because of the aggressive introduction of new models and the market success of low-end models; there was a 40.8 percent increase for the first half over the same period in 1991 to 727,000 units. Dataquest expects full-year 1992 VDP production to increase by 45.7 percent to 1.88 million units.

Japanese VDP production value in 1991 is estimated to be ¥137 billion, which accounted for a mere 4.5 percent of the Japanese video equipment market (see Figure 1). The compound

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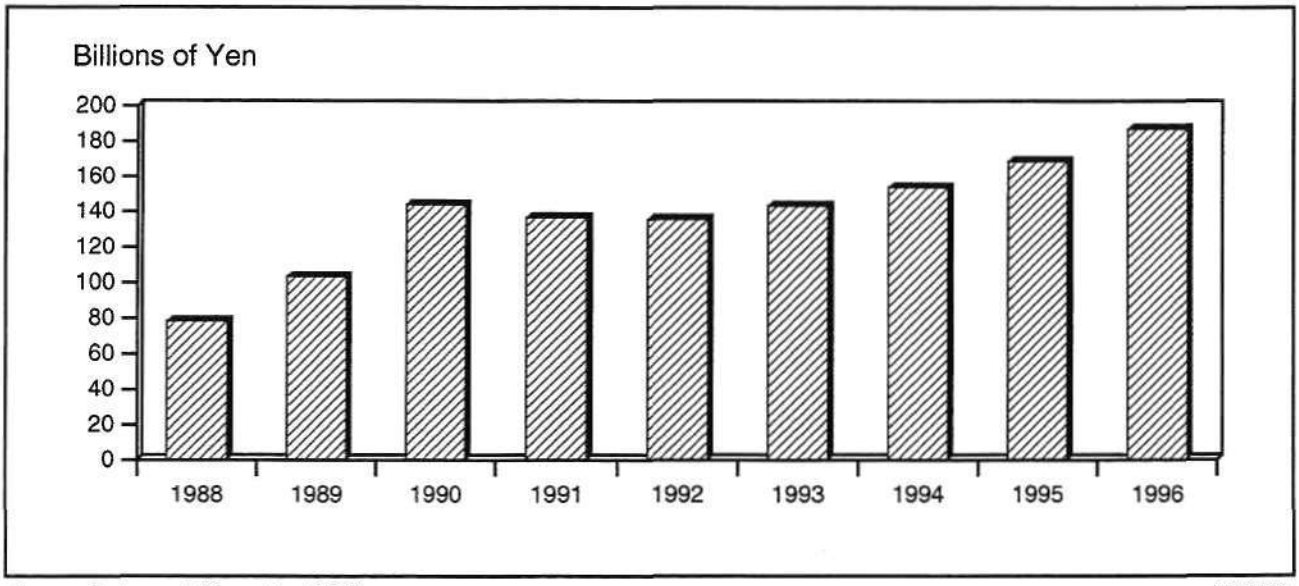
Figure 1
Japanese VDP Production Forecast



Source: Dataquest (December 1992) G2002676

annual growth rate (CAGR) from 1988 to 1991 was 20.4 percent, signifying VDPs as a small but burgeoning market. However, Dataquest expects two consecutive years of negative growth in the value of VDP production because of price erosion resulting from the proliferation of low-end models. In 1992, production will decrease 0.8 percent to ¥136 billion; unit production will jump 45.7 percent. Dataquest expects the value of VDP production to grow annually at 6.5 percent from 1991 to 1996, reaching ¥187 billion in 1996.

VDPs have been exploring the initial market with multidisk machines that integrate CDs and laser disks and have aggressive pricing of less than ¥100,000. This marketing strategy seems to have resulted in a saturated potential market. VDPs for karaoke are estimated to account for a majority of total production within the market. Undoubtedly karaoke has played a key role in eliciting VDP market potential and will continue to create new demand such as replacement of cassette-type karaoke with videodisk-type systems. Upgrading will result from adding automatic features such as auto-changer. Moreover, the emergence of the "karaoke box room" (rental rooms equipped with karaoke sets) market has helped explore a new customer base that includes students and housewives, while serving as a major impetus for proliferation of home-use karaoke sets. Whereas rental video has been a major factor in promoting market acceptance of VCRs, the fact that videodisks have been prohibited from growing into a rental business has adversely affected the proliferation of VDPs. Nevertheless, VDP software prices have declined from more than ¥10,000 at the initial stage to about ¥4,000. With a further price decline and an increase in software products, VDPs are expected to fully penetrate the market.

VDPs and the Semiconductor Market

In 1992, the value of semiconductor consumption for VDPs increased 10.4 percent from 1991 to ¥26.9 billion (see Figure 2). By device type, ASICs/ASSPs for voice processing, image processing, and laser pickup hold the highest share with 31.7 percent, followed by MOS microcomponents for signal processing and mechanical control systems, which account for 24.1 percent (see Figure 3). These devices are relatively costly and comprise 60 percent of total device consumption on a value basis, but ASICs increasingly will be used as the degree of integration rises.

Future technologies receiving much attention are CD-G (CD graphics) and CD-EG (CD extended graphics). At present, VDPs equipped with these features are supplied by the Victor Company of Japan (JVC), Nippon Columbia, and Pioneer (which holds the highest share). These companies are promoting VDPs from both hardware

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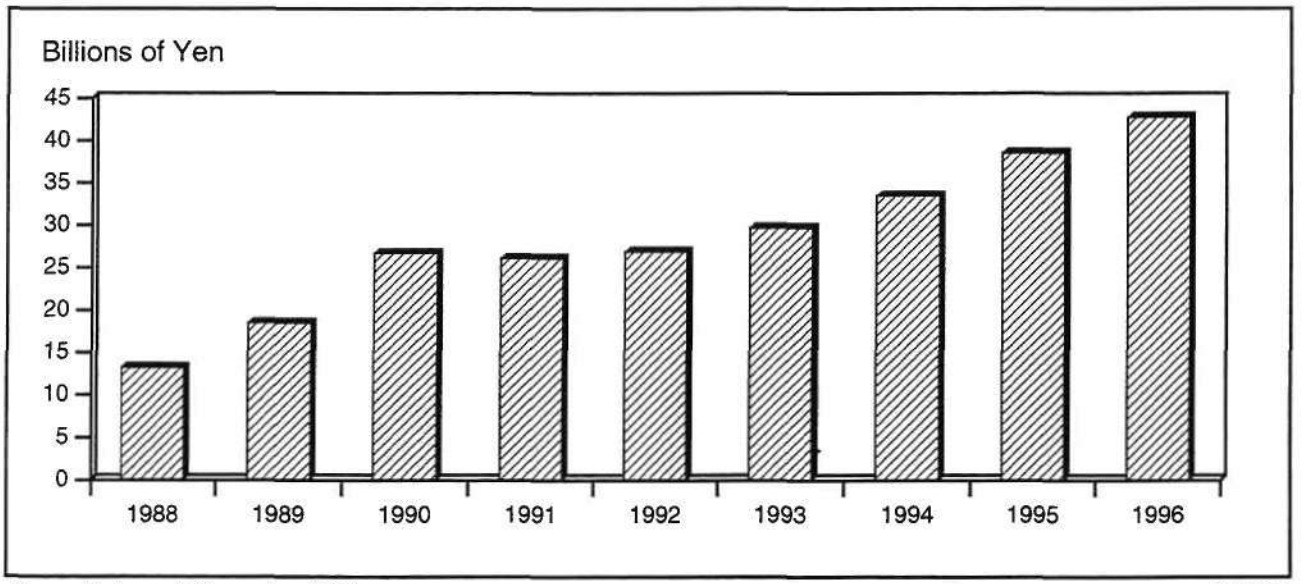
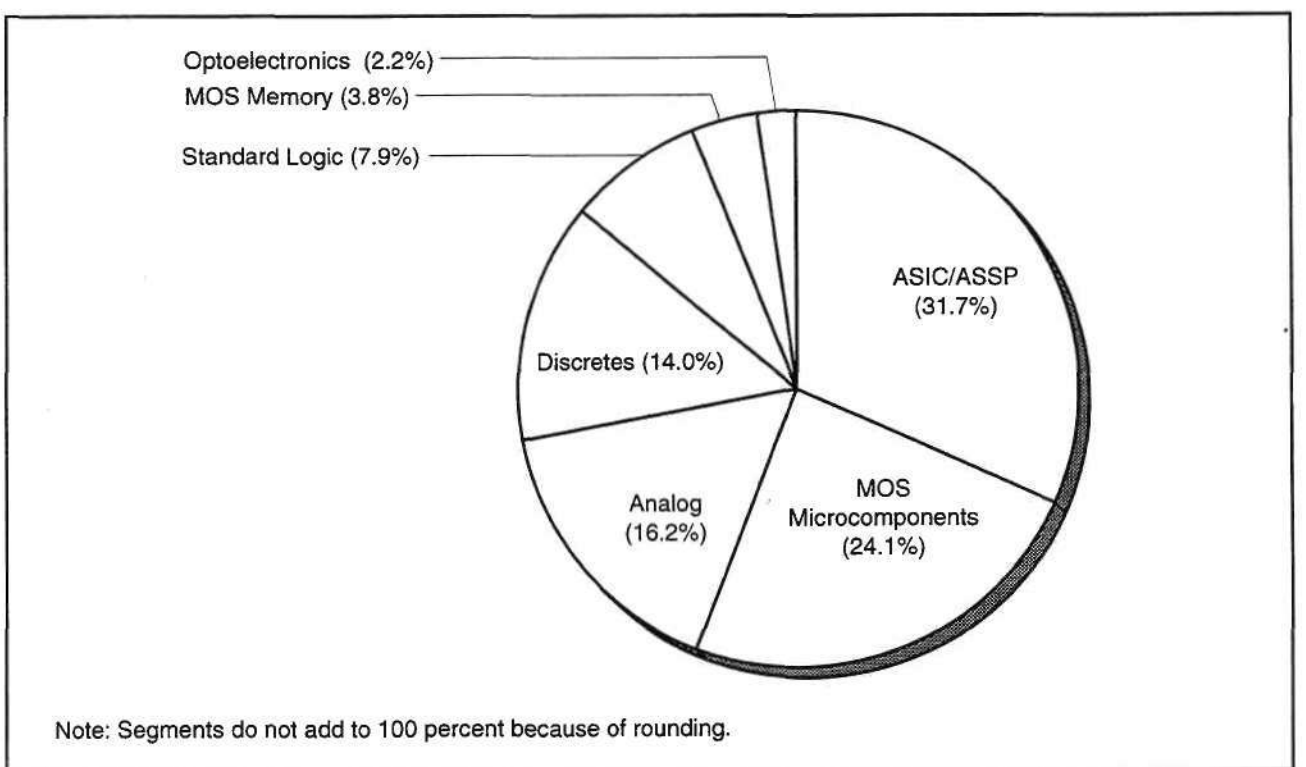
Figure 2
Semiconductor Consumption Forecast for VDP



Source: Dataquest (December 1992)
G2002677

Figure 3
1992 Semiconductor Consumption for VDP, by Device Type



Source: Dataquest (December 1992)
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and software markets. JVC and Hitachi also incorporate VDPs into portable radio/cassette tape recorders. Proliferation of such features is expected to boost demand for CD-G chips.

In the medium term, a standard for CD motion picture karaoke developed by JVC and Philips is attracting attention. A digital moving picture standard that applies compression technology from the Moving Picture Image Coding Experts Group offers a wide range of applications including compact disc-based music software, CD-ROM, and CD-I. If it is adopted as an industrial standard, the use of image compression chips by the Moving Picture Experts Group and the Joint Photograph Experts Group will increase, and it is conceivable that compression technology will become fully commercialized in the market with the coming of the digital audio/visual age. Dataquest expects the value consumption of semiconductors for VDPs to grow at a CAGR of 10.4 percent from 1991 to 1996, reaching ¥42.8 billion.

Dataquest Perspective

VDPs are expected to become a core of home audio/visual entertainment systems in the imminent HDTV and multimedia age. Nevertheless, the VDP market has grown rapidly since its birth and overcame the inevitable slump resulting from the increase in ownership by revitalizing the market through karaoke. Supported by these two factors, the VDP market shows the highest growth prospects within the video industry. Dataquest expects Japanese VDP production to grow at a CAGR of 6.5 percent from 1991 to 1996, compared with 3.4 percent for the consumer electronic equipment market as a whole.

Clearly, the VDP market will continue to grow by riding on the wave of personal electronics and incorporating "play" aspects such as karaoke. At the same time it will serve as the springboard to introduce multimedia into the consumer electronics market in the form of multifunctional systems and CD-I multimedia players in the audio plus visual equipment segment. As for implications to the semiconductor industry, Dataquest believes that the VDP market will generate new semiconductor demand for integrating complex and multifunctional devices, such as enhancement of CD-G capabilities, which will develop into an attractive market.

By Kun Soo Lee

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In Future Issues

The following topic will be addressed in a future issue of Semiconductors Japan *Dataquest Perspective:*

- Preliminary 1992 Japanese semiconductor market share

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Semiconductors *Japan*

SCJA-SVC-DP-9213 November 30, 1992

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online DQ Monday Report notes the differences in regional semiconductor prices.

By Dataquest's Regional Offices *Page 2*

Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

By Dataquest's Japan Office *Page 2*

Market Analysis

Soluble or Insoluble: The Patent Issue Facing the Photoresist Industry

This article analyzes the Japanese photoresist market in 1991 against the backdrop of a new patent covering a positive resist compound. It also discusses the patent's potential impact on the future market.

By Kunio Achiwa *Page 3*

Product Analysis

When Flash Memories Replace Rigid Disk Drives

This article reassesses the outlook for the flash memory market by focusing on changes in the market environment over the past year.

By Akira Minamikawa *Page 5*

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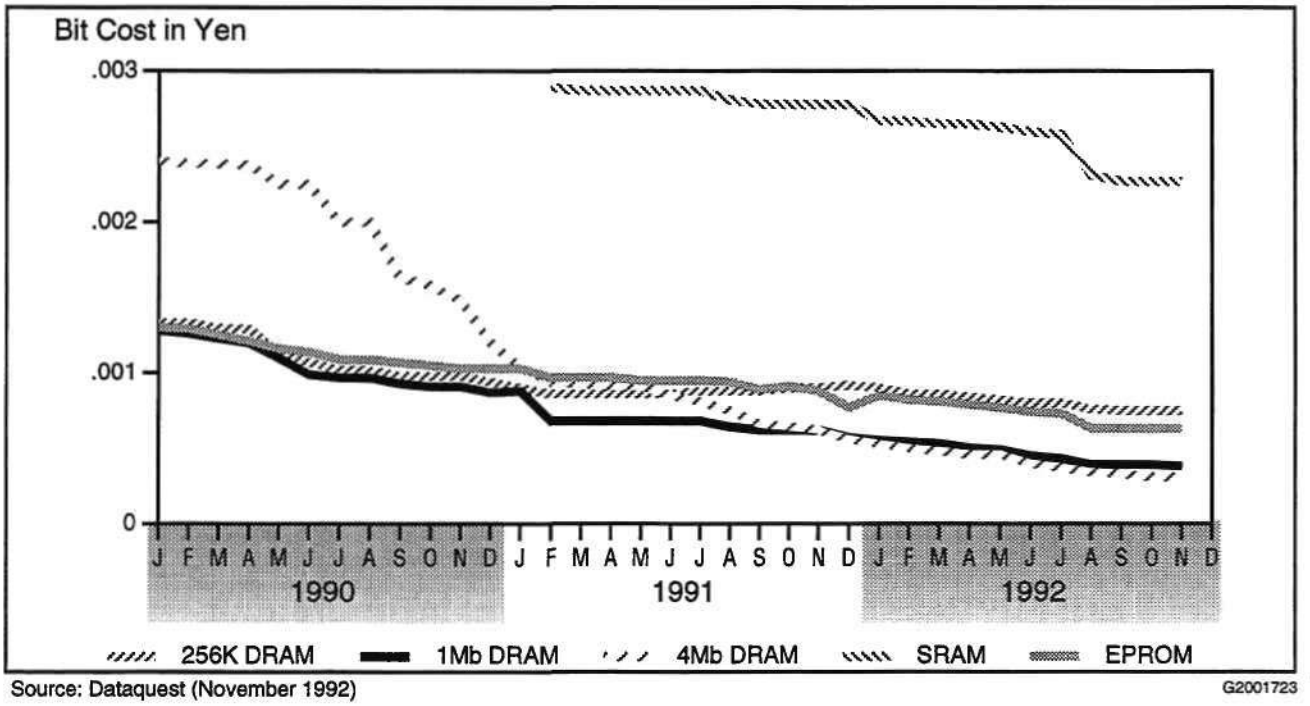
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Korea
DRAM 1Mbx1-8	3.05	2.97	3.30	3.00	2.65
DRAM 4Mbx1-8	11.75	9.99	NA	11.00	10.00
EPROM 2Mb, 170ns	6.25	6.01	4.30	NA	4.60
FLASH 1Mb	7.08	7.03	5.85	6.50	NA
FLASH 2Mb	13.18	13.27	13.50	NA	NA
SRAM 128Kx8-70	11.03	9.76	8.00	10.50	NA
SRAM 32Kx8-70	3.35	3.04	3.00	3.15	NA
SRAM 64Kx4-25	5.38	5.46	4.50	4.00	NA
VRAM 128Kx8-8	7.10	6.40	6.95	10.50	NA
68040-25	385.00	468.35	370.00	NA	NA
80386DX-40	49.00	93.67	85.00	52.50	74.00
80386SX-20	48.50	36.69	38.00	32.75	32.00
80486DX-33	326.50	312.23	350.00	315.00	304.50
R3000-25	90.00	93.67	80.00	NA	NA

Note: These figures correspond with the DQ Monday Report dated November 16, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (November 1992)

Memory Bit Price in Japan



Source: Dataquest (November 1992)
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Market Analysis

Soluble or Insoluble: The Patent Issue Facing the Photoresist Industry

In March 1992, a patent covering a positive resist compound was granted to its applicant, Tokyo Ohka Kogyo. As a result, all high-sensitivity and high-resolution positive photoresist for g-line now infringe the patent: Resist makers are prevented from producing and selling them in Japan, and semiconductor device manufacturers cannot use them. Because of its broad coverage, the patent has the potential to impact the entire semiconductor industry on a scale emulating that of the Kilby patent.

Japanese Photoresist Market in 1991

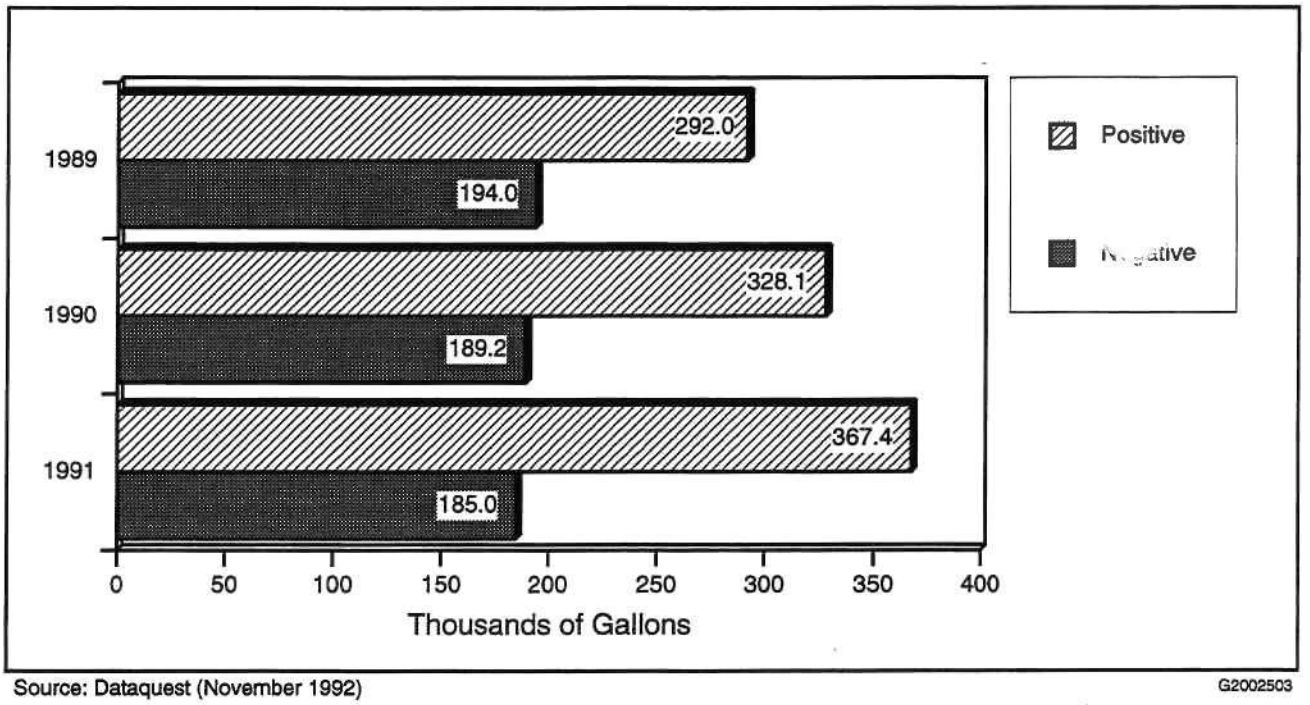
In 1991, the Japanese optical photoresist market for semiconductor applications reached 552,400 gallons (see Figure 1) and exceeded ¥20 billion on a value basis for the first time (¥20.6 billion). Positive photoresist registered a 12.0 percent increase over the previous year to 367,400 gallons and ¥18.6 billion; negative photoresist was down 2.2 percent, totaling 185,000 gallons and ¥2.06 billion. Notably, the entire market showed a 12.1 percent increase on a value basis, compared with a 6.8 percent increase on a volume basis, indicating increased market acceptance of the high-resolution resists that have brought higher added value to the industry.

Comparison of the industry's growth rate with related industries depicts another picture. Japan's semiconductor production in 1991 amounted to ¥3,960 billion, up 4.5 percent from the previous year. The growth pattern was about consistent with that of the photoresist market on a volume basis. Similarly, the Japanese silicon wafer market grew 5.4 percent in 1991 to 1.05 billion square inches. The relatively high rate of growth seems to reflect an increase in photoresist consumption because of the increase in the number of mask processes as a result of proliferating 4Mb DRAMs and other leading-edge devices. This more than compensated for decreased consumption because of reduction in the amount dispensed by coaters.

1991 Japanese Photoresist Market Share

Tokyo Ohka Kogyo continued to dominate both positive and negative resists in the 1991 Japanese photoresist market, with 61 percent and 62 percent share on a volume basis, respectively

Figure 1
Japanese Optical Photoresist Market for Semiconductor Applications



Source: Dataquest (November 1992)

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(see Table 1). In particular, the company recorded an 11 percent increase in sales of positive photoresist. Although Tokyo Ohka Kogyo lagged Sumitomo Chemical and Japan Synthetic Rubber at the startup of the i-line resist market, it successfully gained share in 1991 and is now competing with Sumitomo Chemical to be No. 1 in the market.

Japan Synthetic Rubber, ranked second in the entire market, also enjoyed a good year by expanding its positive photoresist sales by 10 percent. It boosted market share in high-resolution g- and i-lines, and is also active in development of photoresist for the next-generation excimer laser. Sumitomo Chemical also has strength in products for high-resolution g- and i-line processes. With NEC as its major customer, the company advanced to fourth place by shipping 20,000 gallons of positive photoresist out, an 89 percent increase over 1990. Because Sumitomo Chemical and Japan Synthetic Rubber are integrated chemical giants capable of producing raw materials for photoresist, and because they have sizable financial resources for product and process development, they can grow into formidable competitors against Tokyo Ohka Kogyo.

Another potential contender and integrated chemical maker, Mitsubishi Kasei, is in a position less favorable than the other two because it has diversified from sputtering target to photoresist and does not produce resist materials. Although its 1991 sales leveled off in the Japanese market, market share of its high-resolution g-line resists expanded overseas, particularly in Korea. Mitsubishi Kasei recorded a 35 percent increase in worldwide sales.

Finally, Nippon Zeon, a late entrant teaming up with Fujitsu, has successfully marketed ZPP-3200 and ZPP-5500 for 4Mb DRAM production, boosting its revenue from both positive and negative photoresist by 28 percent. An estimated 40 percent to 50 percent of the company's sales come from Fujitsu.

Photoresist for TFT-LCD

TFT's mask process has an average of five to seven steps and about 20cc of photoresist is consumed in each process, resulting in resist consumption of about 120cc per panel. Thus, there is large market potential, compared to semiconductor wafer processing. In 1991, 43,700 gallons of photoresist were consumed in the TFT-LCD process in Japan, equivalent to 8 percent of the photoresist market for semiconductor production. With an average sales price of ¥37,000 per gallon, TFT-LCD photoresist constituted a ¥1.6 billion market. Of that total, Tokyo Ohka Kogyo held an estimated 66 percent share, followed by Hoechst (14 percent), Shipley (12 percent), and Fuji-Hunt Electronics (8 percent). Other resist makers have also made entry, but their applications seem to be limited to TN-LCD and STN-LCD.

Table 1
1991 Japanese Optical Photoresist Market for Semiconductor Applications

	Positive Resist			Negative Resist		
	Shipment (Gallons)	Market Share (Percentage)	Revenue (¥M)	Shipment (Gallons)	Market Share (Percentage)	Revenue (¥M)
Tokyo Ohka Kogyo	224,000	61.0	11,200	115,000	62.2	1,180
Japan Synthetic Rubber	53,000	14.4	2,700	44,000	23.8	574
Fuji-Hunt Electronics	23,900	6.5	1,140	9,000	4.9	115
Sumitomo Chemical	20,000	5.4	1,160	-	-	-
Mitsubishi Kasei	14,000	3.8	742	-	-	-
Shipley	12,000	3.3	588	-	-	-
Nagase	8,000	2.2	376	11,000	5.9	134
Nippon Zeon	7,000	1.9	350	6,000	3.2	60
Hoechst	5,500	1.5	308	-	-	-
Total	367,400	100.0	18,564	185,000	100.0	2,063

Note: Sumitomo Chemical, Mitsubishi Kasei, Shipley, and Hoechst do not manufacture negative resist.
Source: Dataquest (November 1992)

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The New Patent and Its Potential Market Impact

Tokyo Ohka Kogyo's patent covers a positive photoresist compound featuring high sensitivity and excellent heat resistance without producing foreign matters over time when used as a solvent. Thus it is suitable for submicron processing of semiconductor devices including ICs and LSIs. This means that all high-sensitivity and high-resolution positive photoresist for g-line, using 2,3,4,4'-tetra hydroxy benzophenone ester, now infringe the patent and cannot be produced, sold, and used in Japan. Tokyo Ohka Kogyo, whose OFPR-800 and OFPR-5000 are protected by the new patent, already have sent a letter of warning to makers whose products allegedly infringe the patent. The company also reportedly has made the same warning to semiconductor device makers.

Dataquest Perspective

While Tokyo Ohka Kogyo's real intent in obtaining the blanket patent is not known, it bears serious implication for the photoresist and semiconductor industries. If the company uses the patent to force competitors out of photoresist production, it will adversely affect device makers using the products and is likely to alienate them. Certainly, this would not be a wise move for an industry leader boasting dominant market share. In fact, the company's 61 percent share in 1991 already dominates the Japanese positive photoresist market. It is by no means beneficial for the company to further increase the share, which would discourage competition, because the market is likely to suffer from the diseconomies brought on by the oligopolistic environment. This will undoubtedly work against healthy growth of the industry as a whole, as well as the company itself.

It is reasonable to assume that the company may want to collect royalties from its competitors, but Dataquest believes that the move may reflect its fear of losing future share to Sumitomo Chemical and Japan Synthetic Rubber because of the delay in the i-line resist market startup and the lack of its own source of raw materials. In this sense, the new patent will serve as insurance against an intellectual property claim by other companies, i-line companies in particular, allowing the company to use it as a powerful bargaining chip for cross licensing. Furthermore, the patent has the deterrent effect of fending off a real nightmare for the market leader; aggressive pricing strategy by competitors would trigger an endless price war and hit the company hard because of its high market share. Although the patent may prove to be an ace in the hole, Tokyo Ohka Kogyo cannot play the last card because the deterrent effect will work against device makers served by competitors. Under these circumstances, the likely outcome is that most competitors will enter royalty-based licensing negotiations with Tokyo Ohka Kogyo, while some with small market share may withdraw from the infringing product area.

By Kunio Achiwa

Product Analysis

When Flash Memories Replace Rigid Disk Drives

The first issue of *Dataquest Perspective* (October 28, 1991) analyzed the flash memory market and predicted that 4Mb or larger flash memories would replace magnetic storage of notebook and lower-end PCs by 1995, and that adoption by laptop and large models would not occur before the year 2000. The article also forecast that the market then would grow to a size emulating the EPROM market, but likely would not become a real threat to the DRAM market until 2000. One year later, in the midst of a sluggish semiconductor market, the industry still holds heightened expectations for the flash memory market.

This article reassesses the future of the flash memory market by focusing on the changes in the market environment in the past year.

1991 Flash Memory Market

In 1991, the worldwide flash memory market expanded by more than threefold over the previous year to ¥16 billion, or about $120 million (see Figure 1). Intel continued to hold a dominant 90 percent share, followed by Advanced Micro Devices, Atmel, and Toshiba. Intel is pursuing an aggressive price strategy for market expansion and is expected to maintain its position as the price leader for some time.

Although the sales ranking in the flash memory market remained largely unchanged, the climate surrounding flash memory changed significantly during the past year. Semiconductor makers rushed to introduce new products intended to replace magnetic storage. Apparently standardization of specifications for memory cards and market introduction of software products for the use of memory cards has spurred the use of

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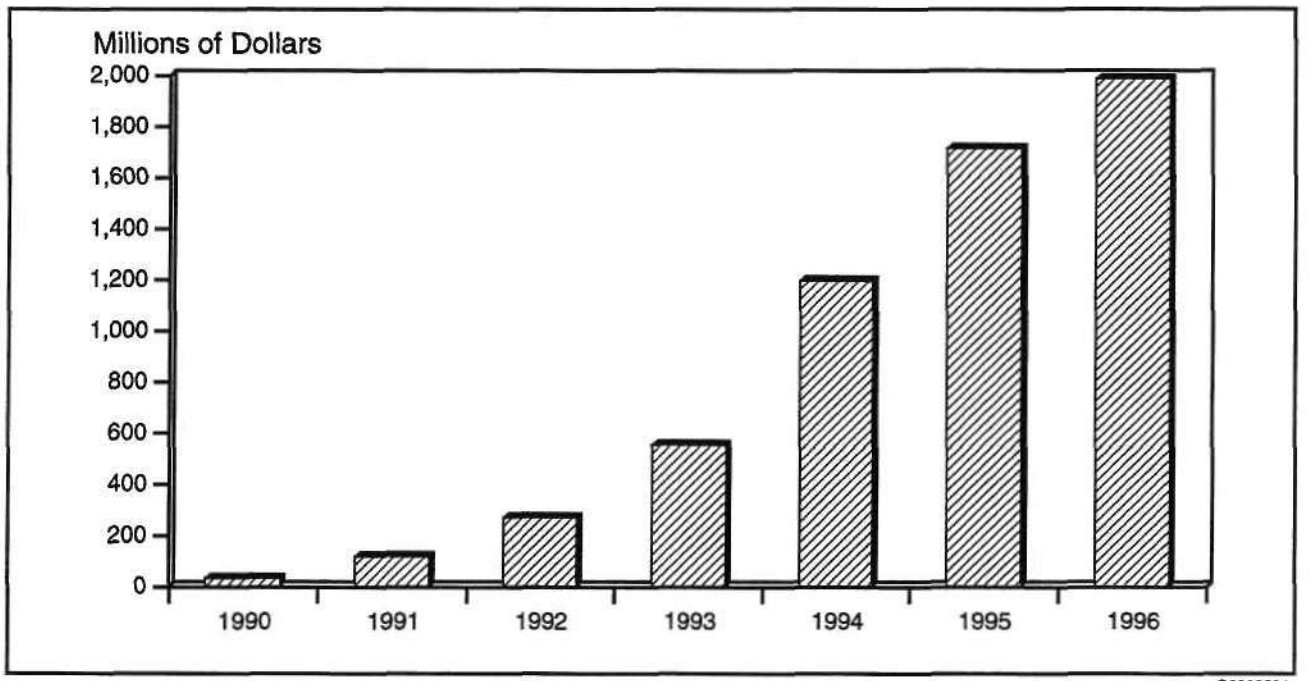
Figure 1
Worldwide Flash Memory Revenue Forecast



Source: Dataquest (November 1992) G2002504

flash memory in systems. Most recently, an MS-DOS-based flash filing system was developed jointly by Intel and Microsoft. The system performs data exchange between individual blocks of a flash memory, just like MS-DOS exchanges data between sectors on a magnetic disk, thus enabling users to use both a magnetic disk and a flash memory at their own selection by simply inputting appropriate MS-DOS commands.

Flash memory chips have been known to have limitations in the number of rewritings—one technological hurdle to be cleared if they are to replace magnetic storage. This limitation is because a thin SiO_2 film constituting the device deteriorates through the forcible passing of electrons in the rewriting process. However, improvement is under way; Microsoft has successfully incorporated into MS-DOS a feature to nominally boost the number of rewritings. Instead of erasing the entire chip or block to rewrite data, new data are written on vacant addresses while leaving an existing data file unerased. The process is repeated until data fill the entire chip, then important files are taken to an external buffer and all the data on the chip are erased before new data are written. Also, improvements are being made in other areas to overcome technical problems for accelerated proliferation.

Promising Markets

Major expected applications of flash memory are as follows:

- BIOS—To accommodate BIOS currently stored in EPROMs. This will eliminate the need for disassembly of systems at the time of renewing BIOS, enabling manufacturers to modify it at the last minute of shipment.
- DOS—To store DOS currently in the magnetic disk, thereby allowing the immediate startup of a computer.
- Memory card—To serve as a memory card to facilitate low-cost data exchange. Significant cost reduction compared to SRAMs, DRAMs, and EPROMs is expected.
- 1.8-inch hard disk—To form a module with the same form and function as the 1.8-inch hard disk. With IDE interface and plug compatibility, flash memory can directly replace the 1.8-inch hard disk. Intel has developed an IDE-compatible semiconductor disk jointly with Conner Peripherals, a leading disk maker.

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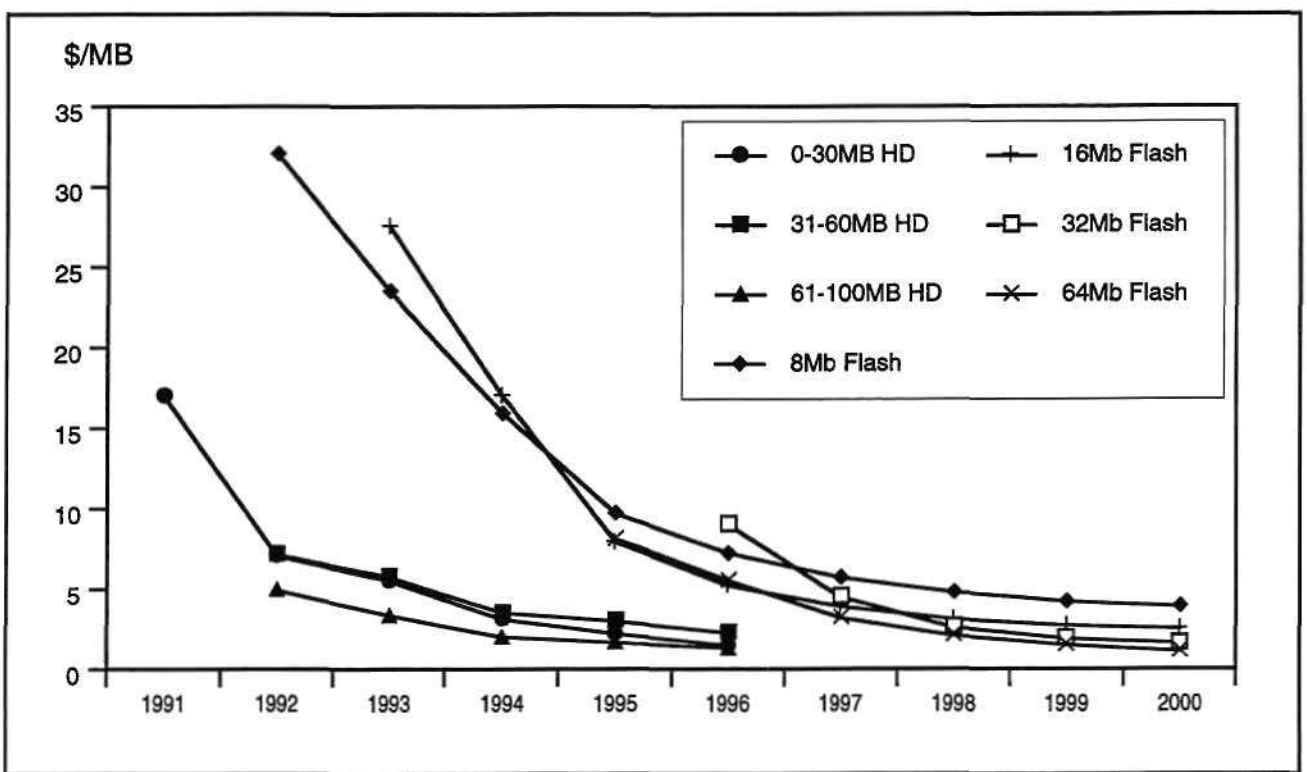
- Palmtop PCs—Use in palmtop PCs positioned between electronic organizers and notebook PCs. Microsoft has developed software to control power consumption in portable PCs. The memory capacity of external storage for portable PCs is expected to be 20MB at minimum and 40 to 60MB for standard systems. This allows manufacturers to allocate ¥10,000 to the 20MB memory (according to Dataquest's estimates, the typical price of portable PCs will be ¥90,000 in 1995). As a result, the per-bit price of flash memory will become close to 2.5 times that of 1.8-inch HDDs (31MB to 60MB) by late 1996 (see Figure 2). Until then, flash memory will mainly be used in small storage not in the range of HDDs.
- HDD—HDDs increasingly are used in facsimiles and printers, which are expected to form a prospective market for flash memory devices. Other potential markets for large-capacity nonvolatile semiconductor memory are digital audio and visual applications, including voice recording and replay, and still camera and other image recording media.

Dataquest believes that the flash memory market will expand through several stages. The first phase of replacement will occur in battery-backup SRAMs and DRAMs used for voice recording and replay, concurrently with replacement of EPROMs, EEPROMs, and OTP ROMs. Then flash memory will be used in place of rigid and floppy disks for miniaturization, faster operation, and weight reduction of computer systems. They will also offer an advantage in operation under unfavorable environments because of resistance to vibration and dust contamination. In particular, shock resistance can be improved significantly by using flash memory; SunDisk's semiconductor disk devices using flash memories withstand a 1,000g impact when not operated and 500g during operation. Unfortunately, makers cannot afford to reflect shock resistance as cost impacts on their products.

Rigid Cost Advantage

Dataquest believes that the per-bit cost of flash memory devices will not drop to a level close to that of HDDs until 2000. For instance, 5.25-inch

Figure 2
Bit Price Forecast: Flash Memory versus 1.8-Inch Hard Disks



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Source: Dataquest (November 1992)

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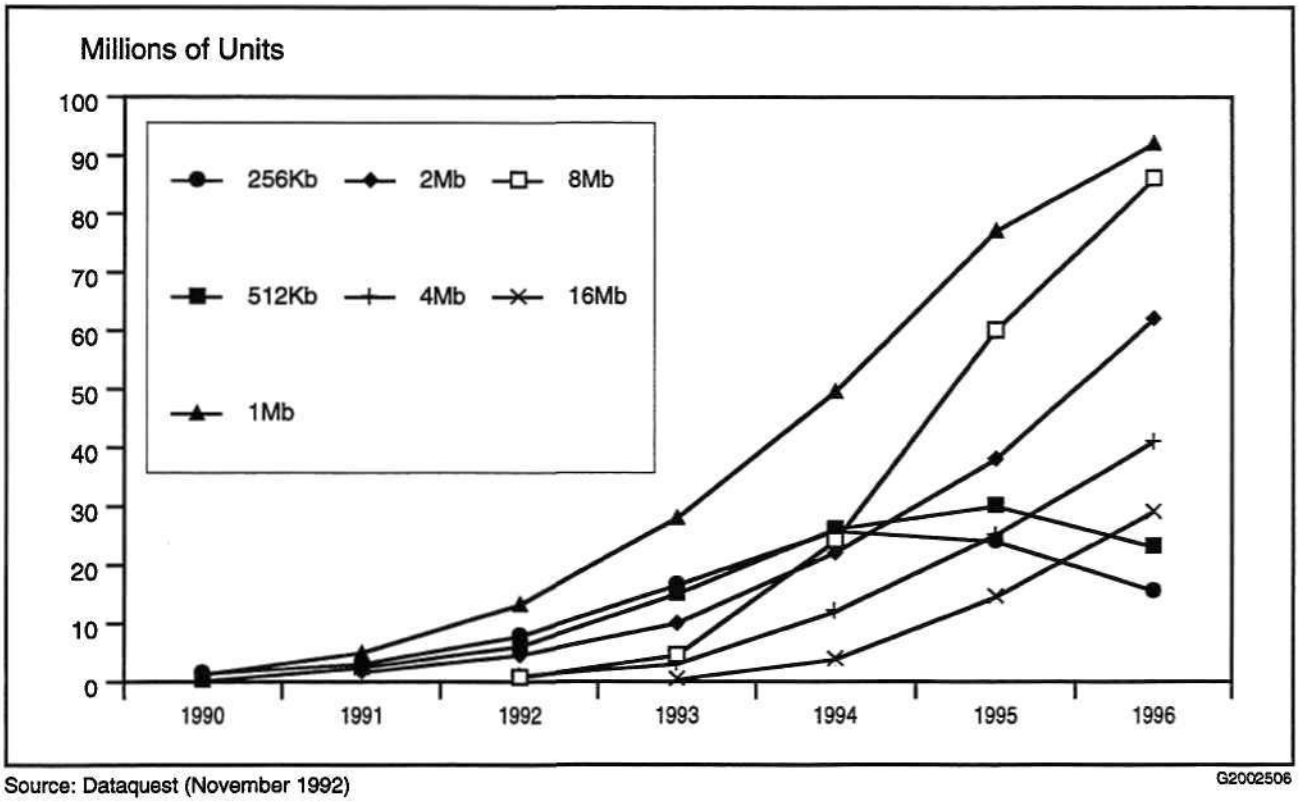
HDDs were introduced in 1980 with 5MB capacity ($180/MB). Then 10MB, 3.5-inch HDDs were announced in 1984 ($47.40/MB), and 20MB, 2.5-inch versions in 1988 ($14/MB). In 1992, Conner Peripherals announced 40MB, 1.8-inch HDDs ($7/MB). Thus market introduction of rigid disk drives with a halved size and a doubled capacity at four-year intervals seems to be the rule. Meanwhile, the per-megabyte price of 1.8-inch HDDs is expected to fall from below ¥2,000 at present to ¥400 in 1994, then to less than ¥100 in 1996. This is because the principal cost elements of HDDs are a motor, a magnetic head, an actuator for head positioning, and a rotation base, while a magnetic disk is a minor cost item. Thus 1MB or 40MB do not make much difference in cost, so that the per-megabyte price of HDDs declines rapidly with the increase in memory capacity.

Dataquest Perspective

In 1971, Intel developed DRAMs, which later replaced magnetic memory (core memory)—the defunct main memory of computer systems. Twenty years later, semiconductor makers announced flash memory devices targeted to replace a remaining foothold of magnetic memories—external storage. HDDs and other magnetic memory have been entrenched from the attack of semiconductor memories because of cost and nonvolatility advantages. Now flash memory seems to have overcome these obstacles. Although actual takeover has not occurred because of the still large cost differential, it will not be long before semiconductor devices reach their economies of scale to become cost-competitive with magnetic memories.

Dataquest predicts that the flash memory market will grow to about $2 billion in 1996 (the size of the EPROM market in 1989), following the $11.8 billion DRAM market and the $6.8 billion SRAM market. In addition, 16Mb and 64Mb devices will start to rapidly replace the 8Mb products that will dominate the market in 1996, because of the lower per-bit price that will be two-thirds that of DRAMs (see Figure 3). The present forecast shows that the typical price of 20MB flash memories in 1993 will be ¥55,000, which is still high for portable PCs.

Figure 3
Worldwide Flash Memory Unit Forecast



Source: Dataquest (November 1992)

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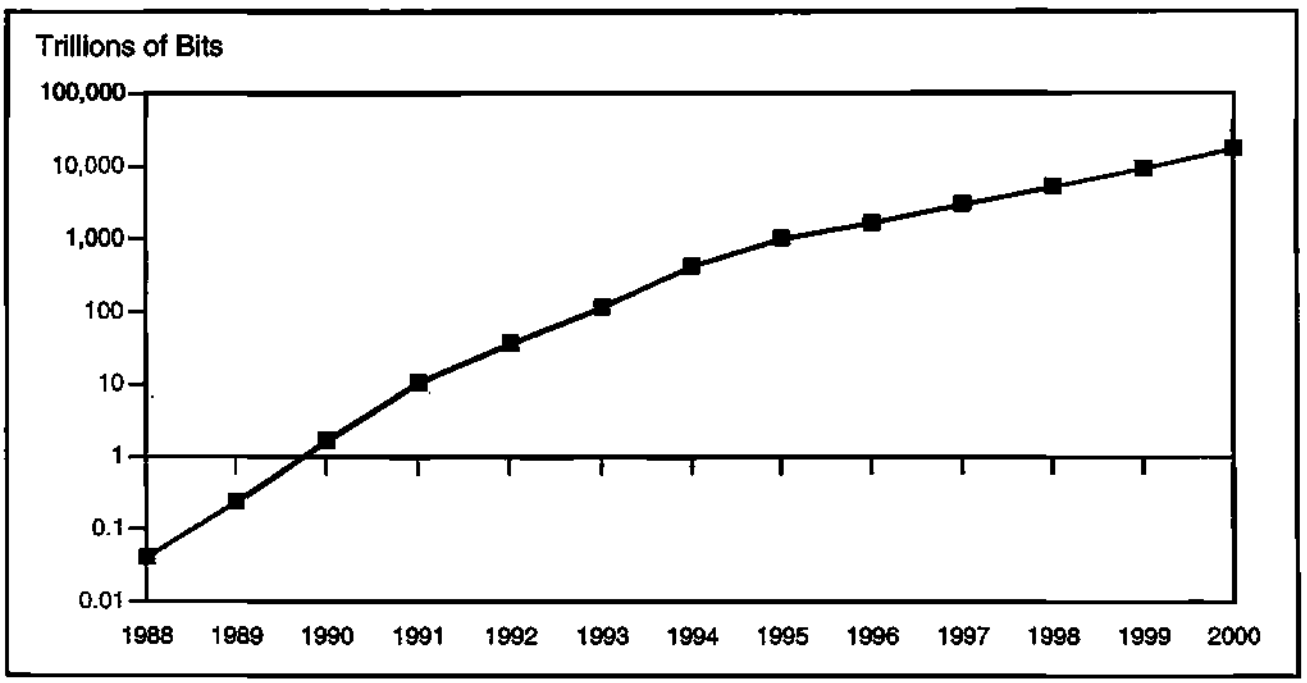
Figure 4
Worldwide Flash Memory Bit Demand Forecast



Source: Dataquest (November 1992)

Dataquest expects replacement of HDDs in portable PCs to start from 16Mb versions, and full-fledged adoption to be seen in 64Mb and larger products. Small systems increasingly are required to operate on battery, which demands increases in battery operating time and further miniaturization and weight reduction. Together with improved vibration resistance, these requirements make semiconductor disks a logical choice. Worldwide flash memory bit consumption is expected to reach 1,627 trillion bits in 1996 (see Figure 4), which is equivalent to the worldwide DRAM market in 1991. It will further grow to 17,000 trillion bits in 2000. Although the flash memory market offers much hope, more than 10 makers have already entered the competitive market and price wars are likely to intensify for market share before full-blown growth occurs. If this happens, flash memory will challenge the price competitiveness of makers to a degree seen in DRAMs, and will eventually become another commodity product with thin profitability.

By Akira Minamikawa

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese electronics company financial analysis
- Japanese semiconductor market forecast for 1993
- Japanese LD player market

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Semiconductors *Japan*

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the difference in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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Product Analysis

The Role of Japanese Manufacturers in the HDTV Industry

This article examines the Japanese HDTV market, which is about to enter the full-scale proliferation stage, and analyzes the potential roles of technologically leading Japanese HDTV manufacturers in the worldwide market.

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Market Analysis

Semiconductor Distributors' Roles: Issues Related to Distribution of Foreign Semiconductors in the Japanese Market, and Possible Strategies

This article analyzes market characteristics of foreign semiconductors and the roles of semiconductor distributors, with emphasis on current issues and future strategies.

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Japanese Semiconductor Alliance Update: The Third Quarter of 1992

Dataquest reports Japanese semiconductor alliance trends and analyses on a quarterly basis. We recorded 13 semiconductor-related strategic alliances during the third quarter of 1992.

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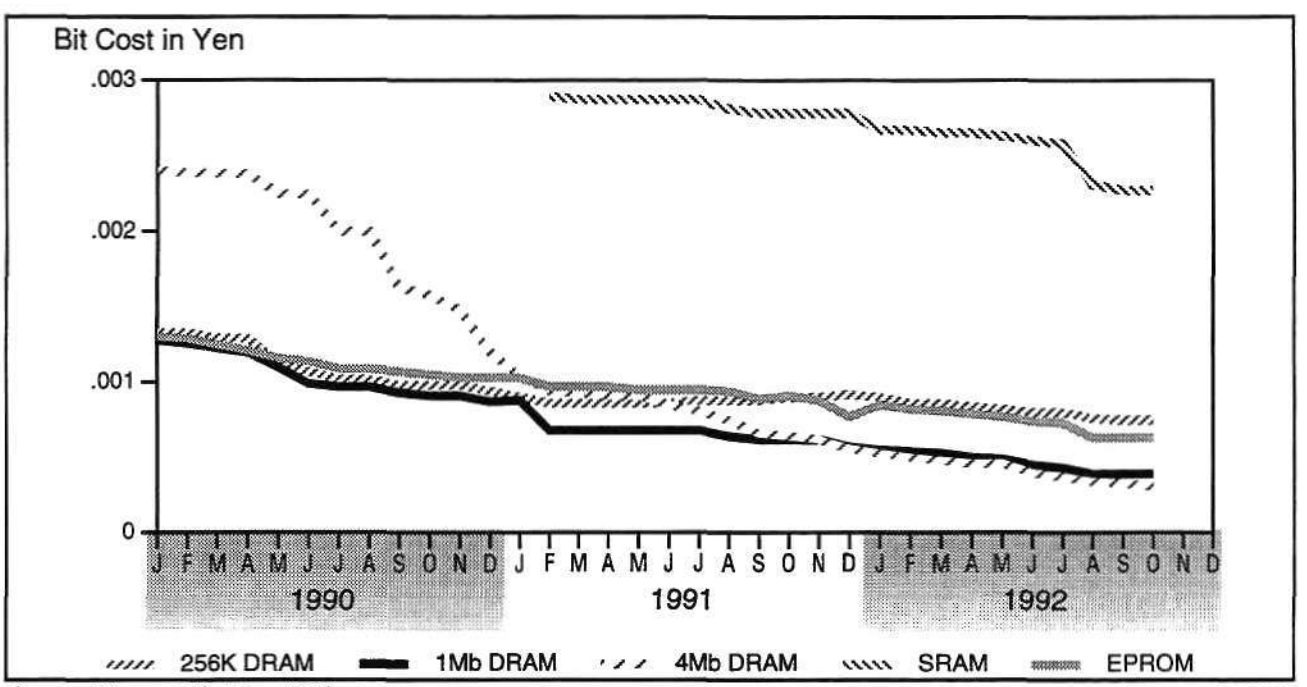
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe*	Taiwan*	Korea
DRAM 1Mbx1-8	2.98	3.22	-	-	2.65
DRAM 4Mbx1-8	10.28	10.46	-	-	9.60
EPROM 2Mb, 170ns	6.45	6.57	-	-	-
FLASH 1Mb	6.95	7.95	-	-	-
FLASH 2Mb	13.88	16.74	-	-	-
SRAM 128Kx8-70	10.90	10.05	-	-	-
SRAM 32Kx8-70	3.30	3.26	-	-	-
SRAM 64Kx4-25	5.30	5.86	-	-	-
68040-25	385.00	-	-	-	-
80386DX-40	-	-	-	-	74.00
80386SX-20	52.00	40.18	-	-	32.00
80486DX-33	204.00	326.50	-	-	-
R3000-25	93.00	100.46	-	-	-

*Data for Europe and Taiwan are not available this month. Look for updated data next issue.
Note: These figures correspond with DQ Monday Report dated October 12, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (October 1992)

Memory Bit Price in Japan



Source: Dataquest (October 1992)

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Product Analysis

The Role of Japanese Manufacturers in the HDTV Industry

Market share wars have already started in the HDTV industry, which holds promising technology for next-generation TV. The recent announcement of a low-cost model may have opened the door for HDTV sets priced below ¥1 million, and is forcing the market entry price of HDTV equipped with the second-generation MUSE decoder IC below the current market price of conventional MUSE decoders.

Dataquest believes that market acceptance of HDTV will accelerate following the scheduled launch of broadcast satellite BS-4 in 1997, when production of HDTV sets will reach 1 million units. HDTV also will replace recently proliferating large-screen TV sets at that time and boost the market to nearly 3.83 million units in 2000. Thus it seems that the Japanese HDTV market will ensure the success of the HDTV-compatible video equipment industry using indigenous "high-vision" transmission standards in the 21st century.

Meanwhile, other markets around the world are moving toward development of different HDTV systems, as if positioning themselves to refuse entry of the mighty Japanese manufacturers into their HDTV industries. The United States has adopted full-digital HDTV standards, and Europe has decided to go ahead with HD-MAC. Nevertheless, the Japanese HDTV industry already is one step ahead of its rivals and has plenty of time to catch up with whatever standards are established and commercialized. This scenario suggests that Japanese manufacturers may dominate the worldwide HDTV market, as they do with other consumer electronic equipment.

This article examines the Japanese HDTV market, which stands at the threshold of full-scale proliferation, and analyzes the roles that technologically leading Japanese HDTV manufacturers may play in the worldwide market.

The General Picture of HDTV Systems and Markets

HDTV differs from conventional TV sets and similar displays in that it produces high-resolution pictures by using 1,125 scanning lines, both in animated and still pictures—a major factor in the high expectations held for the industry. HDTV promises a wide array of applications. A prime example of the full cultivation of HDTV's potential is its ability to show a detailed image of human tissues and organs for doctors, thereby contributing to the success of surgical operations. Other applications for HDTV's high-resolution pictures include PC display units and teleconferencing systems. Nevertheless, HDTV manufacturers see consumer electronics as the core market. HDTV's immense market potential is obvious when the current number of color TV sets is considered; such a market is attractive to the electronics and related industries.

In contrast to these promising factors, the HDTV industry must clear hurdles related to the following issues before it can enjoy a full-fledged market:

- Transmission standards
- Software supply
- Evolution of HDTV systems and shift of generations
- Market direction

In the following paragraphs, we analyze these factors to determine the market's direction and possible development.

Transmission Standards

Japan, the United States, and Europe each have established HDTV broadcast transmission standards. Adoption of these respective standards strongly reflects each country's political consideration of HDTV's market potential and major opportunities for each region's electronics industry and economy. In particular, the U.S. and European governments maintain the position that such political consideration is needed to correct trade imbalances and to ensure domestic market-driven growth of their industries. The different standards likely will prevail, at least until the actual HDTV market takes shape.

In Europe, where Philips, SGS-Thomson, and Nokia are developing HD-MAC-based HDTV products, each country holds increasingly different expectations and positions toward the HDTV market. Furthermore, discord has become noticeable between manufacturers and committees

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organized by governments. The committees have questioned the manufacturers' ability to develop HDTV into a key industry, while the manufacturers have criticized the committees' lack of cooperation and assistance. Clearly, this bodes ill for the future of the European consortium, which has managed to agree on concerted efforts.

Development of full-digital HDTV is under way in the United States, which hopes to lead the worldwide market, but commercialization—including actual broadcasting—is a long way off. Furthermore, even if commercial products are developed, the weakened production base of U.S. manufacturers may not be able to meet burgeoning demand.

Software Supply

Market acceptance of HDTV largely is affected by the quality of software products and their timely supply. HDTV's major features, notably cinema-quality pictures produced by a 16:9 aspect ratio (the proportion of the vertical to horizontal side of a TV screen) and high resolution, would fit applications such as movies, music programs, and certain types of documentaries. There is high consumer demand for movie programs using HDTV software in the United States and Europe. In Japan, which is expected to become the first full-fledged HDTV market, software is a determinant factor in promoting proliferation. At present, "high-vision" TV is broadcast via the BS-3 satellite for 8 hours a day. Japanese marketers await the scheduled 1997 launch of the BS-4, after which all channels will be allocated to broadcasting stations and broadcast time will be gradually increased to eventually provide extensive service emulating conventional TV services. This fact suggests that HDTV cannot appeal to the general public by the efforts of equipment manufacturers alone; it requires the full support and commitment of broadcasting corporations as software providers.

Evolution of HDTV Systems and Shift of Generations

Wide-vision TV and EDTV have been developed and positioned as commercial products to bridge the gap between current NTSC TV and HDTV. In particular, wide-vision TV, considered the springboard for HDTV proliferation, may establish its own market and threaten existence of HDTV—if HDTV software is not produced in pace with hardware development and terrestrial broadcasting continues to maintain its popularity. Full-specification and simplified HDTV models increasingly will compete with each other. This competition is a double-edge sword: although it spurs market expansion, it exerts price pressure on equipment manufacturers and thus erodes profitability. In particular, the simplified system likely will undergo cost reduction in the decoder. Makers focusing on the product segment are expected to initiate major price cuts for market expansion and higher market share (see Figure 1).

Market Direction

Market share wars will intensify among current NTSC large-screen-TV sets, wide-vision TV receivers, and newly introduced wide-vision TVs equipped with MUSE-NTSC converters and EDTV equipment until 1997, when operation of the BS-4 satellite is expected to trigger real growth of the HDTV market. But there is a question of whether market entry of these products can be conducive to burgeoning of the HDTV market—as the next-generation TV—and the HDTV-related video equipment market.

The average product life of consumer electronic equipment offered by Japanese makers is said to be one decade. In other words, it takes a decade to have trade-up demand for major consumer electronic products. This dictates market introduction of HDTV products timed to meet demand to replace large-screen TV sets, proper development of TV receiver demand in a direction favorable to HDTV in the next five years, and a supply schedule of market-acceptable VCRs that needs to begin in the late 1990s to serve the purpose of establishing the high-vision TV age after 2000.

Another prerequisite to sustained growth of the HDTV market is to assure consumers that VCRs purchased in the late 1990s will become the core equipment of high-vision TV systems in the 21st century. Dataquest believes that it is important to market with a long-term viewpoint; introduction of products to secure immediate market share would distort a direction of market growth.

HDTV Production Forecast

Sharp's announcement of a ¥1 million HDTV model with simple specs in April triggered "Sony shock," and Sony introduced a full-spec

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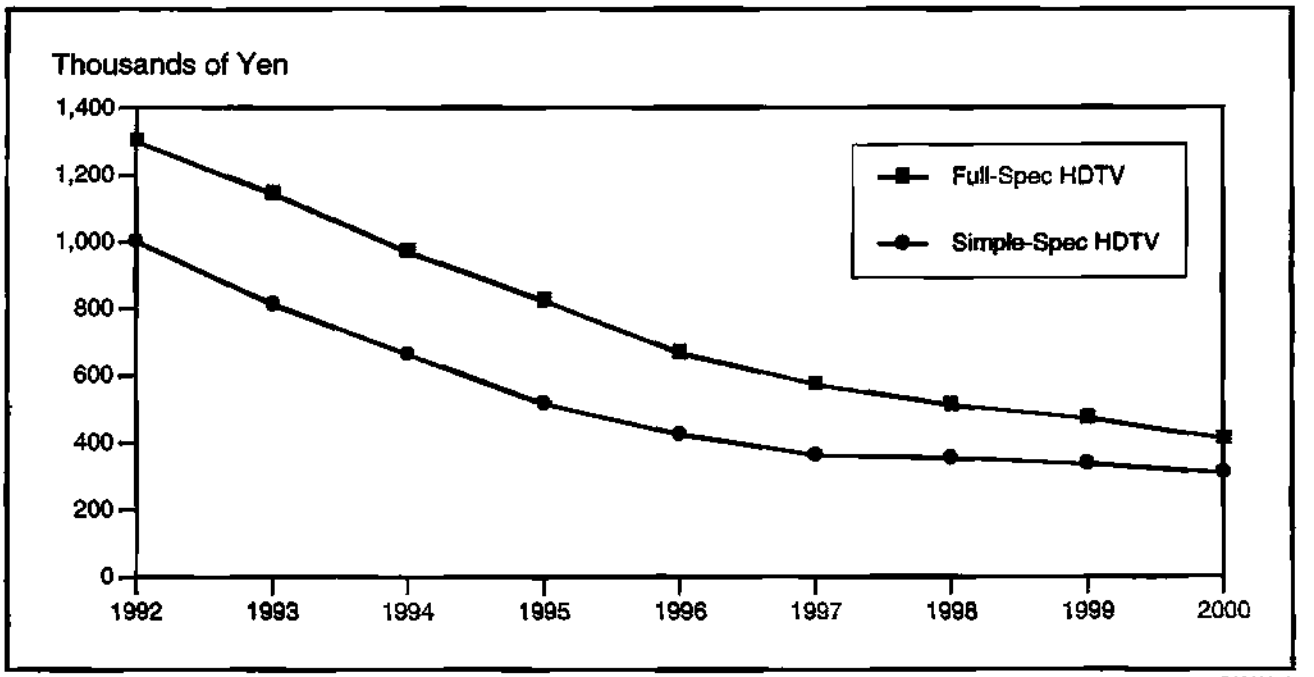
Figure 1
Average Selling Price Forecast for HDTV



Source: Dataquest (October 1992)
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model at ¥1.3 million, half the price of similar models a year ago. The move reflects manufacturers' new marketing strategy to instigate price wars in an attempt to establish a brand image of their own products by capitalizing on the Olympics (this is perceived as the first year of the HDTV age). As a result, HDTV production is expected to reach 10,000 units in 1992.

Nevertheless, prices are still lofty and demand is not likely to grow without much stimulus. Dataquest believes that the stimulus will come in 1996, which is the next year for the summer Olympics and one year before launch of the broadcast satellite. These factors will provide incentives for HDTV makers to seek market share in the wake of growing market opportunities. Because the ¥1 million model introduced this year has helped to make HDTV relatively affordable to consumers, announcement of models with lower price tags is conceivable in 1996. Dataquest predicts that sales prices will decline to ¥600,000 for full-spec models in 1996 and to ¥400,000 for simple-spec models, with respective compound annual growth rates (CAGRs) of negative 16 percent and negative 12 percent between 1995 and 2000. Production on a unit basis also is expected to increase at a CAGR of 148 percent between 1992 and 1996 (see Figure 2).

The full-fledged HDTV market will emerge following launch of the BS-4 in 1997 and development of software products. As a result, production will grow rapidly at a CAGR of 64 percent between 1996 and 2000, reaching 1.68 million units in 1998 and 3.38 million units in 2000, which is equivalent to the current size of large-screen TV sets (25 inches or larger). On a value basis, production will reach ¥496 billion in 1998 and near ¥1 trillion—¥939.9 billion—in 2000 (see Figure 3).

Another factor with significant impact on growth of the HDTV market is competition between full-spec and simplified models. Present major cost differences between the two types lie in the decoder; the number of circuits also is reduced in the simplified system, which lowers the cost. There will be little demand for still pictures at home during start-up of the HDTV market, when software and peripheral markets are at the infancy stage. This gives a clear competitive edge to the low-price simplified system, which is expected to serve as a market driver. Thus Dataquest expects the simplified system to contribute greatly to market growth. At the same time, aggressive pricing of the simple-spec models may trigger steady price declines in all types of HDTV, causing some manufacturers—those focusing on full-spec products in

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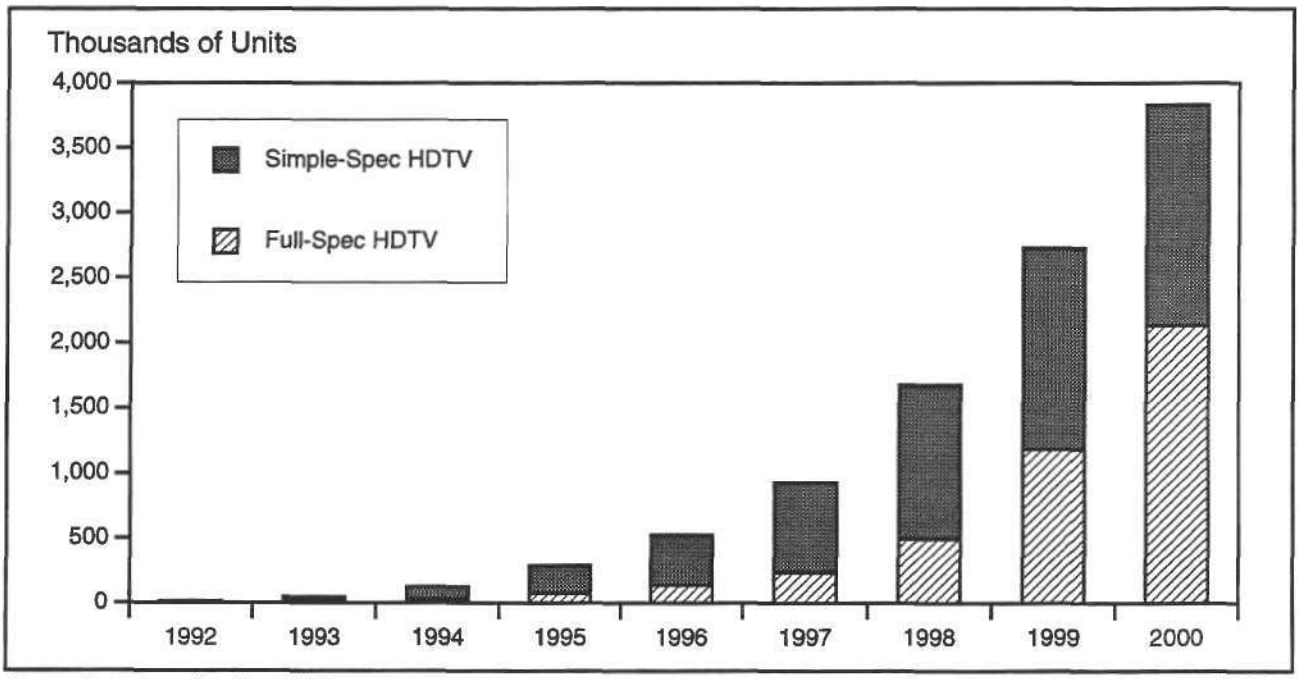
Figure 2
HDTV Production Forecast, Unit Basis



Source: Dataquest (October 1992)
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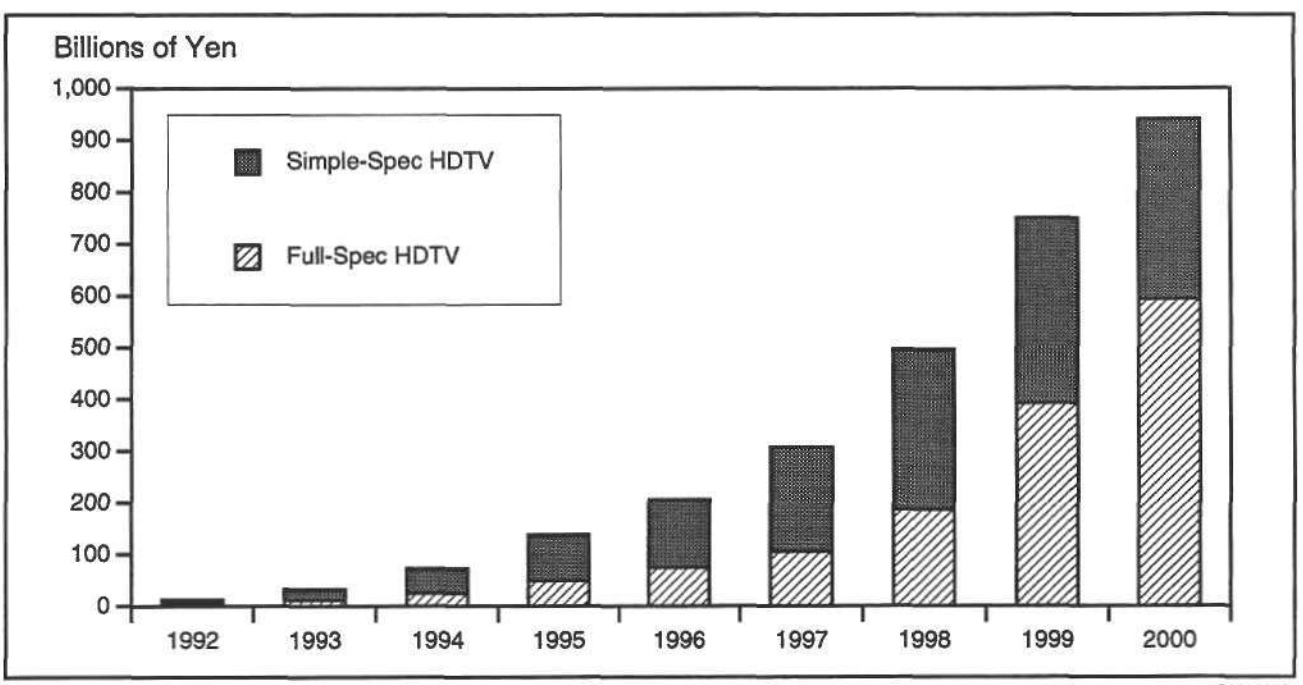
Figure 3
HDTV Production Forecast, Value Basis



Source: Dataquest (October 1992)
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particular—to lose profitability before enjoying economies of scale. HDTV makers will need accurate readings of the changing market environment, and flexible responses. Dataquest believes that this will encourage makers to offer a full lineup of simplified to full-spec types.

HDTV Cost Analysis and Semiconductor Consumption

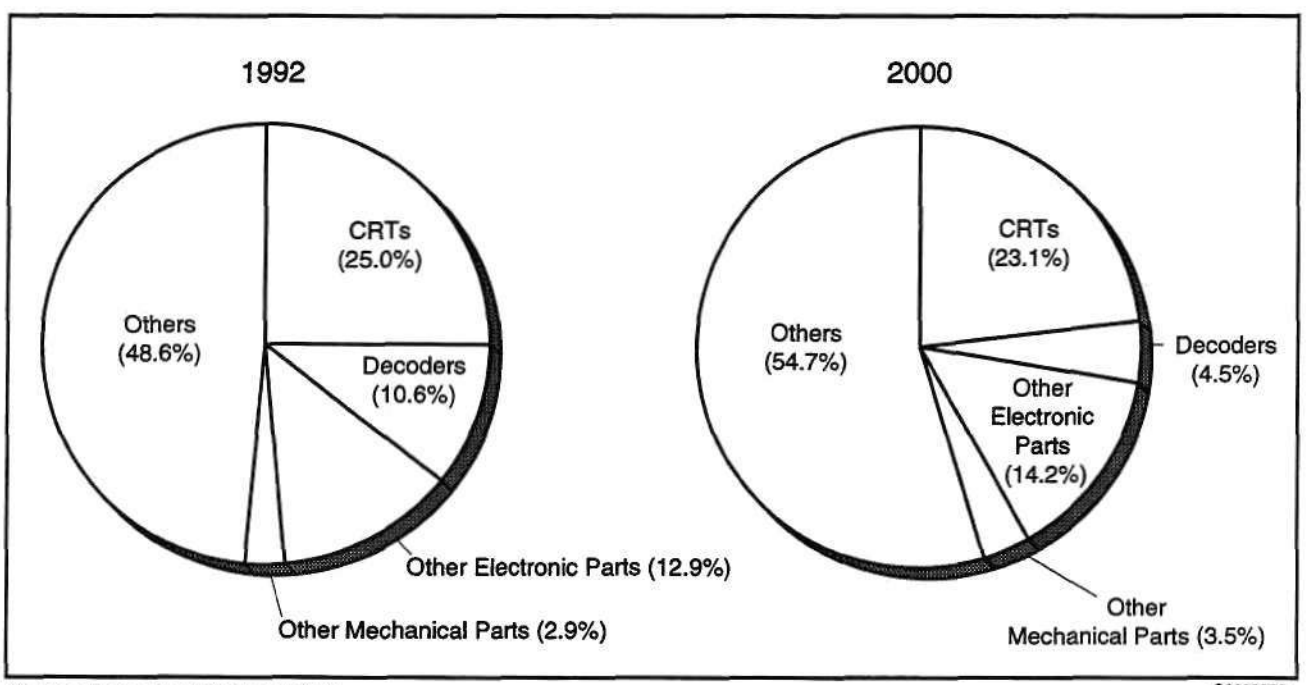
Undoubtedly, the HDTV market will create major demand for VCRs and semiconductors, for two reasons. First, unlike conventional TV receivers, HDTV systems require an array of signal-processing circuits including VHF, UHF, and BS tuners, a MUSE decoder, and a MUSE-NTSC converter. Second, as the worldwide DRAM production base, Japan can expect major memory demand for still-picture processing units of MUSE decoders, which each would consume 12 to 20MB of DRAM.

Because of the increased power consumption and power units required for major circuits, there are other applications for consumer semiconductors. Dataquest estimates that the MUSE decoder unit accounts for 10.6 percent of the simple-spec system and 23.8 percent of the full-spec system (see Figures 4 and 5). The CRT unit represents 25.0 percent and 18.1 percent, respectively.

These cost structures are not likely to change significantly. As a result, reduction of the CRT cost will be a key to maintaining competitiveness of the simple-spec models. Chances are that makers will vie for market share in order to enjoy economies of scale (see Figure 6). On the other hand, the full-spec system requires additional cost reduction for the MUSE decoder unit. The simple-spec system will help the full-spec system to achieve cost reduction for the CRT unit by boosting the overall HDTV market size, without undue price competition, while the simple-spec system may take some market share from the full-spec system prior to the start of full-scale commercial HDTV broadcast. In this sense, the simple-spec system would serve as a market precursor paving the way for proliferation of the advanced system.

To maintain competitiveness, the full-spec system also must keep the price differential at about ¥100,000, thus requiring significant reduction of the decoder cost. This will not be beneficial to HDTV or semiconductor makers and presents the risk of impeding sound market formation. One incentive for these makers is

Figure 4
Cost Contribution for Simple-Specification HDTV



Source: Dataquest (October 1992)

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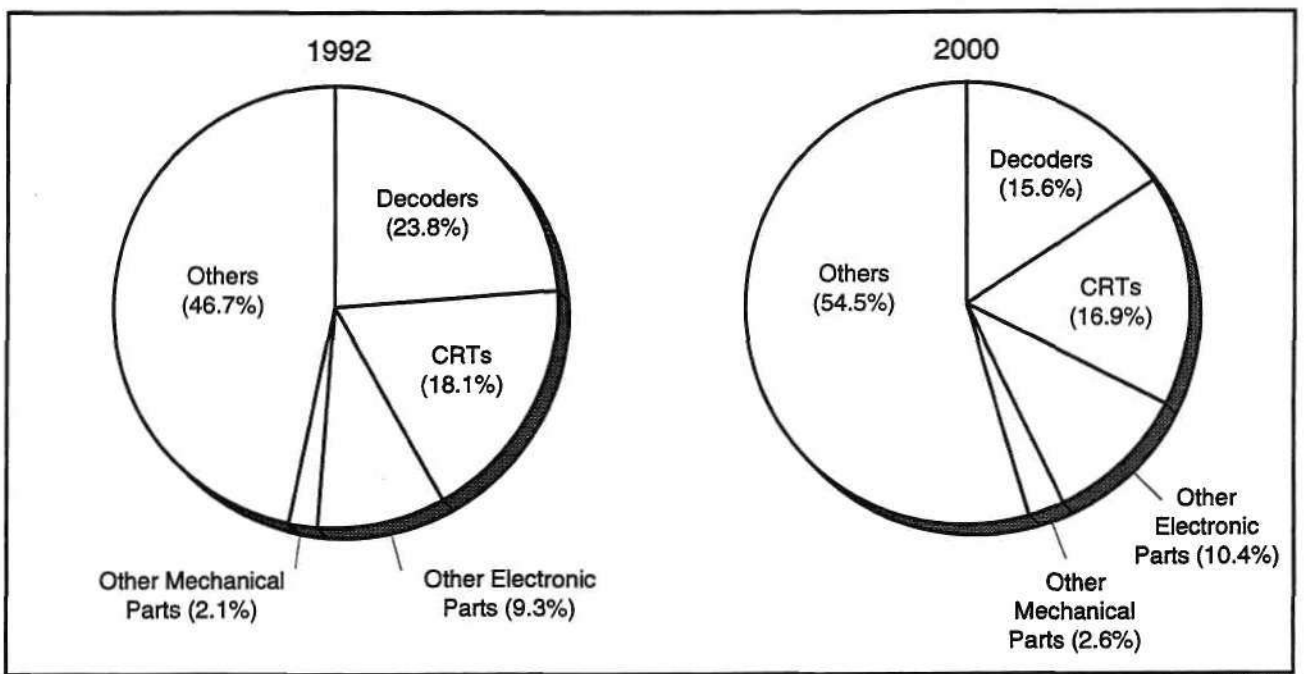
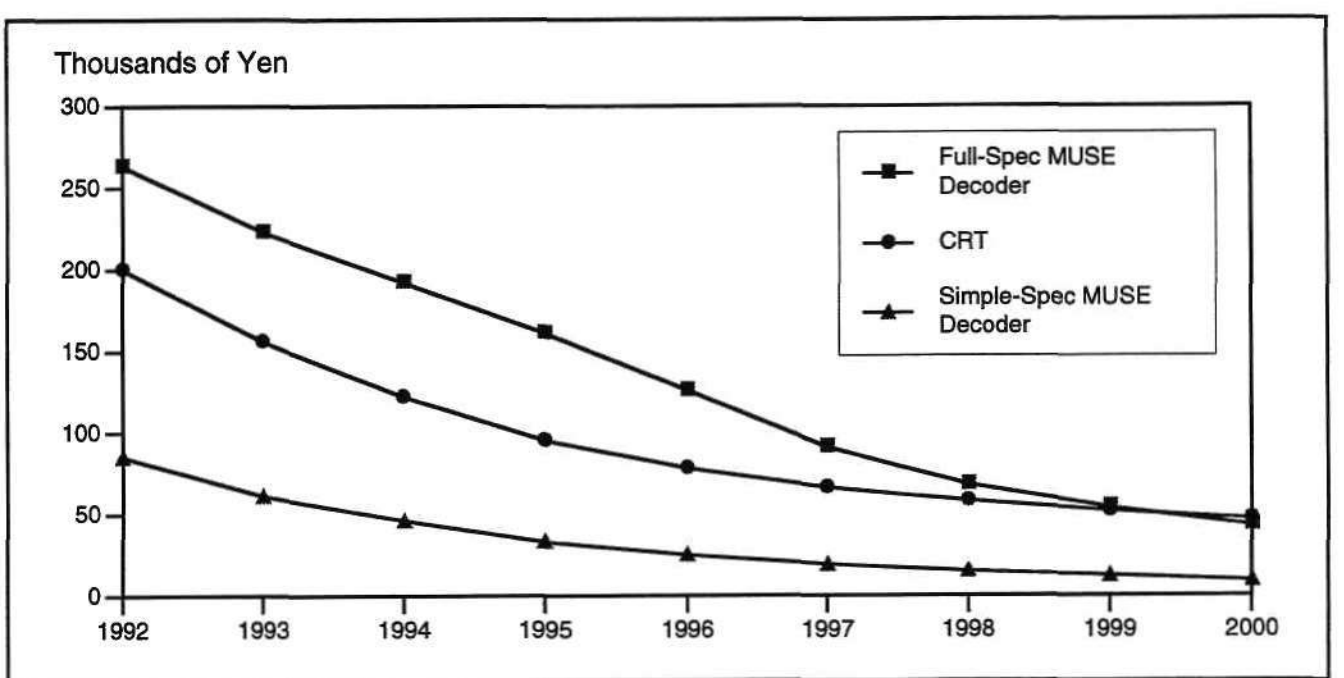
Figure 5
Cost Contribution for Full-Specification HDTV



Source: Dataquest (October 1992)

Figure 6
HDTV Parts Forecast



Source: Dataquest (October 1992)

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market share, which can be gained by focusing on post-CRT HDTV markets, including the projection type and VCRs equipped with MUSE decoders.

Dataquest estimates that semiconductor consumption in the HDTV market was ¥1.9 billion in 1992. This total is relatively large for the first year of the HDTV age because HDTV systems are not simple TV receivers and the MUSE decoder unit is costly because of leading-edge ASSPs. In today's market, the MUSE decoder unit comprises second-generation MUSE decoder LSIs. Its product life seems assured through the end of the century, for the following reasons:

- HDTV production trends indicate delayed recovery of development cost.
- The MUSE decoder unit has achieved a certain level of miniaturization in relation to the volume of TV receivers, with diminishing benefit from further size reduction.
- Annual HDTV production of 500,000 units represents monthly demand for each type of decoder IC equivalent to 100 wafers.

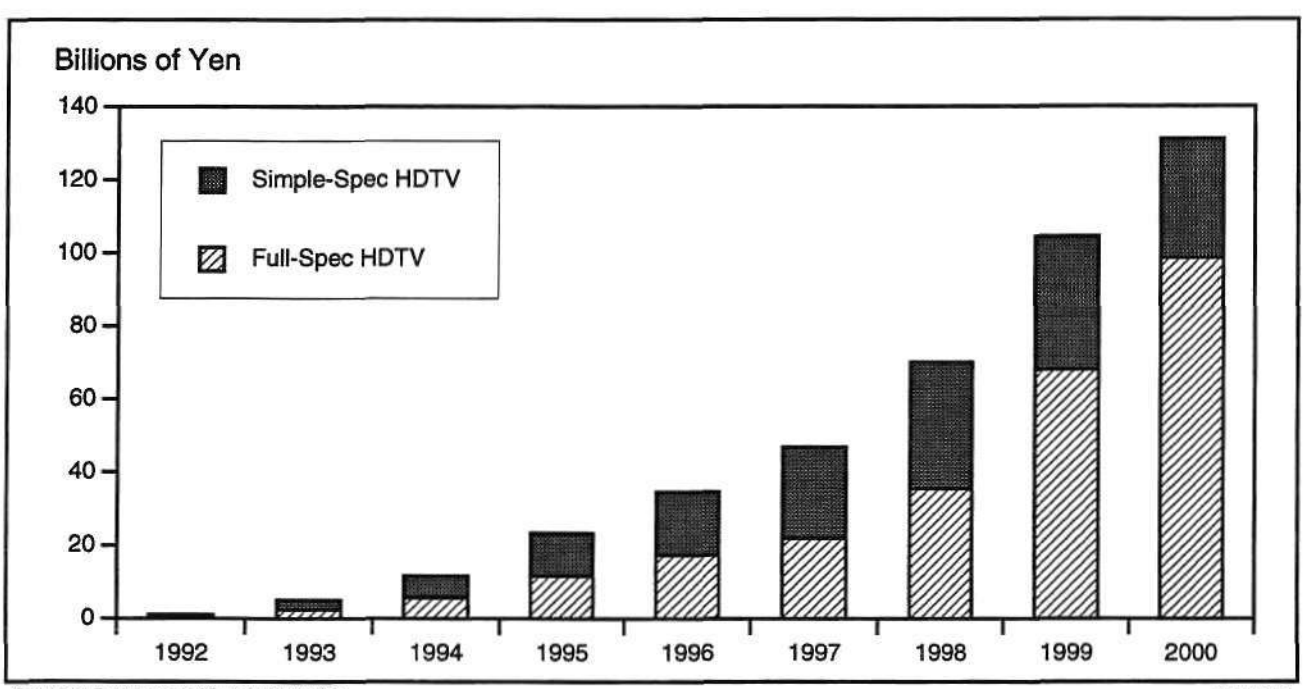
Dataquest expects semiconductor consumption in the HDTV market to be about the same size for both the full-spec and the simple-spec systems to 1998 (see Figure 7), when each system will consume about ¥35 billion worth of semiconductors. Then the full-spec system will drive the market—as seen in production trends—whose overall size will reach ¥131.1 billion in 2000.

Dataquest Perspective

Positioning of HDTV in the Japanese VCR Equipment Market

HDTV is likely to replace current NTSC TV sets, but various factors such as wide-vision TV sets and the required move from terrestrial to satellite broadcasting will inhibit smooth shifting of generations. Yet Dataquest believes that HDTV offers products with sufficient marketability to check the hollowing of Japanese electronic equipment and semiconductor manufacturers, which is expected to occur by the end of the century. As a result, HDTV production in Japan will grow to ¥939.9 billion in 2000, of which semiconductors will account for ¥131.1 billion—a figure that represents significant contribution to the semiconductor industry. At the same time, HDTV will create new demand for VCRs, video disks, and video cameras with aspect ratios of 16:9. New

Figure 7
Semiconductor Consumption Forecast for HDTV



Source: Dataquest (October 1992)
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demand for VCRs will be near that of video equipment production, ¥3.43 trillion in 1991, as trade-up demand for the 16:9 screen enters a full-growth stage.

Japanese Makers in the HDTV Industry

Delay in development of proprietary standards in the United States and heightened discord between European governments and makers have already caused these regions to lag Japan in formation of the HDTV market. Even if U.S. makers successfully develop and commercialize full-digital HDTV with technological edges over current MUSE and HD-MAC systems, Japanese makers will be able to maintain worldwide dominance because of production technology and product control know-how accumulated throughout the period. Japanese makers are considered to be five years ahead of other makers in HDTV hardware, including CRTs, thus they are in a good position to lead the worldwide HDTV industry. It is likely that Japanese makers will win a sizable market share if components are included. However, if they treat the new market as one for major worldwide export, they will invite the same trade issues existing today. In the new international order following the end of the cold war, Japanese makers will have to determine the role they will play in the worldwide market and take initiative in solving the various issues facing them.

The electronic equipment industry thus far seems to have offered numerous and lucrative market opportunities for Japanese makers with strength in hardware production. However, it has become apparent that this made sense only when hardware and software suppliers were clearly differentiated and hardware requirements led software technology. In the coming multimedia age, software and hardware will become closer and the boundaries between them will blur, making the conventional hardware-oriented industrial structure difficult to keep alive. If Japanese makers insist on their present strategy, products developed through huge investment will face price wars because they will be mere commodity devices running proprietary software developed by others. The Japanese makers could even reverse roles and become "subcontractors" for captive makers.

Similarly, worldwide export of electronic equipment such as VCRs and video cameras has contributed greatly to establishing Japan's position as a world-class production base, and to robust growth of its economy. However, the accumulating trade surplus only attracts criticism and provokes protectionism in other countries. If Japanese makers choose to contribute to the worldwide economy and the international community only as product suppliers, the gap between Japan and the rest of the world inevitably will widen. After all, the HDTV industry is the important first step toward development of the next-generation electronic equipment industry, led by multimedia, LCD, and full-digitization technologies.

If Japanese consumer electronics makers are to lead the worldwide HDTV industry, Dataquest believes that they must assume an important role: help direct sustainable growth of the industry on a global basis as well as foster balanced HDTV markets and makers in each region.

By Naotoshi Yasuhara
Kun Soo Lee

Market Analysis

Semiconductor Distributors' Roles: Issues Related to Distribution of Foreign Semiconductors in the Japanese Market, and Possible Strategies

In 1991, the worldwide semiconductor market reached $59.7 billion. The Japanese market accounted for 37.7 percent of this total, or $22.5 billion, and became the largest semiconductor consumer. Analysis of semiconductor distribution routes in Japan shows the important role of distributors, who accounted for about 40 percent of the total. Foreign-made semiconductors also have steadily increased their market share in recent years as foreign semiconductor makers have penetrated the Japanese market; 60 percent are now sold through distributors.

This article analyzes market characteristics of foreign semiconductors and the role of semiconductor distributors, with emphasis on current issues and future strategies.

Foreign Semiconductors in the Japanese Market

In 1991, the Japanese semiconductor market totaled ¥3,060 billion, of which foreign-made

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semiconductors accounted for 14.0 percent, or ¥429.6 billion (see Figure 1). Of the 14.0 percent, the top five U.S. semiconductor makers—Texas Instruments, Motorola, Intel, National Semiconductor, and Advanced Micro Devices—accounted for 62.5 percent, or ¥268.3 billion. In 1986, foreign semiconductors held a meager 8.5 percent share (¥167.7 billion) of the ¥1,980 billion market, and U.S. top five makers accounted for 69.2 percent (¥116.1 billion). Thus, foreign semiconductors recorded an annual compound growth rate (CAGR) of 20.7 percent during the past five years, which was far above the 9.1 percent CAGR of the Japanese semiconductor market. Foreign makers other than the U.S. top five recorded an impressive 25.6 percent growth supported by semiconductor distributors, who account for about 60 percent of the foreign semiconductors sold in Japan. These data indicate that the strong sales growth for foreign makers in Japan largely comes from distributors and their capabilities.

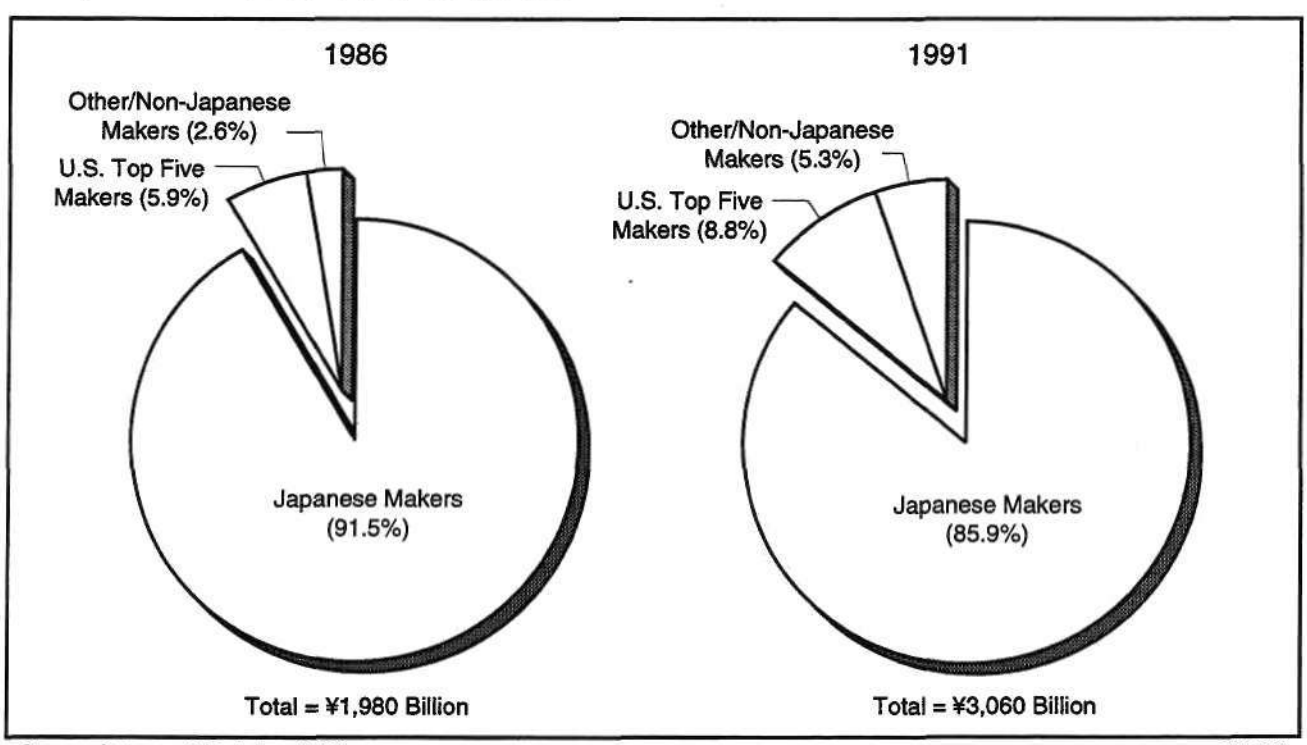
Analysis of Distributors Handling Foreign Semiconductors

Japanese semiconductor distributors are divided into distributors keeping close ties with particular semiconductor makers and independent distributors without any particular relationship. Foreign semiconductors, with few exceptions, are marketed mainly by independent distributors, many of whom are small in size compared to affiliated distributors. Measured by annual sales, only two independent distributors—Tokyo Electron and Marubun—ranked among the top 10 semiconductor distributors (see Table 1). However, sales ranking does not necessarily reflect the sales activity of independent distributors with strength in particular product segments. The following sections summarize the contribution of independent distributors to sales of foreign semiconductors by major product segment.

Microprocessors

Foreign products hold a high share of the microprocessor segment of the Japanese market. In 1991, they accounted for 71.1 percent (¥59.6 billion) of the total market size of ¥83.8 billion. The 32-bit MPUs supplied by Intel, AMD, and Motorola—the 80X86 and 68000 families—in particular dominated the Japanese market. These sales by foreign manufacturers included direct sales by the three companies, but also contributing were sales agencies including Tokyo Electron,

Figure 1
Non-Japanese Market Share in Japan, 1986 and 1991



Source: Dataquest (October 1992)

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Table 1
1991 Estimated Japanese Distributors Sales Ranking

	Company	Product Lines	Revenue (Billions of Yen)
1	Ryosan	NEC	101.8
2	Ryoyo Electro	Mitsubishi Electric, Intel, Hewlett-Packard	95.3
3	Sanshin Electric	NEC	76.9
4	Fujitsu Device	Fujitsu, Cypress Semiconductor	72.0
5	Toshiba Device	Toshiba	57.3
6	Tokyo Electron	Advanced Micro Devices, Motorola, Fujitsu	49.3
7	Hitachi Micro Devices	Hitachi	49.2
8	Satori Electric	NEC	48.5
9	Marubun	Texas Instruments, Motorola, Catalyst Semiconductor	43.0
10	Ryoden Trading	Mitsubishi Electric, National Semiconductor, Hewlett-Packard	42.5

Source: Dataquest (October 1992)

Marubun, DiaSemicon Systems, and Ryoyo Electro. Similarly, PC chip sets used with MPUs are exclusively supplied by U.S. makers such as VLSI Technology, Chips & Technologies, and Western Digital, who in fact hold a 100 percent share of the worldwide market. Sales in the Japanese market are made through various distributors including Tokyo Electron and Ascii Mitsui Bussan Semiconductor.

MOS Memories

Foreign products accounted for 14.4 percent, or ¥82.6 billion, of the ¥575 billion 1991 Japanese MOS memory market. The foreign share of EPROMs reached 37.2 percent. Furthermore, EEPROMs are wholly supplied by foreign makers. Xicor, Catalyst Semiconductor, Microchip Technology, and other medium-size companies lead the market. Their sales distributors in Japan include Internix, Marubun, and Marubeni Hightech.

MOS Programmable Logic Devices

In 1991, foreign products accounted for 97.3 percent of the ¥9.9 billion Japanese MOS programmable logic devices (PLD) market. Altera, Xilinx, and Lattice Semiconductor held a combined share of 63 percent, and distributors including Macnica and Okura had active sales promotion. In particular, high-end PLDs are expected to grow significantly because they can meet requirements for shorter turnaround time as well as small lots and multitype production. They also will replace some gate array products, which were a ¥180 billion market in Japan in 1991.

Analog

In 1991, foreign analog products amounted to ¥95.6 billion, or 17.8 percent, of the ¥537.7 billion Japanese market. Dependency on foreign products increased significantly for mixed-signal ICs. For instance, facsimile modem ICs are mainly supplied by Rockwell International, which uses distributors including Kanematsu Semiconductor.

Clearly, demand for foreign-made semiconductors is oriented toward proprietary products and technologies not available from domestic suppliers, rather than toward those competing with Japanese semiconductors. A key factor for market success for foreign semiconductor makers that cannot have a major production base in Japan is to create and maintain differentiation of their own products from those locally available. Independent distributors conduct high-value-added business as partners of these foreign makers; nevertheless, they find it difficult to expand their business because of their relatively small size or staff shortages.

However, affiliated distributors tend to sell foreign-made semiconductors for the purpose of supplementing the products of affiliated makers. For instance, Ryoyo Electro—an affiliated company of Mitsubishi Electric—sells

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Intel's products, and Fujitsu Device trades in those from Cypress Semiconductors. Affiliated distributors with strong sales forces and networks have competitive edges in the sales promotion of standard products and feedback of market needs. However, they often cannot decide which products to sell, because they are controlled by their parent semiconductor makers. The fact that only a few leading semiconductor distributors can sell foreign-made semiconductors at their discretion is characteristic of the Japanese market, which is one reason that the top five U.S. makers prefer direct sales. In contrast, most major semiconductor distributors in the United States are independent, forming a completely different market structure from Japan.

Dataquest Perspective

In the semiconductor industry, which is increasingly diversifying in response to market needs, semiconductor distributors have been playing a critical role in introducing domestic as well as world technologies to the Japanese market—an intangible benefit as important as sales—thereby spurring circulation of new products through market channels. Nevertheless, distribution of foreign-made semiconductors in the Japanese market is by no means sufficient, despite the availability of many niche products.

Whether foreign semiconductors will be able to further increase market share in Japan depends upon how well product concepts, rather than the products themselves, are understood by and appeal to Japanese users. Semiconductor distributors are expected to look for the best match of user needs with product concept. Accordingly, their efforts to urge foreign semiconductor makers to develop or to jointly develop marketable products with them are becoming increasingly important, as is the selling of completed products. Such efforts require technical, marketing, and financial resources. Unfortunately, semiconductor distributors with these resources are limited in number, and the difficulty that foreign makers often face in finding good partners results in unsatisfactory business. Obviously, growth of semiconductor distributors to a sufficient size is essential in improving the situation. What will it take to nurture growth? The following paragraphs describe possible strategies for independent and affiliated distributors.

If a few independent distributors with a niche strategy succeed in selling the products of leading makers, they can set a good example for others. For instance, independent distributors selling the products of the top five U.S. suppliers will help improve their management resources. In fact, Tokyo Electron and Marubun have had good performance by selling products from two of the top five U.S. makers.

An effective strategy for affiliated distributors is actively promoting sales of foreign semiconductors for the purpose of supplementing the affiliated distributors' products. Many Japanese semiconductor makers are in alliance with foreign makers for a variety of purposes. Use of affiliated semiconductor distributors for increased trade in foreign semiconductors is also an effective means of maximizing the marketing ability of parent semiconductor makers.

So far, foreign semiconductors have steadily increased their share of the Japanese market. To sustain such growth, semiconductor distributors should develop competitive positions. Dataquest believes that they can assume a leading role in promoting the smooth market introduction of Japanese and foreign semiconductors through effective communication with users and makers. Above all, they can help make the Japanese distribution system more transparent to foreign makers.

By Satoru Oyama

Japanese Semiconductor Alliance Update: The Third Quarter of 1992

Dataquest recorded 13 new alliance agreements involving Japanese semiconductor companies during the third quarter of 1992, which ended on September 30 (see Table 1). During the first two quarters of 1992, Dataquest observed an average rate of 23.5 new alliances per quarter. The 13 newly formed alliances of the third quarter represents a significant deceleration of the alliance formation rate for Japanese companies. If the past is used as the basis of a forecast, then this declining trend in new alliances will likely continue to the end of the calendar year because fourth quarter performance has typically been below rates recorded during the first three quarters of a year.

In contrast to the decline in the number of new alliances, the percentage of agreements tying a Japanese company to a U.S. partner appears to be on the rise. As seen in Table 1, all but one of this quarter's new alliances involve the partnership of a Japanese company with a company based in the United States. The strong coupling

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of the U.S. and Japanese electronics industries, together with recession in both countries, no doubt has contributed to creating an environment conducive to joint ventures allying Japanese companies and their U.S. counterparts. Past semiconductor slowdowns have frequently been followed by periods of rapid rebound that caught many companies in a contracting mode. Alliances also will likely serve to help companies hedge against unexpected demand should markets rebound more rapidly than anticipated during the recovery period from the recession.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 1.

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

Memory Investment Alternatives

This quarter's new alliance activity reinforces assertions made in previous publications that the high cost of developing high-density commodity memories is driving most market participants into utilizing alliances as a viable method of diversifying inherent risks of this business. While most major Japanese semiconductor companies continue to believe that their involvement in making leading-edge DRAMs is a necessity, if for no other reason than to use DRAMs as a technology driver, many Japanese executives no longer pursue DRAM supremacy with the religious fervor demonstrated in the 1980s. Consequently, there exists today greater openness and

Table 1
Japanese Semiconductor Alliances—Third Quarter of 1992

Company 1	Company 2	Product	Agreement Type	Date
Seiko Instruments	Digital Equipment	CAD/CAM/CAE software	LA	7/92
Toshiba	IBM/Siemens	256Mb DRAMs	JD	7/92
Fujitsu	AMD	Next-generation EEPROM, flash memory	JV, JD	7/92
NEC	AT&T	256Mb DRAMs	JD	7/92
Oki	Matra	Telecommunication ICs	LA, JV	7/92
Hitachi	National Semiconductor	CMOS logic devices	FA	7/92
Kuroda Electric	IBM	4Mb DRAMs	SA	7/92
Sony	Texas Instruments	Chip set for HDTV and multimedia	JD	8/92
Mitsubishi	Motorola	4Mb DRAMs	FA	8/92
Oki	Catalyst Semiconductor	4Mb flash memory	JD	8/92
Kanematsu Semiconductor	Concurrent Logic	FPGA	SA	9/92
NEC	Oak Technology	MCU for hard disk controller	LA	9/92
NEC	Micron Technology	Memories	FA	9/92

Source: Dataquest (October 1992)

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a willingness to participate in alliances structured around the marketing of DRAMs.

Japanese semiconductor companies as a group have been badly bruised by sluggish memory businesses mainly because of their heavy dependence on DRAM revenue. Furthermore, aggressive technology and pricing policies, at times provided by government subsidies, have allowed manufacturers from other Asian countries to capture market share and are threatening to deprive the Japanese of their DRAM return on investment. Some of these investments are the residue of earlier price competition to gain market share in 1Mb markets and to establish a lead in a 4Mb market, which never fully blossomed. Many of these recent events have forced Japanese and U.S. chip producers to restructure their semiconductor operations into more flexible, sophisticated, and agile competitors. There is increased emphasis on incorporating higher levels of customization, through integration, into customers' products. In this scenario, commodity DRAMs, flash EEPROMs, and TFT LCDs all will be produced by joint ventures while internal resources focus on accelerating all phases of chip implementation. The successful chip supplier of tomorrow is sure to be much more service-oriented than the supplier of yesterday. Achieving the new profiles entails more software tools and creation of highly responsive teams of engineers to interface with chip customers.

Flash EEPROM memory is attracting the interest of many Japanese manufacturers because flash is now viewed as a potential large scale replacement of other types of nonvolatile memories, particularly magnetic disks, in the burgeoning markets of notebook and subnotebook computers. The flash memory market had a volume of about $120 million worldwide last year, and Intel held the dominant market position with about 85 percent share of the total market. Previously, Intel licensed Sharp its flash memory technology, and Toshiba teamed up with IBM in an effort to establish a competitive flash technology.

In July, Fujitsu and Advanced Micro Devices (AMD) announced that they will jointly develop and manufacture next-generation EEPROM and flash memories. This alliance is rather unique in that Fujitsu has distinguished itself for some time by being the only large Japanese electronics company to not engage in a major alliance with another semiconductor manufacturer. Fujitsu's use of a partnership to enter the flash market reiterates the universal appeal of the alliance strategy and its ability to provide risk shelters to every type of corporate personality. During the third quarter, Oki and Catalyst Semiconductors also announced a cooperative agreement targeting the flash memory business.

A similar story was found in DRAMs this quarter when Toshiba announced that it will cooperate with IBM and Siemens in a project to develop 256Mb DRAMs. The development cost is expected to be more than $10 billion, or about equivalent to Sematech's five years of budget.

NEC and AT&T announced that they will corporate to develop 0.25-micron process technology. NEC will apply the technology to 256Mb DRAMs and AT&T will use it for microprocessors and logic chips.

Hitachi and Texas Instruments are expected to create a similar partnership.

Big Blue's Business Plans

The recent announcement that IBM will sell its semiconductors in merchant markets has had an impact on chip makers, particularly Japanese memory manufacturers. IBM's current merchant chip sales are estimated to be about $1 billion, and the company expects to increase that level to $5 billion within the next five years. This would account for about 10 percent of the company's semiconductor revenue.

IBM Japan has selected Kuroda Electric, a small Osaka-based Japanese distributor, to market its 4Mb DRAMs, produced by its Yasu plant, in the Japanese domestic market. IBM reportedly will package the 4Mb DRAMs to meet customer specifications.

IBM also teamed with Toshiba earlier and continues to have ongoing projects to codevelop both TFT LCDs and flash memories. To further demonstrate their willingness to work together, IBM and Toshiba, together with Siemens, have begun a high-profile alliance to jointly develop technologies to be employed in 256Mb DRAM production.

Although both IBM and Toshiba are corporate giants in the memory and computer businesses, Toshiba's stature as a merchant chip producer is well matched to IBM's goals of establishing

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itself as a broad-line supplier of semiconductors. Thus, by working with Toshiba, IBM may ease customer fears over its expanding role as a merchant semiconductor supplier. Because IBM owns one of the largest semiconductor producing capabilities, it is a revenue-generating resource that IBM must capitalize on in ways other than just the sale of their systems. As IBM loses market share in desktop systems, or as the main frame markets contract, all other revenue-generating alternatives will be considered out of necessity. This course of vertical integration or diversification, so prevalent among the Japanese electronics companies, will likely be the archetype for U.S. companies such as IBM, Intel, TI, Apple, and even Microsoft.

Intellectual Property

An eventual normalization of international patent standards to cover the European community, Asian nations, and the United States now seems an inevitable necessity to continued commerce in the semiconductor sector. The economic slowdown of the past few years has caused many international semiconductor companies to reassess their approach to protecting competitive advantage by leveraging their intellectual property, often to an obsessive degree. Along these lines, companies such as Intel, IBM, and Texas Instruments have implemented entire business strategies that function to maximize returns on intellectual property.

TI continues to passionately pursue compensation and royalties from its patent portfolio, which includes the Kilby patents for "integrating" semiconductor components. TI has taken Sanyo to court with the claim that Sanyo has violated TI's patents. In response, Sanyo has held negotiations with TI since the end of 1990, when their previous contract expired. Sanyo subsequently filed a countersuit, claiming that TI has violated antitrust laws. Fujitsu has also had a dispute with TI over the validity of TI's patent claims pertaining to its coverage of Fujitsu's technology. This theme is becoming common. Mitsubishi, NEC, and Toshiba were in a dispute with Wang Laboratories over use of Wang's SIMM patent. Intel sues virtually all competitors, including AMD, engaged in X86 microcode reverse engineering.

Recent activity involving intellectual property arrangements between the United States and Japanese companies reiterates issues that have sparked international discussions about modifying both the U.S. and Japanese patent systems such that they would be, if not more ideal, at least more uniform or compatible. A strong patent portfolio is necessary for competing in mainstream markets in either the United States or Japan. In order to deal with the flood of intellectual property disputes that threatens to cripple the industry, it does appear likely that many competitors will find refuge in alliances as a way of getting extra mileage from their patents. This would be accomplished by effectively using the collective bargaining power of the sum of the alliance partners' patents to defend against incurring high royalty claims by a competitor. Such a subtle benefit of an alliance is probably not a competitive advantage that alliance participants would readily publicize. Hence, documenting any alliances borne out of these motives would be difficult to verify. Nevertheless, the legal web threatening to entangle everyone in the industry is full of nuances that escape public scrutiny but absolutely must be dealt with in some manner by all members of the semiconductor community.

Dataquest Perspective

Most Japanese semiconductor companies have reduced their fiscal year 1992 capital expenditures in efforts to remain profitable. Whether these cost-cutting measures have hindered their ability to engage in new alliance activities is unclear. However, it seems plausible that uncertainty in the semiconductor markets and the unknown time frame for recovery may be delaying many new alliances in the pipeline as administrators adopt a more conservative wait-and-see attitude. Toshiba's recent postponement of a project involving Integrated Device Technology to codevelop next-generation microprocessors could easily be a symptom of the current conservative climate.

Traditionally, Japanese electronics companies have maintained their R&D spending levels even during market recessions. The continued increase in long-term R&D-oriented alliances, such as those to develop 256Mb DRAM technologies, support the hypothesis that R&D investment by Japanese companies will proceed at all costs regardless of the current market conditions. Hence, while the number of new alliances per quarter may be falling, it may also be true that

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many agreements signed recently represent long-term commitments of more strategic value to the allies involved.

Strategic Alliances

Following are brief summaries of strategic alliances that Dataquest recorded during the third quarter.

Fujitsu/AMD

Fujitsu and AMD have linked up to collectively pursue the EEPROM-based segment of the nonvolatile memory business. The comprehensive agreement between the two involves all of aspects of marketing, including the joint development, manufacture, and sales of silicon based nonvolatile memories. Their combined investment will total $700 million for construction of a new manufacturing facility with 0.5-micron line-width capabilities to be located in Japan. The facility is expected to begin producing EEPROM and flash memory chips in 1994, at which time a monthly throughput of 20,000 8-inch wafers is anticipated. Fujitsu and AMD are also considering a reciprocating purchase of each other's common stock, rumored to be in the range of a 5 percent interest, to seal their long-term arrangement and to strengthen their mutual long-term commitment.

Toshiba/IBM/Siemens

Toshiba, IBM, and Siemens have agreed to jointly develop 256Mb DRAMs, the first time that an international consortium has been formed to develop 256Mb DRAMs. The initial development cost, estimated to exceed $10 billion, will be equally funded by each participating company. Researchers and engineers from all three companies have already been assigned and have begun the collaborative project at IBM's semiconductor R&D facility in New York. The total number of the project engineers is expected to reach 200 at the peak of the investigative period.

NEC/AT&T

NEC and AT&T will collaborate on developing a 256Mb DRAM chip, which most likely will necessitate further refinements of the submicron process the two already are exploring for a 64Mb chip. The resulting 256Mb process technology will be used by the NEC-AT&T group both to produce 256Mb DRAMs and drive the process technology for application to other chips such as microprocessors and logic chips.

Mitsubishi/Motorola

Mitsubishi has agreed to supply DRAMs to Motorola for sale in Japan. The chips will be produced in Mitsubishi's Kochi plant; Motorola will market them using the Motorola brand name through its Japanese subsidiary. The move is part of a growing trend in the worldwide semiconductor industry to encourage cooperative efforts even if they only involve sales activities. The agreement with Mitsubishi will expand the range of the 4Mb DRAM product line that Motorola can market in Japan, where about 400 types of 4Mb DRAM products are sold.

By Junko Matsubara

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese electronics companies' financial analysis
- Japanese flash memory market
- Patent issues surrounding photoresist industry

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Semiconductors *Japan*

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DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the difference in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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Market Analysis

What LCD Manufacturing Equipment Makers Should Know, but Are Afraid to Ask About: Their Future

This article examines the credibility of the alleged claim of a ¥1 trillion Japanese LCD market in 1995 by comparing its growth patterns with the development history of the semiconductor industry, and attempts to answer an important question: Will the LCD equipment market be able to follow the path of the semiconductor equipment market?

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Semiconductor Trade Agreement and Japanese Market: In Search of Peaceful Coexistence

This article analyzes the Japanese semiconductor industry and the Semiconductor Trade Agreement, with particular emphasis on captive production by Japanese makers, and considers possible ways to improve market access within the framework of the agreement.

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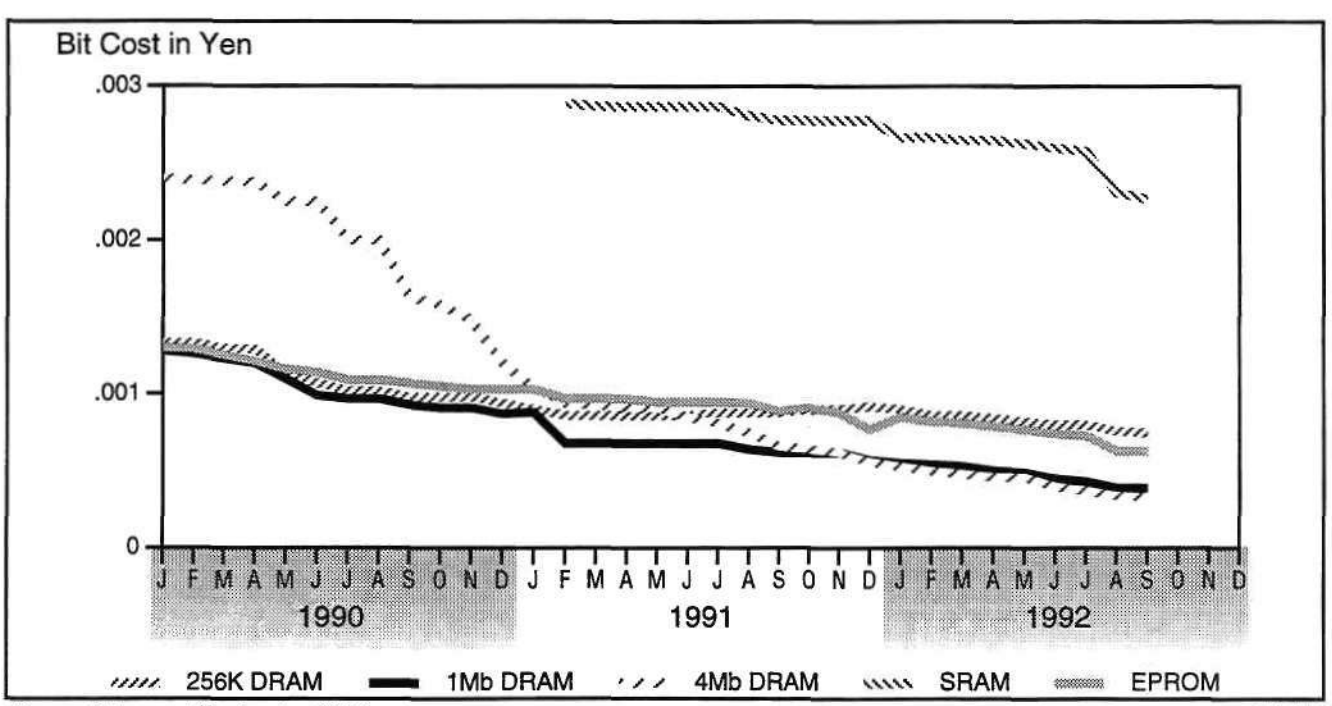
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	2.98	3.12	3.00	2.70		2.85
DRAM 256Kx1-8	1.13	1.56	1.50	0.75		1.05
DRAM 4Mbx1-8	10.78	10.54	10.70	9.50		10.00
EPROM 1Mb, 170ns	3.03	3.16	2.70	2.20		2.40
EPROM 2Mb, 170ns	6.45	6.48	4.30	3.60		4.70
SRAM 1Mb, 128Kx8	10.90	10.49	9.25	9.00		7.90
SRAM 256K, 32Kx8	3.28	3.16	3.20	3.70		3.15
SRAM 64K, 8Kx8	1.68	1.56	1.55	1.45		1.10
68020-16	27.00	29.57	26.00	32.00		NA
80286-16	6.88	9.12	10.00	8.00		6.90
80386DX-25	90.00	99.23	94.00	78.00		70.00
80386SX-16	38.50	42.93	45.00	40.00		37.00
R3000-25	94.50	101.26	80.00	NA		NA

Note: These figures correspond with DQ Monday Report dated September 14, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (September 1992)

Memory Bit Price in Japan



Source: Dataquest (September 1992)

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Market Analysis

What LCD Manufacturing Equipment Makers Should Know, but Are Afraid to Ask About: Their Future

Semiconductors and liquid crystal displays (LCDs) share a number of common elements, including their market structure. In fact, the present expansion of the LCD market resembles the start-up of the semiconductor market 14 years ago. A widely held belief is that the Japanese LCD market will reach ¥1 trillion (about $7.43 billion) in 1995 and ¥2 trillion (about $14.85 billion) in 2000.

The semiconductor market has accompanied the rapid growth of the semiconductor equipment market. In the nascent stage, semiconductor makers made major capital spending at a level comparable to the current value of semiconductor production. Although the investment/production ratio has declined with the maturing of the industry, its level is still an impressive 20 percent. Nevertheless, the similarity in growth patterns between the semiconductor and LCD markets does not necessarily suggest the rosy future for the LCD manufacturing equipment industry enjoyed by the semiconductor equipment industry. There is a crucial difference between the two equipment industries.

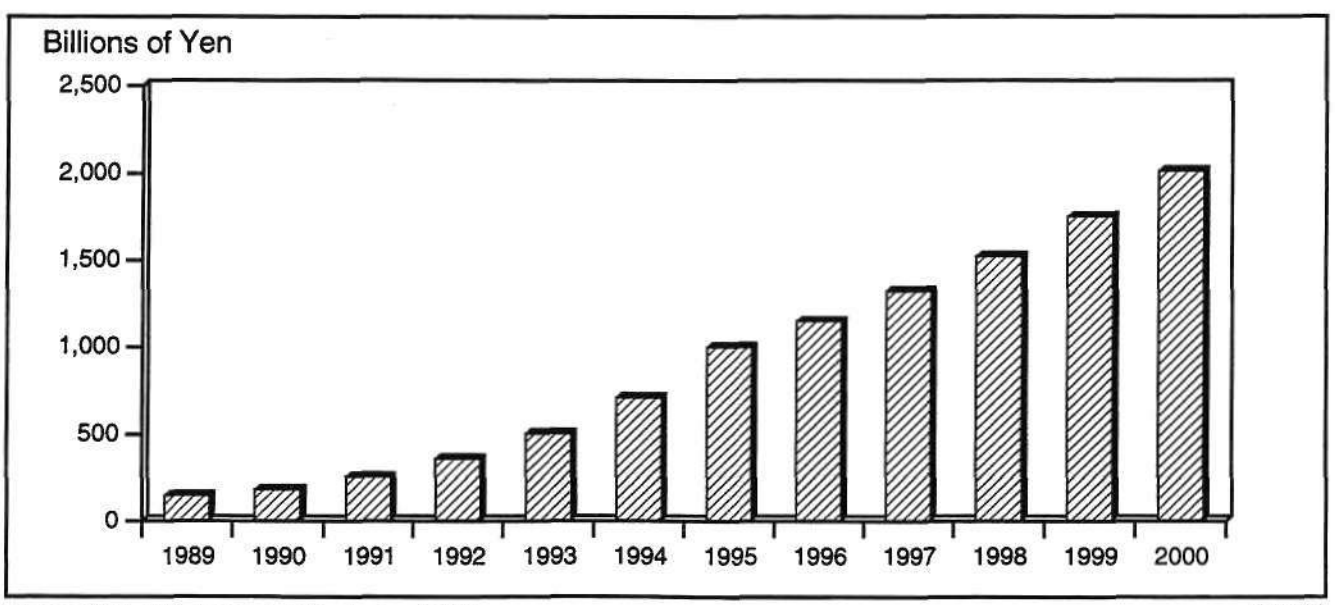
This article examines the credibility of the alleged claim for a ¥1 trillion market in 1995 by comparing the growth patterns of the LCD market with the development history of the semiconductor industry. We also will try to answer the question of whether the LCD equipment market will be able to follow the path of the semiconductor equipment market.

LCD Industry

The Japanese LCD market neared ¥200 billion ($1.49 billion) in 1990. A compound annual growth rate (CAGR) of about 40 percent in the subsequent five years is forecast, reaching ¥1 trillion in 1995. Although the growth pace will slow to 15 percent afterward, the market will reach ¥2 trillion in 2000 (see Figure 1). Undoubtedly, a number of the advantages offered by LCDs—thinness, light weight, low voltage, and low power consumption—promise that LCDs will become a mainstay of flat panel displays with significant growth potential when combined with technological advancements in color graphics, higher resolution, and larger display.

High expectations for the LCD industry are intensifying as the semiconductor industry nears the maturing stage and LCDs become regarded as another semiconductor industry. This is mainly because the growth pattern of the LCD

Figure 1
Japanese LCD Production



Source: MITI, NRI, Dataquest (September 1992)

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industry resembles that of the burgeoning semiconductor industry 14 years ago. Because there are various similarities between LCDs and semiconductors, it is useful to review the semiconductor's history when forecasting for the LCD industry. Similarities between the two industries are as follows:

- Both are high-tech industries characterized by high risk and high return
- Many competitors are involved in both markets (see Table 1)
- Manufacturing processes are similar (see Table 2)
- Both require massive investment (see Table 3)
- PCs are a major application for both industries

Is there credibility to the LCD production forecast of ¥1 trillion in 1995 and ¥2 trillion in 2000? Although forecast demand for PCs and wall-hanging TVs—major applications of LCD panels—would seem to support the projections more accurately, our forecast relies on the similarity of the LCD and semiconductor industries.

The semiconductor industry emerged in 1975. For the purpose of comparison with LCDs, semiconductor production is indexed as a multiple of the 1975 production for every five years after 1975 (see Figure 2). The active matrix-based LCD market started full-scale growth in 1989, and again, subsequent production is indexed as mentioned previously. As Figure 2 shows, the start-up time of the two markets is 14 years away, but the growth pattern of the Japanese LCD production closely resembles that of the semiconductor market, suggesting credibility of the ¥1 trillion and ¥2 trillion markets in 1995 and 2000, respectively. If the current pace of market growth continues, LCD production is expected to reach ¥4 trillion ($29.70 billion) in 2010 at the worldwide semiconductor production growth rate and ¥6 trillion ($44.55 billion) at the Japanese semiconductor production growth rate.

LCD Capital Spending Trends

Most electronics makers will announce poor operating results for the first half of the fiscal year ending September 1992, as well as downward adjustment of future performance. The business environment surrounding the LCD industry is becoming increasingly murky. Factors causing the poor performance of the electronics industry include delayed recovery of the computer market, cutbacks in capital investment by the securities and banking industries, and sluggish demand for consumer electronic equipment, audio/visual equipment in particular. As a result, electronics makers are paring their capital investment. Toshiba, for example, announced a ¥30 billion ($222.75 million) reduction of semiconductor investment in

Table 1
Participants in the Semiconductor and LCD Markets

	NEC	Toshiba	Hitachi	Fujitsu	Mitsubishi	Matsushita	Sanyo
Semiconductor	Y	Y	Y	Y	Y	Y	Y
LCD	Y	Y	Y	N	Y	Y	Y
	Sharp	Sony	Oki	Seiko Epson	Stanley	Kyocera	Citizen
Semiconductor	Y	Y	Y	N	N	N	N
LCD	Y	Y	Y	Y	Y	Y	Y
	Casio	Hoshiden	Alps	Optorex	Seiko Instrument	Rohm	
Semiconductor	N	N	Y	N	Y	Y	
LCD	Y	Y	Y	Y	Y	Y	

Y = Participant
N = Not a participant
Source: Dataquest (September 1992)

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Table 2
Comparison of Manufacturing Processes: TFT LCD and LSI

	TFT LCD	LSI
Mask Layers	5 to 7	15 to 20
Line Geometry	3 to 5 micron	0.8 micron
Integration	1 million to 1.5 million	4 million
Size	300 to 700 cm^2/panel	0.8 cm^2/chip

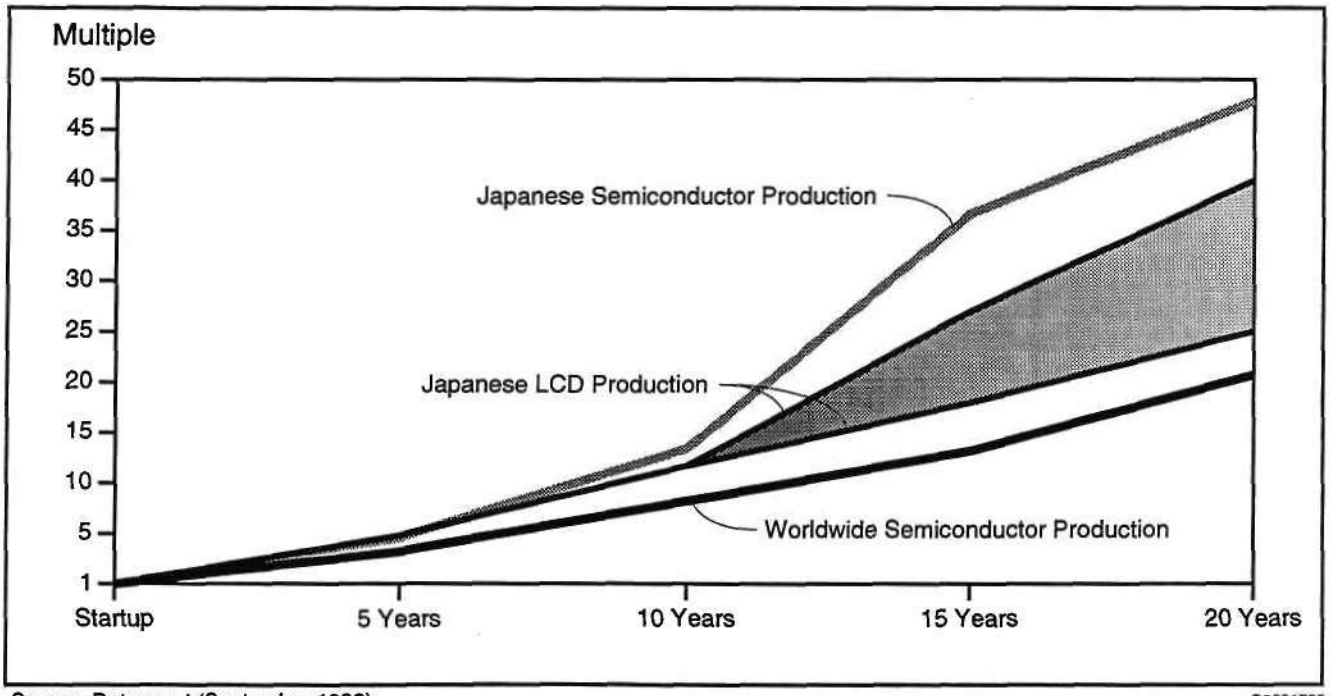
Source: Sharp, Dataquest (September 1992)

Table 3
Comparison of Fab Lines

	TFT LCD	DRAM
Production Capacity	15,000 panel	20,000 wafer
Substrate/Wafer Size	300 x 400 mm^2	6 inch
Output	2 panels/substrate	133 units/wafer
Yield (Percentage)	60	85
Fab Cost (¥)	15 billion	40 billion

Source: Dataquest (September 1992)

Figure 2
Production Expansion of LCDs and Semiconductors



Source: Dataquest (September 1992)
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FY1992, on top of a previous ¥20 billion ($148.50 million) cutback. This is the first time that such a major cutback in capital spending has been launched in the industry during the current term, which suggests not only the magnitude of recession being encountered, but also creates uncertainties about future LCD investment. Because the LCD industry largely consists of semiconductor companies, semiconductor recession is hitting the LCD business and capital spending hard. Principal causes for the present semiconductor recession are as follows:

- Sluggish demand for DRAMs, consumer analog ICs, and single-chip microcomputers
- Eroded financial position because of nearing maturity of warrants
- Difficulty in equity financing because of the recent stock market slump

In addition, slowdown in LCD-related investment is a direct result of the stagnated PC industry—which is the largest consumer of LCDs—and improvement in LCD yield that will ensure sufficient supply capacity and thus eliminate a pressing need for new fab lines. As a result, LCD makers such as Sharp and Display Technology—a joint venture of Toshiba and IBM—postponed construction of new LCD production lines. Nevertheless, current LCD production capacity is far from meeting future demand. Dataquest believes that initial investment will continue in the coming few years, and that the current slowdown is temporary because of the repercussions of the slackened semiconductor market.

LCD Equipment Industry

LCD production lines basically consist of the same processes as semiconductor production such as lithography and film deposition, except that LCDs use glass substrate in place of silicon wafer. Also, both processes are extremely sensitive to dust particles. It is not surprising that semiconductor equipment makers flocked to the LCD business.

When forecasting the future of the LCD industry from the viewpoint of a correlation between production and capital spending, it should be remembered that any industry is required to make initial investment almost equivalent to the value of production at the start-up phase, which declines gradually to settle at a certain level when actual demand and supply capacity are balanced.

The investment/production ratio indicates efficiency of investment. The semiconductor industry's efficiency of investment in the initial year was 65.1 percent. It declined to 54.9 percent in the second year, then to 45.1, 35.0, 29.9, and 20.0 percent. Thereafter, it averaged 20.7 percent between 1982 and 1991, with some deviations because of the business cycle (see Figure 3).

On the other hand, the LCD industry's efficiency of investment is estimated to be 54.6, 69.9, 69.4, and 43.6 percent from 1989 through 1992, respectively. Assuming that it will generally follow the declining trend of the semiconductor industry, say 35 and 30 percent in 1993 and 1994, respectively, then remain stable at 20 percent from 1995 (see Figure 4), the LCD equipment industry could expect to have a bright future.

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However, this simulation based on experience in the semiconductor industry does not take into account a critical difference between LCDs and semiconductors, a difference that dims the apparent bright future of the LCD equipment industry. What lacks in the LCD industry is "generation shift."

The semiconductor industry has been spawning a new generation of products with miniaturized circuit patterns every three years, which spurred a suitable semiconductor equipment market that grew side-by-side with products. In contrast, LCDs are expected to provide high resolution that can be satisfied visually at a certain level, but not require a higher level of miniaturization emulating the submicron geometries of leading-edge devices. Thus, there is little impetus for development of new generations of LCDs.

Next, consider the potential LCD demand for a larger panel size. So far the LCD industry has been slow in standardizing substrates, whose sizes differ from one maker to another. Accordingly LCD equipment makers are expected to supply equipment with flexible designs to accommodate the different sizes; they already supply large chamber systems for higher throughput. In particular, dry systems such as

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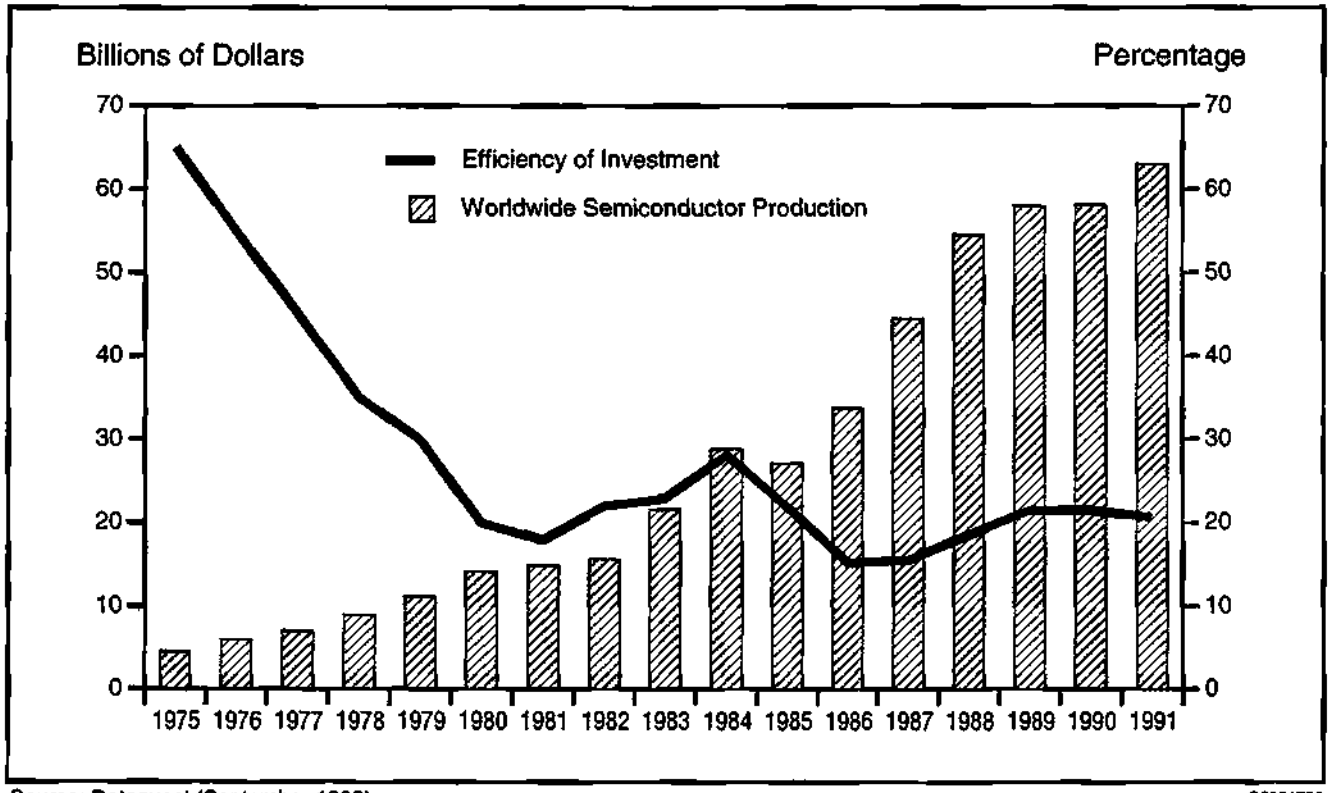
Figure 3
Worldwide Semiconductor Production and Efficiency of Investment



Source: Dataquest (September 1992) G2001726

CVD and sputter are designed to process four panels in one batch, so that the increase in panel size can be accommodated by reducing the number of panels in each batch. This basically eliminates a strong need for increase in equipment size. Although technological advancement will certainly continue in a number of areas—for example, TFT's yield, improved brightness, and response time—the LCD equipment market will not undergo repeated technological shifts from generation to generation, a critical difference from the semiconductor equipment market. And a lack of generation shift means less opportunity for an equipment market expansion.

Nobody disputes the similarities between LCDs and semiconductor devices, and the growth potential of the LCD industry. At the same time, it should be reiterated that the LCD equipment industry is intrinsically different from the semiconductor equipment industry. The semiconductor industry has consistently made, at least until now, capital investment equivalent to about 20 percent of its production, a figure that served as the lifeblood of the equipment market. On the other hand, the LCD equipment industry seemingly is doomed to face a setback of capital spending once production lines to satisfy panel demand are completed and come online.

The LCD equipment industry has experienced a healthy growth of initial investment, which will continue for a while, but not forever. It is becoming an increasingly risky business for semiconductor equipment makers to enter, for growth potential of the LCD industry is deceptive; it will not provide much fruit to the LCD equipment industry and will leave only a tantalizing taste of success.

By Kunio Achiwa

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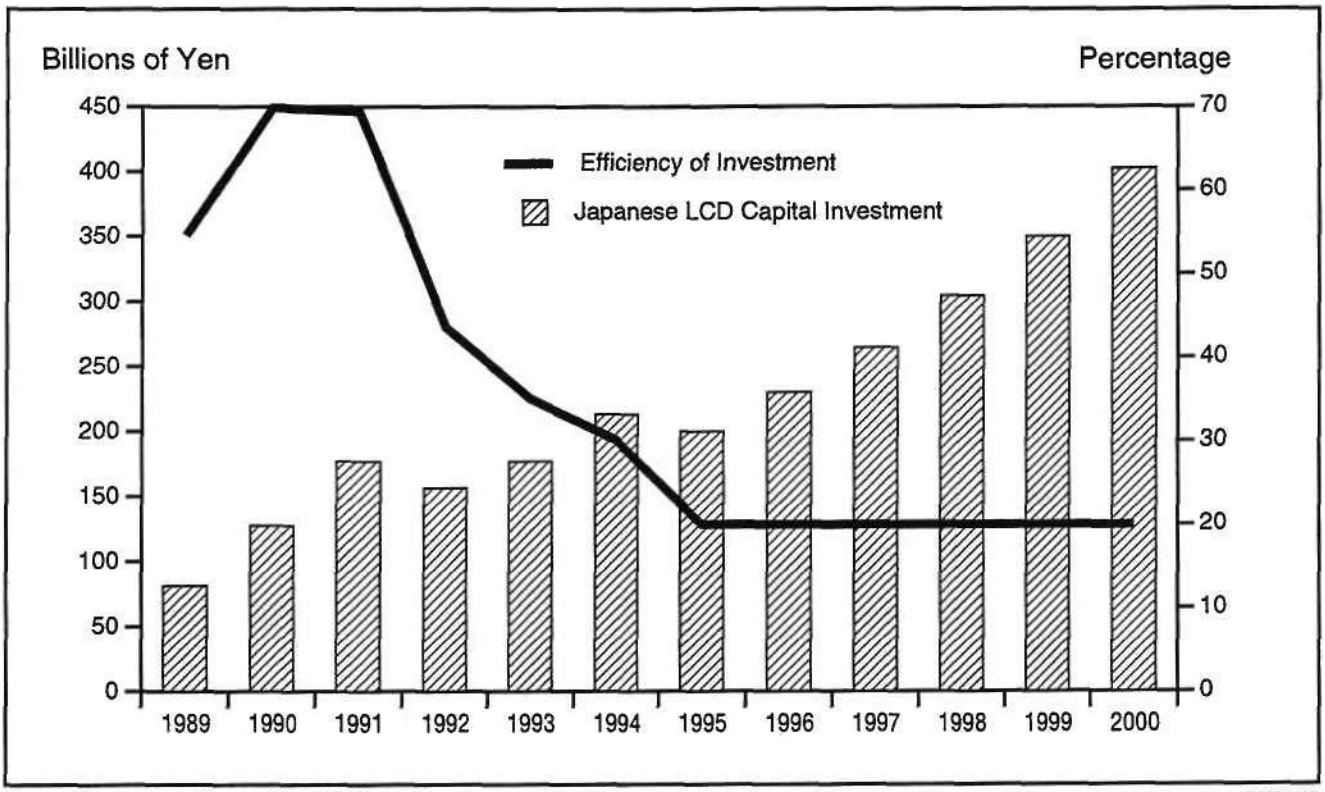
Figure 4
Japanese LCD Capital Investment and Its Efficiency (Optimistic Forecast)



Source: Dataquest (September 1992)
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Semiconductor Trade Agreement and Japanese Market: In Search of Peaceful Coexistence

When U.S. companies were beginning to lose their No. 1 position in the worldwide semiconductor market to Japanese makers in 1985 or so, the issue of semiconductor trade friction increasingly made headlines (see Figure 1). The place-trading occurred against a backdrop of semiconductor recession in the United States that started at the end of 1984. While U.S. makers accelerated their withdrawal from the memory market, Japanese memory makers continued capital spending in anticipation of the payback over a long period—a marked difference in attitude that further widened the gap. Consistent investment was a determining factor in winning the market share battle in the increasingly capital-intensive industry. It did not take long before Japanese makers gained a dominant share worldwide, supplanting the U.S. companies and creating a hot potato between the two countries that still exists.

In the U.S.-Japan Semiconductor Trade Agreement (STA) renewed in May 1991 in an attempt to cool the discord, only the "20 percent share" issue received focused attention. Obviously, such an approach does not help build a common ground for devising a workable solution for Japanese and U.S. makers.

This article analyzes the Japanese semiconductor industry and the STA, with particular emphasis on the implications of captive production by Japanese makers, and considers possible ways to improve market access within the framework of the agreement.

Japanese Semiconductor Market and Captive Production

Dataquest's estimates show that the Japanese semiconductor market grew 4.9 percent in 1991 over the previous year to ¥3,060 billion, of which Japanese makers accounted for 86 percent, or ¥2,630 billion. While revenue of Japanese makers increased by a moderate 3.8 percent, foreign makers recorded a 12.2 percent increase to gain ¥430 billion and boost their share (see Table 1).

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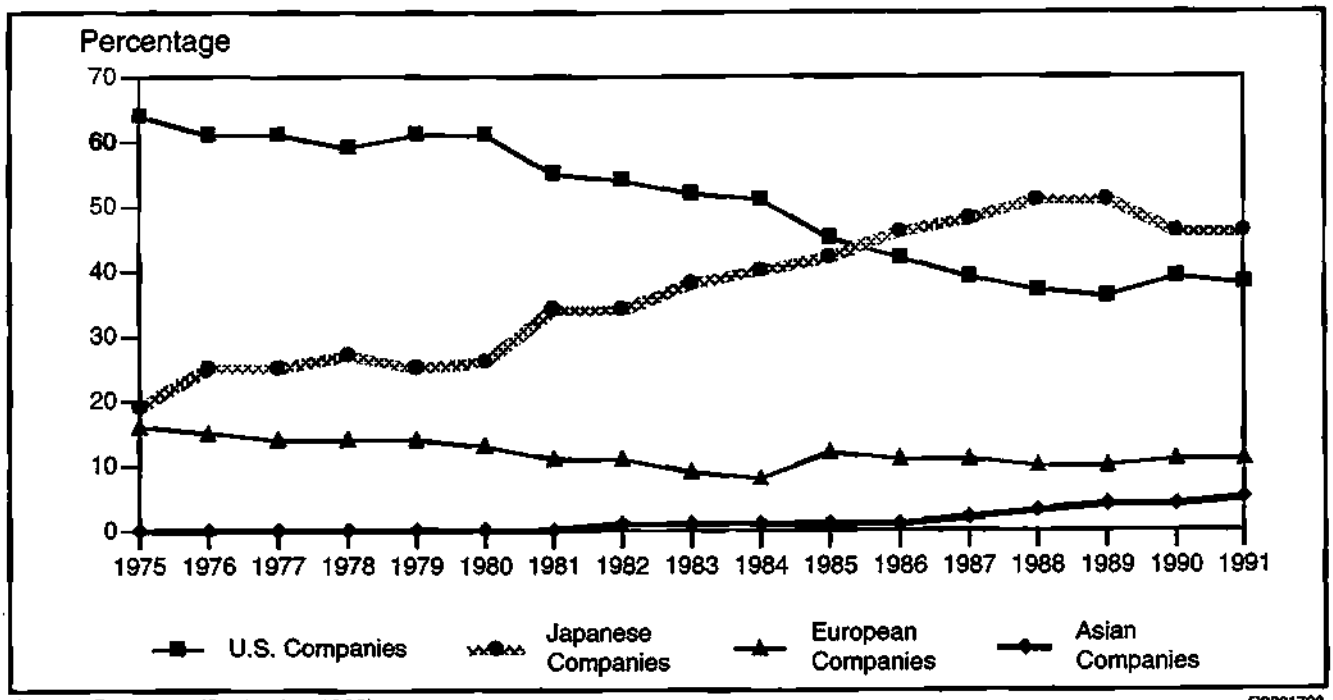
Figure 1
Worldwide Semiconductor Market Share, by Ownership



Source: Dataquest (September 1992)

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Table 1
1991 Japanese Semiconductor Market (Billions of Yen)

	1990	1991	Growth (%)
Semiconductor	2,917	3,059	4.9
Total IC	2,274	2,350	3.3
Bipolar Digital	235	196	-16.7
MOS Memory	604	575	-4.8
MOS Micro	428	487	13.7
MOS Logic	503	554	10.2
Analog	504	538	6.7
Discrete	428	467	9.2
Optoelectronic	215	243	13.0
Japanese Companies' Revenue	2,534	2,630	3.8
Non-Japanese Companies' Revenue	383	430	12.2

Source: Dataquest (September 1992)

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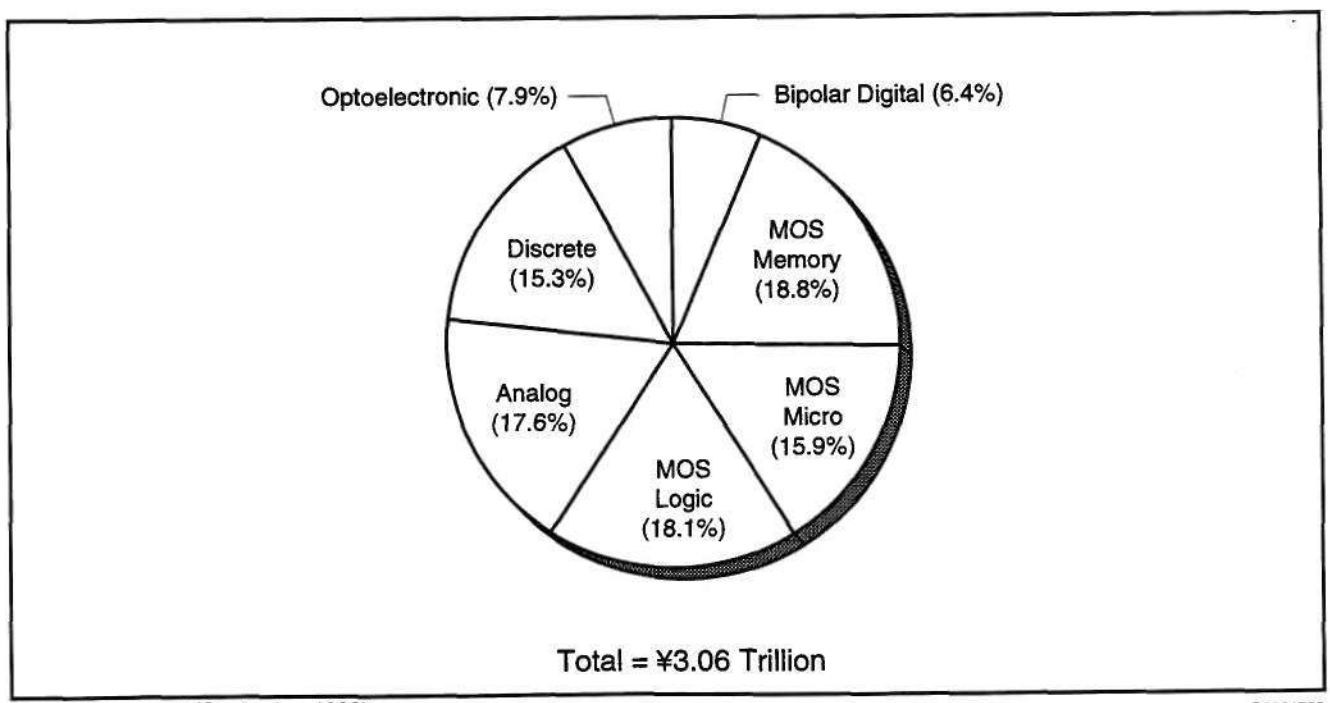
Analysis of market share by foreign makers by device points out the strengths and weaknesses of domestic and foreign makers. MOS memory was the largest Japanese semiconductor segment in 1991, registering ¥575 billion revenue (18.8 percent of the total), followed by MOS logic with ¥554 billion (18.1 percent) (see Figure 2). Figure 3 shows foreign companies' semiconductor revenue in Japan, by product. Of the total ¥430 billion revenue of foreign makers, MOS micro won first place with ¥113 billion, representing 23.3 percent of the entire MOS micro market in Japan. Analog followed with ¥97 billion (a 17.7 percent share of the total Japanese analog market). In contrast, discrete and optoelectronic products respectively reported ¥17 billion with a meager 3.7 percent share and ¥7 billion with 3.0 percent share in each product's market.

This clear difference in sales and market share between major devices reflects the fact that U.S. companies have strength in certain market segments with leading-edge products. Intel and Advanced Micro Devices (AMD) hold dominant shares in microprocessors for PCs, and Analog Devices supplies high-precision analog products. As a result, the share of foreign semiconductors in the 1991 Japanese market surged to 14.0 percent, compared to 13.1 percent in 1990. However, the slackened Japanese market in 1992 may slow the pace of market access improvement.

In analyzing the Japanese semiconductor market, captive production needs to be fully taken into account because leading Japanese semiconductor makers are all vertically integrated. They are generally classified into five general electronics makers (Fujitsu, Hitachi, Mitsubishi Electric, NEC, and Toshiba) and four consumer electronics makers (Matsushita Electric Industrial, Sony, Sharp, and Sanyo Electric). According to Dataquest's estimates, the combined revenue of the five general electronics makers from semiconductors in the Japanese market amounted to ¥1,628 billion, 60 percent of the domestic revenue of Japanese makers. When the ¥640 billion of the four consumer electronics makers is added, the share exceeds 86 percent.

In-house consumption accounts for 17.6 percent of total semiconductor revenue of the first group and 24.6 percent for the second group, evidence that leading Japanese semiconductor makers have huge internal markets (see Figure 4). The

Figure 2
1991 Japanese Semiconductor Market, by Product



Source: Dataquest (September 1992)

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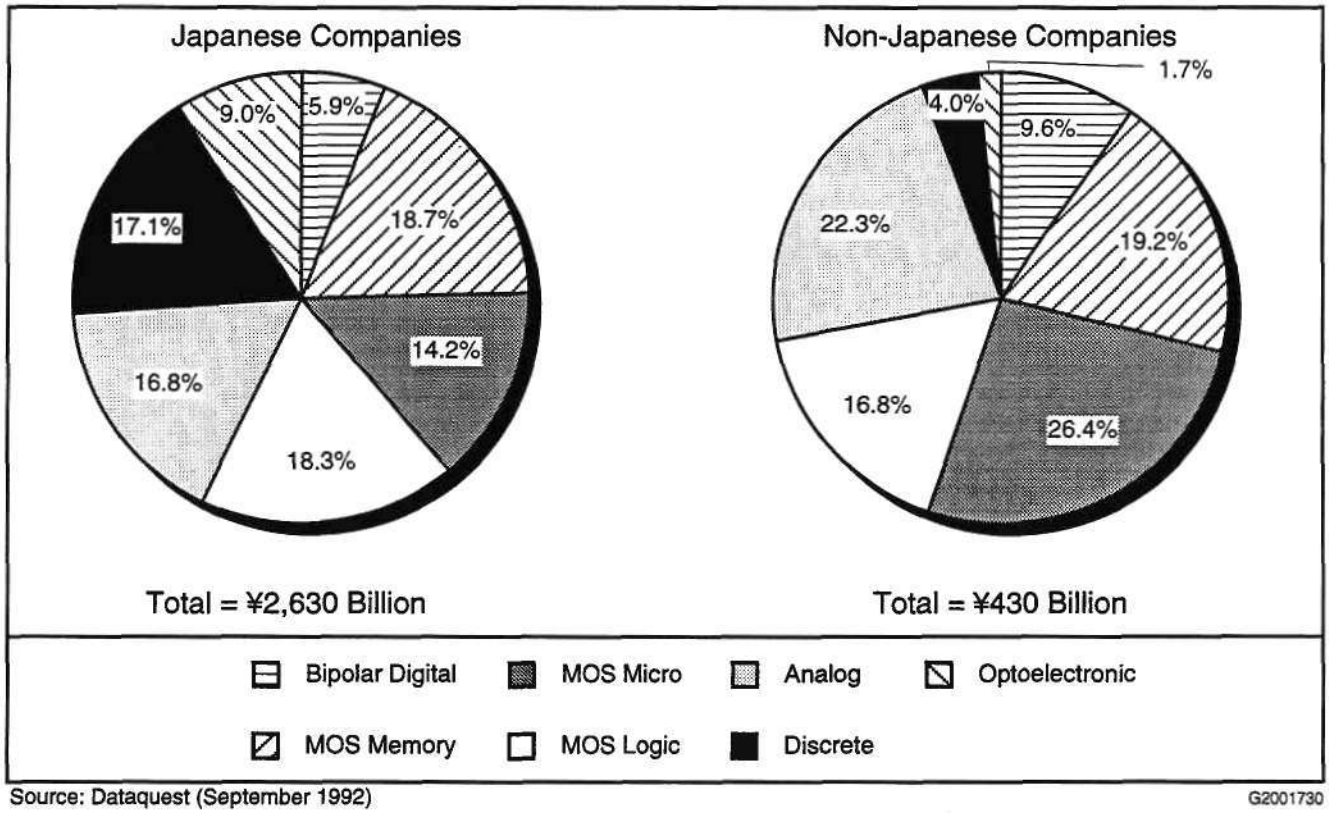
Figure 3
1991 Semiconductor Revenue in Japan, by Product



Source: Dataquest (September 1992)
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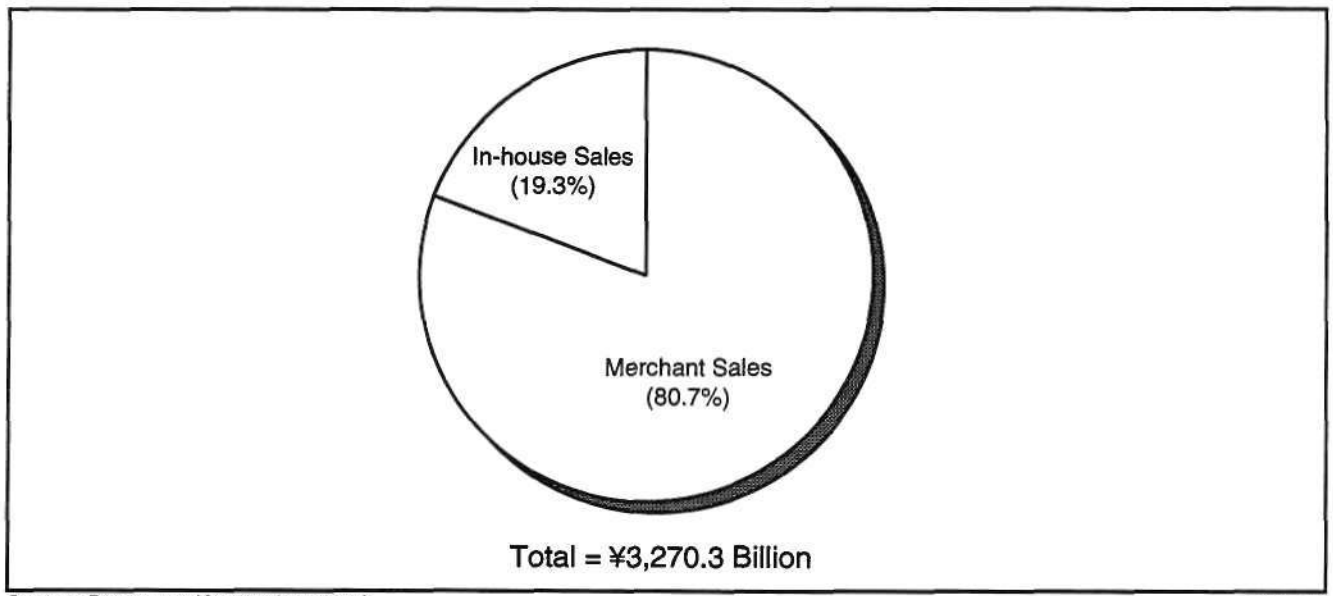
Figure 4
Top Nine Japanese Semiconductor Manufacturers, In-House Sales



Source: Dataquest (September 1992)
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Japanese information system market is estimated to have grown 3.7 percent in 1991, measured by the value of production, while the consumer electronics market showed a 7.2 percent increase. This clearly reflects the stagnation of the five general electronics makers, who have a large share of the information system market, compared to the robust growth of the four consumer electronics makers.

Current Status of Market Access

Foreign-made semiconductors account for more than 20 percent of the total procurement for many leading Japanese semiconductor users. In fact, purchase by these users seems to have reached a level where further increases in procurement of foreign chips would require an approach based on a long-standing view. Most Japanese users have purchased mainly commodity products so far. However, these users must start purchasing for special products such as ASICs, which take longer to design-in. Because 52 percent of their procurement is commodity ICs (easily replaced by competing products), the design-in approach is expected to play an increasingly important role. The Ministry of International Trade and Industry (MITI) recently increased the number of semiconductor users subject to "encouragement to procure foreign chips" from 60 to 220 in an attempt to expand the customer base. Undoubtedly, it will take some time to repeat the campaign for the new potential users, which includes promotional meetings and technical evaluation.

In early June, a negotiation team of the Semiconductor Industry Association (SIA) visited Tokyo to discuss market access improvement measures with MITI, the International Semiconductor Cooperation Center (INSEC), and the Distributors Association of Foreign Semiconductors (DAFS). A major outcome was the promise of unprecedented assistance by Japanese leading users, who will submit a semiconductor procurement list to foreign suppliers. This is simply against normal business practice and such "encouragement" is not a rational approach to the issue. Japan is vitally interested in allaying the trade friction and ensuring harmonious relations with the world, but the government should not use political pressure to coerce business corporations to do something against their will and interest. No U.S. companies would yield to such pressure, which would provide enough reason for shareholders to kick out management.

Aside from the "fair business practice" argument, an important and fundamental question needs to be asked of Japanese semiconductor users: Is the STA all that bad? It certainly brings a risk of limiting procurement sources. But it also has created an opportunity for Japanese users to purchase semiconductor products at economical prices and to obtain products that Japanese makers no longer supply because of low profitability, such as standard logic. Unfortunately, however, standard logic is increasingly being replaced with ASIC so that it cannot be a source of long-term expansion of semiconductor trade with foreign suppliers. Again, a long-term and step-by-step approach seems to be called for; joint development and production of technologically competitive products to be incorporated into systems would reduce risk for both sides.

Changes for Japanese and Foreign Makers

The main concern about foreign semiconductor makers is a lack of quick reaction in times of trouble. Although leading foreign makers with production bases in Japan are making efforts to deal with the issue, there is still a significant difference in attitude between smaller foreign makers and Japanese makers. In fact, there are many cases in which Japanese users are reluctant to use technologically competitive products because of tepid troubleshooting; Japanese makers are quick to analyze defective products, replace them, and bear all the related costs. Foreign makers still have a long way to go before achieving this level of service.

Secondly, U.S. semiconductor makers must offer products backed up by a long-term development plan, instead of just peddling existing product lines including commodity products with STA assistance. In particular, some smaller foreign makers are enjoying a windfall by hawking present products, while keeping product development at minimum. Furthermore, because these manufacturers are expected to increase business with Japanese makers, preparation of data sheets and user manuals in Japanese is necessary. Many system designers need to work with data sheets written in their own language.

On the other hand, Japanese semiconductor makers have to reconsider their attitude toward intellectual property. Their product strategy of following a precursor in droves repeatedly causes excess competition and oversupply. More

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importantly, this attitude seems to exemplify a lack of respect for the patent rights and copyrights of competitors. Unless they stop pursuing immediate profits by making similar products and foster proprietary technology, they face a slow but sure decline over the long haul.

Challenges for the Japanese Government

As part of its efforts to smooth semiconductor trade friction, the Japanese government—spearheaded by MITI—has launched an initiative to promote reciprocal interaction with foreign countries in the areas of investment and trade. Two pillars of the initiative are the support for foreign semiconductor makers in entering the Japanese market, and the development of foreign access bases. The former is designed to assist foreign chipmakers in minimizing high entry costs, raising funds, obtaining investment information, and recruiting employees. The latter is to help establish physical access to the Japanese market at specific locations near ports and airports by local governments, including various initiatives to facilitate import procedures and strategic investment on import-related infrastructure through quasigovernmental organizations. Toward this end, government organizations and banks, including the Industrial Infrastructure Development Fund, Japan External Trade Organization, and Japan Development Bank, will provide ¥20 billion in the form of loan guarantee. Also, the government is considering low-cost loans and other tax incentives for foreign makers.

Business practices and rules in Japan must be clarified and made available to foreign companies in a visible form. This will help avoid unnecessary misunderstanding or ineffective communication in the coming negotiations with 220 foreign makers. Similar consideration is needed for the 220 Japanese users, some of which may have achieved the 30 percent procurement level relatively easily. There are users that require great effort to clear the 20 percent target level or cannot even fulfill the 10 percent level because the devices they want are not readily available from U.S. companies. It is unrealistic and irrational to allocate the 20 percent share as the uniform "quota" to all the users, regardless of their actual need for semiconductor products and possible sources. This is political coercion under the cloak of administrative guidance.

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The argument between the U.S. and Japanese governments can be supported by a simple simulation of the semiconductor market when the 20 percent target is assumed to be accomplished by the end of 1992. Dataquest predicts that the Japanese semiconductor market in 1992 will be down 9.4 percent from the year before to ¥2,772 billion; 20 percent of this amount is ¥554 billion, compared to ¥430 billion (actual) in 1991. This means that procurement of foreign-made semiconductors is expected to grow 29.0 percent. However, 1992 sales of Japanese semiconductor makers in the domestic market are expected to decrease by 15.7 percent to ¥2,218 billion. It appears that increased sales of foreign semiconductor makers in the midst of the dwindling Japanese market is unrealistic and runs a risk of further plaguing the Japanese semiconductor industry, which is under legal attack of U.S. makers that wield the sword of patent and copyright.

The role of the semiconductor industry in the 1980s was to supply electronic parts, and Japanese makers have grown to market leadership through ceaseless capital spending for capacity expansion and upgrading. Ever-increasing investment requirements, however, have caught up with a single company's ability to meet the need. The semiconductor industry of the 1990s is transforming itself to a system creator. Semiconductors increasingly are expected to create new markets, such as multimedia. This software-driven market is still dominated by U.S. makers. If the transformation process continues, U.S. makers are likely to regain the industrial leadership in the 1990s.

Today, Japanese semiconductor makers maintain world-class technologies and enjoy an indisputable position in the worldwide market. This does not necessarily mean that they have to be victimized by quirky political stopgap concessions. The semiconductor industry has already grown into a key industry that serves as the foundation of all industries, and the semiconductor market has become large enough to keep the world economy in balance. Semiconductor technology attracts new entrants from other areas because of its potential to lead industrial development, and it is becoming a political weapon for various countries as the semiconductor market goes global.

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In this sense, the semiconductor industry is uniquely positioned as a borderless industry capable of empowering world industries to integrate through strategic alliances. The Japanese semiconductor industry is no exception and is mandated to form the foundation of the world economy. To let the industry play such a critical role, both Japan and the United States should avoid making semiconductors a political issue. Mutual understanding and cooperation are the only feasible ways to secure a constructive relationship between U.S. and Japanese semiconductor makers and users.

By Akira Minamikawa

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese flash memory market
- Semiconductor distributors in Japan
- Japanese semiconductor alliance update: The third quarter of 1992

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Semiconductors *Japan*

SCJA-SVC-DP-9210 August 31, 1992

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the difference in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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Product Analysis

Japan's Mobile Telephone Market on the Move

This article analyzes the rapidly changing market environment for mobile telephone, and its implications on the semiconductor industry. Dataquest categorizes three major products of mobile telephones: car phones, portable phones, and personal handy phones (PHPs).

By Naotoshi Yasuhara *Page 3*

Semiconductor Industry in Transition from Expansion to Fusion: Multimedia Implications

Although multimedia has yet to clear a number of technological hurdles including standardization, Dataquest believes that it will play a significant role in transforming the semiconductor industry to the true design-intensive industry. This is the first analysis of the multimedia market to focus on alliances as a source of fostering the market.

By Kazunori Hayashi and Kun Soo Lee *Page 8*

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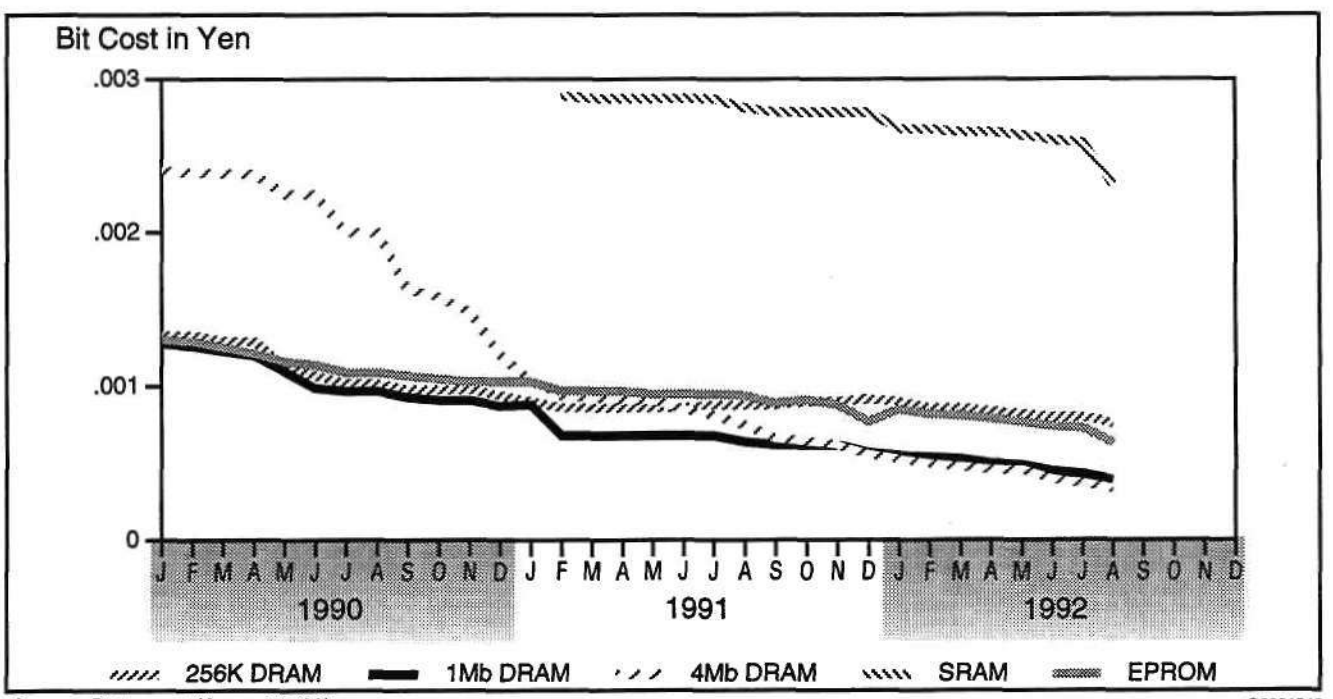
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.00	3.06	3.20	2.90		3.00
DRAM 256Kx1-8	1.10	1.53	1.55	1.00		1.05
DRAM 4Mbx1-8	10.90	10.67	10.80	10.50		10.20
EPROM 1Mb, 170ns	3.03	3.14	2.60	2.50		2.40
EPROM 2Mb, 170ns	6.53	6.43	4.55	4.50		4.70
SRAM 1Mb, 128Kx8	11.10	10.59	9.25	11.50		NA
SRAM 256K, 32Kx8	3.38	3.18	3.20	3.00		3.15
SRAM 64K, 8Kx8	1.70	1.53	1.55	1.20		1.10
68020-16	27.00	29.80	26.00	32.00		NA
80286-16	7.15	8.82	10.00	8.00		6.90
80386DX-25	90.00	103.90	94.00	78.00		70.00
80386SX-16	40.50	43.92	45.00	40.00		37.00
R3000-25	94.50	109.78	80.00	NA		NA

Note: These figures correspond with DQ Monday Report dated August 17, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (August 1992)

Memory Bit Price in Japan



Source: Dataquest (August 1992)
G2001543

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Product Analysis

Japan's Mobile Telephone Market on the Move

Electronic equipment targeting personal use is rapidly becoming a shining star in the increasingly dim-looking Japanese electronics market. The center of this gleaming segment is mobile telephone equipment, which increasingly is oriented to a flexible use not constrained by a conventional public telephone network. Mobile telephone equipment clearly reflects current drives toward downsizing and personalizing of electronic equipment and meets the need for a ubiquitous means of communication among people on the move. At the same time, technological breakthroughs are needed to meet the expectations and even the dreams of highly demanding consumers, making mobile telephone equipment truly technology-driven electronic products.

This article analyzes the rapidly changing market environment for mobile telephones, and its implication on the semiconductor industry.

History: Mobile Radio Communications Equipment in Japan's Phone Service

Dataquest here analyzes three major products of mobile telephones: car phones, portable phones, and personal handy phones (PHPs). Traditionally, radio communication has been the sole means of ubiquitous communication, but its use has been limited to persons with a specific license or approval. An amendment of the Wireless Telegraph Act in 1987 eliminated license requirements for radio equipment with output of less than 10mW, thus enabling the handy use of radio telephones.

Since 1979, the Japanese telephone market has shown significant changes, including the following events:

- 1979: Start of automobile telephone service
- 1985: Establishment of privatized Nippon Telegraph and Telephone Corporation (NTT) and Liberalization of the telecommunications market and entry of type I, new common carriers (NCCs)
- 1987: Start of portable telephone service

Liberalization of competition in the fixed telephone networks and commencement of portable telephone service has transformed the traditional telephone business, which relies on the network of fixed telephone circuits exclusively controlled by NTT, to a highly competitive marketplace. In response, NTT separated its mobile telephone business on July 1, 1992, establishing NTT Mobile Communications Network Inc.

Meanwhile, the number of telephone subscribers in Japan attained 54 million in 1990, with 2.2 persons per subscription and 86.6 percent coverage of all households. Cordless phones—a forerunner of the portable telephone market—are estimated to account for 18 percent of that total, indicating that the market for conventional telephone sets is still strong.

Mobile Telephone Service Market

Since the start of commercial service in 1979, car phones have grown steadily to form the core of the mobile telephone market. After 1990, however, NCC's portable phones made inroads and the number of subscribers outpaced car phones (see Figure 1). Then, in 1991, the number of automobile telephone subscribers showed negative growth, partly because charges became less affordable as the Japanese economy entered a downturn after the collapse of the bubble economy in 1991, and partly because car phones completed the first round of market saturation for business use. NCC's portable phones also are offered with adapters to be used as car telephones.

Overall, the mobile telephone market is expected to reach 5 million subscribers in 1996 (see Figure 2), a compound annual growth rate (CAGR) of 31 percent from 1991 to 1996. Such rapid growth is comparable only to the increase in household telephones in the fixed circuit network, which grew to 10 million subscribers between 1961 and 1971. Some predict further accelerated growth, 8 million car phones, 9 million to 18 million portable phones, and 6.5 million to 13 million PHPs by the year 2000. This means CAGRs of more than 30 percent for car phones and portable phones from 1991 to 2000. At the same time, PHPs—positioned as digital cordless phones—have great potential in personal use and office applications. All in all, the burgeoning of the mobile telephone market is expected to bring future shock that emulated

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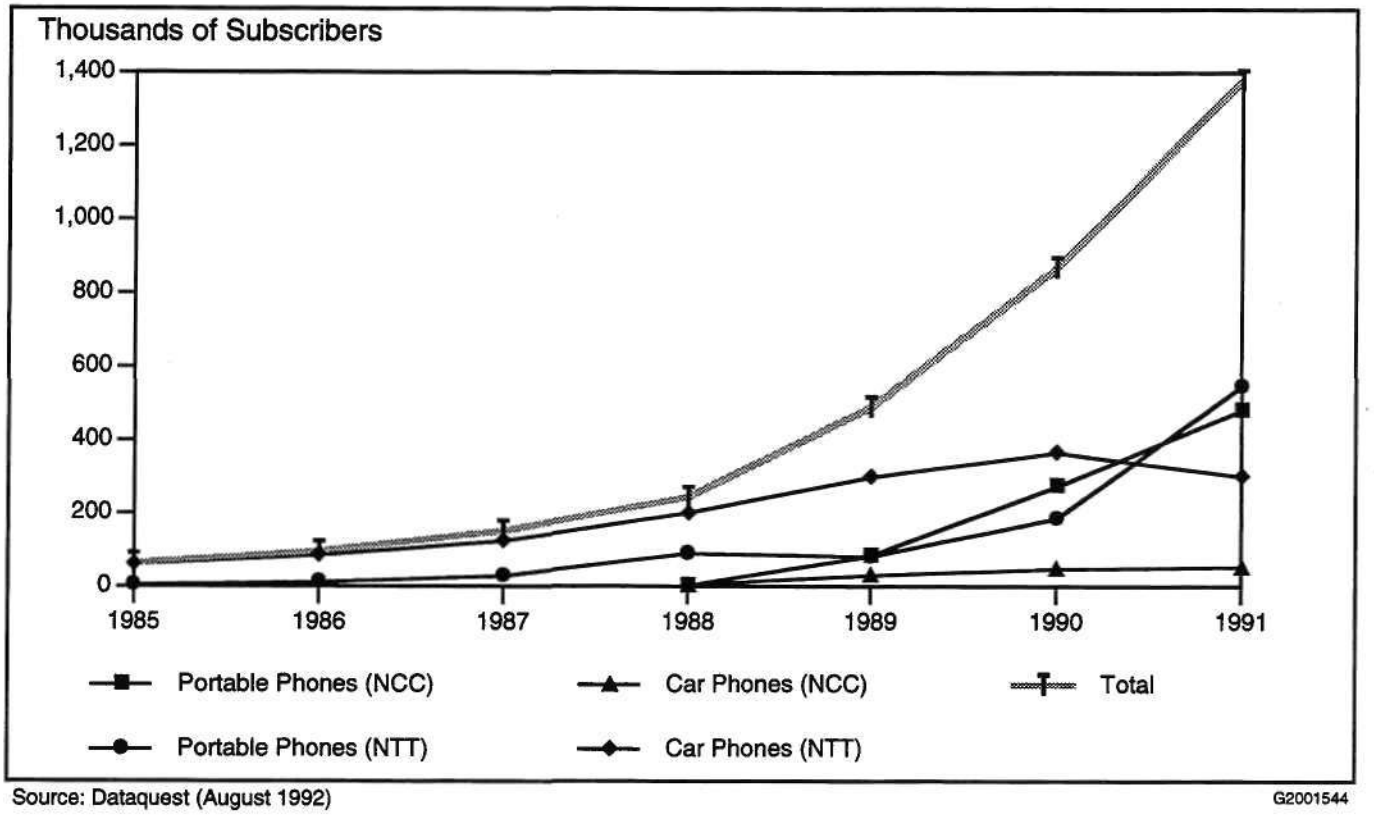
Figure 1
Japanese Mobile Telephone Subscribers



Source: Dataquest (August 1992) G2001544

introduction of telephones into a society that depended on mail service as its sole means of communication.

Evolution of Mobile Telephone Service

So far, the history of mobile telephone service is best described by the changes in its standards, driven by the improvement of the efficiency in frequency use and the limitation of accommodation capacity in an allocated band.

The original analog 800-MHz band service is about to be changed to a digital system in the same band, which will be commercialized in 1992. The use of a semimicrowave band is scheduled to start in 1993. These are part of efforts to establish an effective frequency use to expand capacity to accommodate radio telephone communication, including adoption of a 1.5-GHz digital system and allocation of the 800-MHz analog band to the digital band. At the same time, PHPs based on a 1.9-GHz digital system are scheduled to be introduced in 1994 for expansion of mobile telephone service and its applications. Then, in 1998 at the earliest, commercialization of the Future Public Land Mobile Telecommunications System promoted by the Consulting Committee of International Radiocommunication (CCIR) and satellite-based wide area public mobile telephone service, such as the Iridium Program proposed by Motorola, is expected. Thus, mobile telephone service is expected to make a quantum leap in the coming decade.

In particular, PHPs have been under service test since March 1992, led by the Research and Development Center for Radio Systems (RCR). PHPs have various technical hurdles to clear before commercialization, for example, traffic frequency (1.9 GHz), price constraint (less than ¥50,000 for low-end products), and the need for a large number of stations because of the small zone (a few hundred meters in radius). Nevertheless, because of their small power consumption to permit small battery capacity—an optimum feature for downsizing electronic equipment—PHPs are viewed as promising digital cordless telephones and a mainstay of future telephones designed for personal use. Also, PHPs use circuit configuration that is basically

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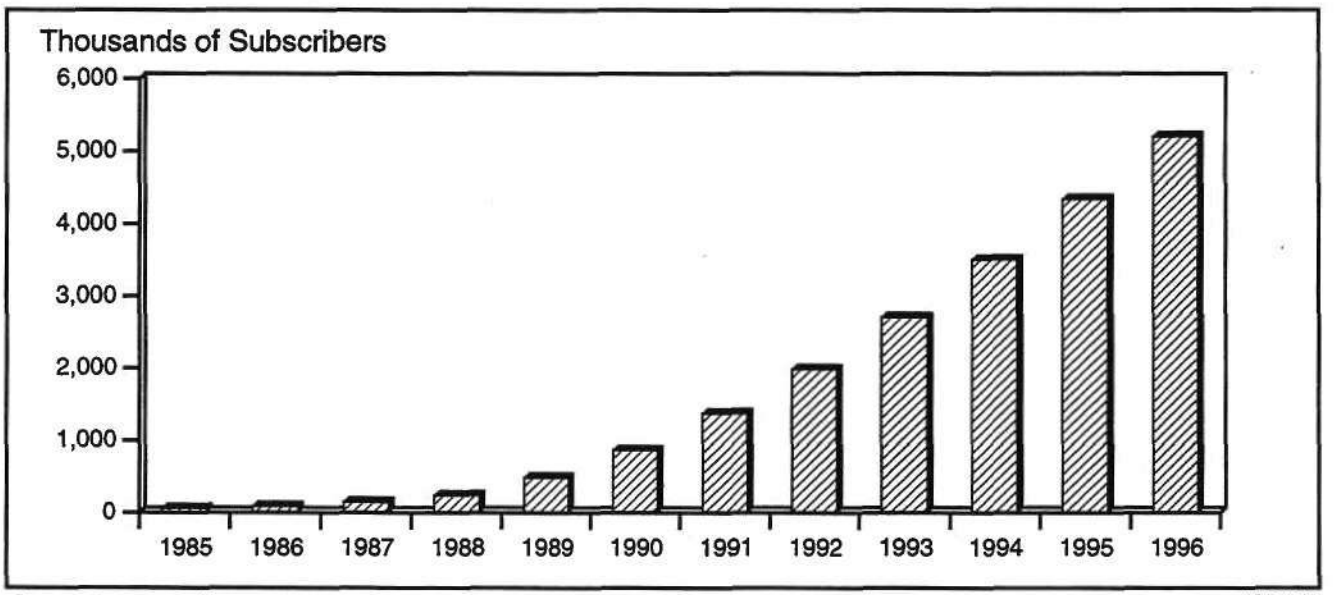
Figure 2
Japanese Mobile Telephone Subscribers Forecast



Source: Dataquest (August 1992) G2001545

the same as that for portable phones. This means that technological prowess in the portable telephone market can be used as an edge in the PHP market, making the portable phone market highly attractive to telephone equipment makers.

Mobile Telephone Production Trends

Japanese electronics makers must consider two distinctive aspects of the mobile telephone market. First, mobile telephones have widely penetrated world markets. In fact, the European and U.S. markets have grown to a size eight times that in Japan. Previously, this would have been a target of an export drive. Today, Japanese makers have learned a lesson from trade friction experience and are ready to establish a local production base after initial market introduction.

The second issue is technical standards for mobile telephone systems. Two analog standards currently used—NTT and TACS systems—demand unification for increased market access to foreign makers. Thus, the mobile telephone market is highly international, offering promising market opportunities for both Japanese and foreign makers. Major players in the Japanese mobile telephone market are Motorola, NEC, Fujitsu, Matsushita Communication Industrial, Mitsubishi Electric Industrial, Japan Radio, Hitachi, Toshiba, Kyocera (Oki Electric Industry), and Sony, with annual production of 500,000 units. Once the "sellout" system for mobile telephone equipment is introduced as scheduled in 1993, telephone equipment makers, audio equipment makers, and foreign makers are expected to enter the Japanese market, which will grow into an international marketplace accommodating 20 or more suppliers.

Figure 3 shows production forecasts for mobile telephone equipment on a value basis. Production in 1991 was of ¥212.1 billion and 1.68 million units. Dataquest believes that the Japanese mobile telephone market—measured by the number of subscribers—will grow 11 percent annually. Then, driven by the increase in production for overseas markets, the production will reach ¥502.5 billion in 1996, a CAGR of 18.8 percent.

At present, Japanese makers are developing overseas production bases, primarily in North America. Suppliers that are meeting overseas demand by exports are also expected to make a shift to local production as nascent digitization in foreign markets spurs demand for digital phones.

Semiconductor Consumption for Mobile Telephone

Portable phones basically comprise a receiver, transmitter, tuning circuit, intermediate frequency detector, voice signal processor, and communications controller.

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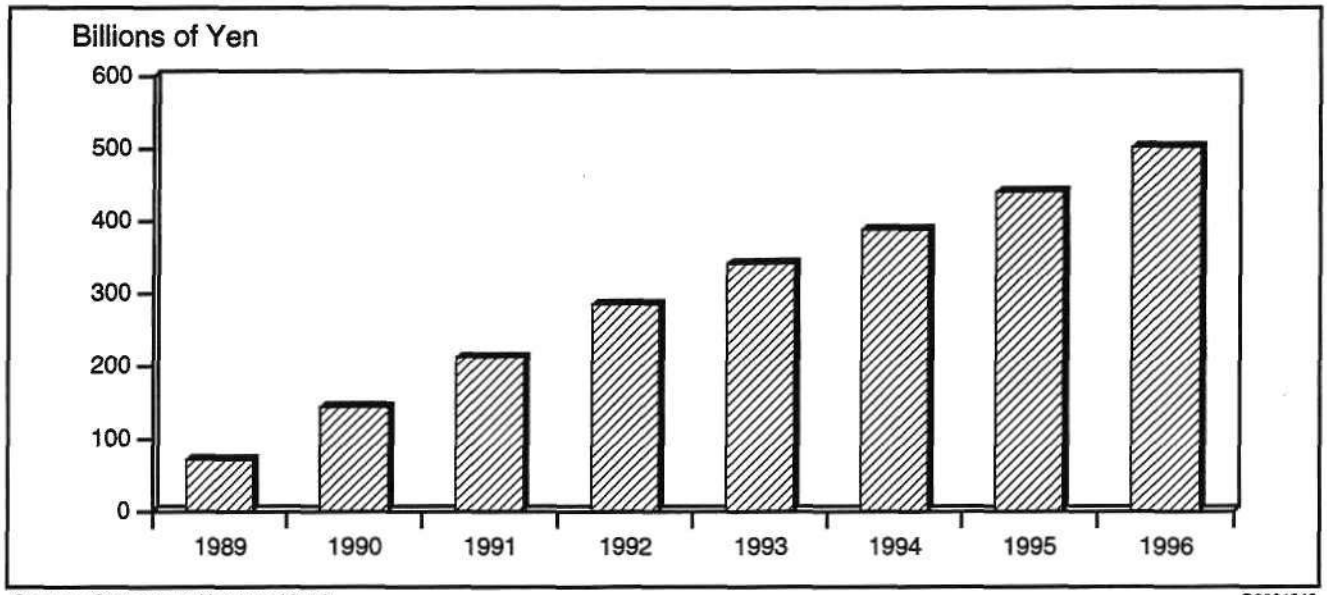
Figure 3
Japanese Mobile Telephone Market Forecast



Source: Dataquest (August 1992) G2001546

The transmitter's power amplifier uses gallium arsenide (GaAs) FETs that feature a high efficiency and noise factor, while silicon semiconductors are used up to the 1.5-GHz band because of cost considerations. Current R&D efforts are focused on integration of high-frequency circuits and mixers in the receiver and transmitter into LSIs, and integration of phase-locked loops (PLLs), synthesizers, and voltage controlled oscillators (VCOs) in the tuning circuit by BiCMOS technology, then possibly incorporating high-frequency circuits of the receiver and transmitter. Finally, the communications controller performing digital processing is being equipped with main and standby microcontrollers for reduced power consumption.

Migration from analog to digital requires additional voice codec and equalizers in the voice signal processor. This will inevitably increase the external size of digital portable phones. Although initial products will use general-purpose semiconductor devices and gate arrays to meet market demand, further integration and downsizing can be accomplished through use of microcontrollers and DSPs equipped with analog interface. In addition to analog circuits around transmission/receiving signals and voice signals, the digital signal processor will comprise analog and digital circuits, suggesting an increase in demand for analog devices (including mixed-signal ICs). Besides circuit configuration, efforts are being made to improve packaging for further miniaturization and higher reliability: for example, very thin QFP, multichip packages, hybrid packages accommodating a CPU, and gate arrays and memories, in addition to standard PQFP.

Figure 4 shows the semiconductor consumption forecast in the mobile telephone market. In 1991, semiconductor consumption in the market was estimated at ¥16.5 billion. Analog devices accounted for 29.9 percent of the total (see Figure 5), followed by 8-bit and 16-bit microcontrollers (20.0 percent), and mass-consumed gate array logic (19.8 percent). Note that GaAs FETs used in transmission RP modules are included in discrete devices. According to our forecast, semiconductor consumption in the mobile telephone market will reach ¥39.9 billion in 1996, with 19.3 percent CAGR from 1991 to 1996. In particular, digitization is expected to boost the share of mixed-signal ICs, and analog devices will account for 46.8 percent of total semiconductor consumption in 1996, amounting to ¥18.6 billion.

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Compared to other electronics markets, the mobile telephone market is unique in that it is

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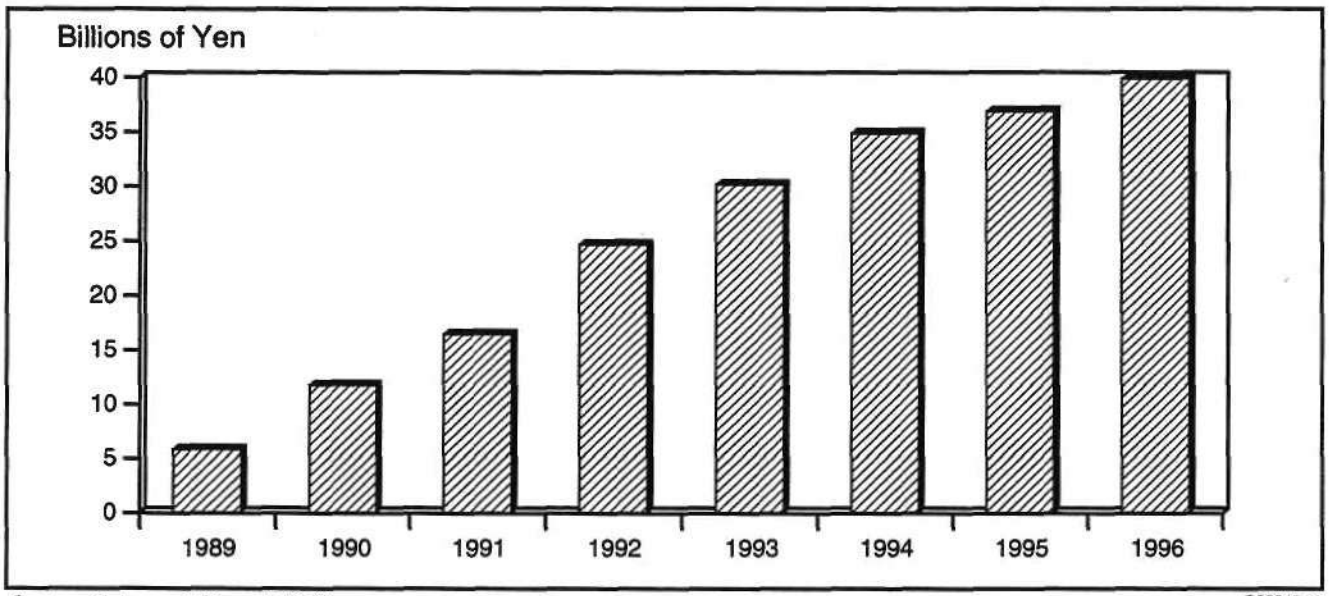
Figure 4
Japanese Semiconductor Consumption for Mobile Telephones



Source: Dataquest (August 1992)
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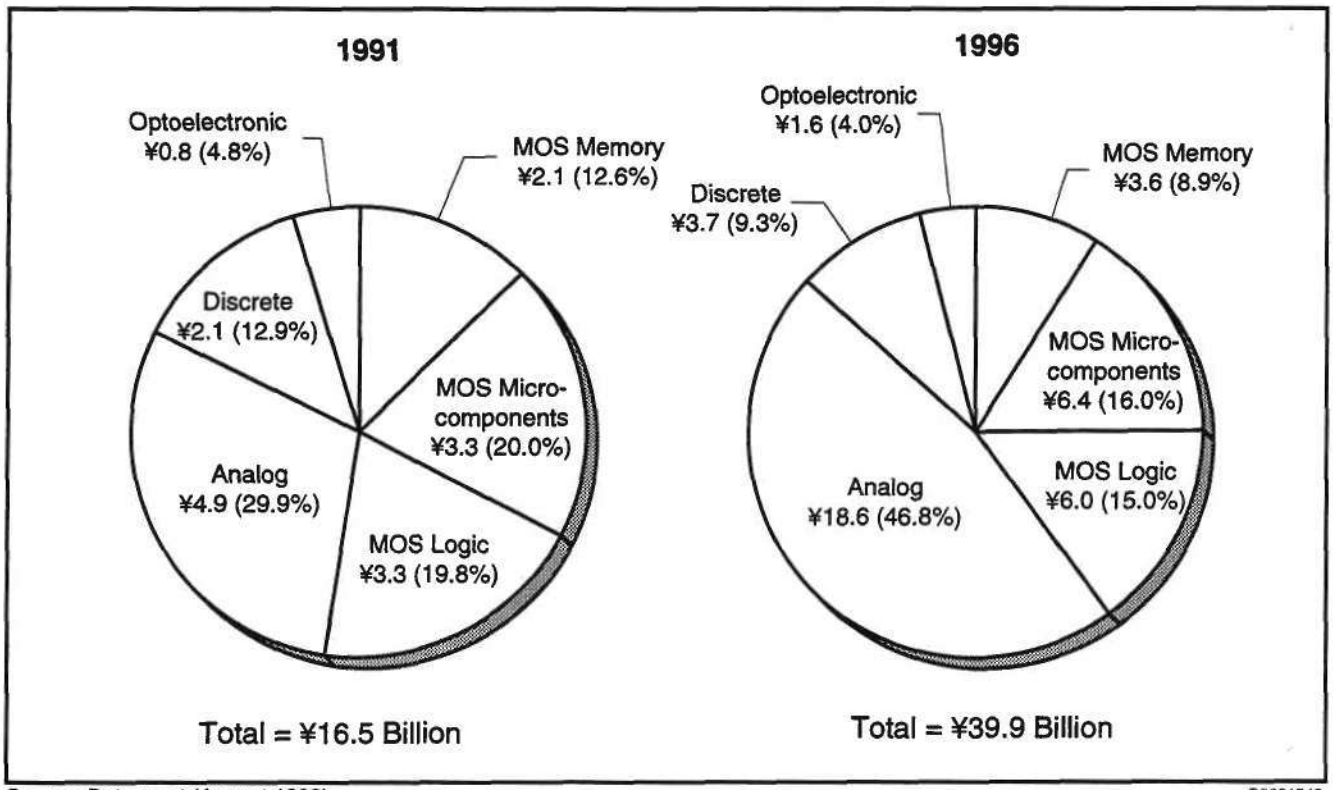
Figure 5
Japanese Semiconductor Consumption for Mobile Telephones, by Device (1991 and 1996)



Source: Dataquest (August 1992)
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driven by common carriers. It is expected to grow into a market size emulating personal equipment for manufacturers of communications equipment, household appliances, audio equipment, and semiconductors.

Mobile telephone equipment has been developed by major communications equipment makers that are also producing semiconductors. Today, the changes in equipment standards at a basic configuration level, as seen in migration from analog to digital, create uncertainties about how far semiconductor devices should be integrated. In fact, semiconductor makers are unsure of how their products will be developed and supplied to fit the needs of equipment in the middle of this evolution, as evidenced by their varying reactions.

Still worse, this situation can be a major obstacle to makers that intend to enter the market by obtaining semiconductor devices required to develop competitive products.

From the standpoint of semiconductor technology, mobile telephone equipment faces a number of technical issues, including the following:

- Transition to the semimicrowave band
- Integration of peripheral circuits including high-frequency circuits
- Application of BiCMOS technology
- Market deployment of digital/analog mixed circuit (mixed-signal) ASSPs
- Development of low-voltage, integration, and mounting technologies to ensure portability
- Design techniques for high frequency and digital/analog mixed circuits
- Establishment of evaluation methods

Nevertheless, Dataquest believes that these issues do not preclude mobile telephone equipment from being positioned as a leading indicator of semiconductor technology for portable electronics equipment. Also, for companies that make both semiconductors and communications equipment and comprise the current mobile telephone market, the market entry of companies with global potential is expected to create demand for advanced ICs, notably analog ASSPs, in accordance with market expansion. At the same time, intensified competition among new entrants to secure critical market share will increase price pressure on mobile telephone equipment. Dataquest believes that, under these circumstances, Japanese communications equipment makers will help establish a new order in the international market through balanced leadership and maintenance of competitive edges.

By Naotoshi Yasuhara

Semiconductor Industry in Transition from Expansion to Fusion: Multimedia Implications

The semiconductor market of the 1990s seems to be behaving quite differently from the market of the 1980s, for the following reasons:

- Drastic changes in industrial structure initiated by downsizing
- Sluggish sales of 4Mb DRAMs
- Deterioration of productivity of investment in DRAM business
- Significant decline in semiconductor revenue of Japanese semiconductor manufacturers

And these factors have led to new views of the semiconductor market. In short, the semiconductor industry in the 1990s has no choice but to transform itself from a supplier to a creative designer, and multimedia holds the key to success in the new role. Various alliances related to the multimedia market, under the leadership of U.S. manufacturers such as Apple Computer and IBM, are structurally changing the semiconductor market. Clearly, multimedia—which embraces everything from computers to telecommunication—is the key market for determining the semiconductor market in the 1990s.

This article presents the first analysis of the multimedia market focusing on alliances as a source of fostering the market.

Semiconductor Industry to Become Creativity-Intensive

The semiconductor market in the 1990s faces a change from bloated expansion to strategic focus. Apparently, the market has started to redirect itself from market-share-driven expansion to high-value-added marketing. The semiconductor industry is expected to transform from a parts industry insisting on market expansion to a creativity-intensive industry.

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In the past, the semiconductor industry grew steadily, fueled by leading electronics products such as VCRs. In the 1990s, however, it can no longer rely on an old market mechanism developed in its heyday; the semiconductor market has undergone structural changes because of fundamental changes in the computer market that have driven the industry in recent years. In particular, the silicon cycle governing ups and downs of the semiconductor market has fluctuated less, suggesting future market trends characterized by moderate growth. One factor leading these changes is a major shift in market positioning of DRAMs, which used to be the locomotive of the semiconductor market, from standard ICs to application-specific products.

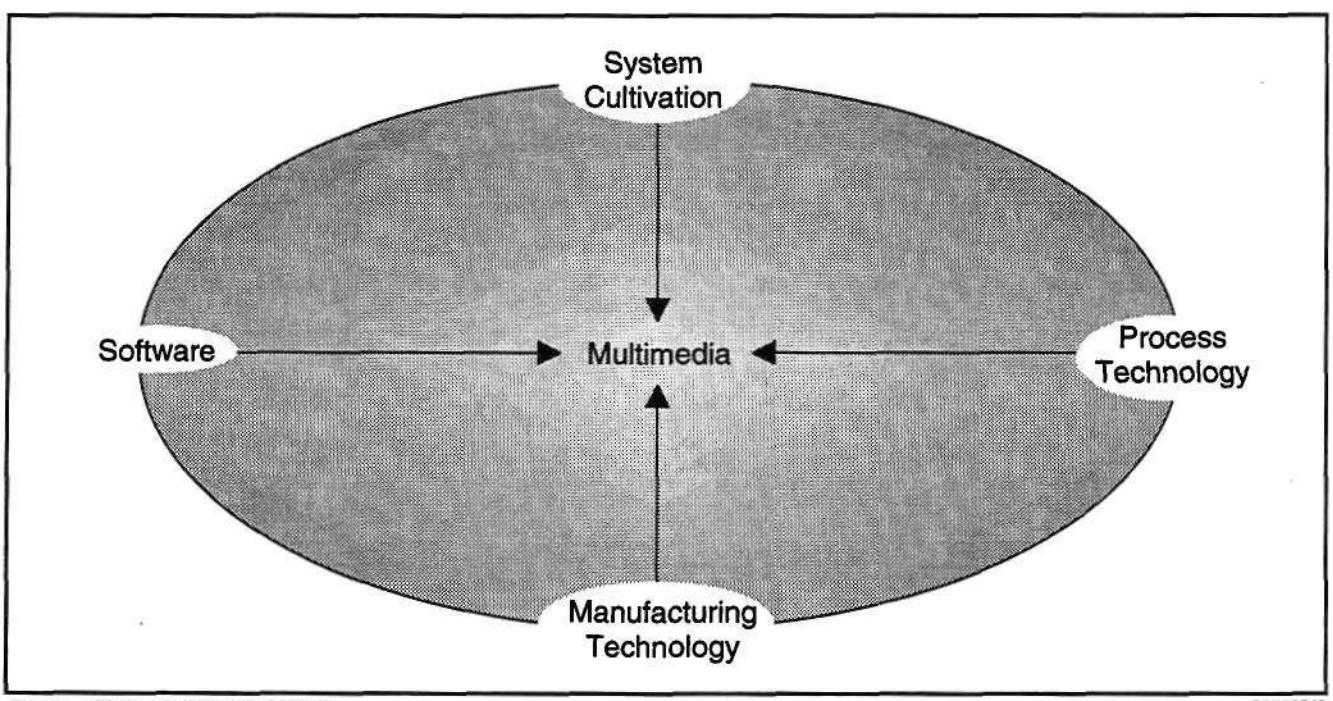
Also, the increase in memory production lines processing two generations of DRAMs side-by-side has raised the percentage of semiconductor equipment in capital expenditure. Such unexpected increases—triggered by fundamental changes in memory production cycles from 4Mb DRAMs—have negative effects in terms of productivity of investment. Dataquest believes that the semiconductor industry needs to focus on profitability and production planning to ensure long product life cycles rather than to expand market share, and on strategic investment emphasizing appropriate returns instead of capacity expansion.

Multimedia Industry and Alliances

Multimedia receives much attention as a possible means of promoting the semiconductor industry's expected transition from a parts industry to a creativity-intensive industry. Because commercialization of multimedia requires a wide range of technologies from process to system software (see Figure 1), various companies with advanced technologies have entered alliances as a first step. These alliances are considered a sign of future multimedia strategies for semiconductor manufacturers.

Kaleida, established by IBM and Apple for the purpose of developing multimedia technology, is expected to play a leading role in standards and other aspects. However, some companies are rushing to separate alliances aiming at their own standards and products (see Figure 2), including interindustry alliances such as Sony and Nintendo, or Sega Enterprises. This move suggests the development of increasingly complex and wide relationships in the field of multimedia.

Figure 1
Multimedia Environment



Source: Dataquest (August 1992)

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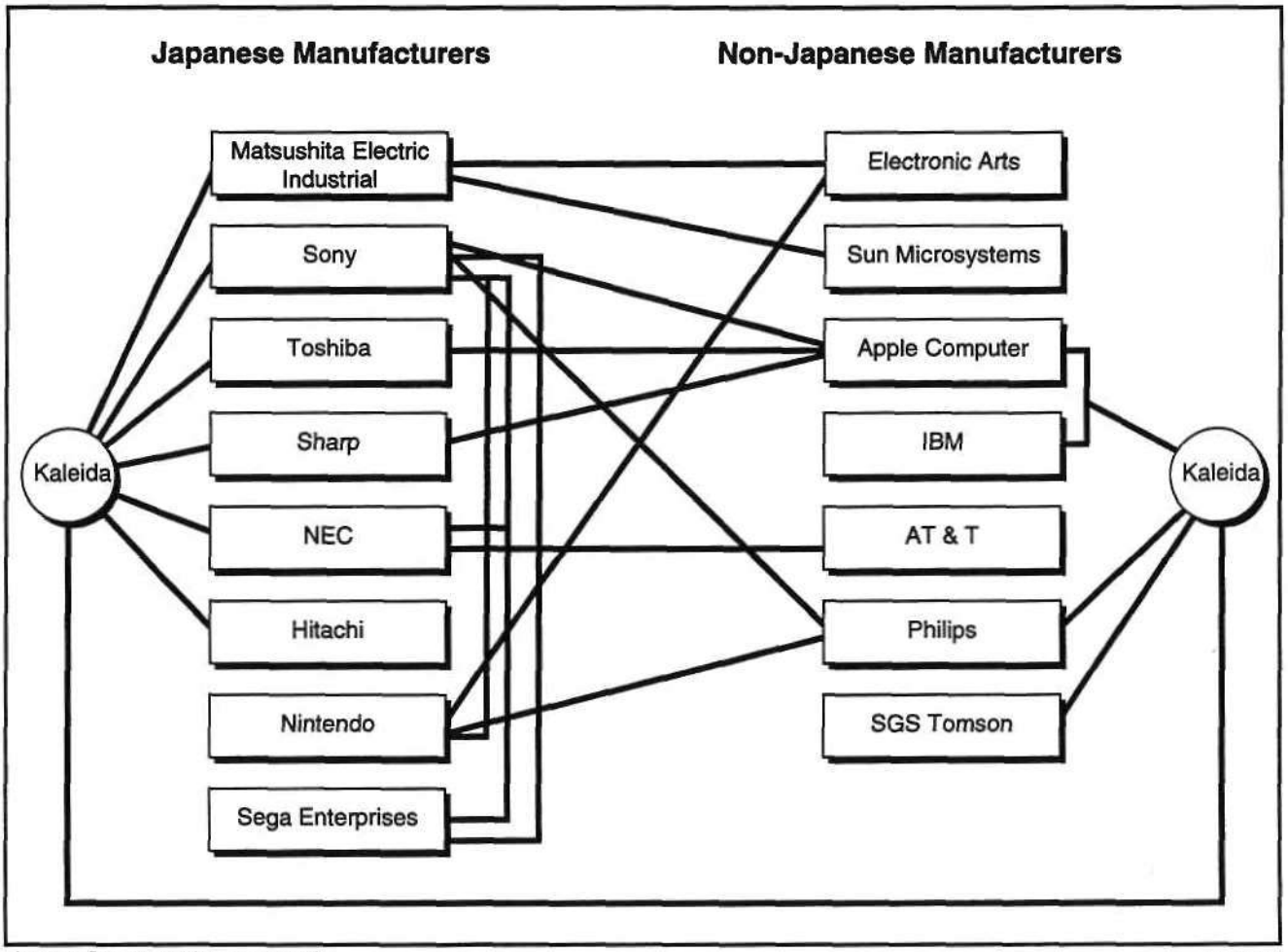
Figure 2
Multimedia Alliances



Source: Dataquest (August 1992) G2001550

The most aggressive company in the multimedia camp is Apple Computer, which attempts to establish uniform standards on the basis of its PCs—which are said to be closest to Kaleida's image of multimedia systems. Apple also is absorbed in joint ventures with Japanese consumer electronics manufacturers, such as Sony, Sharp, and Toshiba, which have strength in downsizing hardware. As a result, Apple is scheduled to introduce multimedia products by the end of this year at the earliest, under joint development with Japanese manufacturers—clearly one step ahead of other rivals in terms of strategy building and implementation.

In Japan, Japanese companies targeting the multimedia market have been stepping up their activities of late. Their strategies clearly reflect the fields they target. Conceptually, the multimedia industry covers a wide range of areas from hardware to broadcasting and telecommunication, and the software-related market segment is expected to exceed the size of the hardware market. The widely held belief that the United States has strength in software and Japan in hardware indicates competitive edges held by the U.S. industries in the multimedia industry. This means that Japanese companies are running the risk of becoming mere suppliers of hardware products to U.S. companies that can control software products for multimedia systems. Thus Dataquest believes that acquisition of U.S. movie companies by Sony and Matsushita Electric Industrial are attempts to supplement the weakness of the hardware-driven Japanese multimedia industry.

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Dataquest Perspective

The multimedia industry combines a variety of technologies including computer, consumer electronics, visual media, and communication. Manufacturers of these products worldwide are fostering the emerging industry through a wide range of alliances aimed at establishing production technology to integrate hardware and software technologies, among other purposes. And these alliances seem to reflect the strength of the U.S. companies in software and that of Japanese companies in hardware. Each company forms a variety of alliances with different companies, each of which in turn establishes similar relations with others, forming a complicated chain of technological ties.

The emerging world of multimedia, which must be developed through integration of leading-edge technologies, seems to portend the future of the semiconductor industry and market. The increase in alliances between semiconductor manufacturers, manufacturers in other industries, and a combination of both, will remove a traditional boundary between semiconductors and their applications. There also will be increasing cases of partnership between former competitors, including Japanese manufacturers. The recent series of alliances related to multimedia, with Apple Computer as a central figure, foretell a variety of combinations to come. There will be few traditional partnerships characterized by limited membership.

Multimedia is breaking the traditional framework of the semiconductor industry and creating a new industrial order. Although multimedia has yet to clear a number of technological hurdles including standardization, Dataquest believes that it will play a significant role in transforming the semiconductor industry to a true design-intensive industry.

By Kazunori Hayashi and Kun Soo Lee

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- The United States-Japan semiconductor agreement and Japanese semiconductor market
- Is the HDTV market about to take off?

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Conference Announcement

Dataquest's 18th Annual Semiconductor Industry Conference

Each October, Dataquest brings together the top executives in the electronics industry for a forum on the latest issues facing this industry. This year's conference will focus on today's semiconductor marketing and technology issues, and preview tomorrow's major semiconductor applications that are *Fueling the Engines for Growth.*

Highlights of the conference are as follows:

- Special guest speaker: David Packard, Cofounder and Chairman of the Board of Hewlett-Packard.
- Eleven top industry executives sharing their insightful perspectives, real-world experiences, lessons, and bottom-line analyses.
- Two interactive panel discussions covering ASICs and strategic processor directions. Panels will be moderated by Dataquest and feature key industry leaders.
- Four breakout sessions presented by Dataquest senior analysts. The sessions will focus on manufacturing trends, semiconductor procurement issues, and two emerging applications areas: personal information and communications devices (PICDs), and multimedia.

In addition to the presentations and panel discussions, this year's agenda has been designed to allow social time for conferring with your peers on the critical issues and challenges facing the industry. You'll find the two days interesting, very informative, and, we hope, thoroughly enjoyable.

Seats are limited for this premier semiconductor event. To register for this conference, or to request a complete conference agenda, please call our toll free number, 1 (800) 457-8233, today!

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Monterey, California
October 5 and 6, 1992
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Nonclient Rate: $1,295

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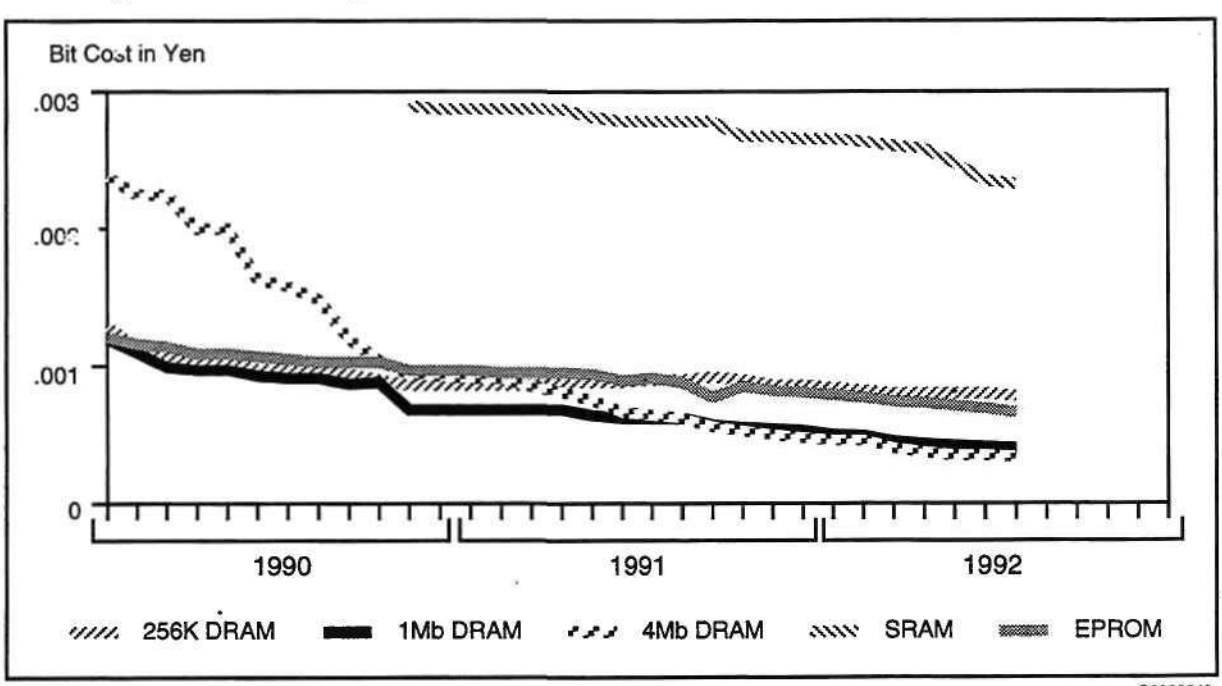
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	2.95	3.20	3.30	2.90	3.10	3.00
DRAM 256Kx1-8	1.10	1.60	1.55	1.00	1.20	1.05
DRAM 4Mbx1-8	10.80	10.92	11.50	10.50	12.50	10.40
EPROM 1Mb, 170ns	3.08	3.28	2.65	2.50	3.10	2.40
EPROM 2Mb, 170ns	6.50	6.72	4.60	4.50	6.20	4.70
SRAM 1Mb, 128Kx8	11.25	10.80	9.25	11.50	13.60	NA
SRAM 256K, 32Kx8	3.25	3.28	3.20	3.00	3.80	3.10
SRAM 64K, 8Kx8	1.65	1.56	1.55	1.20	1.43	1.40
68020-16	27.25	32.81	26.00	32.00	31.50	NA
80286-16	7.15	9.20	10.00	8.00	10.10	6.90
80386DX-25	94.50	116.42	94.00	78.00	96.00	70.00
80386SX-16	41.00	46.81	45.00	40.00	47.20	37.00
R3000-25	100.00	116.02	110.00	NA	NA	NA

Note: These figures correspond with DQ Monday Report dated July 20, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (July 1992)

Memory Bit Price in Japan



Source: Dataquest (July 1992)

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Market Analysis

Final 1991 Japanese Semiconductor Market Shares: Slower Growth than Previously Reported

According to Dataquest's final 1991 market share figures, worldwide semiconductor sales totaled $59,694 million, a 9.4 percent increase over 1990. The Japanese market captured 37.7 percent of the global 1991 market with $22,496 million in sales and provided Japanese industry with an 11.1 percent annual growth rate. The Japanese market expanded by a slight 0.6 percent, relative to the world market, during the one-year period.

In terms of suppliers, Japan's 46.4 percent share of the 1991 global market nearly matched the 1990 figure of 46.3 percent. Asia-Pacific/ROW suppliers made market share gains at the expense of North American and European companies.

Table 1 summarizes the final estimates of the 1990 world semiconductor market, broken down by both market location and the suppliers' point of origin.

Japanese Market

The Japanese economy historically has been characterized by positive half-cycles now officially called "Heisei Boom." Although many economic forecasts predicted an earlier end of the most recent boom in Japan, it lasted until the third quarter of 1991. This period buoyed semiconductor revenue as Japanese consumer spending and corporate investment responded positively to the economic indicators. In contrast, the Japanese economy quickly cooled in the fourth quarter as the recession advanced more quickly and deeply than most industries expected.

Domestic manufacturers supplied $19,337 million, or 86 percent, of the $22,496 million worth of semiconductors purchased in Japan during 1991, a 0.9 percent decrease in market share from the previous year for Japanese chip producers. The U.S.-Japan Semiconductor Agreement, extended an additional five years in August 1991, specified a 20 percent foreign-chip market share of the Japanese market by the end of 1992. According to Dataquest's figures, 14 percent of the semiconductors sold during 1991 in the Japanese market were non-Japanese made. Although Japanese companies still retain a dominant position in their domestic market, North American, European, and ROW suppliers all increased their market presence in Japan. Despite absolute monetary figures that remain small, the ROW companies—Korean companies in particular—recorded the highest growth rates among suppliers to the Japanese market.

Japanese companies have had improved growth in all product categories except bipolar products, which may be vanishing as a category because many previously pure bipolar products are evolving into more sophisticated BiCMOS circuits with improved speed-to-power-consumption performance. MOS memory products grew a modest 0.8 percent, recovering from a 23 percent drop the previous year. Although memory unit shipments increased during 1991, heavy memory price erosion resulted from intense competition by Korean commodity

Table 1
Estimated Final 1990 Semiconductor Market Share (Millions of Dollars)

	Regional Market				Worldwide	Company Base
	North America	Japan	Europe	Asia/Pacific	Revenue	Share (%)
North America	11,856	2,833	4,780	3,471	22,940	38.4
Japan	3,429	19,337	1,756	3,162	27,684	46.4
Europe	1,062	167	4,146	961	6,336	10.6
Asia/Pacific	643	159	332	1,600	2,734	4.6
Total Regional Market	16,990	22,496	11,014	9,194	59,694	
Share (%)	28.5	37.7	18.5	15.4		100.0

Source: Dataquest (July 1992)

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memory manufacturers and contributed to diminished profit margins for Japanese manufacturers. The memory market in Japan has also been depressed by a lack of growth in application products. Sales of data processing and audio-visual products, which are usually large consumers of semiconductor components, showed little growth in a sluggish economy that is encountering market saturation. Greater demand for memory is anticipated in 1993, however, as memory-hungry operating systems such as Microsoft's Windows and IBM's OS/2 begin to emerge on desktop systems. The heavy use of portable machines in Japan will stimulate demand for high-density and low-power memory products. Adoption of graphical user interface multitasking operating systems on these portables would further accelerate demand for high-performance memory products. Taken collectively, the software and hardware applications are nearly in place to drive demand for memory product consumption during the next few years in Japan.

While the MOS memory market was sluggish during 1991, MOS microcomponents showed a 20.3 percent growth rate during the same period (see Table 2). Microcontroller products made up 64 percent of the microcomponents sold in Japan. Microcontroller production was propelled by consumer electronic markets that remained vibrant through the first half of 1991 and caught the tail end of the Heisei Boom. Although microprocessors accounted for only 15 percent of the Japanese microcomponent market, Intel's 30 percent annual growth rate made it the second highest performer in the Japanese microcomponent market, trailing only NEC. The growth in sales of Intel's 386 and 486 microprocessors is another good sign for memory suppliers, because more and more are being purchased for use in Windows-based systems with high memory demands. Furthermore, the competition brought on by companies trying to clone the 386 and 486 families of microprocessors will likely force a reduction in prices as CPU supplies swell, which should again stimulate memory consumption.

Japanese Companies' Performance in 1991

Although the Heisei Boom lasted longer than previously expected, Japan's economy plunged into a recession much more quickly and deeply than most industries anticipated. Consumer electronics production grew by a modest 4.4 percent, driven in part by domestic consumer demand in the first half of 1991. The U.S economy did not shown much indication of a recovery during 1991; the U.S. semiconductor market grew by only 3 percent. Many Japanese subsidiaries operating in the United States lost money for the year.

The fluctuation in regional economies during 1991 had widely varying effects on the major Japanese electronics companies, whose product mixes were subject to purchasing trends beyond their control. Figure 1 shows the top 10 Japanese semiconductor manufacturers with their 1991

Table 2
Final 1991 Japanese Semiconductor Market by Product (Millions of Dollars)

Product	1990	1991	Change (%)
Total Semiconductors	20,257	22,496	11.1
Total Integrated Circuit	15,794	17,277	9.4
Bipolar Digital	1,635	1,442	-11.8
MOS Function	10,660	11,881	11.5
MOS Memory	4,196	4,228	0.8
MOS Microcomponents	2,974	3,579	20.3
MOS Logic	3,490	4,074	16.7
Analog	3,499	3,954	13.0
Total Discrete	2,969	3,432	15.6
Optoelectronics	1,494	1,787	19.6

Source: Dataquest (July 1992)

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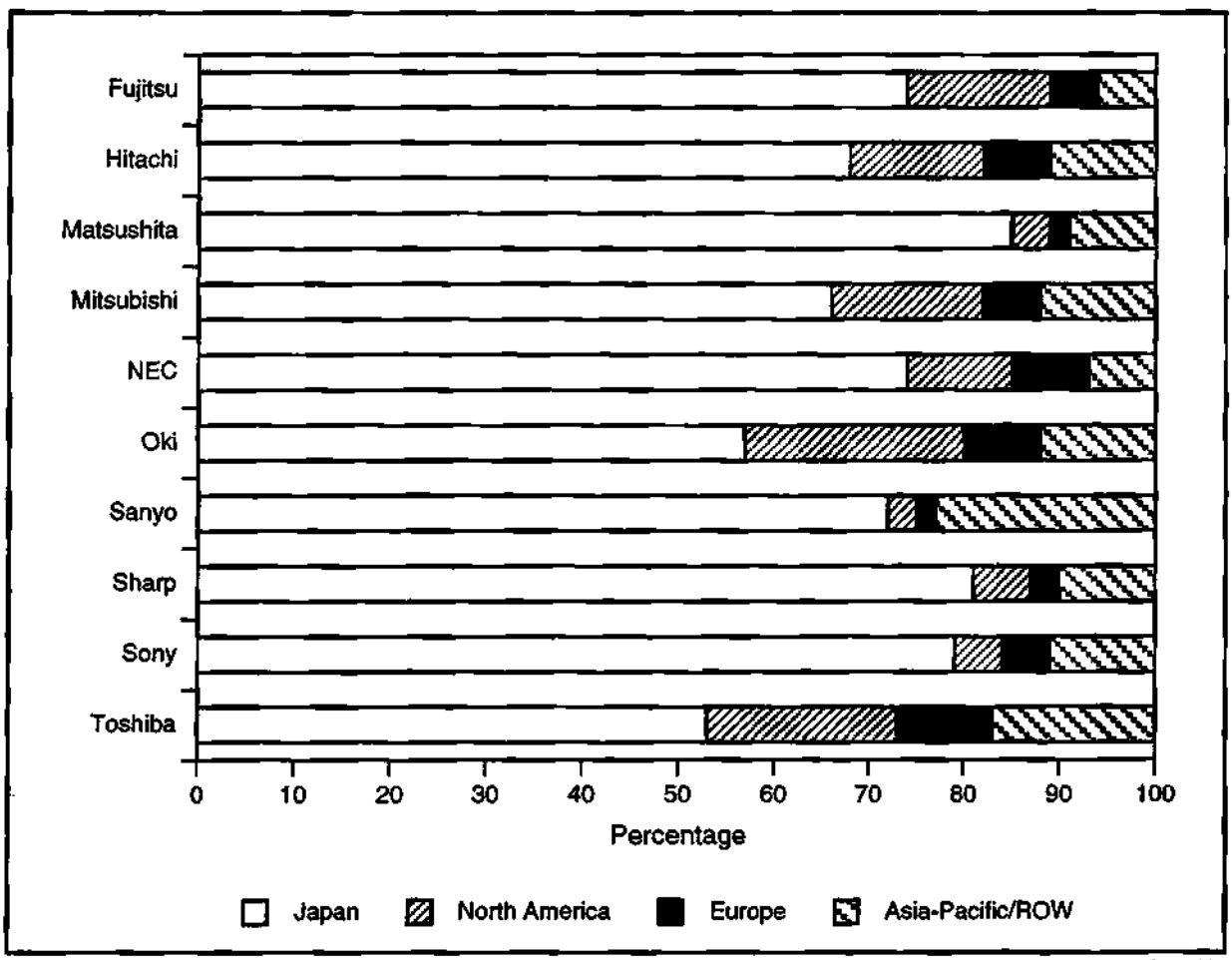
semiconductor sales divided into regional components. Companies such as Oki and Toshiba sell a larger percentage of their semiconductor chip products in foreign markets than do most of their Japanese competitors. However, many companies in Figure 1 are vertically integrated and sell a large portion of their chips to their own captive market subsidiaries primarily situated in Japan. The final products of the subsidiaries may often have a much greater dependence on foreign markets than do the semiconductor components of the parent companies. Hence it is important to properly interpret the regional semiconductor sales figures when comparing the relative performance of Japanese suppliers to foreign semiconductor markets. As an example, Matsushita and Sony produce much of their semiconductors for internal consumption in Japan. This tends to diminish their market share in foreign semiconductor markets—even though their final products incorporating their own semiconductors may actually effectively export larger numbers of Japan-made chips than do some products by Japanese competitors that have sold more chip components abroad.

Figure 2 shows the semiconductor product mix in the worldwide market by the top 10 semiconductor revenue producing Japanese companies. NEC is noteworthy because it is especially well balanced in its distribution of semiconductor product emphasis.

Figure 1
Top 10 Companies Sales by Region



Source: Dataquest (July 1992)

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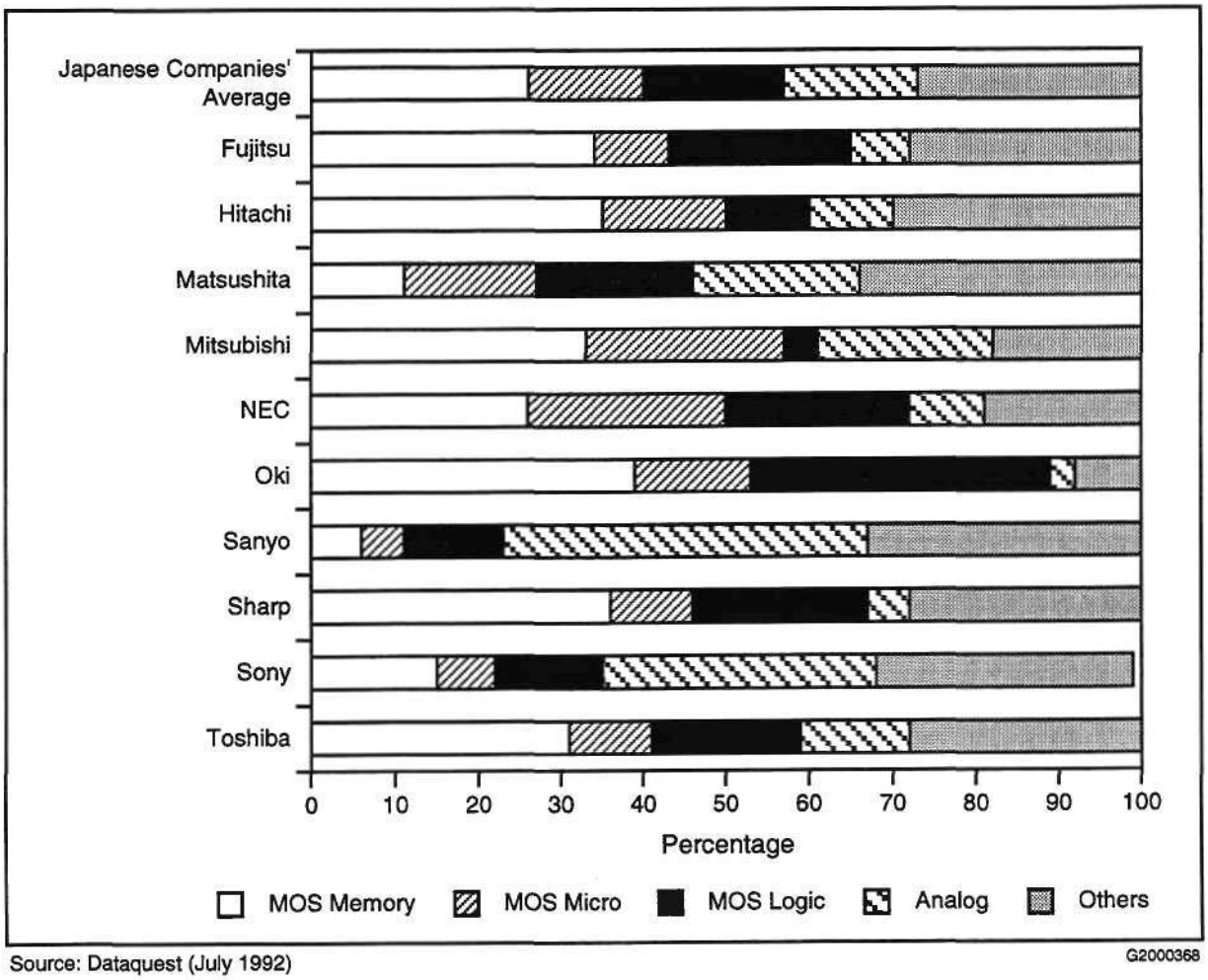
Figure 2
Top 10 Companies' Sales by Product in the Worldwide Market



Source: Dataquest (July 1992)
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Table 3 shows the change in semiconductor revenue rankings of the top 40 suppliers to the Japanese market from 1990 and 1991. (Dataquest has also published detailed tables of various product segments of the Japanese market.)

Dataquest Perspective

Two distinct economic phases characterized Japan in 1991. The year began in the midst of a Heisei Boom period and concluded with a dive into recession. The semiconductor industry should have reached a half-cycle peak in 1992 as a follow-up to the steady rise in 1991, according to historical trends of the silicon cycle. Although this did not occur, the Japanese semiconductor market grew a healthy 11.1 percent during 1991. But economic conditions needed to sustain growth were absent at the end of the year. Dataquest now forecasts the Japanese semiconductor market to decline by 9.4 percent in 1992.

By Junko Matsubara

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Table 3
Final Estimated 1991 Japanese Market Share Ranking, Total Semiconductor
(Millions of Dollars)

Rank 1991	Rank 1990		1990	Revenue 1991	Change (%)	Market Share (%)
1	1	NEC	3,106	3,479	12.0	15.5
2	2	Hitachi	2,441	2,566	5.1	11.4
3	3	Toshiba	2,205	2,436	10.5	10.8
4	4	Fujitsu	1,856	1,975	6.4	8.8
5	5	Matsushita	1,491	1,717	15.2	7.6
6	6	Mitsubishi	1,461	1,512	3.5	6.7
7	7	Sharp	956	1,070	11.9	4.8
8	8	Sanyo	885	974	10.1	4.3
9	9	Sony	778	946	21.6	4.2
10	10	Rohm	629	760	20.8	3.4
11	11	Texas Instruments	614	730	18.9	3.2
12	12	Oki	561	556	-0.9	2.5
13	13	Motorola	436	492	12.8	2.2
14	14	Intel	367	470	28.1	2.1
15	15	Sanken	300	357	19.0	1.6
16	16	Fuji Electric	254	256	0.8	1.1
17	17	Shindengen Electric	144	166	15.3	0.7
18	18	National Semiconductor	139	146	5.0	0.6
19	20	Seiko Epson	134	143	6.7	0.6
20	19	Advanced Micro Devices	139	135	-2.9	0.6
21	22	New JRC	119	132	10.9	0.6
22	21	Yamaha	120	123	2.5	0.5
23	23	Ricoh	89	94	5.6	0.4
24	24	Rockwell	80	83	3.8	0.4
25	26	Samsung	60	83	38.3	0.4
26	25	Philips	67	77	14.9	0.3
27	27	LSI Logic	58	77	32.8	0.3
28	29	Burr-Brown	49	56	14.3	0.2
29	30	Analog Devices	42	52	23.8	0.2
30	32	SGS-Thomson	38	48	26.3	0.2
31	39	Exar	19	46	142.1	0.2
32	28	Toko	54	41	-24.1	0.2
33	34	Silicon Systems	23	26	13.0	0.1
34	31	Harris	41	25	-39.0	0.1
35	33	ITT	25	25	0.0	0.1
36	37	Siemens	21	25	19.0	0.1
37	54	MOSel	9	25	177.8	0.1
38	35	General Instrument	23	24	4.3	0.1
39	36	Cirrus Logic	23	23	0.0	0.1
40	41	Hewlett-Packard	17	23	35.3	0.1
		Total Market	20,257	22,496	11.1	100.0

Source: Dataquest (July 1992)

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Japanese Semiconductor Alliance Update: Second Quarter 1992

During the second quarter of 1992, which ended on March 31, Dataquest recorded 25 new alliance agreements involving Japanese semiconductor companies (see Table 1). Dataquest observed an average rate of 22 new alliances per quarter during 1991 and the first quarter of 1992. The 25 newly formed alliances of the second quarter, and the 23.5 average per quarter for the first half of 1992, indicate that alliance formation rates of the past few years continue to be nearly constant. In addition, while the current Japanese recession has been both deeper and longer than the industry at large had anticipated, it seems that the recession has not altered the perception that strategic alliances are of value to Japanese corporations.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 1:

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

U.S.-Japan Semiconductor Trade Agreement

The semiconductor trade agreement, which was renewed in August 1991, explicitly mandates a goal of 20 percent of Japanese chip consumption supplied by foreign-based companies by the end of 1992. Although Japanese industry has remained skeptical about the prospects of achieving the specified level of foreign market share, many Japanese semiconductor companies have made conspicuous efforts toward increasing their levels of foreign chip procurement.

Alliances involving OEM sales and marketing alliances were particularly active in the second quarter of 1992. NEC was busy building three sales alliance bridges to North American companies during the second quarter. NEC established a joint sales company with its long-time partner AT&T to promote AT&T chips in Japan. NEC also announced a marketing exchange venture with Micron Technology. Micron's memory products will be sold through NEC's distribution channels worldwide, and NEC will have some of its own products marketed by Micron on an OEM basis. Because both AT&T and Micron products would be classified as foreign-made chips under the guidelines of the new trade agreement, NEC expects these new ventures to contribute to a boost in foreign chip consumption in Japan.

Updating an alliance formed last year, AT&T will construct and dedicate the output of a fab line in AT&T's Thailand plant for the exclusive purpose of supplying Mitsubishi as a captive customer. The products from the AT&T fab should help raise Mitsubishi's level of foreign chip procurement.

Some semiconductor trading houses in Japan, such as Hakuto, Kanematsu, and Sumisho Electronics, not only market their suppliers' chips but also invest and transfer know-how to medium-size and small semiconductor companies to boost foreign chip marketability. Furthermore, some of these trading houses are playing active roles in initiating ventures in which foreign chip fabrication capacity is utilized to implement third-party Japanese chip designs. This role can elevate the profile of trading houses because they are perceived as progressive traders while also assisting the larger Japanese companies in fulfilling their foreign chip purchasing obligations.

Next-Generation Memory Alliance

Competition in the commodity DRAM business has been heightened to new levels as this market segment continues to demand ever-increasing capital investment. An indication of the cost requirements to enter these markets is the heavy government subsidies to projects in both Korea and Taiwan. Japanese semiconductor companies, some of which had become heavily dependent on DRAM revenue during the past few years, have suffered during the recent slowdown and are trying to diversify their memory

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Table 1
Japanese Semiconductor Alliances—Second Quarter 1992

Company 1	Company 2	Product	Agreement Type	Date
Anelva	Plasma & Materials Technologies	High-density plasma system	LA	4/92
Kanematsu	Quality Semiconductor	Quick switch, high-speed TTL, SRAM	SA	4/92
Sumisho Electronic Device	AT&T	DSP, communications ICs	SA	4/92
Mitsubishi	New Japan Radio	Consumer semiconductors	JD	4/92
Okura Trading	Star Semiconductor	DSP	SA, IV	4/92
NEC	MIPS Computer	R4000 RISC MPU	JD	4/92
Fujitsu	Wang Laboratories	SIMM license	LA	4/92
Mitsui & Co.	AT&T and others	Communications chip set	SA	4/92
NEC	Mitsubishi	DRAM disk	SS	4/92
Hitachi	Oki	MIPS RISC MPUs	JD, CO	4/92
Rohm	Texas Instruments	Kilby patent	LA	4/92
Sanyo	Information Storage Devices	Analog memory device	SA, FA	4/92
Fujitsu	Samsung	Cross-licensing	LA	4/92
Hitachi	Texas Instruments	BiCMOS bus interface	SA, FA, CO	4/92
NEC	AT&T	Memory, logic ICs	SA	5/92
Fujitsu	Mosel	Memory	FA	5/92
Toshiba	National Semiconductor	CMOS logic ICs	FA, JD	5/92
Hakuto	SGS-Thomson	Semiconductors	SA	5/92
NEC	Micron Technologies	256, 1Mb DRAMs	SA	6/92
NEC/ASCII	CrossPoint Solutions	FPGA, development systems	SA	6/92
Oki	Mosel/Vitelic	4Mb DRAM, ASM	OT	6/92
Matsushita	SunDisk	4, 8Mb flash memory	FA	6/92
Toshiba	IBM	Flash memory	SA, JD	6/92
Sony	AMD	Next-generation EPROM	JD	6/92
Mitsubishi	Texas Instruments	Patent cross-license	LA	6/92

Source: Dataquest (July 1992)

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chip portfolios. High-speed DRAM products incorporating novel on-chip caching schemes are becoming a popular method for several Japanese manufacturers to meet the demand for memories that can keep up with the latest generation of microprocessors. These products also give the Japanese producers a way to differentiate their memories from the commodity low-end products produced in other Asian countries.

Flash EEPROM memory is another area attracting the interest of many Japanese manufacturers, as flash is now viewed as a potential large-scale replacement for other types of nonvolatile memories, particularly magnetic disks, in the burgeoning markets of notebook and subnotebook computers. Both cached DRAM and flash memory technologies require circuit design innovation coupled with advanced manufacturing capabilities to achieve competitive densities and performance figures.

The flash memory market had a volume of about $120 million worldwide last year, and Intel held the dominant market position with about 85 percent share of the total market. Flash memories that rely on diverse approaches and processes are being developed by several manufacturers. Although Toshiba claims that it invented flash memory, its technology is apparently quite different from that of Intel's. Toshiba has now teamed with IBM to establish a competitive flash technology. By adding to its joint development of thin film active matrix transistor liquid crystal displays, this latest venture further links the fate of these two corporate giants in the laptop and notebook-related markets. An added benefit to IBM in these two joint ventures with Toshiba is that IBM can gradually acclimate both customers and itself with IBM's expanding role as a merchant semiconductor supplier. It now appears that many U.S. systems and component manufacturers are striving to attain the levels of vertical integration that are so prevalent among their Japanese competitors. IBM is in a particularly good position to sell components because its semiconductor production capabilities have been world class for some time.

Intellectual Property

The economic slowdown of the past few years has caused many international semiconductor companies to reassess their approach to protecting competitive advantage by leveraging intellectual property. A normalization of international patent standards among the companies and governments of Korea, Japan, and the United States is expected to evolve considerably during the next couple of years. Fujitsu and Samsung recently reached a five-year patent cross-licensing agreement. Under this agreement, Samsung will pay an estimated ¥4 billion in royalties to Fujitsu. In other Japanese-Korean mediations, NEC, Hitachi, and Toshiba are all believed to be heading toward talks with Korean semiconductor companies to license technology. Korean semiconductor companies have been very aggressive in capturing market share in world commodity semiconductor markets and have attempted to model their growth after the Japanese successes during the 1970s. In 1991, Samsung ranked 12th among all semiconductor suppliers worldwide with particular strengths as a DRAM supplier. As Texas Instruments continues to pursue compensations and royalties from its patent portfolio, Rohm and Mitsubishi are the latest Japanese semiconductor manufacturers to sign cross-licensing agreements with TI. The Mitsubishi signing concluded a comprehensive 10-year cross-licensing agreement that included the Kilby patent.

Dataquest Perspective

The current Japanese economic slowdown clearly has had no impact on the high value that Japanese companies place on long-term strategic alliances. Although the true benefits of strategic alliances between companies from different countries may not be determined for some time, it is certainly an educational experience that will help the internationalization of smaller companies just beginning to compete abroad. Furthermore, if the U.S. trade deficit with Japan is reduced through the proliferation of strategic alliances, then both countries should benefit, as their economies are so interdependent.

Many Japanese semiconductor companies plan large cutbacks in their capital expenditure during fiscal year 1992. The Japanese and U.S. semiconductor industries seem to have permanently deviated from historical trends often described as the periodic silicon cycles. As a result of these deviations and forecasts, overcapacity has been found in some large-investment product categories. Successive generations of these products continue to require even more capital and have higher associated risk. In these cases, alliances are often borne of necessity as the only alternative to totally abandoning these risky ventures.

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Strategic Alliances

The following section briefly summarizes some strategic alliances that Dataquest recorded during the second quarter.

Mitsui & Co./AT&T/Technekron

Mitsui & Co. teamed up with AT&T to develop a next-generation digital car/portable phone chip set for the North American market. Mitsui will work with AT&T Microelectronics, Technekron Communication Systems, and Mitsui's sales subsidiary, Mitsui Comtech. The chip set will use AT&T's high-speed DSP and will be released for sale in North America in 1993. AT&T will be in charge of production, and Mitsui will market the chip sets to Japanese communications equipment markers that have production operations in North America.

Fujitsu/Samsung

Fujitsu signed a cross-licensing agreement with Samsung Electronics of Korea. The five-year agreement enables each company to use all of the other company's semiconductor patents in the United States, Japan, and Europe. Because Fujitsu's patents are valued higher than are Samsung's, Samsung will pay an additional ¥4 billion to Fujitsu. It appears that Fujitsu was determined that Samsung pay royalties on Fujitsu semiconductor patents so as not to set a weak enforcement precedent in a rapidly expanding Korean semiconductor industry. Samsung's semiconductor production totaled $1.5 billion last year, up 12 percent over 1990. Fujitsu's move is likely to encourage other Japanese and U.S. chip makers to initiate patent payment negotiations with Korean semiconductor companies.

NEC/AT&T

NEC and AT&T agreed to set up in June a sales company in Japan to sell AT&T semiconductors. The two companies have been cooperating in production technology, such as a joint memory chip development project. The sales company will obtain 51 percent of its capital from AT&T and 49 percent from NEC. The joint company will initially sell microprocessors, static read-only memories, and general-purpose microchips, including those for use in communications equipment, to NEC group companies.

NEC/Micron Technology

NEC will market Micron Technology's DRAMs in the Japanese market. The two companies agreed that NEC will market Micron's 256K and 1Mb DRAMs at an estimated rate of 10,000 units per month. The industry consensus is that the alliance was intended to be a demonstration of NEC's willingness to promote foreign chip consumption in Japan prior to the joint EIAJ/SIA meeting held the first week of June.

Toshiba/IBM

Toshiba and IBM agreed to jointly develop flash memories. The two companies are expected to sign an official agreement by late August. Toshiba, which was the first to develop a flash EEPROM circuit in 1984, will provide IBM with its proprietary NAND flash memory technology. Toshiba and IBM will cooperate on developing a flash memory-based card-size external data storage device, which will possibly replace floppy disk drives in portable applications. IBM plans to start production of flash memory drives next year and will market them to other computer makers.

By Junko Matsubara

Product Analysis

The Other Side of Downsizing: Lower Operating Voltage for DRAMs

The operating voltage of logic LSIs—and to DRAMs as well—soon will be lowered from 5V to 3.0V or 3.3V. And although DRAM makers linger over the choice between 3.3V and 3.0V, chances are that both versions will be offered for the time being.

The current drive for voltage drop has been initiated by semiconductor makers that see it as a solution for the lower reliability of devices that have reached a submicron level. Now system makers have joined the cause, led by PC makers that find the reduction of power dissipation to be a new competitive edge, and workstation makers that have to find ways to control noise and heat because of increased power dissipation. Now that semiconductor suppliers and system makers share the same view and goal, the

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industry can be expected to move toward full-fledged market introduction of low-voltage devices.

This article focuses on DRAMs, which are about to enter an important transition period in their history, and examines the current market position and outlook of low-voltage DRAMs.

Road to the 3V World

Two main reasons motivate the decrease in supply voltage. One reason is the motivation to deal with the problems of increased power dissipation and of deteriorated reliability in MOSFET, which are unavoidable consequences of the 0.5-micron process used to miniaturize semiconductor devices. Another motive reflects the need for lower voltage and power consumption in response to market growth for battery-operated portable electronics equipment. The following section takes these factors into account and analyzes the advantages and disadvantages of the lower operating voltage, along with its directions.

3.0V or 3.3V?

The present supply voltage, 5V, was adopted a decade ago and its successor is still to be designated. Although 3.0V and 3.3V are seen as candidates, there is no clear direction toward unification. 3.3V's legitimacy rests on its being named the JESD 8.0 standard (now upgraded to 8.1) set forth by the Joint Electron Device Engineering Council (JEDEC) in 1984, but the increasing use of batteries definitely makes 3.0V a favorable choice. Nevertheless, failure of semiconductor makers to agree on uniform specifications likely will result in new products with two different source voltages, at least for the time being.

As for DRAMs, 3.0V±10 percent or 3.3V±0.3V products are likely candidates. DRAMs operating at 3.3V have specifications different from those with 3.0V, particularly a significant difference in access time. Dataquest expects 3.3V versions to be used for high-speed and high-end systems such as workstations because of high-speed operation, whereas 3.0V products will be adopted for notebook PCs and other systems that emphasize low-power consumption. In fact, microprocessors already use different voltages according to applications, and single-chip microcomputers are operated at relatively low voltages for watches, remote controllers, cameras, telephones, and hand-held calculators. Thus, it is a logical progression for DRAMs to follow this application-driven trend: 3.0V versions for portable systems, and 3.3V for workstations and other high-performance systems.

Advantages of the Lower Voltage

The drive for lower supply voltage is powered by the following three sources:

- PC makers that know the increasing importance of reduced power consumption required for battery-operated portable PC market success
- Workstation makers that face heat and noise problems after surviving the competition for high performance
- Semiconductor makers that have to address the long-standing issue of maintaining reliability of devices under submicron design rules

The decrease in supply voltage is expected to solve most of these problems. For instance, the lower voltage impacts reduction of power dissipation.

Power consumption of LSIs increases proportionally to the square of the voltage. If supply voltage is decreased from 5.0V to 3.0V, power consumption can theoretically be reduced to a level equivalent to 36 percent of the power consumed at 5.0V. Such power consumption savings offer significant advantages for portable electronic equipment. The increased operating time leads to fewer batteries used in system products, which in turn enables smaller and lighter products. Also, reduced heat generation decreases the packaging cost. These improvements can be translated to a smaller power unit and a reduced overall product cost—quite a plus for notebook PC designers that have been struggling to reach saving levels of 5 to 10 percent by improving CPU circuit designs and carefully selecting components with less power consumption. The decrease in supply voltage offers a major breakthrough for such cut-to-the-bone efforts, which are about to reach their limit.

The first notebook PC operating at 3.0V was Fujitsu's FMR-CARD, which operated with two small (M3-size) alliance batteries for 8 hours. Compared with similar products that typically could operate for only 2 hours, the effect of

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the lower supply voltage is evident. However, because the FMR-CARD sacrificed standard features such as floppy and hard disk drives in order to achieve maximum power savings, it received a cold reception from users. Certainly users want to have battery-operated PCs that can last longer; manufacturers should remember that they also want to see the same level of performance.

Another immediate effect of lower supply voltage relates to noise control. Today, high-end workstations show a significant upgrade in performance, with typical operating frequencies exceeding 40 MHz. This will continue to be the market norm—100-MHz processors will be used in 1994 and 500-MHz by 2000. Operation of microprocessors at such speeds, however, makes it extremely difficult to design boards using LSIs with TTL-level I/O interface because of the incremental influence of LSIs' switching noise and ground bounce. Again, the decrease in supply voltage offers a solution by reducing the amplitude of signals, which leads to decreased switching noise. Radiation noise can also be reduced at a rate proportional to the square of the voltage. Finally, lowering of the supply voltage would take care of reliability problems originated in design rules smaller than 0.5 microns (for example, shorter product life caused by hot electrons).

Disadvantages

While the advantages will certainly spur quick acceptance of semiconductor devices operating at lower voltages, there are various disadvantages to overcome. The first problem is the product mix and timing of market introduction. If LSIs are operated at different voltages on the same board, dual power units will impact cost and take up more space. An effective design solution is needed for the interface between LSIs with different operating voltages. Use of a signal-level conversion circuit would lead to the deterioration of system performance. The need to secure the same maximum voltage rating (7V) for both 3V and 5V products is another important consideration to prevent 3V LSIs from being damaged. Finally, lower voltage means increased vulnerability to electrostatic noise, necessitating modification of noise test methods. Intel, Motorola, and Advanced Micro Devices have announced processors operating at 3.3V. Texas Instruments and Signetics are preparing for supply of their 3.3V version ACT Logic Series. Nevertheless, these products likely will not become available in a timely manner to quickly replace 5V products.

Compared with other devices, memories require some technical solutions to operate at lower voltage. Unlike logic LSIs, which become operable through modification of MOSFET, DRAMs have a special data-retaining mechanism in their memory cells that may cause software errors when the operating voltage is low enough to decrease the accumulated amount of electric charges. This is dealt with by using stack cells having small diffusion layers. Most DRAM makers have adopted this solution at 4Mb production, which has proven applicable to 16Mb DRAMs with operating voltages of 3.3V.

Market Forecast for 3V DRAMs

Expected market acceptance of low-voltage DRAMs does not necessarily mean they will immediately replace 5V products. As more than two generations of DRAMs continue to coexist, refuting the traditional product life cycle, it is reasonable to expect two or more operating voltages to become the norm of the marketplace. Dataquest believes that 3.0V or 3.3V versions will hit the market as third-generation 4Mb DRAMs and will increase their share rapidly in 16Mb DRAMs. Obviously, price will determine market expansion. 16Mb DRAMs operating at 5V are designed to drop the voltage inside, thus their production cost is expected to be about the same for both 3V and 5V versions. In contrast, the very first 3.3V product of 4Mb DRAMs will be 20 to 30 percent more expensive than 5V versions, partly because it will use 16Mb DRAM technology and partly because it will not reach mass production. From a user's perspective, the 10 percent price difference would make 3V versions significantly attractive.

According to Dataquest's forecast, the portable PC's share of worldwide PC shipments will increase from 7.6 percent in 1991 to 64.2 percent in 1995 (see Figure 1). In particular, rapid penetration of laptop and notebook PCs portend even larger potential markets for portable PCs in Japan, including DC-powered laptop PCs that use low-voltage components. Semiconductor makers already made an unsuccessful attempt to reduce the operating voltage for 1Mb DRAMs

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when it became apparent that 1.2-micron design rules would reduce MOSFET hot carrier withstand voltage to below 5V. Users opposed it for the sake of interoperability with peripheral LSIs operating at 5V. And, as it turns out, 5V has been keeping up with the first-generation 16Mb DRAMs, which use the 0.5-micron technology. With the introduction of 3.3V versions for other LSIs, however, Dataquest believes that 3.3V 16Mb DRAMs will make inroads in the second generation (see Figure 2).

Market forecasts for the low-voltage DRAMs have to take into account the concurrent move to lower operating voltages in MPUs and ASICs. In fact, microprocessors lead DRAMs and ASICs in adopting the new operating voltages. Intel in 1990 started shipments of 16-bit 80X86 versions with the insured 3.0V operation. In 1991, AMD announced 80386-compatible 32-bit microprocessors capable of operating at 3.3V. Several makers will ship gate arrays and cell-based ICs dedicated to 3.3V operation by the end of 1992. The industry seems ready to push the new operating voltage in the 0.5-micron environment.

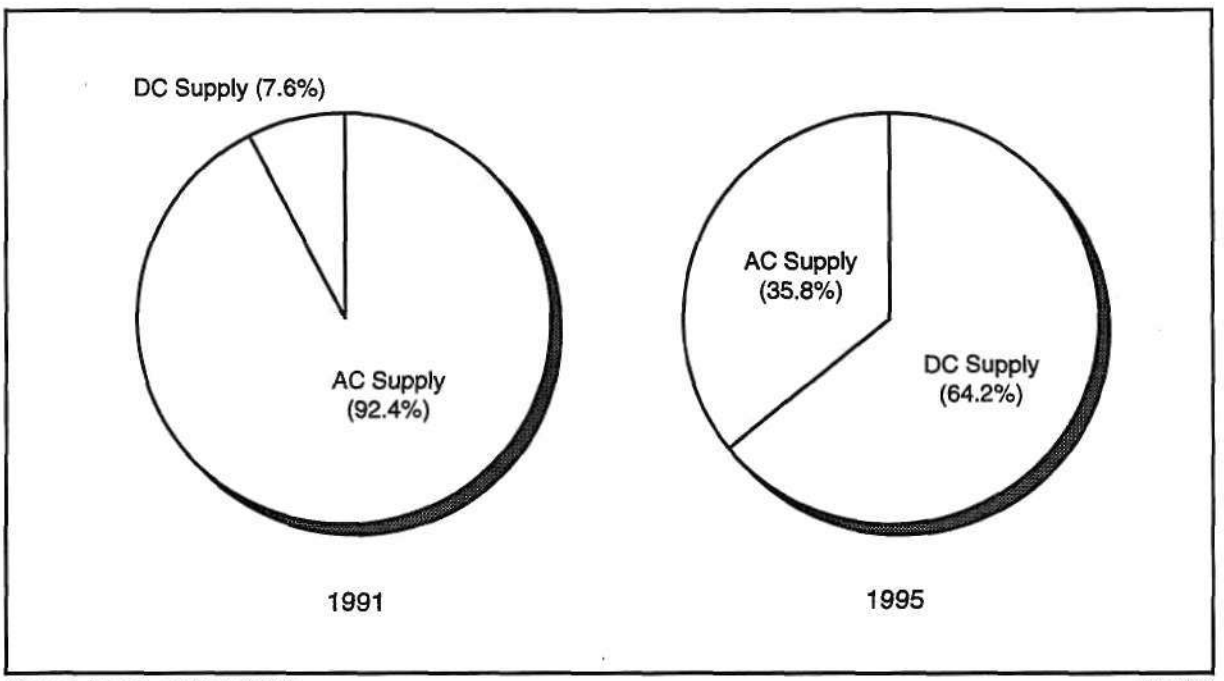
Dataquest Perspective

Dataquest estimates that 1,126 trillion bits of DRAMs will be consumed worldwide for PCs and expanded memories in 1992 (see Figure 3), of which 11 percent—124 trillion bits—will be used for portable PCs. In other words, the potential market for the low-voltage DRAMs, which amounts to 31 million 4Mb DRAMs, will account for 7.5 percent of worldwide consumption. Considering that the supply of 3V DRAMs is still limited, however, Dataquest predicts that 8 million units (2 percent of total worldwide 4Mb DRAM consumption) will be used for portable PCs in 1992, which equals 2.8 percent of worldwide DRAM consumption for PCs and expanded memories.

Further, 10 million units will be used if consumption by other portable electronics equipment is added (see Figure 4). In 1995, worldwide DRAM consumption for PCs and expanded memories will grow to 3,701 trillion bits, of which 64.2 percent will be used for portable PCs. Thus, Dataquest estimates 2,376 trillion bits as the potential market for low-voltage DRAMs. In 1995, 3V versions will amount to 558 trillion bits of 4Mb DRAMs (18 percent of total) and 1,824 trillion bits of 16Mb DRAMs (24 percent of total) consumed by portable PCs.

By Akira Minamikawa

Figure 1
PC Forecast Voltage, 1991 and 1995



Source: Dataquest (July 1992)

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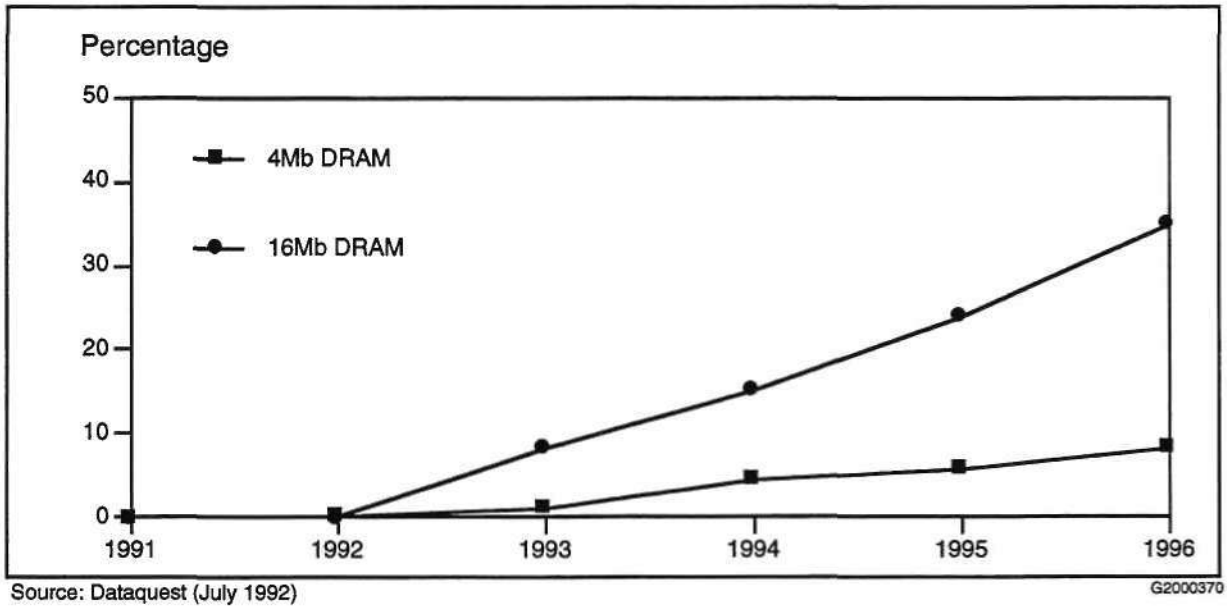
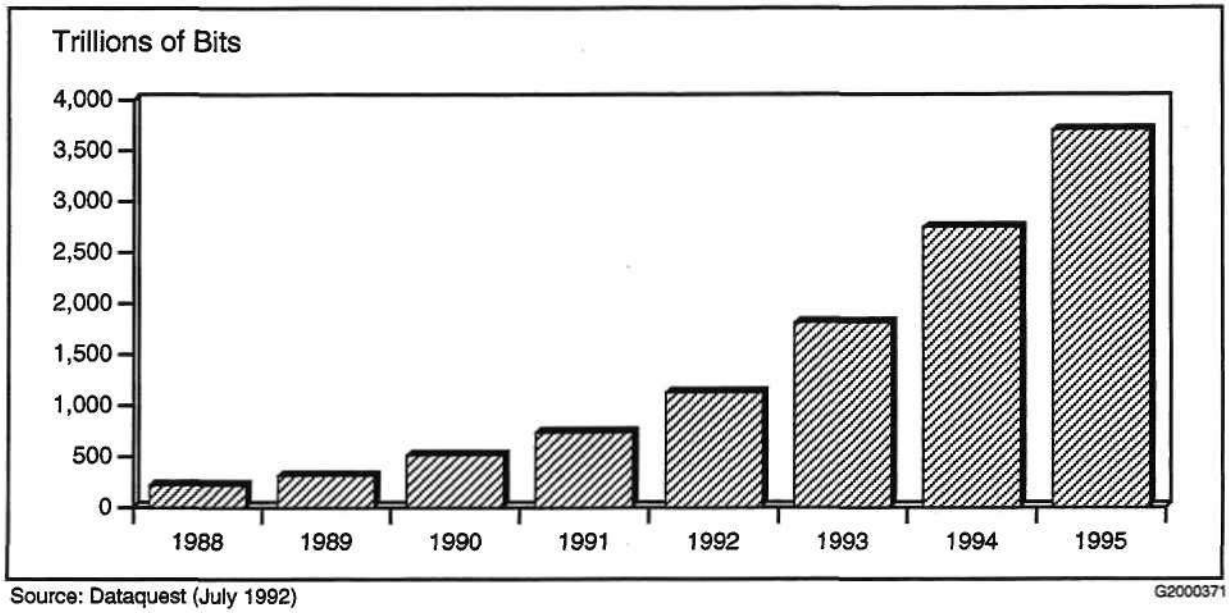
Figure 2
Worldwide Low-Voltage DRAM Share



Source: Dataquest (July 1992)
G2000370

Figure 3
Worldwide DRAM Bit Consumption Forecast, PCs



Source: Dataquest (July 1992)
G2000371

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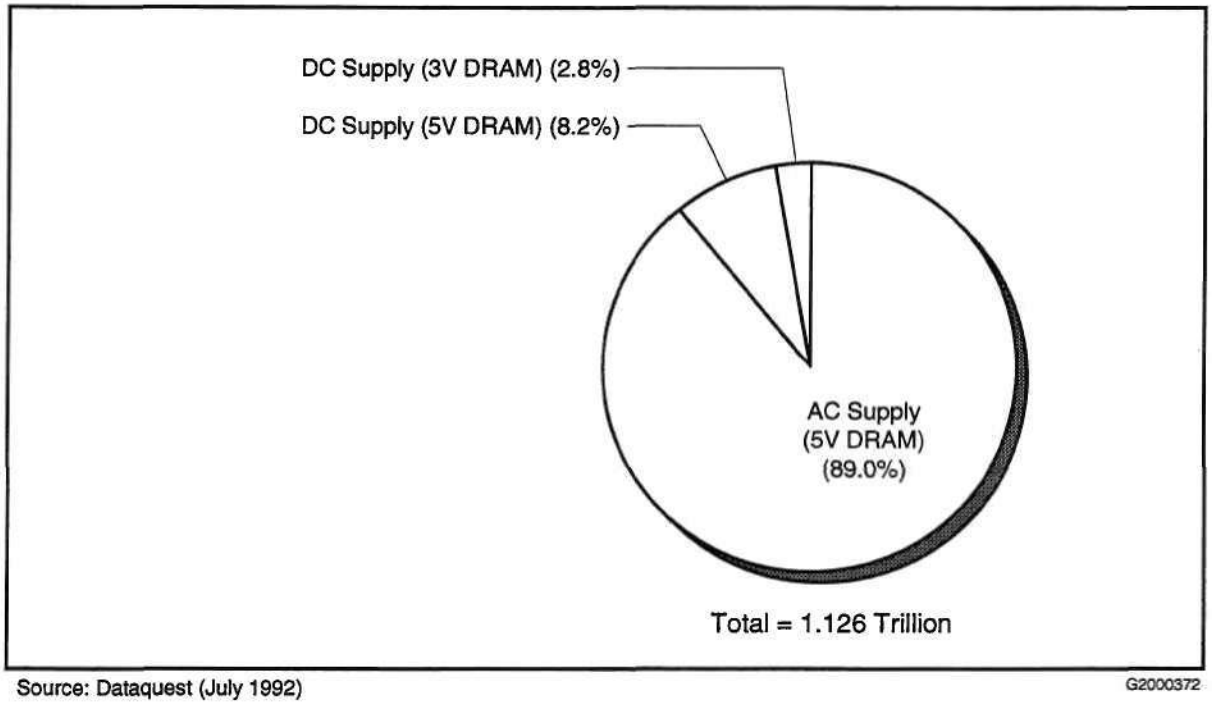
Figure 4
1992 DRAM Bit Consumption, PCs



Source: Dataquest (July 1992) G2000372

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Growing cellular phone market in Japan
- Multimedia market viewed from semiconductor industry

For More Information . . .

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Dataquest Perspective

Semiconductors *Japan*

SCJA-SVC-DP-9208 June 29, 1992

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DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the difference in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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DQ Feature—Electronics Companies' FY1991 Financial Results

Most Japanese electronics companies ended fiscal year (FY) 1991 on March, 31, 1992. Financial reports from electronics companies have recently been filed with both the Japanese Ministry of Finance and the companies' respective shareholders.

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Market Analysis

Semiconductor Equipment Industry at the Turning Point

In 1991, the worldwide semiconductor equipment market grew by 3 percent from the previous year to reach ¥813.4 billion. This article analyzes the semiconductor equipment market in 1991 by major segment.

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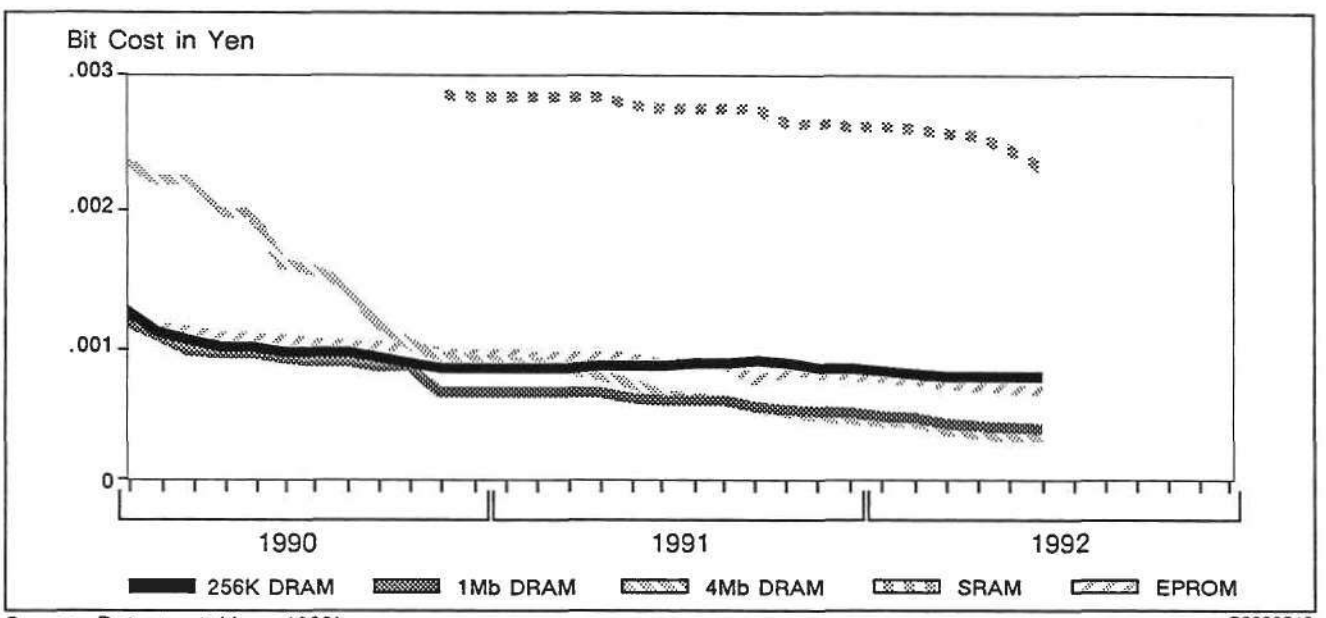
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.18	3.24	3.20	3.33	3.10	3.25
DRAM 256Kx1-8	1.13	1.62	1.55	1.05	1.20	1.05
DRAM 4Mbx1-8	11.60	11.17	11.50	12.25	12.50	11.00
EPROM 1Mb, 170ns	3.15	3.47	2.85	3.03	3.10	2.40
EPROM 2Mb, 170ns	6.70	7.02	4.20	5.70	6.33	4.70
SRAM 1Mb, 128Kx8	11.63	10.85	9.25	13.50	13.60	NA
SRAM 256K, 32Kx8	3.70	3.28	3.25	3.45	3.80	3.20
SRAM 64K, 8Kx8	1.78	1.56	1.55	1.30	1.37	1.40
68020-16	27.25	35.51	26.00	33.75	31.50	NA
80286-16	8.00	9.27	10.00	9.50	10.10	6.90
80386DX-25	94.50	124.26	94.50	99.50	96.00	75.00
80386SX-16	46.00	48.52	45.00	48.00	47.20	37.00
R3000-25	100.00	118.35	110.00	NA	NA	NA

Note: These figures correspond with DQ Monday Report dated June 22, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (June 1992)

Memory Bit Price in Japan



Source: Dataquest (June 1992)
G2000540

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Company Analysis

Electronics Companies' FY1991 Financial Results

Most Japanese electronics companies ended fiscal year (FY) 1991 on March 31, 1992; the sole exception was Sanyo, which closed on November 30, 1991. Financial reports from electronics companies recently were filed with both the Japanese Ministry of Finance (MOF) and the shareholders of the respective companies. Table 1 lists the top 10 Japanese companies in alphabetical order and summarizes their financial reports, including percentage changes over the previous year's results. Table 2 breaks down the revenue contributions of the operating divisions that make up the individual companies.

FY1991 Summary

Fiscal year 1991, which started on April 1, 1991, was characterized by two distinct economic phases. Although many economic forecasts predicted an earlier end to the Japanese historical growth cycle known as the Heisei Boom, Japan in the first half of FY1991 enjoyed a boom period that extended until September 1991, thus making this Heisei one of the largest in recorded history. In contrast, the Japanese economy quickly cooled in the latter half of the fiscal year as the recession advanced faster and deeper than most industries expected. Even though the U.S. economy began showing a glimmer of recovery during the first quarter of 1992, the Japanese economy continued to decline.

In FY1991, the top electronics companies recorded their highest revenue in terms of total corporate sales. In net income, however, all companies except Sony reported large negative figures. In particular, net income at Fujitsu and Oki declined 85.2 and 95.1 percent, respectively.

Of the 10 companies, only Fujitsu and Matsushita recorded double-digit growth in their total corporate revenue. A milestone for Fujitsu was its surpassing Mitsubishi in total sales for the first time. Much of the growth at Fujitsu and Matsushita may, however, have come from recent acquisitions; Fujitsu invested in ICL and Matsushita acquired MCA. Although these acquisitions contributed to total sales, their effect on profits was insufficient to offset the large interest payments due on these purchases. As a partial result of these activities, both Fujitsu and Matsushita registered changes in their net income that were worse than the average 48.6 percent decline in net income recorded by the top 10 Japanese companies. Furthermore, in FY1991, Matsushita decreased its

Table 1
Fiscal Year 1991 Japanese Electronics Companies' Financial Results
(Billions of Yen)

	Total Sales		Percentage	Net Income		Percentage	Overseas
	FY1991	FY1990	Change	FY1991	FY1990	Change	Sales
Fujitsu	3,441.9	2,971.5	15.8	12.2	82.7	-85.2	29.8
Hitachi	7,765.5	7,737.0	0.4	127.6	230.2	-44.6	23.8
Matsushita	7,449.9	6,599.3	12.9	132.9	258.9	-48.7	48.2
Mitsubishi	3,343.2	3,316.2	0.8	36.0	79.8	-54.9	21.0
NEC	3,773.8	3,698.8	2.0	15.2	54.4	-72.1	21.0
Oki	681.3	660.9	3.1	.5	9.9	-95.1	30.0
Sanyo	1,587.2	1,471.8	7.8	16.8	17.5	-3.8	40.7
Sharp	1,517.5	1,496.1	1.4	39.1	46.9	-16.7	48.9
Sony	3,821.6	3,616.5	5.7	120.1	116.9	2.7	74.7
Toshiba	4,722.4	4,695.4	0.6	39.5	120.9	-67.3	29.1

Source: Company Literature, Dataquest (June 1992)

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interest/dividend revenue by 43 percent. The MCA purchase by Matsushita appears to have depleted cash savings, which had been yielding higher returns for the company in financial markets. Sony has had generally greater success in its entertainment divisions, which now include Columbia pictures.

The trends of 1991 also displayed a clear departure from the historical trend sometimes referred to as the Silicon Cycle; following this historical tendency would have meant a semiconductor upturn during 1991. This of course never happened, as semiconductor sales fell rapidly in the fourth quarter of 1991. Electronics companies, especially those that rely heavily on memory products, suffered from price erosion, oversupply of 4Mb DRAMs, and heavy capital investments required for ramp-up of 16Mb DRAM manufacturing facilities.

Dataquest estimates that electronic equipment production in Japan grew by a rate of 4.4 percent in 1991. The biggest cause of this growth was a large increase in consumer electronics production, particularly of home appliance products. Sales of data processing and audio-visual products, which are traditionally large consumers of semiconductor components, showed little growth, which was attributed to both a sluggish economy and market saturation.

Dataquest Perspective

The Bank of Japan lowered the central bank interest rate to 3.75 percent on April 1, 1992, the lowest rate since 1990, to stimulate the Japanese economy. Most economists are optimistically forecasting that Japan's economy will recover by the latter half of the current fiscal year. However, the sluggish stock market has made equity financing scarce and limited the source of capital needed for industry expansion. Thus during FY1991 the volume of capital raised by equity financing by Japanese companies was only one-eighth of its peak volume established in 1986. Most Japanese electronics companies are still in a cost-cutting mode as they continue to announce cuts in their capital spending for FY1992.

Although Dataquest forecasts that the 1992 semiconductor growth rate will be 7.1 percent worldwide, we predict the Japanese market to contract by 4.5 percent. Most companies, with the exception of Matsushita and Sony, already predict negative growth rates for FY1992.

By Junko Matsubara

Table 2
Fiscal Year 1991 Japanese Electronics Companies' Financial Results by Division
(Billions of Yen)

Company	Division	FY1991	FY1990	Percentage of Total	Growth Rate
Fujitsu	Communications Systems	444.9	442.0	12.9	0.7
	Computers and Data Processing Systems	2,510.7	2,055.6	72.9	22.1
	Semiconductors and Electronics Components	348.5	348.9	10.1	-0.1
	Other Operations	137.8	125.0	4.0	10.2
	Total	3,441.9	2,971.5		
Hitachi	Information Systems and Electronics	2,920.8	2,781.4	37.6	5.0
	Power and Industrial Systems	2,459.4	2,357.9	31.7	4.3
	Consumer Products	1,066.6	1,107.4	13.7	-3.7
	Materials and Others	2,105.4	2,100.9	27.1	0.2
	Eliminations	-786.6	-610.5	-10.1	28.8
	Total	7,765.5	7,737.0		

(Continued)

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Table 2 (Continued)
Fiscal Year 1991 Japanese Electronics Companies' Financial Results by Division
(Billions of Yen)

Company	Division	FY1991	FY1990	Percentage of Total	Growth Rate
Matsushita	Video Equipment	1,699.8	1,694.2	22.8	0.3
	Audio Equipment	631.7	597.9	8.5	5.7
	Home Appliances	982.2	899.5	13.2	9.2
	Comunication and Industrial Equipment	1,678.6	1,553.4	22.5	8.1
	Electronic Components	862.7	841.7	11.6	2.5
	Batteries and Kitchen-Related Products	367.8	349.4	4.9	5.3
	Others	600.7	600.3	8.1	0.1
	Entertainment	626.4	62.9	8.4	NM
	Total	7,449.9	6,599.3		
Mitsubishi	Heavy Machinery	713.3	698.2	21.3	2.2
	Industrial Products/Automation Equipment	600.2	606.7	18.0	-1.1
	Info. and Communications Sys./Elec. Device	1,118.0	1,127.8	33.4	-0.9
	Consumer and Other Products	1,106.4	1,059.8	33.1	4.4
	Intersegment Sales	-194.7	-176.4	-5.8	10.4
	Total	3,343.2	3,316.1		
NEC	Communications Systems and Equipment	1,001.6	1,040.0	26.5	-3.7
	Computers and Industrial Electronic Systems	1,949.0	1,756.6	51.6	11.0
	Electronic Devices	617.1	649.1	16.4	-4.9
	Other Operations	206.1	253.1	5.5	-18.5
	Total	3,773.9	3,698.8		
Oki	Telecommunication Systems	158.3	167.0	27.0	-5.2
	Information Processing Systems	279.0	274.6	47.6	1.6
	Electronic Devices	135.6	130.3	23.2	4.1
	Others	12.7	10.2	2.2	24.6
	Total	585.6	582.1		
Sanyo	Video Equipment	292.0	286.9	18.4	1.8
	Audio Equipment	149.0	145.4	9.4	2.5
	Home Appliance	361.5	348.2	22.8	3.8
	Industrial and Commercial Equipment	274.3	247.6	17.3	10.8
	Information Systems and Electronic Devices	364.7	319.4	23.0	14.2
	Batteries and Other Products	145.6	124.3	9.2	17.1
	Total	1,587.1	1,471.8		

(Continued)

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Table 2 (Continued)
Fiscal Year 1991 Japanese Electronics Companies' Financial Results by Division
(Billions of Yen)

Company	Division	FY1991	FY1990	Percentage of Total	Growth Rate
Sharp	TV and Video Systems	393.4	413.3	25.9	-4.8
	Audio Systems	171.6	192.8	11.3	-11.0
	Appliances	265.7	244.0	17.5	8.9
	Information Systems and Electronic Devices	686.8	646.0	45.3	6.3
	Total	1,517.5	1,496.1		
Sony	Video Equipment	896.4	908.4	23.5	-1.3
	Audio Equipment	947.8	881.8	24.8	7.5
	Televisions	592.6	552.5	15.5	7.3
	Other Products	616.8	542.4	16.1	13.7
	Musical Entertainment	438.8	474.0	11.5	-7.4
	Filmed Entertainment	329.2	257.5	8.6	27.8
	Total	3,821.6	3,616.5		
Toshiba	Info./Com. Systems and Electronic Devices	2,501.0	2,522.5	53.0	-0.9
	Heavy Electrical Apparatus	1,052.9	1,000.7	22.3	5.2
	Consumer Products and Others	1,547.9	1,507.1	32.8	2.7
	Elimination	-379.4	-334.9	-8.0	13.3
	Total	4,722.4	4,695.4		

NM = Not meaningful
Note: Sanyo's fiscal year ends November 30.
Source: Company Literature, Dataquest (June 1992)

Market Analysis

Semiconductor Equipment Industry at the Turning Point

The 1990s seem to mark the beginning of the new era for the semiconductor manufacturing equipment market, a new era that does not mimic past silicon cycles. Historically, the semiconductor equipment market has followed semiconductor device market trends with a one-year lag and formed its own business cycle. Since 1989, however, the market has been on a plateau with few ups and downs, partly because experience has been an effective teacher. In 1991, the worldwide semiconductor equipment market grew by 3 percent from the previous year to reach ¥813.4 billion. This is considered to be a very healthy growth for the existing market size and the equipment industry in the 1990s.

The situation appears to be similar in the Japanese market, which recorded a moderate 1 percent growth. Under the calm sea, however, 1991 proved to be very stormy for the industry, which suggests important clues that indicate the industry's direction. This article analyzes the semiconductor equipment market in 1991 by major segment.

Worldwide Market Trends in 1991

In 1991, the worldwide semiconductor equipment market increased by 3 percent on a dollar basis from the previous year to $6,039.5 million (¥813.4 billion) (see Table 1). The Japanese market, which grew by 1 percent to $3,016.7 million (¥406.3 billion), holds a 50 percent share (see Table 2). In contrast, the U.S. market declined by 4 percent, a continuation from the previous year, to $1,536.3 million (¥206.9 billion). The European

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Table 1
Worldwide Semiconductor Equipment Market by Region
(Millions of Dollars)

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
United States	1,105.8	1,535.7	1,665.9	1,597.1	1,536.3	8.6
Growth (%)	3	39	8	-4	-4	
Japan	1,277.5	2,270.3	2,806.0	2,986.5	3,016.7	24.0
Growth (%)	25	78	24	6	1	
Europe	527.5	662.7	725.4	767.6	634.2	4.7
Growth (%)	16	26	9	6	-17	
Rest of World	229.8	519.1	820.1	520.1	852.3	38.8
Growth (%)	41	126	58	-37	64	
Worldwide	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8
Growth (%)	16	59	21	-2	3	

Source: Dataquest (June 1992)

Table 2
Worldwide Semiconductor Equipment Market Share by Region
(Percentage)

	1987	1988	1989	1990	1991
United States	35	31	28	27	25
Japan	41	46	47	51	50
Europe	17	13	12	13	11
Rest of World	7	10	14	9	14
Worldwide	100	100	100	100	100

Source: Dataquest (June 1992)

market suffered a major setback of 17 percent to a total of $634.2 million (¥85.4 billion), a market share drop of 11 percent that allowed the Rest of World (ROW) segment to pass. ROW recorded a 64 percent increase to $852.3 million (¥114.8 billion) because 1990 was a bottom year for capital spending. ROW now has 14 percent of the worldwide market.

In terms of ownership, U.S. equipment companies lost 0.5 percent share to 35.4 percent, and European companies decreased by 1.3 percent to 7.8 percent. Japanese companies gained 1.9 percent to 53.1 percent share.

The U.S. market had a compound annual growth rate (CAGR) of about 9 percent from 1987 to 1991. Japan's CAGR was 24 percent, Europe's about 5 percent, and ROW's almost 39 percent. The worldwide semiconductor equipment market showed 18 percent CAGR during the period.

Japanese Market Trends in 1991

Major highlights of the Japanese semiconductor market in 1991 are as follows:

- Although seemingly a flat year with annual growth of 1 percent, the market went through violent ups and downs—a 39 percent increase in the first quarter over the same period in 1990; a 32 percent increase in the second quarter; a 3 percent decrease in the third quarter; and a 33 percent decrease in the fourth quarter.

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- Only the deposition equipment markets—PVD and CVD—recorded notable growth.
- Stepper shipments declined, as evidenced in the downward adjustment of stepper sales by Nikon.
- The standalone track market was active.

Market fluctuation in 1991 was characterized by two factors: strong growth until the second quarter, supported by a backlog of orders continued from the previous year; and the virtual halt of shipments in the third quarter resulting from canceled or postponed capital expenditure by device makers facing unprofitable DRAM business and experiencing difficulties in raising funds through equity finance—once the most popular financial source driven by the booming stock market. In particular, Nikon's downward adjustment of stepper sales, widely reported in the press, served as a further blow to the dim outlook for the semiconductor industry. Thus, the 1 percent growth estimated by Dataquest on a calendar-year basis translates to negative growth for the fiscal year ended March 1992.

Among major categories of semiconductor equipment, only deposition equipment showed notable growth; other major processes ended up in near negative growth (see Table 3) because device makers initiated a diversified product mix strategy in response to the sluggish 4Mb DRAM market, resulting in additional purchase of deposition equipment. This also explains characteristic stepper sales.

Market trends point to the shifting of strategic focus by device makers, which is described as follows:

- It was realized that the DRAM business was no longer profitable.
- As a result, the previous capital investment policy focusing on DRAMs was reconsidered, and much 1991 investment was halted or postponed.
- Microprocessor and ASIC production lines were considered alternative profit centers to DRAM lines.
- Additional deposition equipment was introduced to enable existing DRAM lines to produce ASICs.

Steppers

The worldwide lithography equipment market, including steppers, amounted to $1,223.6 million (¥164.8 billion), of which the Japanese market totaled $607.9 million (¥81.9 billion). The worldwide stepper market was $1,029.1 million (¥138.6 billion) and the Japanese market $502.1 million (¥67.6 billion).

Table 3
1991 Japanese Wafer Fab Equipment Market
(Millions of Dollars)

	Japan	Worldwide	Percent of Total	Japanese Market Growth (%) 1990-1991
Total Lithography	607.9	1,223.6	49.7	-3.7
Total Track	179.3	368.6	48.6	4.6
Total Etch and Clean	630.5	1,245.5	50.6	-8.9
Total Deposition	700.9	1,420.3	49.3	16.7
Diffusion	154.1	335.1	46.0	-10.8
RTP	14.4	41.8	34.4	56.5
Ion Implantation	200.7	343.2	58.5	-4.4
Total Process Control	300.4	641.3	46.8	6.9
Factory Automation	132.0	227.0	58.1	9.1
Other Equipment	96.5	193.1	50.0	-0.6
Total Wafer Fab Equipment	3,016.7	6,039.5	49.9	1.0

Source: Dataquest (June 1992)

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While the respective worldwide and Japanese stepper markets decreased by 2 percent and 6 percent from the previous year on a value basis, worldwide unit shipments declined significantly from 771 in 1990 to 679 in 1991, a 12 percent decrease. The comparative low rate of decrease on a value basis reflects the increase in average selling price because of increased market acceptance of i-line steppers for 16Mb DRAM production (see Table 4).

After much debate on exposure systems after 64Mb DRAMs, NEC's recent announced decision to use i-line steppers for volume production of 64Mb seems to have established i-line as the mainstay for the time being. The i-line stepper boosted the lens numerical aperture to 0.6—a level considered to be a theoretical limit—capable of an illumination technique suitable for submicron processing without phase shift mask, which would thereby enable reliable processing for 0.35-micron geometries. The stepper's field size allows the exposure of three 16Mb chips at one time. With commercialization of phase shift technology in the future, i-line steppers will be capable of 256Mb DRAM process.

Although Nikon's forecast for sluggish sales made headlines in the 1991 stepper market, the actual decline turned out to be 9 percent, from 384 to 350 units. On the other hand, Canon recorded a mere 3 percent decrease from 150 in 1990 to 145. The difference lies in the fact that, while Nikon has specialized in DRAM production lines, Canon has maintained strength in ASIC lines. This clearly indicates that the 1991 semiconductor equipment market was driven by ASIC-related investment, rather than DRAMs, reflecting a diversified product mix strategy increasingly adopted by DRAM makers.

Track

In 1991, the worldwide track (coater/developer) market recorded an impressive 13 percent growth from the previous year to $368.6 million (¥49.6 billion), and the Japanese market grew by nearly 5 percent to $179.3 million (¥24.1 billion). Because track systems are often installed in-line with steppers in DRAM production lines, the track market trend has been aligned with the stepper market. However, 1991 saw expansion of the track market despite the downbeat stepper market. Possible reasons for this are as follows:

- Market adoption of the random-access system has led to an increase in average selling price.
- Small footprints and improved uniformity have spurred demands for upgrades in volume production lines as well as R&D facilities.
- The diversified product mix strategy of device makers created demand for stand-alone track systems to ensure flexibility in production.

In the track market, Tokyo Electron ran a dead heat with Dainippon Screen. Following introduction of the random-access system, Tokyo Electron maintained dominance in recent years. In 1991, however, Dainippon narrowed the difference slightly as its track systems gained market recognition for saving developer chemicals by 65 percent.

Table 4
Worldwide Stepper Unit Shipment by Technology
(Percentage)

	1985	1986	1987	1988	1989	1990	1991
g-line	85	82	82	79	69	56	28
i-line	1	4	8	12	21	36	60
Excimer/Deep-UV	0	0	0	0	3	3	6
1X	14	14	10	9	7	4	6
Total Stepper	100	100	100	100	100	100	100

Source: Dataquest (June 1992)

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Wet Process

The worldwide wet process equipment market recorded a moderate 1 percent growth over the previous year to $405.0 million (¥54.5 billion), while the Japanese market was down 17 percent to $204.8 million (¥27.6 billion). The slacking Japanese market is evident in the business performance of Dainippon Screen, the largest maker of wet process equipment. For instance, its exports of wet stations jumped from 5 percent of total production in 1990 to 53 percent in 1991, partly because the company aggressively explored foreign markets. Another interpretation is that the company was simply busy with domestic business in 1990 and was not capable of shipping products abroad.

A major highlight in the 1991 wet process market is the carrierless system for 16Mb DRAM production using 8-inch wafers, which was introduced by Dainippon Screen, Dan Science, Fuji Electric, Kuwano Electric, Shimada Rika, and Sugai. Sankyo Engineering also is developing its own product. The carrierless system offers several advantages: eliminated carryover of chemicals attached to the carrier; space-saving effects; and chemical consumption savings because of a smaller chemical tank. Dataquest expects rapid growth in this market.

Another surprise was the entry of Tokyo Electron in the wet process market. Until recently, the company represented Sugai's wet stations. Major reasons for the sudden entry seem to be as follows:

- The growing wet station market.
- Concern about the lack of a post-16Mb DRAM technological base at other makers.
- The company, with established market position in vertical diffusion/CVD systems, wants to in-line wet cleaning equipment with its VTR.

The entry of Tokyo Electron means increased competition with Dainippon Screen.

Dry Strip

In 1991, the worldwide dry strip equipment market was $119.1 million (¥16.0 billion), a 1 percent increase over the previous year. The Japanese market decreased by 18 percent to $62.1 million (¥8.4 billion). Again, the major decline was largely attributable to investment cutbacks in DRAM lines; the decrease in sales of the top three makers in Japan—Plasma System, Tokyo Ohka Kogyo, and Ramco—tells the story. In particular, Ramco suffered a 36 percent decrease in sales, suggesting that its main product, batch-type plasma ashers suitable for volume production, has reached its limit. Dataquest expects the single-wafer operation system downstream ashers—and not the batch system—to become the mainstay after 16Mb DRAMs, because they are less damaging. Each maker emphasizes its capability to remove high-dose photoresist, but no significant technological advancement was seen in any of the available mechanisms, except for the multichamber type 2 step asher announced by Shinko Seiki, a new entrant in 1991. The system consists of double chambers using RF and microwave; high-dose photoresist is removed by mixing H_2O gas. In 1991, Alcan Tech, a joint venture with Canon, was the only company to boost sales of microwave ashers, by 64 percent.

Dry Etch

In 1991, the worldwide dry etch market rose 2 percent to $704.7 million (¥94.9 billion); the Japanese market was down 3 percent to $356.6 million (¥48.0 billion). In worldwide sales rankings, Applied Materials maintained first place, despite a 12 percent decrease from the previous year, followed closely by LAM Research with a 16 percent growth, then Hitachi and Tokyo Electron.

Low-pressure magnetron and ECR systems are being accepted by the market because etching after 16Mb DRAMs will require high selectivity, profile controllability, low damage, and low particles. Applicationwise, Tokyo Ohka Kogyo's plasma etchers for polysilicon films have been eroded by Hitachi's ECR systems. In oxide, Tokyo Electron's magnetic field assist RIE maintains market dominance, with some competition from ANELVA and LAM Research. Applied Materials and Hitachi show strength in metal films, while nitride films are dominated by Tokyo Electron and Tokyo Ohka Kogyo's plasma etchers.

CVD

The worldwide CVD market grew by 4 percent in 1991 to $747.4 million (¥100.7 billion), and the Japanese market increased by

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8 percent to $369.7 million (¥49.8 billion). In the vertical LPCVD market, Kokusai Electric and Tokyo Electron boosted sales, and the market recorded an impressive 34 percent growth. Because the thickness of gate oxide will be further reduced to 15nm to 10nm from 16Mb to 64Mb, demand will increase for vertical furnaces with reduced particle inclusion, better uniformity, and adaptability to automation. Dataquest expects future standard systems to be equipped with a loadlock mechanism or an N_2 blow.

Watkins-Johnson increased its share of atmospheric pressure CVD for intermetal dielectrics through the TEOS + O_3-based system. Alcan Tech successfully penetrated the Japanese market with the same system, recording a 79 percent increase in sales, while Amaya lagged in TEOS and lost share. In metal CVD systems for interconnection, Genus still dominates the market, although it suffered a major decrease (21 percent) in sales. Another important move is that ULVAC increased its share through selective tungsten systems. Table 5 shows CVD market forecast by application.

PVD

In 1991, the worldwide PVD market grew by 16 percent to $474.0 million (¥63.8 billion). The Japanese market increased by 18 percent to $232.4 million (¥31.3 billion). The worldwide sputter market expanded 22 percent to $437.7 million (¥58.9 billion) and the Japanese market grew by 23 percent to $218.9 million (¥29.5 billion). PVD and CVD systems recorded major growth, while the semiconductor equipment market as a whole remained flat because of additional demand for deposition equipment to reflect the product mix diversification strategy of device makers.

In terms of worldwide ranking, ANELVA maintained first place, followed by Varian, MRC, Applied Materials, and ULVAC. In the Japanese market, ANELVA ranked first, followed by ULVAC, MRC, Varian, and Applied Materials. Applied Materials entered the sputter market in 1990, with its ultrahigh-vacuum ENDURA 5500, which had sales of $55 million (¥7.4 billion) in 1991, evidence of the company's strength in wafer transportation systems and of well-timed market introduction.

Silicon Epitaxy

In 1991, the worldwide silicon epitaxial equipment market recorded annual 30 percent growth to reach $88.6 million (¥11.9 billion), and the Japanese market registered an impressive 153 percent growth, totaling $46.1 million (¥6.2 billion). Ranked by worldwide market share, Applied Materials held the No. 1 position with a 36 percent share, followed closely by ASM Epitaxy (34 percent), Toshiba Machine (14 percent), and Kokusai Electric (7 percent). Major reasons for rapid growth of the Japanese market are as follows:

- Major silicon wafer makers rushed to strengthen epitaxial wafer production capacities:
  - Shin-Etsu Handotai—Isobe plant
  - Komatsu Electronic Metals—Nagasaki plant

Table 5
Worldwide CVD Market Forecast by Application

	1990	1991	1992	1993	1994	1995
CVD Market ($M)	717	747	675	775	951	1,076
Oxide (%) (Doped and Undoped)	52	51	49	48	47	46
Plasma Nitride (%)	20	19	16	16	15	14
Poly (%)	11	12	12	12	12	13
Thermal Nitride (%)	5	5	5	4	4	4
Metal (%) CVD	12	13	18	20	22	23
Total (%)	100	100	100	100	100	100

Source: Dataquest (June 1992)

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  - Mitsubishi Materials Silicon—Noda plant
  - Tokuyama Ceramics
- Sophistication and miniaturization of consumer and communications equipment spurred the power IC market to high-voltage-withstand and large-current applications, including the following:
  - Inverters and switching devices
  - IGBT (insulated gate bipolar transistor)
- Wafer makers started preparing for the possible use of epitaxial wafers in advanced DRAM and flash memory.

Toshiba Machine enjoyed rapid growth of epitaxial equipment and an increased installed base because of the robust growth of Toshiba's power MOS ICs, which use thick epitaxial films.

Diffusion

The worldwide diffusion market grew by 3 percent from 1990 to $335.1 million (¥45.1 billion), while the Japanese market was down almost 11 percent to $154.1 million (¥20.8 billion). Within the market, vertical furnaces achieved full market penetration, recording 89.5 percent CAGR between 1987 and 1991. The shift from horizontal to vertical was completed in 1990. Because the vertical system is advantageous in volume production using 8-inch wafers, the shift corresponds to the transition period from 6- to 8-inch wafers. Vertical diffusion furnaces have the same construction as vertical LPCVD systems, except for fewer gas-related processes, so both products are supplied by the same makers.

In terms of worldwide market share of vertical diffusion, Kokusai Electric ranked first with 31 percent, followed by Tokyo Electron (28 percent), Silicon Valley Group (13 percent), Disco (5 percent), and ASM (5 percent). However, if Varian/TEL is added, Tokyo Electron takes over first place with a 32 percent share. In the Japanese vertical diffusion market, Tokyo Electron maintained a 45 percent share, followed by Kokusai Electric (29 percent), clearly indicating face-to-face competition between the two companies in this market as well as in the vertical LPCVD market.

Ion Implantation

The worldwide ion implantation market declined 7 percent in 1991 to $343.2 million (¥46.2 billion), and the Japanese market decreased by 4 percent to $200.7 million (¥27 billion). The market is characterized by significant growth attributed to the change in wafer size, compared to DRAM generation-oriented growth of steppers. Thus, the industrywide delay in introduction of 8-inch wafer lines in 1991 seriously affected the ion implanter market. The single-digit negative growth is considered to be the best of the worst results.

While medium-current ion implanters for 4Mb DRAM production—near technological perfection—can be used for 16Mb production, high-current ion implanters have various hurdles to clear, such as charge-up problems and dissociation of BF_2 ions. Furthermore, technological breakthroughs are necessary to achieve higher integration and faster access times, including junction technology to implant ions in the shallow part (less than 0.1 micron from a silicon surface) and technology to form embedded collectors by implanting ions in the deeper part (more than 0.5 microns from a silicon surface).

Varian's sales of medium-current ion implanters increased by 41 percent from the previous year. Varian replaced Nissin Electric in first place. In the high-current implanter market where sales decreased for all makers, Sumitomo Eaton Nova maintained first place. Genus increased its share in the high-energy segment.

A major highlight in 1991 was the introduction of high-energy ion implanters by Mitsubishi Electric to form retrograde wells in 16Mb DRAM production. This helped improve software error tolerance by a factor of 20. Although the high-energy ion implanter is priced at about ¥500 million, the elimination of double-mask processes leads to a further decrease in other processes and results in a lower total investment requirement. If accepted by other DRAM makers, the high-energy ion

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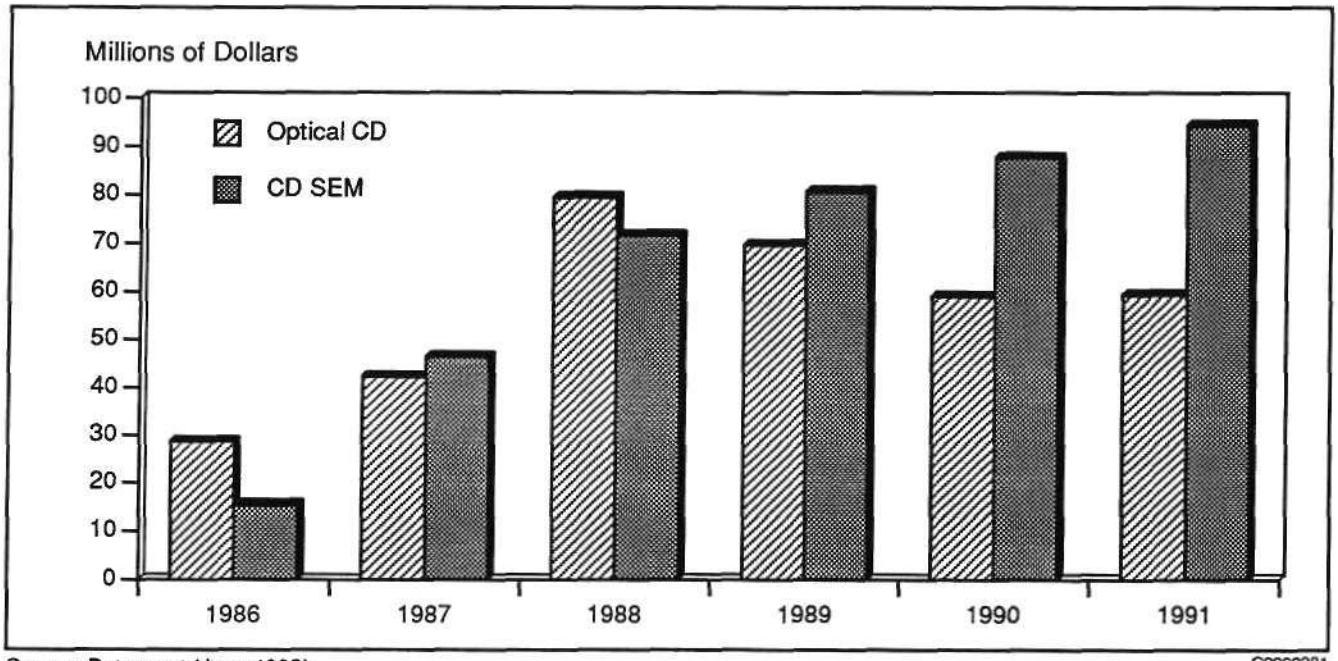
implanter market will finally become full-fledged.

Process Control

In 1991, the worldwide optical critical dimension (CD) market grew by 1 percent to $59.3 million (¥8 billion), and the Japanese market recorded 26 percent growth to $19.3 million (¥2.6 billion). The worldwide CD SEM market increased by 8 percent to $94.3 million (¥12.7 billion), and the Japanese market rose by 8 percent to $59.0 million (¥7.9 billion). The mainstay of the CD market has shifted from optical to CD SEM since 1989 (see Figure 1), because the optical system is not suitable for measurement of less than 1 micron. Interestingly, the segment grew compared with the 1991 Japanese market because of growth in the measurement of overlay registration applications. As for CD SEM, Hitachi dominated both the worldwide and Japanese markets with 74 percent and 77 percent share, respectively. In 1991, however, JEOL reentered the market after some years of absence and is expected to cause some change in market share. Because device makers have accumulated know-how related to CD SEM, Dataquest believes that no alternative system is likely to be accepted and that CD SEM will dominate the market in years to come. Possible improvement is expected in throughput, which will be doubled to 30 wafers per hour.

The worldwide wafer inspection market in 1991 declined by 1 percent from the previous year to $89.7 million (¥12.1 billion). The Japanese market grew by 2 percent to $41.1 million (¥5.5 billion). According to Dataquest's definition, wafer inspection systems are divided into two types; microscope-based wafer visual inspection systems equipped with automatic wafer transfer systems (such as Nikon's Optistation) and image processing technology-based systems to detect circuit defects (supplied by KLA Instruments and Insystems). Historically, Japanese makers have specialized in the former. In 1991, Hitachi started to supply the latter type and is expected to compete with KLA Instruments and Insystems. In light of its dominance in CD SEM, Hitachi is likely to make inroads into KLA Instruments' share.

Figure 1
Optical CD and CD SEM Equipment Market



Source: Dataquest (June 1992)

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Company Ranking

Table 6 shows the worldwide semiconductor equipment market ranking in 1991. The top 10 ranking comprises seven Japanese and three U.S. makers. Major changes in 1991 show General Signal dropping from 7th in 1990 to 14th place; ANELVA and Kokusai Electric each moving up one place from 9th and 10th, respectively, in 1990; Dainippon Screen moving from 11th in 1990 to 10th; and Silicon Valley Group falling from 6th to 7th.

It should be noted that, as Dataquest's survey is limited to front-end wafer fab equipment and counts joint ventures such as TEL/Varian and Varian/TEL separately in terms of ownership, Tokyo Electron ranked third.

Dataquest Perspective

Clearly, the most important factor in assessing the outlook for the semiconductor equipment market is the positioning of DRAM business by semiconductor device makers. Because they could enjoy prior investment benefits up to 1Mb DRAMs, they have been engaged in fierce competition to establish supply capacity for leading-edge devices, and they have been rewarded by recovering capital investment within a relatively short period. However, although Hitachi took the lead in commercial 4Mb production, the buildup of the supply capacity in excess of market need has forced it to wait for an increase in actual demand.

At the same time, the addition of new fab lines has created oversupply conditions, leading to plummeting 4Mb prices in a short period. Thus, today's DRAM business has become unprofitable even if a company is quick to start volume production. Given the technical feasibility of introducing 16Mb, 64Mb, and 256Mb, it is questionable whether the application market will grow enough to consume such large memories. Higher integration requires larger and more advanced production facilities, for example, the increase in the number of mask processes, which will entail sizable capital expenditure. Dataquest estimates that semiconductor equipment for 16Mb DRAM production will cost about ¥52.5 billion, ¥71.5 billion for 64Mb, and ¥85.8 billion for 256Mb. Undoubtedly, device makers will have to secure the market to justify such investment, but no clear prospect has been found.

Because many Japanese device makers are highly integrated, compared with U.S. makers, they are likely to stay in the DRAM business for a while and will seek ways to secure profits

Table 6
1991 Worldwide Wafer Fab Equipment Company Ranking
(Millions of Dollars)

1991 Rank	1990 Rank	Company	Worldwide Revenue
1	1	Nikon	557.2
2	2	Applied Materials	493.3
3	3	Tokyo Electron	397.3
4	4	Hitachi	327.6
5	5	Canon	291.5
6	8	Varian	180.8
7	6	Silicon Valley Group	180.3
8	9	ANELVA	154.6
9	10	Kokusai Electric	138.2
10	11	Dainippon Screen	138.0

Source: Dataquest (June 1992)

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from the total semiconductor business by using DRAMs as a major technology driver, or by incorporating leading-edge devices into high-value-added equipment. Nevertheless, Dataquest believes that they have to find critical mass for DRAM production—naturally on a much smaller scale—to maintain profitability, as invisible hands guide them toward the new order of "only one fab line per one generation" production.

By Kunio Achiwa

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Final Japanese semiconductor market share
- Japanese semiconductor alliance update: second quarter of 1992
- Japanese personal computer market

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Dataquest Perspective

Semiconductors *Japan*

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DQ Monday Report: Volume Mean Pricing

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The figure illustrates current memory bit prices in the Japanese market.

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Are TV Video Games Multimedia's Route to the Home Market?

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Gate Array Prospects and Problems

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Company Analysis

Japanese Semiconductor Alliance Update: The First Quarter of 1992

Dataquest reports Japanese semiconductor alliance trends and analyses on a quarterly basis. During the first quarter of 1992, we recorded 22 semiconductor-related strategic alliances.

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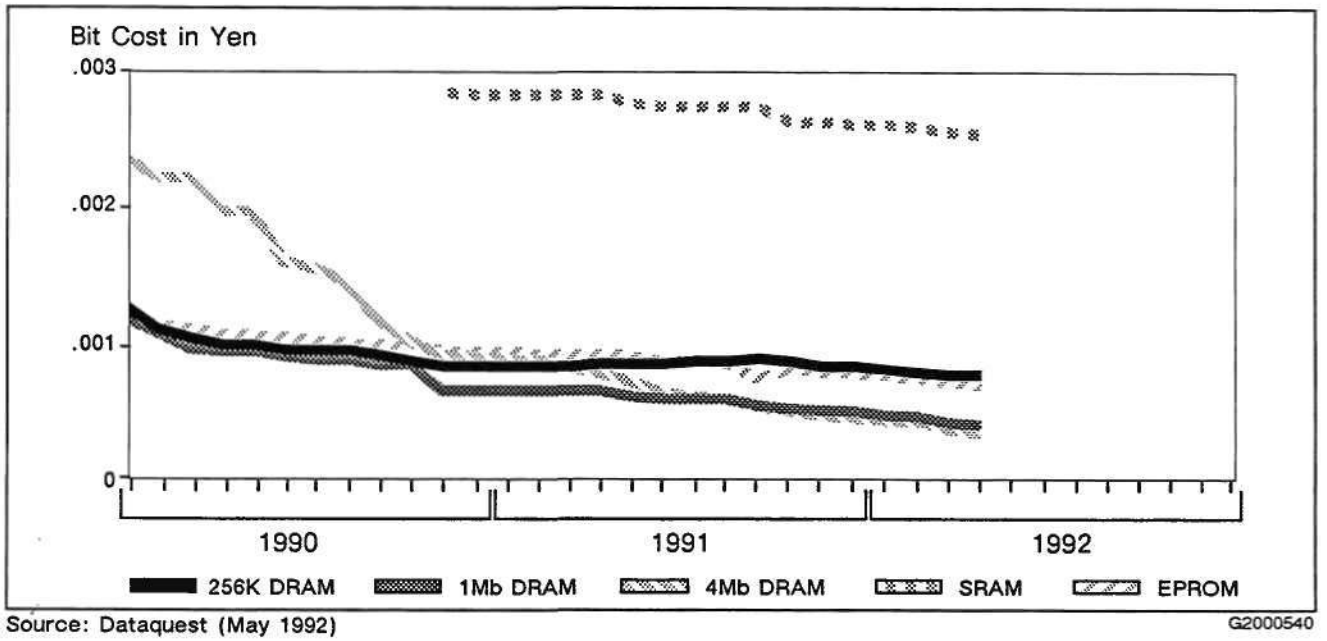
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.25	3.20	3.15	3.33	3.40	3.30
DRAM 256Kx1-8	1.13	1.58	1.52	1.05	1.20	1.05
DRAM 4Mbx1-8	11.83	11.11	12.00	12.50	13.60	11.30
EPROM 1Mb, 170ns	3.15	3.55	2.90	3.03	3.30	2.40
EPROM 2Mb, 170ns	6.85	6.94	4.40	5.60	7.00	4.70
SRAM 1Mb, 128Kx8	12.25	10.99	9.30	13.50	14.40	NA
SRAM 256K, 32Kx8	3.58	3.39	3.25	3.45	3.80	3.30
SRAM 64K, 8kx8	1.78	1.53	1.65	1.30	1.37	1.40
68020-16	27.25	37.40	26.00	35.00	33.20	NA
80286-16	8.08	9.64	10.00	9.50	11.10	7.00
80386DX-25	92.50	136.86	95.00	100.50	116.00	98.00
80386SX-16	46.50	51.66	47.50	49.00	52.10	48.00
R3000-25	105.00	123.37	110.00	NA	NA	NA

Note: These figures correspond with DQ Monday Report dated May 25, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (May 1992)

Memory Bit Price in Japan



Source: Dataquest (May 1992)
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Market Analysis

Are TV Video Games Multimedia's Route to the Home Market?

Nearly half the homes in Japan own television video games, which are becoming the lifeblood of the consumer electronic equipment market in the coming "personal electronics" era. TV video games have quickly emerged as a revolutionary indoor recreational product and have become a phenomenon beyond just a popular toy. TV video games have brought computers closer to children and now serve as a sufficient installed base for multimedia systems that will drive the growth of home information systems. With an eye to market potential, various manufacturers plan to enter the currently oligopolistic TV video games market. Competition is expected to become intense in terms of standard and software, in addition to hardware.

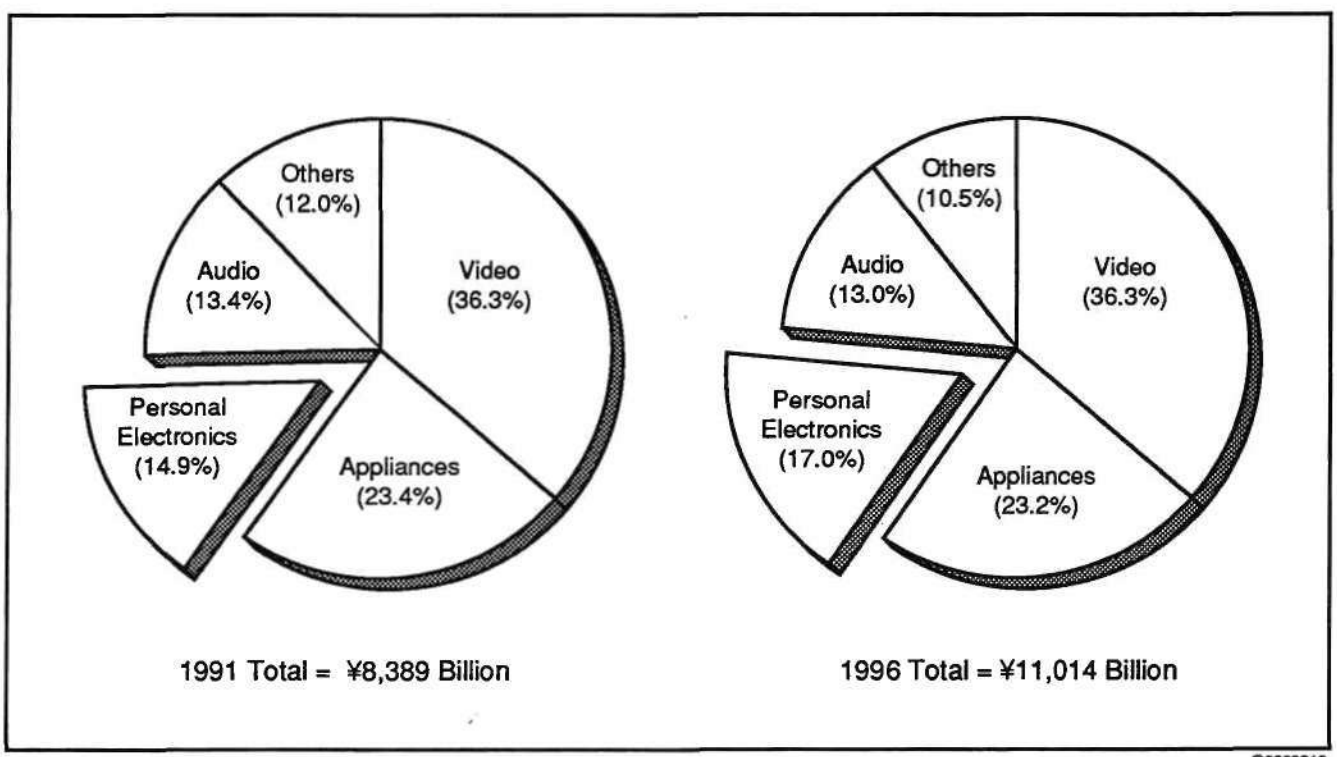
This article analyzes the market for TV video games, which is the forerunner of multimedia systems, and takes a look at semiconductor consumption trends for the market.

TV Video Games Production Outlook in Japan

In 1991, production of consumer electronic equipment in Japan amounted to ¥8,389 billion (see Figure 1), accounting for 34.1 percent of electronic equipment production as a whole. In a market that has had no star product in recent years, TV video games have recorded rapid growth since 1988, with 1991 production totaling ¥229 billion, a 37.1 percent increase from the previous year. As a result, production of personal electronic equipment including TV video games reached ¥1,247 billion, representing 14.9 percent of consumer electronic equipment.

Dataquest forecasts that production of personal electronic equipment will increase at a compound annual growth rate (CAGR) of 8.4 percent from 1991 to 1996, reaching ¥1,868 billion, or 17.0 percent of consumer electronic equipment production. Thus, Dataquest believes that personal electronic equipment—TV video games in particular—will be a key part of the

Figure 1
1991 and 1996 Japanese Consumer Electronic Equipment Production



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consumer electronic equipment market by directing evolution toward more personalized and integrated electronic systems. TV video games are expected to play a leading role.

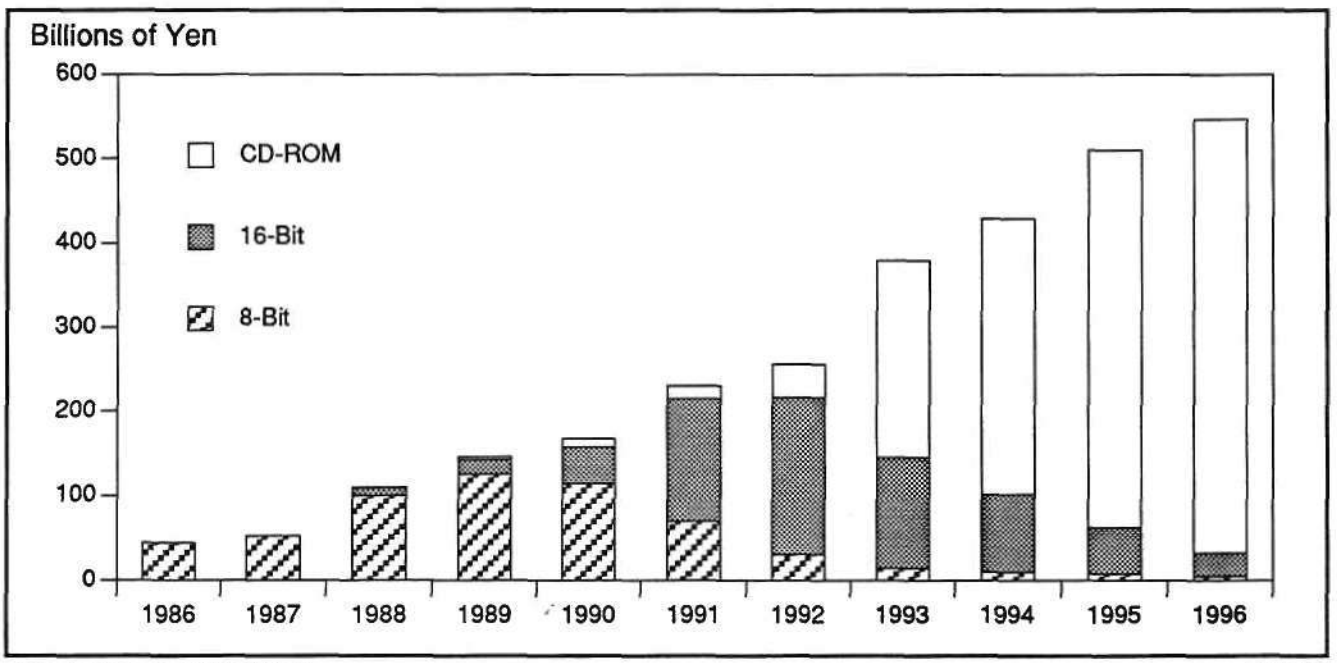
Since introduction of family computers (famicon) by Nintendo in 1983, TV video games have successfully made a generation shift from 8- to 16-bit, while their value of production increased steadily because of the rise in unit price—a growth pattern that will be sustained into the foreseeable future. Note that the value of production of TV video games here includes 8- and 16-bit machines as well as CD-ROM versions, but not portable games. TV video games production in 1991 is divided into ¥145 billion for 16-bit machines, ¥70 billion for 8-bit machines, and ¥15 billion for CD-ROM versions (see Figure 2). In particular, 16-bit machines boosted their share in production value from 25.7 percent of all video game systems in 1990 to 63.3 percent in 1991, completing the generation-shift from 8-bit machines in just about one year. The TV video games boom based on 8-bit machines spread from Japan to the United States and Europe, reaching its peak in 1989.

Meanwhile, the 16-bit Mega Drive introduced by SEGA Enterprises Ltd. in 1988 spurred worldwide demand, particularly in the United States. Nintendo's 16-bit Super NES, announced in August 1991, and SEGA's Genesis, which began to establish its position in the U.S. market, are still competing for the market share. In any case, Dataquest believes that 16-bit TV video games production will peak in 1992.

In 1993, Nintendo plans to introduce a CD-ROM-based TV video games system. Although it may not show record sales over previous two generations at the initial stage, the increase in unit production will hinge on development of optical disk-based game programs. At the same time, enhancement of the CD-ROM operating environment will stimulate development of optical disk-based software programs, creating an attractive market for optical disk drives.

In the near future, the CD-ROM drive market for TV video games is likely to exceed that for electronic data processing (EDP). However, its growth pattern will not be as steep as it was for 8-bit machines; rather, CD-ROM-based TV video games will follow a steady growth pattern. Dataquest expects 32-bit RISC processor-based TV video games and 64-bit RISC

Figure 2
Estimated TV Video Games Production Forecast



Source: Dataquest (May 1992)

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processor-based arcade game systems to emerge in about 1996, because of semiconductor cost considerations. If data compression technology such as JPEG and MPEG is added to optical disk-based software and RISC-based hardware, it will form a firm basis for production of CD-ROM-based TV video games.

Strategies of TV Video Games Manufacturers

Nintendo dominated market share in the 8-bit TV video games market from its birth in 1983 until 1989. Then, SEGA surprised Nintendo and was the first to introduce 16-bit version. SEGA captured a sizable share of the U.S. market, establishing its strong position in the market and becoming Nintendo's biggest competitor.

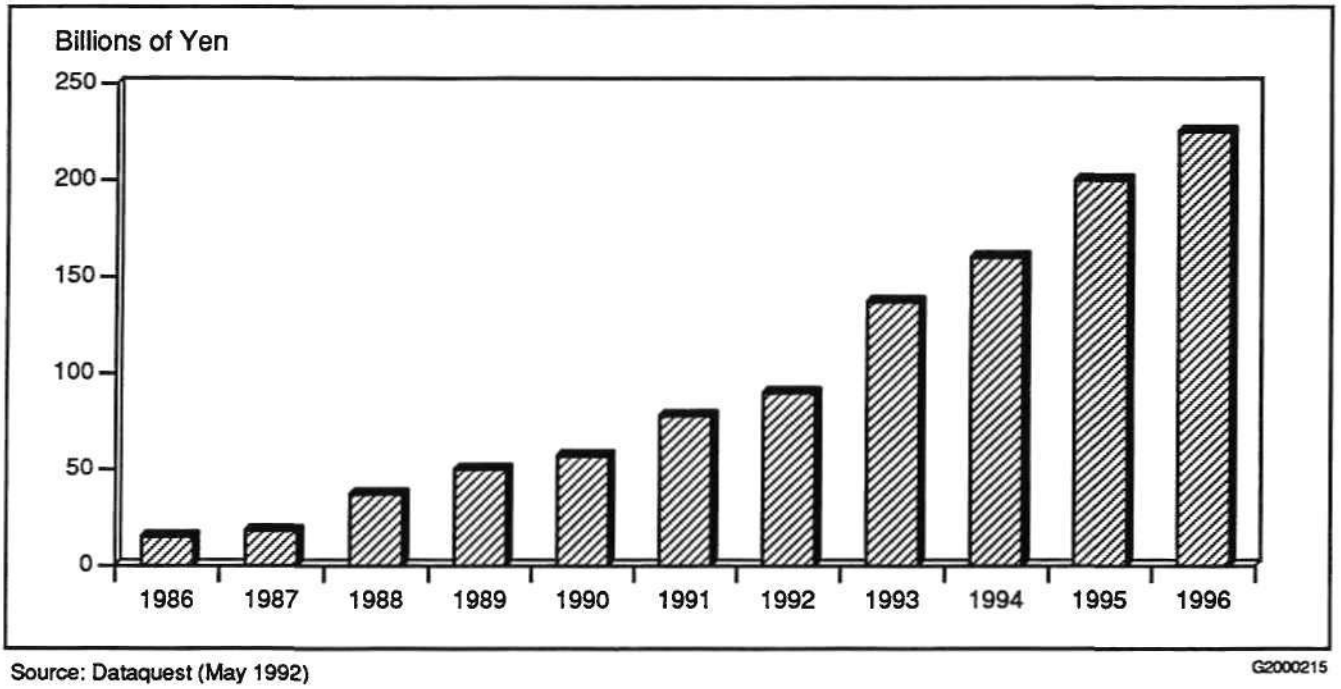
The TV video games industry also attracts major consumer electronic manufacturers such as Matsushita and JVC (equipment supplier to SEGA) that have been facing sluggish demand since the end of 1991, clearly indicating the market's high growth potential. Some entered through alliances with leading TV video games manufacturers. A primary example is Nintendo and Philips. Nintendo needs to supply optical disk-based game software because of capacity limitation in semiconductor memories, whereas Philips intends to develop its proprietary CD-I (compact disk interactive) for its main business. Nintendo has also entered a similar agreement with Sony. Through alliances with Apple Computer in the PC area and Nintendo in the TV video games area, Sony hopes to be the leader in the multimedia market.

Semiconductor Market for TV Video Games

Dataquest predicts that semiconductor consumption by TV video games will grow at a CAGR of 23.6 percent, from ¥78 billion in 1991 to ¥225 billion in 1996 (see Figure 3). In terms of product category, ASICs will hold a dominant 43.3 percent share (see Figure 4), and MOS memories and MOS micros will have relatively small shares on a value basis, because of strong cost pressure. This reflects the fact that, while the TV video games market is expected to surpass the domestic PC market, the TV video games manufacturers have been winning price cuts for standard ICs in exchange for massive consumption. Obviously, ASICs are less susceptible to general market trends.

Nevertheless, the present semiconductor contribution for 16-bit machines is expected to change

Figure 3
Estimated Semiconductor Consumption Forecast for TV Video Games



Source: Dataquest (May 1992)

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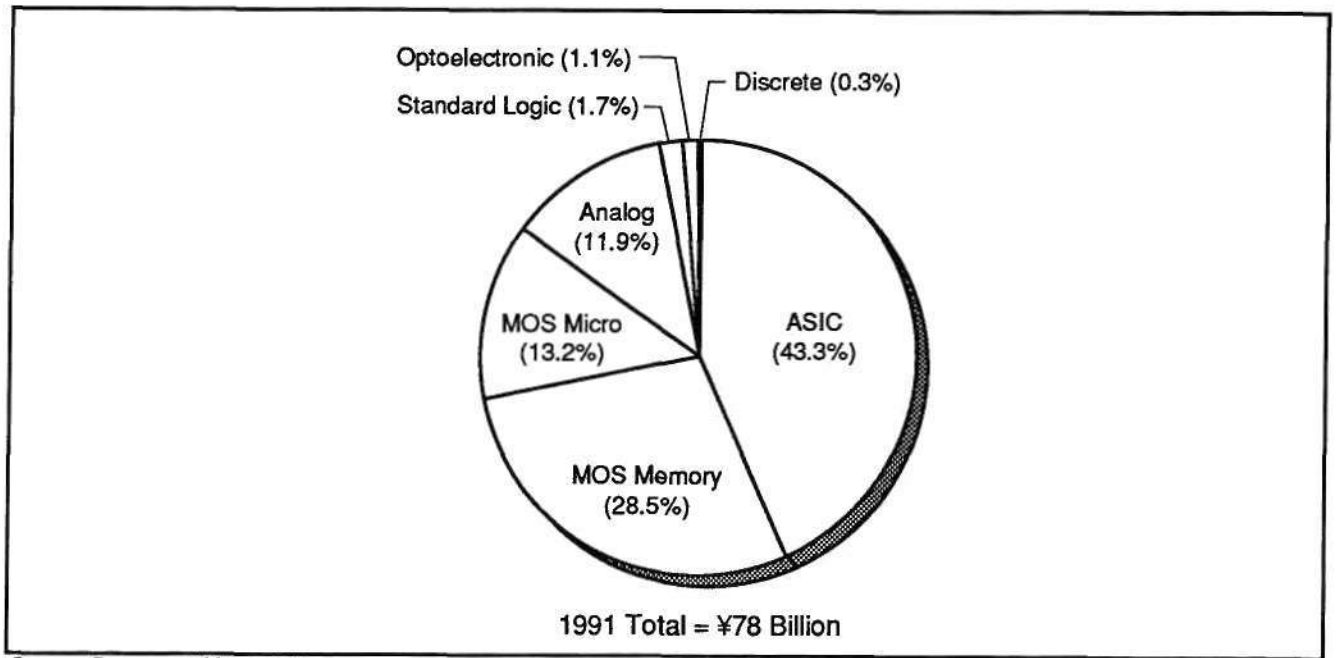
Figure 4
Estimated 1991 Semiconductor Contribution for TV Video Games



Source: Dataquest (May 1992)

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significantly in 1996, when CD-ROM/RISC processor-based advanced TV video games will require massive main memory for clearer still pictures, more realistic motion pictures, and more color variation. At the same time, cost consideration will lead to mass consumption of 1Mb and 4Mb DRAMs for main memories in 1996, boosting share of MOS memories as well as MOS micros in the total semiconductor consumption.

Dataquest Perspective

Although multimedia has become an everyday word, its real image is still blurred because it has not been clearly defined in terms of both hardware and application software, which are available in many types. Multimedia applications are generally divided into information systems for business and home uses, but their boundaries and positioning are still too unclear to require the establishment of a unified framework including each standard.

Dataquest expects the multimedia environment to grow over a boundary between data processing and consumer electronic equipment markets. In particular, the office-based multimedia system will emerge as a new EDP system based on currently available workstations and PCs. Once enhanced by multitask capability as well as two-way digital communication (teleconference and integrated service digital network) and artificial intelligence capabilities, the multimedia system will establish its position as the vital information terminal for each office worker.

On the other hand, the home multimedia system will be configured around TV video games as the low-cost terminal. TV video games are expected to incorporate present PC capabilities, including retrieval and processing of information for all family members. At the same time, HDTV, whose demand will grow earlier than expected, will become another pillar of the home multimedia system. Finally, the market will meet ISDN and revolutionize personal information retrieval and processing means, creating a gigantic market encompassing EDP and consumer electronic equipment markets. It will blur the boundary between these two industries.

Undoubtedly, the electronic equipment industry and semiconductor industry in the 21st century will be driven by multimedia. Its impacts are such that manufacturers not directly involved in the multimedia market may find it difficult to survive in either industry. At the same time, considering that PCs and workstations are in

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one of the most competitive markets, companies intending to enter the multimedia market will see the TV video games market as an accessible gateway, together with its massive consumption of semiconductor devices. In particular, the prospective use of 32-bit RISC processors for next-generation CD-ROM game machines, scheduled in 1996, will attract RISC manufacturers, in addition to Advanced Micro Devices, which has established its position in the present arcade game market.

Dataquest considers the video game system as the low-cost multimedia equipment, which will be priced at about ¥60,000 for commercial models. If this price level is to coincide with significant improvement of system performance, semiconductor manufacturers will face further cost pressure. Meanwhile, some ASICs currently separated from CPUs are likely to be integrated into RISC processors, causing a major change in whole chip configuration. At the same time, future video game systems will consume as many microprocessors and as much memory as PCs do.

Dataquest believes that the home multimedia system based on the TV video games system is assured of market penetration exceeding that of the current TV video games. It will grow to a colossus and have a major impact on the semiconductor industry by mass consumption of memories and microprocessors.

By Kun Soo Lee

Product Analysis

Gate Array Prospects and Problems

According to the worldwide semiconductor market survey conducted by Dataquest in November, the MOS gate array market in 1991 grew 17.7 percent from the previous year to $3,034 million (the industry average is 11.5 percent). Together with MOS micros, MOS gate array is the fastest-growing segment in the industry. Current expansion of gate array and other ASIC markets is driven by increasing demand for the downsizing of electronic equipment with higher performance and wider variations. Meanwhile, semiconductor makers are shifting their strategic focus to ASICs to secure stable profitability by reducing the impact of memory recession experienced in the past two years.

This article analyzes the 1990 Japanese MOS gate array market on the basis of Dataquest's survey, and looks at technological trends and challenges.

Market Structure by Gate Count

Frequency distribution of gate array development projects by gate count in Japan shows that 3K to 6K products held the highest share in 1989 and 1990; the share was 29.5 percent in 1990 (see Figure 1). Compared to the U.S. market, which was dominated by 10K to 20K products in 1990, the Japanese gate array market has been relying on smaller products. Nevertheless, comparison of the 1989 and 1990 data reveals that development of 10K or more products replaced that of less than 3K, and 70K or larger gate arrays emerged in 1990—accounting for a meager 0.3 percent, suggesting a strategic shift toward larger products.

The most advanced MOS gate array has 400,000 gates formed by a 0.8-micron triple-layer CMOS process. However, most products (78.8 percent) designed in today's market have less than 10K gates. Currently, gate array is primarily used for integration of random logic devices and addition of special capabilities for product differentiation. Few cases are used for development of large-scale circuits integration. Also, few macro libraries such as memory and MPUs are incorporated, with most memory being 4K or less. This reflects the fact that development of large-scale gate array must largely depend on the abilities of designers and CAD systems, with some hurdles to be cleared in product tests, so that advancement of semiconductor manufacturing technology does not necessarily lead to use of the highly integrated gate array.

On the other hand, larger products are designed in the United States because of the presence of chip set makers with strength in design. The U.S. gate array market is being eroded by programmable logic devices (PLDs), resulting in less development of 10K or less products. Although the impact has yet to be felt in the Japanese market, Dataquest sees some signs. The development of highly integrated CMOS PLDs has led to an increased number of domestic chipmakers (Fujitsu, Toshiba, Matsushita Electronics, and Ricoh) using PLDs in the initial design of gate array development.

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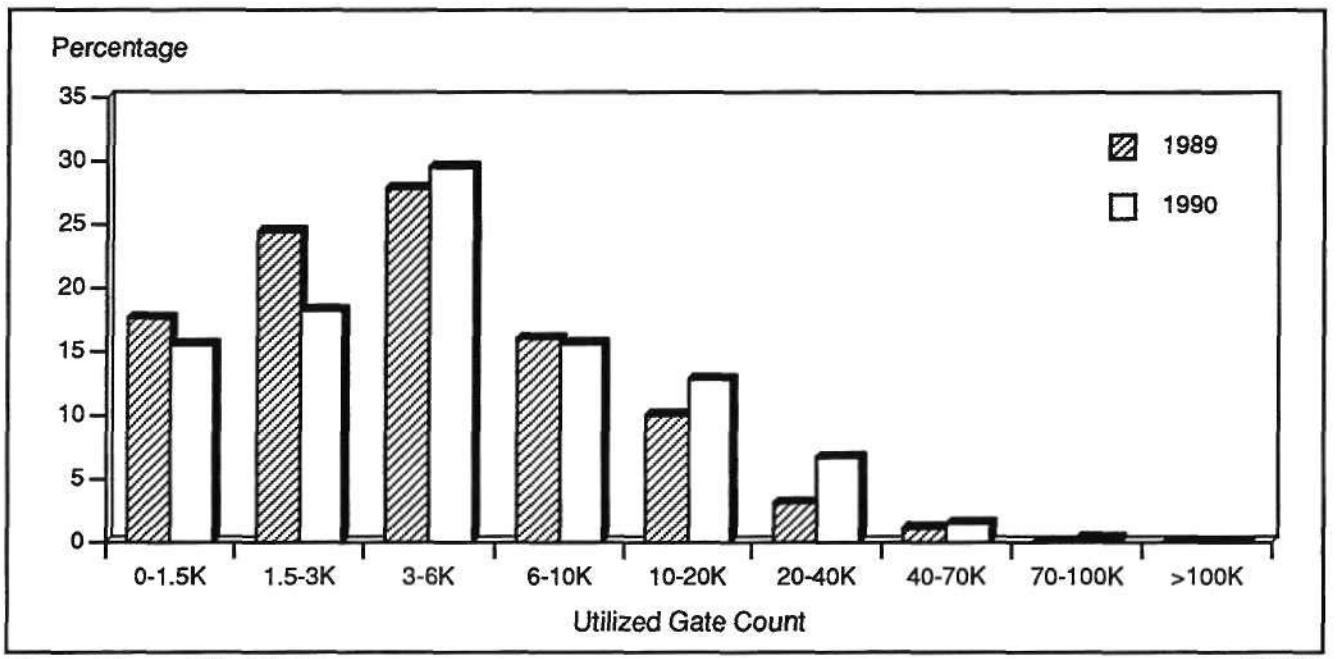
Figure 1
1990 Distribution of MOS Gate Array Design



Source: Dataquest (May 1992)

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Sales Volume Distribution and Product Life Cycle

In terms of sales volume per development, less than 10,000 units per life accounted for 54.7 percent of the total (see Figure 2). Coupled with a relatively low hit ratio (the number of development projects leading to volume production/the number of all gate array development projects) of 50 to 60 percent, gate array is not a highly profitable business. Designs with more than 100,000 units or large gate size are shifted to cell-based ICs (CBICs), further limiting the roles of gate array. At the same time, all respondents expected a shorter life cycle (see Figure 3). Thus, gate array is becoming a tough job for semiconductor makers, where an increase in the number of developments contracts does not lead to increased revenue.

There is a comfort to match the dim outlook, however. Although growth of gate array sales per development is limited by market pressure for small-lot production of electronic equipment with wider variations, the learning effect on the user side and the upgrading of CAD and other development tools are expected to help reduce turnaround time and boost the hit ratio.

Market Share by Product Type

Gate array based on sea-of-gate (SOG) technology, which was introduced in 1988, has been steadily growing in sales and grabbed a majority (51.7 percent) of the gate array market in 1990 (see Figure 4). SOG sales differ by vendor and are classified into three groups: those developing SOG-based gate arrays only (Toshiba and Mitsubishi Electric), those with a high percentage of SOG products (Matsushita Electronics and Oki Electric), and those still focusing on the conventional fixed-channel type.

Interconnection for SOG products is dominated by double-layer metallization (DLM); triple-layer metallization (TLM) accounts for a mere 4.1 percent. However, SOG products using the 0.8-micron CMOS process have become a mainstream of many suppliers in 1991, so that TLM is expected to boost its share. Furthermore, 1991 saw a wave of embedded gate array (EGA) announcement by NEC, Toshiba, and Fujitsu; there were none in 1990. With its advantages of short turnaround time of gate array and the use of highly integrated megacells equivalent to CBICs, EGA shows high growth potential.

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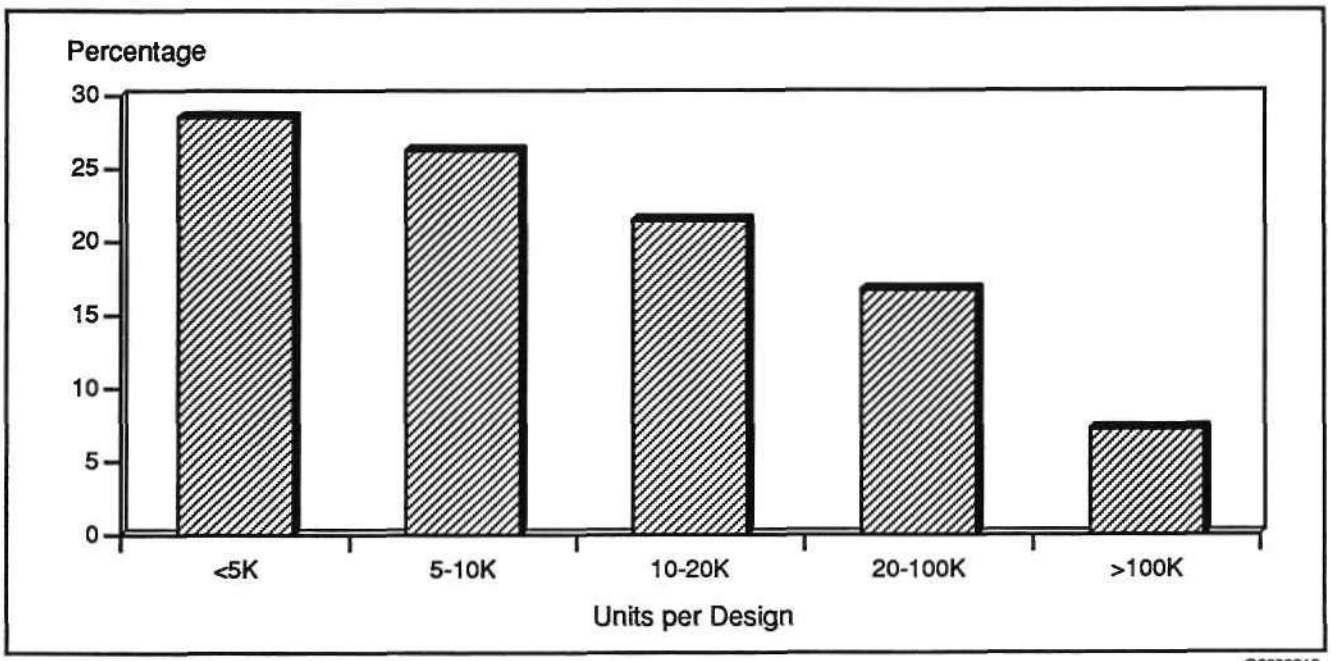
Figure 2
1990 MOS Gate Array Unit Shipments



Source: Dataquest (May 1992)
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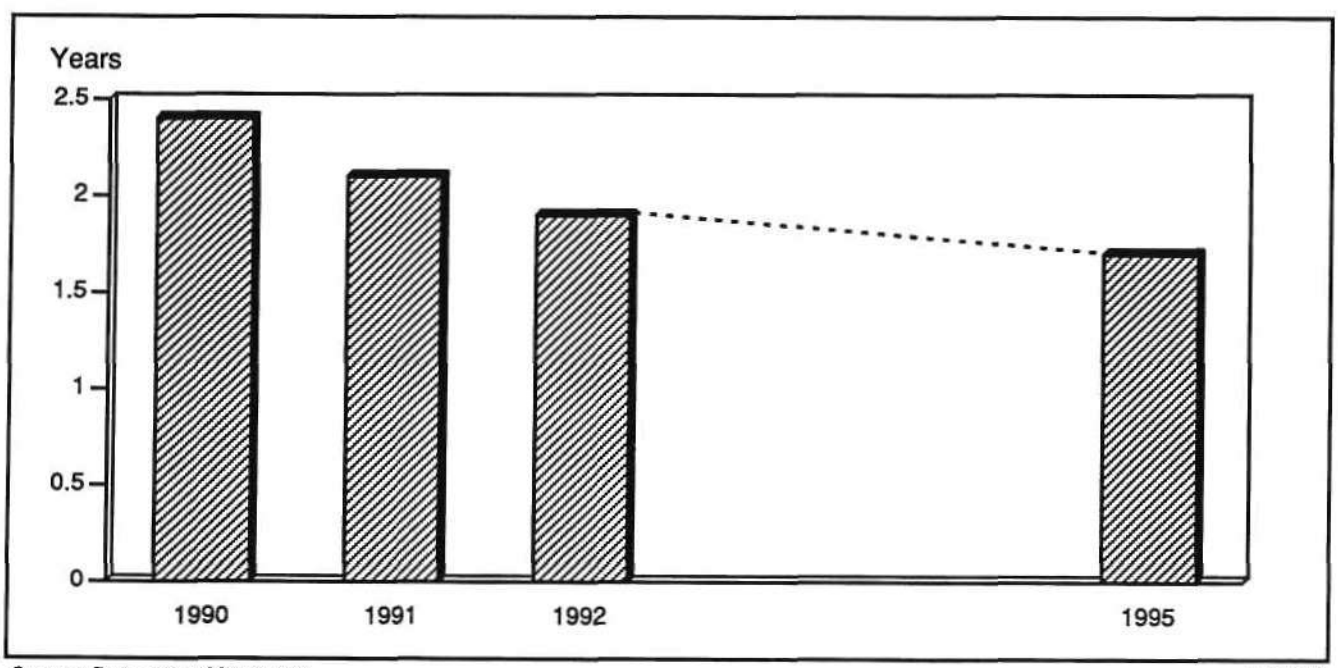
Figure 3
Average MOS Gate Array Life Cycle



Source: Dataquest (May 1992)
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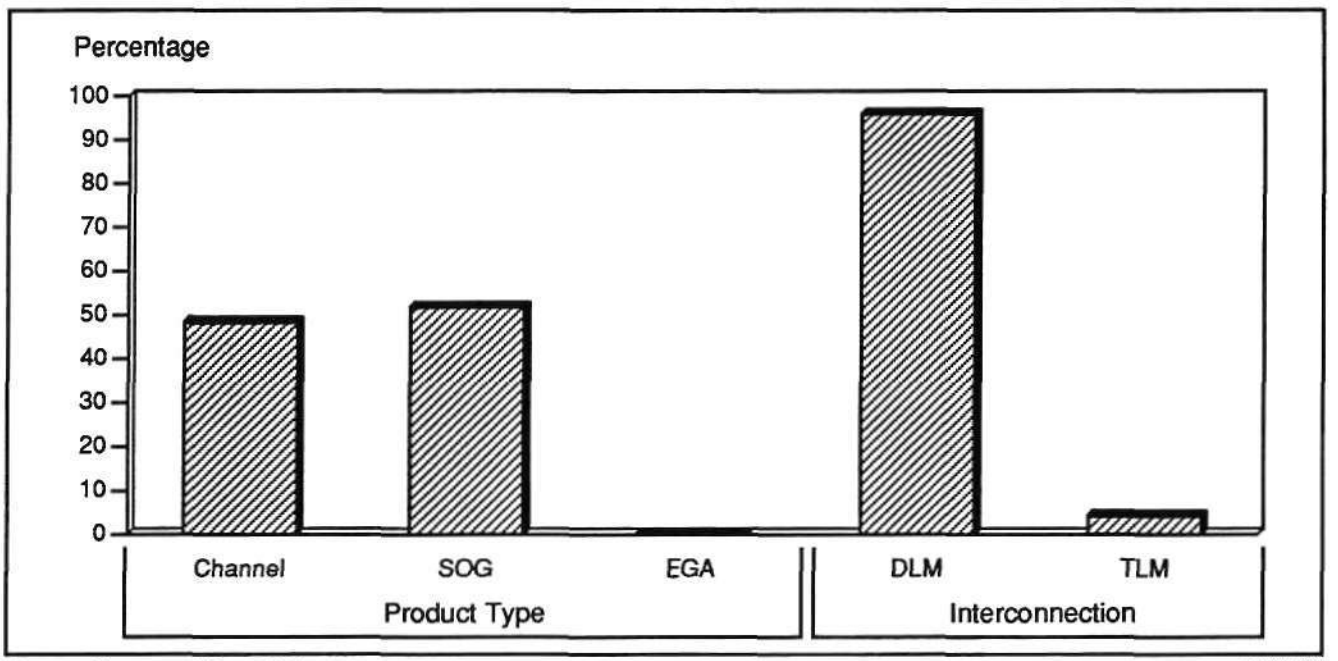
Figure 4
1990 MOS Gate Array Device Features



Source: Dataquest (May 1992) G2000220

Distribution by Macro Feature and Memory Capacity

SOG has spurred the increase in gate arrays incorporating RAM, whose share increased from 3.3 percent in 1989 to 11.0 percent in 1990 (see Figure 5). However, memory capacity is limited because of constraints from integration and cost, and less than 4Kb accounts for 81.5 percent (see Figure 6). As a result, major applications are buffers and registers, rather than memories, and many makers use CBICs for MPUs, micro peripherals (MPRs), and analog ICs.

The scan pass test's high share is attributed to the high implementation rate of a few vendors; others omit it because of cost considerations. Built-in self test (BIST) will be introduced by NEC, Fujitsu, and Oki Electric, which signed agreements with Cross Check Technology in an attempt to improve testability for the next-generation gate array of 0.6 micron or less.

Package Pin Count and Clock Speed

The standard package for gate array in Japan is surface-mount, multipin-compatible, and low-cost PQFP, which accounts for 66.6 percent of the total (see Figure 7). Long-awaited TAB will be increasingly used for space saving in the next-generation notebook PCs. Both in the United States and Japanese markets, 85-195 pin types are most common (see Figure 8), representing 64.2 percent in the Japanese market. In the number of gates used, however, the U.S. market is mainly 10 to 20K, and the Japanese market 3 to 6K, which depicts the dominance of multipin products with small gate counts in Japan.

In terms of clock speed, the U.S. market is dominated by 20- to 32-MHz, the Japanese market by less than 16 MHz, accounting for 36.8 percent (see Figure 9). At the same time, 50-MHz or faster applications hold a small share (4.6 percent). Thus, Dataquest believes that a next major challenge would be improved product testing for highly integrated and faster speed gate array. In the U.S. and Japanese markets, gate array's largest application is the computer and peripherals market, which takes up a 62.0 percent share in the United States and a 43.5 percent share in Japan (see Figure 10). However, the two markets have different features. While major applications in the U.S. market are computer systems including PCs and workstations, which consume high speed, high integration, and large pin count products, the

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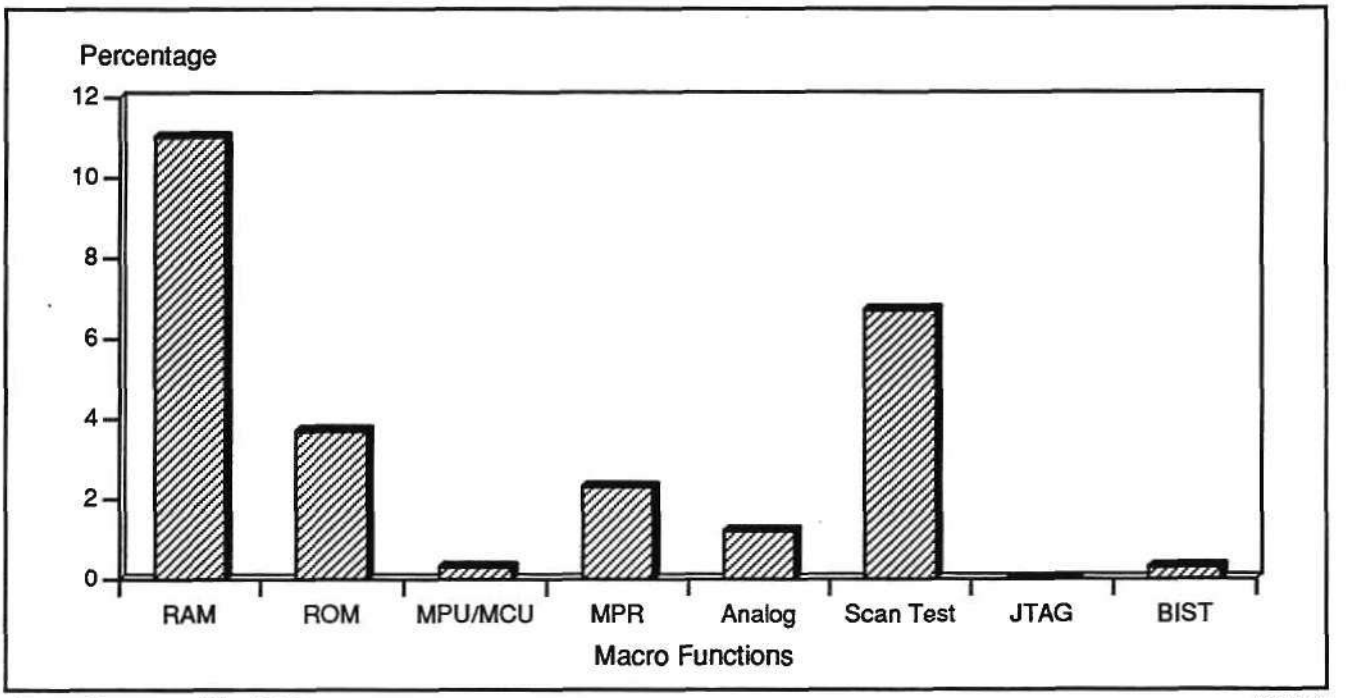
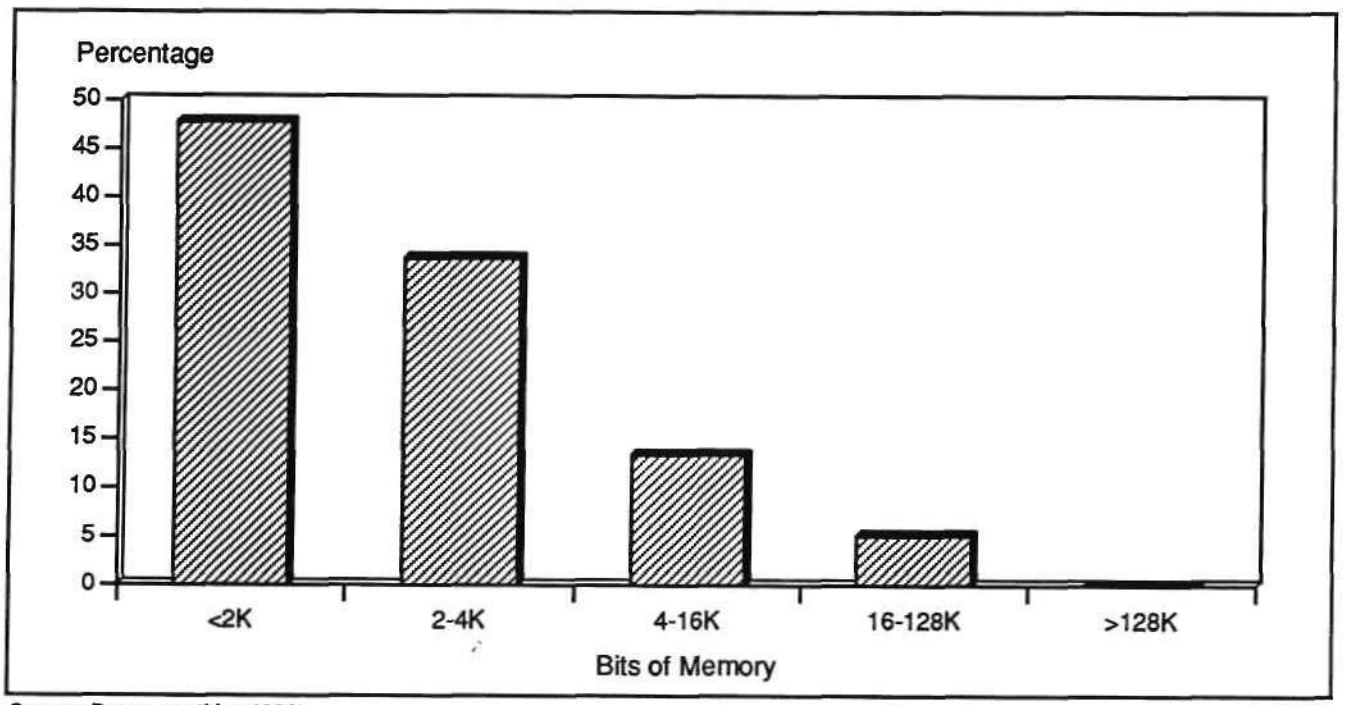
Figure 5
1990 MOS Gate Array Market by Function



Source: Dataquest (May 1992)
G2000221

Figure 6
1990 MOS Gate Array Memory Capacity



Source: Dataquest (May 1992)
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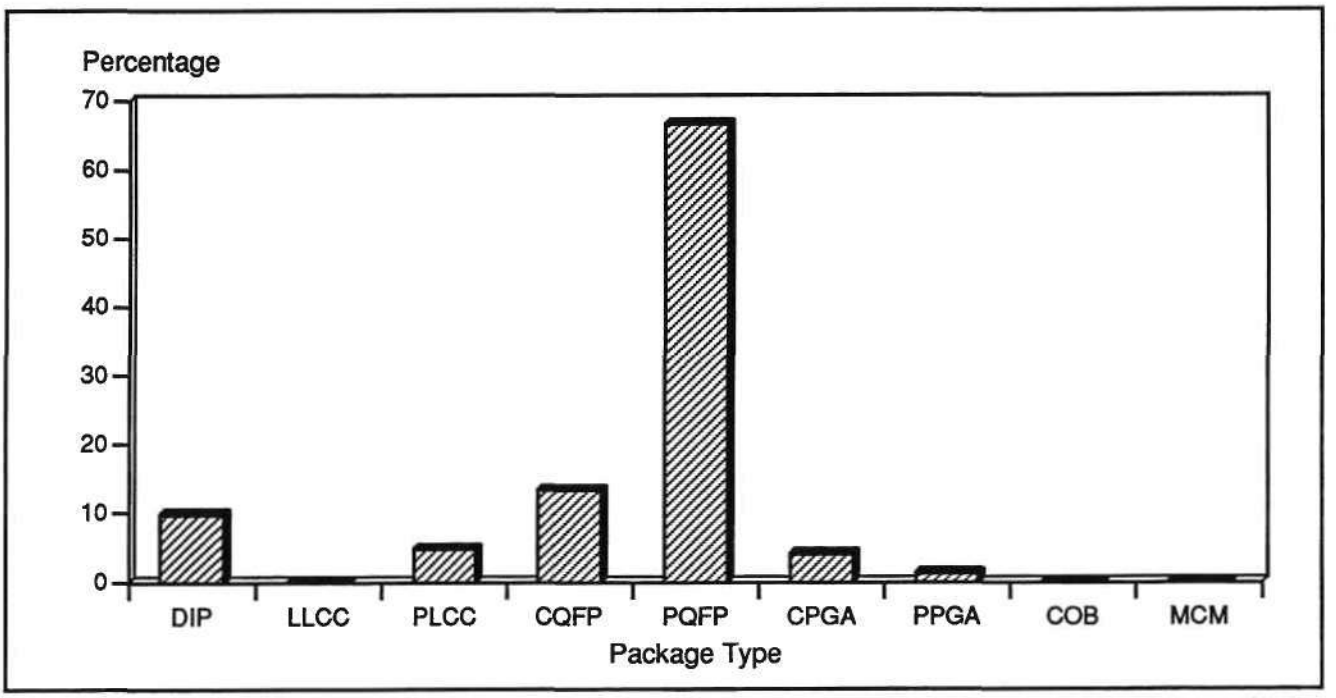
Figure 7
1990 MOS Gate Array Market by Packaging



Source: Dataquest (May 1992)

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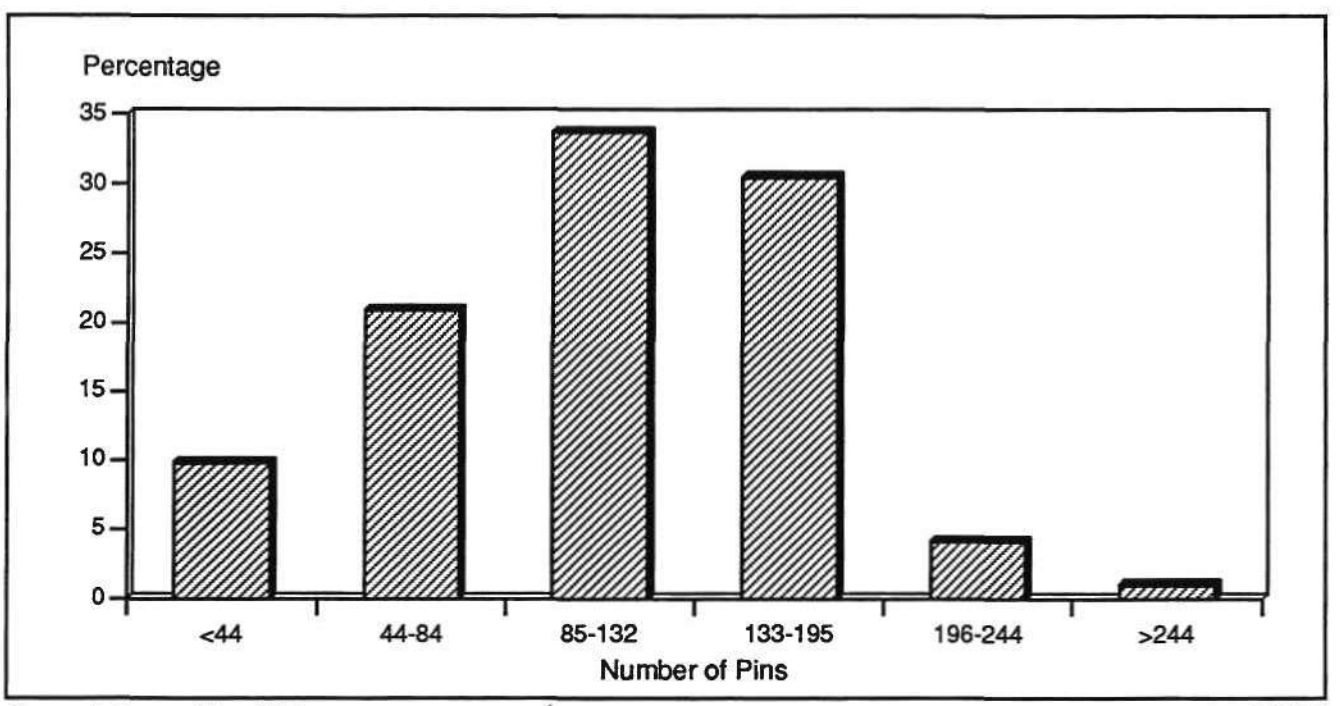
Figure 8
1990 MOS Gate Array Market by Pin Count



Source: Dataquest (May 1992)

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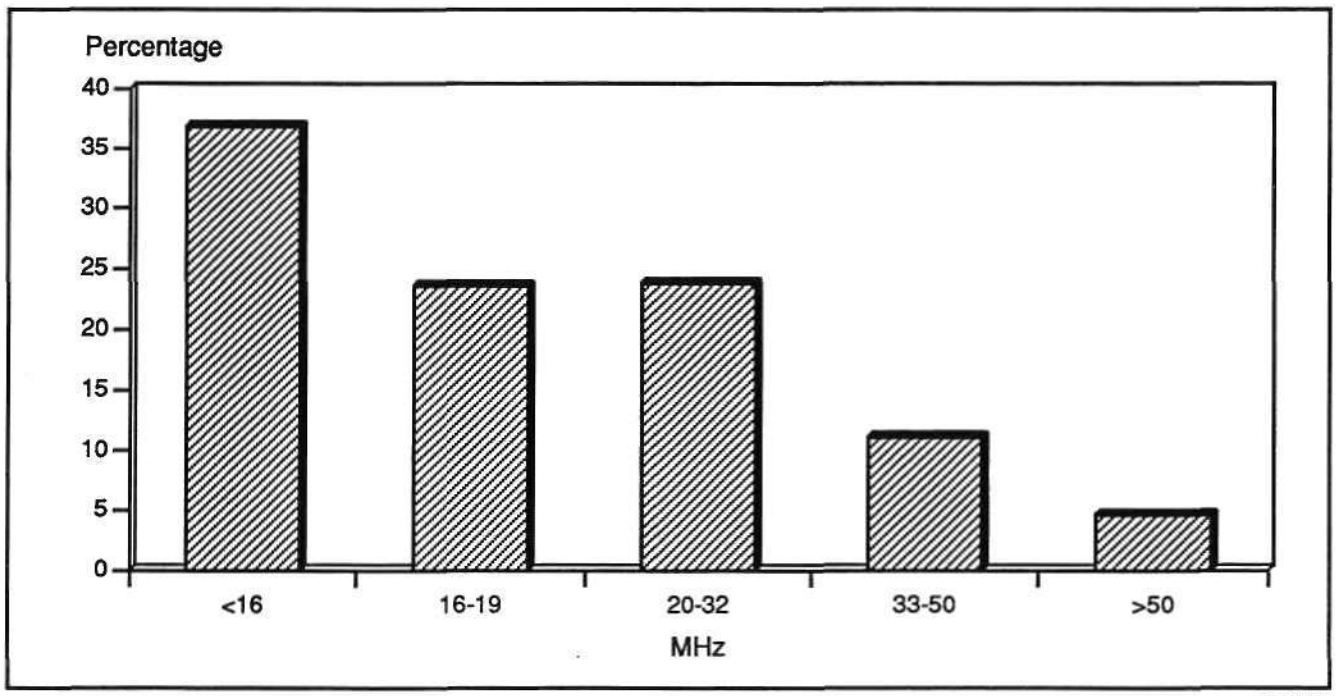
Figure 9
1990 MOS Gate Array Market by System Clock Speed



Source: Dataquest (May 1992) G2000225

Japanese market mainly consumes slower speeds, lower integration, and larger pin count gate arrays for peripherals such as printers and floppy disk drives.

Also, in Japan gate array is finding increasing applications in consumer, industrial, and communications equipment using 4- to 16-bit MCUs, which appear to justify the features described earlier.

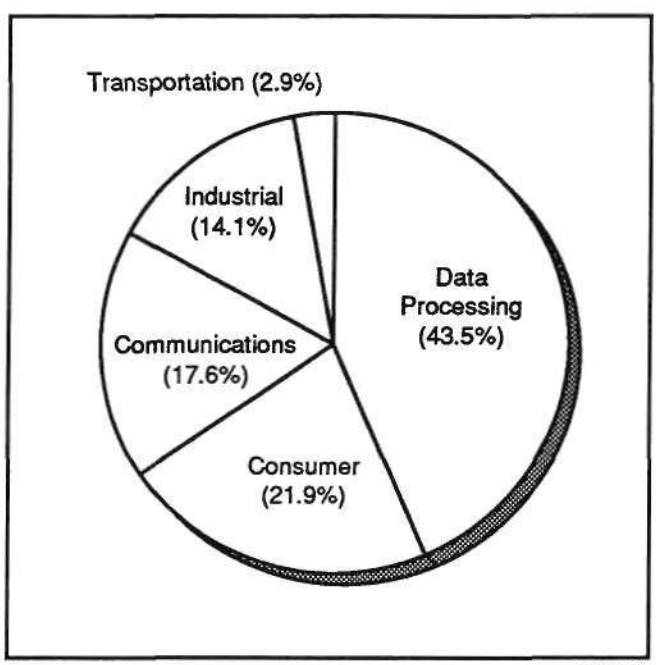
Source Voltage

Higher integration of gate array, the downsizing of electronic equipment, and growth of portable equipment create demand for lower power consumption, and source voltage for gate array is expected to decrease to 3V or 1.5V. In 1990, only 6.6 percent of all gate arrays developed used a 3V source (see Figure 11) because other devices such as CPUs and memories use 5V. Dataquest expects 3V gate array to increase its share to 16.6 percent by 1993. In fact, some makers have already developed 3V products, with 1.5V as a next target, and many makers are positioning low-voltage gate array as a strategic product.

Dataquest Perspective

Clearly, semiconductor suppliers are shifting their strategic focus to ASICs, as evidenced by recent announcements to strengthen their ASIC business. This not only helps them to establish a sustainable customer base by serving

Figure 10
1990 MOS Gate Array Market by Application



Source: Dataquest (May 1992) G2000226

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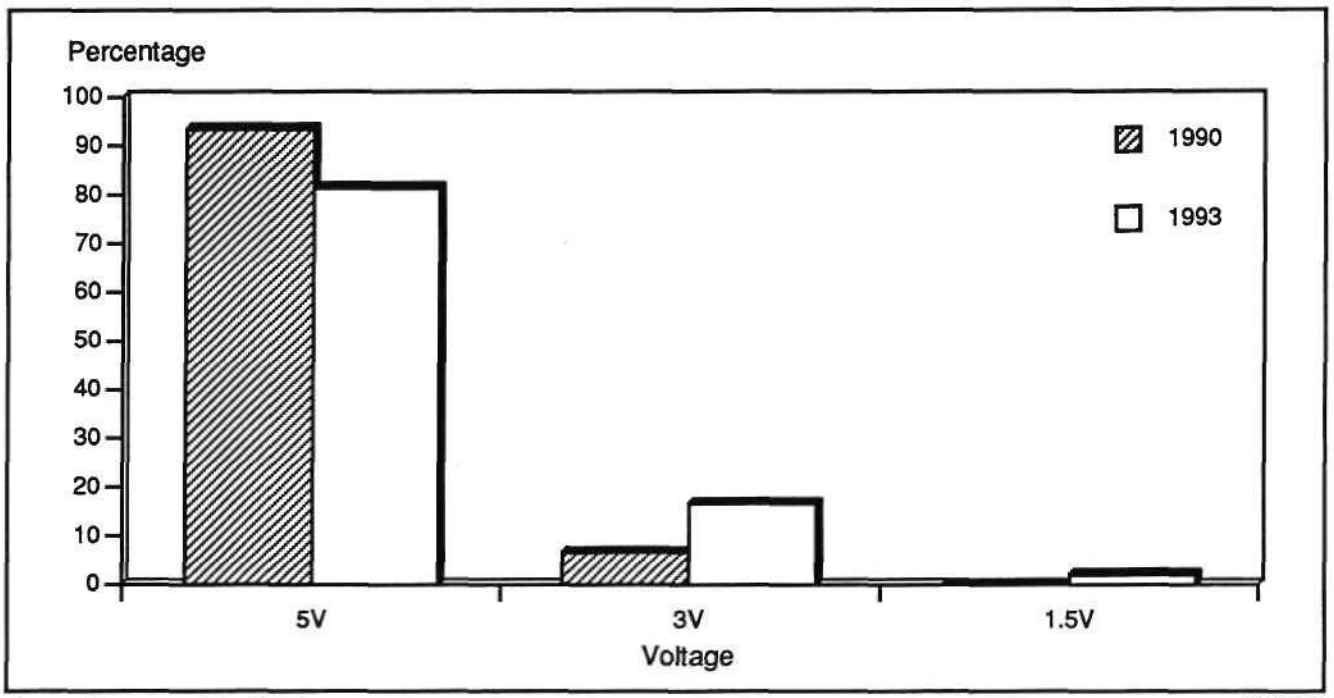
Figure 11
MOS Gate Array by Power Supply Voltage



Source: Dataquest (May 1992)
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ever-increasing needs for customization, but also to secure profitability by boosting revenue from ASICs, which are less sensitive to price fluctuation.

Nevertheless, gate array business is by no means immune to various challenges facing the semiconductor industry, including the following:

- Meet technological advancement for higher integration
- Manage an expanding product line from gate array to ASIC microcontroller
- Move toward open standards for ASIC development tools
- Price declines

Gate array using a 0.5-micron CMOS process—the same geometry level as 16Mb DRAMs—is expected to make debut in the market in late 1992. The new product will have 500,000 to 700,000 gates, allowing large-scale circuits on a single chip. This clearly indicates that development of gate array using the leading-edge technology, like DRAMs, is becoming essential.

Currently, the seemingly unstoppable increase in circuit integration is about to change the ASIC business by introducing products that grow out of conventional categories. PLDs with more than 10,000 gates made inroads into applications previously served by gate array. In the gate array segment, a new face is EGA, which can incorporate megacells with a high level of integration equivalent to that of CBICs, which in turn are capable of incorporating CPUs, memories, and analog circuits, offering ASIC microcontrollers. Obviously, traditional categories of gate array, CBICs, and microcontrollers are not a major concern for users, who want a desired function or capability to be implemented in the most efficient manner.

In 1991, Fujitsu, NEC, and Sony concluded separate agreements with Cadence Design Systems for joint development of CAD systems to design ASICs and custom LSIs. Cadence, Mentor Graphics, and other CAD vendors are offering integrated CAE Framework tools, which accommodate libraries of semiconductor makers to enable them to develop ASICs on a common database and under the same operating environment. Development tools have been a source of competitive edge in the ASIC business, and Framework is expected to unleash users from dependence on a certain semiconductor vendor.

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A recent concern is the decline in gate array prices triggered by a rapid increase in supply as major semiconductor makers shifted their production lines from sluggish 4Mb DRAMs to gate array. Price competition also is intensifying.

As discussed earlier, the gate array market faces drastic changes in the business environment and is becoming increasingly competitive and difficult to survive for suppliers that continue to rely on their conventional strategy based on the high growth potential of the ASIC market. The key to success in the future gate array business lies in effective use of large-scale gate array. Dataquest's latest survey revealed that gate array design did not fully benefit from highly integrated semiconductor technology.

Dataquest believes that the future gate array business will evolve into diversification or specialization. Major manufacturers will develop a complete product line from PLDs to ASIC microcontrollers to serve all needs and wants of customers. Smaller makers that lack resources will be forced to develop products for specific applications. Because EGA can accommodate highly integrated macro functions, each maker has a choice for product differentiation. In other words, gate array makers can distinguish themselves from each other by making proprietary technologies such as CPUs, digital signal processors (DSPs), and graphics, available to customers as macro features.

As the semiconductor business changes from supply of components to systems, Dataquest believes that each maker can establish its market position and competitive edge by incorporating highly integrated semiconductor technologies and system development capabilities into macro features tailored to the needs of customers.

By Susumu Kurama

Company Analysis

Japanese Semiconductor Alliance Update: The First Quarter of 1992

During the first quarter of 1992, which ended on March 31, Dataquest recorded 22 new alliance agreements involving Japanese semiconductor companies (see Table 1). For the previous four quarters that made up 1991, Dataquest recorded a total of 87 Japanese semiconductor corporation-involved alliances; this resulted in an average quarterly rate of 22 new agreements signed per quarter during 1991. Thus, the 22 newly formed alliances of the past quarter represented a continuation of a nearly level trend. In addition, it appears that the recession has not altered the alliance strategies of Japanese corporations as a group.

Dataquest classifies strategic alliances into the following major categories, as applied in Table 1.

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

Active RISC Alliance

Alliances relating to reduced-instruction-set computing (RISC) microprocessors vied for publicity during the first quarter of 1992. NEC and MIPS Computer, soon to be a subsidiary of Silicon Graphics Inc., agreed to extend their RISC microprocessor license agreement until March 1999. Although their previous agreement would not have expired for another two years, the decision to extend the arrangement confirmed NEC's commitment to the MIPS architecture and established NEC as a leading

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Table 1
Japanese Semiconductor Alliances (First Quarter of 1992)

Company 1	Company 2	Product	Agreement Type	Date
Sharp	Altera	Field-programmable gate array	FA	1/92
NEC	AT&T	4Mb SRAMs	JD	1/92
NEC	Seiko Instruments	CAD system	JD	1/92
NEC	Mentor Graphics	Logic circuit design system	SA	1/92
Matsushita	ITT Intermetal	Transistors, IC wafers	SA, FA	1/92
Toshiba	Intel	8-year patent cross-license	LA	1/92
Oki	General Information Systems	IC card software	LA	2/92
NEC	MIPS Computer	MIPS RISC MPU	LA	2/92
Sharp	Intel	Flash memory	LA, SA, FA	2/92
Rohm	Hana Semiconductors	Semiconductors	JV	2/92
Kubota Computer	Digital Equipment	DEC Alpha RISC MPU	SA	2/92
Sony	Cadence	CAE system consulting	JD	2/92
Marubun	Spectron Microsystems	Floating/fixed-point DSPs	SA	2/92
Fujitsu/NEC/Toshiba	Rambus	Memory interface technology	LA	3/92
NEC	Schlumberger	LSI defect analyzer	JD	3/92
Advantest	Electro Scientific	Defect recovery system	JD	3/92
Sumitomo Corporation	Fera Speed	VHDL support software	SA	3/92
Ricoh/Sharp	Texas Instruments	Kilby patent	LA	3/92
Matsushita	Mentor Graphics Japan	CAD tool	LA, SA	3/92
Hitachi	Wang Laboratories	SIMM	LA	3/92
Matsushita	Symertrix	Ferroelectric thin-film technology	JD	3/92
Four Japanese companies	Hewlett-Packard	HP PA-RISC MPU	JV, CO	3/92

Source: Dataquest (May 1992)

May 25, 1992

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supporter within the MIPS and Advanced Computing Environment (ACE) camps.

Hewlett-Packard disclosed that it has established a consortium to promote HP's Precision Architecture (PA) RISC chips; eight U.S. and Japanese chip manufacturers and users are charter members. Japanese participants in the effort include Hitachi, Mitsubishi, Oki, and Yokogawa. The consortium will disseminate PA technology and long-term strategies to its members, while providing an environment conducive to technology, information, and business exchanges.

Digital Equipment Corporation has announced that it will begin marketing its Alpha RISC chips. Japan's Kubota has apparently elected to use the Alpha chip as a CPU in its high-end workstations, even though it had previously established a joint venture company with MIPS Computer and has been marketing MIPS' RISC-based workstations. Cray Research also declared its support for Alpha as a possible building block in massively parallel supercomputer design.

The number of proprietary RISC architectures is clearly declining as RISC vendors quickly follow the lead of SPARC International's open-systems approach to marketing RISC systems. IBM, HP, and Digital were the last major RISC players to license their designs through a consortium. The basic premise of this approach is that a platform will not be able to reach a sufficient installment base to activate software development unless the architecture is open or accessible to competitors. It now appears that at least several RISC architectures will coexist as standards for some time, in relative contrast to the dominant position enjoyed by the Intel 80X86-based family of microprocessors in the CISC world. Furthermore, now that Intel has effectively lost its 80X86 monopoly, it is likely that the 80X86-compatible will continue to evolve and dominate the PC world as long as the performance of 80X86 CPUs remains competitive with their RISC counterparts.

Intellectual Property

Toshiba and Intel have reached a comprehensive patent cross-licensing agreement that will run through the year 2000. Under this agreement, royalties from Toshiba and Intel patent portfolios, excluding certain microprocessor patents, will essentially be equated such that they offset one another.

Ricoh and Sharp are the latest Japanese semiconductor manufacturers to sign cross-licensing agreements with Texas Instruments (TI). The two companies will pay an estimated 3 to 5 percent of their semiconductor revenue on products that employ TI-developed technology.

After an extended court case, Hitachi and Wang Laboratories finally reached an agreement regarding Wang's SIMM patents.

The recent activity involving intellectual property arrangements between U.S. and Japanese companies reiterate some of the issues that have sparked international discussions about modifying both the U.S. and Japanese patent systems to be, if not more ideal, at least more uniform or compatible with one another. Traditionally, Japan's patent system has favored the larger company by giving less protection to original patent holders with limited resources to follow up patents with supporting patents. Today, the situation in high-technology electronics does not favor the smaller companies in the United States, Japan, or Europe. A strong patent portfolio is virtually a prerequisite for competing in mainstream markets in either the United States or Japan in order to leverage against incurring prohibitively high royalty payments.

Dataquest Perspective

The current Japanese economic slowdown does not seem to have had a negative impact on alliance formation rates. Alliances are regarded by many in Japan as investments in the future and, in some sense, modernized extensions of the traditional keiretsu philosophy, which professes long-term business thinking.

In the third quarter of 1991, Hitachi announced that it would seek 4Mb DRAMs from NMB Semiconductor on an OEM basis. Although the agreement has not yet been implemented because of low demand for 4Mb DRAM parts, apparently Hitachi remains determined to assist NMB overcome its recent financial turmoil. This support of a recently allied company is already a growing trend in the high-risk world of semiconductor manufacturing where the collapse of even a competitor is seen as a loss of resources

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by the high-technology community at large. Perhaps this perspective is a reflection of an optimistic outlook that projects in the not-too-distant future more demand for semiconductors than existing manufacturers can supply. It is this desire to preserve capacity, while production and foundry service agreements have slowed during the past several quarters, that has stimulated other types of alliances. Thus, it seems possible that licensing and joint development alliances have remained vibrant during the first quarter of 1992 by design in order to compensate for the slowdown in other types of alliances.

Strategic Alliances

The following paragraphs briefly summarize some strategic alliances recorded by Dataquest during the first quarter.

Toshiba/Intel

Toshiba and Intel signed an eight-year patent cross-licensing agreement that covers all of both companies' semiconductor patents in all nations, excluding Intel's 32-bit microprocessor patents. Under the agreement, patent usage fees will be mutually offset such that the two companies will not have to make payments to each other. The agreement was signed in December and is valid until the end of 1999.

NEC/MIPS Computer

NEC and MIPS Computer Systems agreed to extend their RISC microprocessor licensing arrangement for another five years, which would end in March 1999. After the two companies signed a license agreement in March 1989, NEC developed the 32-bit VR3000 and 64-bit VR4000 series MPUs based on the MIPS architecture. NEC decided to extend the agreement two years prior to expiration of a prior licensing contract to clearly show its support for the MIPS chips and establish itself as an innovative development leader among MIPS-compatible RISC MPU merchant manufacturers.

Sharp/Intel

Sharp teamed up with Intel in the flash memory business. The agreement, which will last 7 to 10 years, covers various activities ranging from R&D and production to mutual supply of products. Sharp will introduce 0.6-micron flash memory processing technology from Intel and produce 8Mb or larger flash memory chips on an 8-inch wafer line at its Fukuyama plant, and will supply wafers to Intel and also market the chips under its own brand name. The two companies also agreed to develop next-generation flash memory chips that will use 0.5-micron or finer processes.

Ricoh/Sharp/Texas Instruments

Ricoh and Sharp signed cross-licensing agreements with TI. The agreement remains effective through March 1996 and covers many TI patents, including the Kilby patent, which TI claims all integrate circuits employ and hence all manufacturers must license. Fujitsu is currently contesting the TI claim in court, with potential widespread ramifications for TI should Fujitsu win. A subtle issue in this case is whether the Japanese patent system intentionally delayed recognizing a patent, in some cases perhaps beyond the useful life of the patent, in order to promote industry in Japan and, if so, whether retroactive royalties are reasonable. Ricoh will pay about 3 percent, about ¥10 billion, of the value of its semiconductor production to TI over the next four years. Sharp is also expected to pay about 5 percent of the value of Kilby-related semiconductor production.

Four Japanese Companies/Hewlett-Packard

Hewlett-Packard set up the Precision RISC Organization (PRO) in Cupertino, California, to promote its PA-RISC microprocessor technology. Among the eight American and Japanese companies joining the group are Hitachi, Mitsubishi, Oki, and Yokogawa Electric. Both HP and Hitachi manufacture the chip; Mitsubishi and Yokogawa will act primarily as customers and marketers. PRO will also encourage member companies to exchange technologies and cross-license their designs.

By Junko Matsubara

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- 1991 final Japanese semiconductor market share
- FY1991 Japanese company financial report

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Dataquest Perspective

Semiconductors *Japan*

SCJA-SVC-DP-9206 April 20, 1992

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Offshore Production: A Growing Trend in Japanese Semiconductor Manufacturing Strategy

This article will survey the offshore manufacturing activities of Japanese semiconductor companies from the past two years. Activities for the most part have been concentrated in three regions: the United States, Europe, and other parts of Asia.

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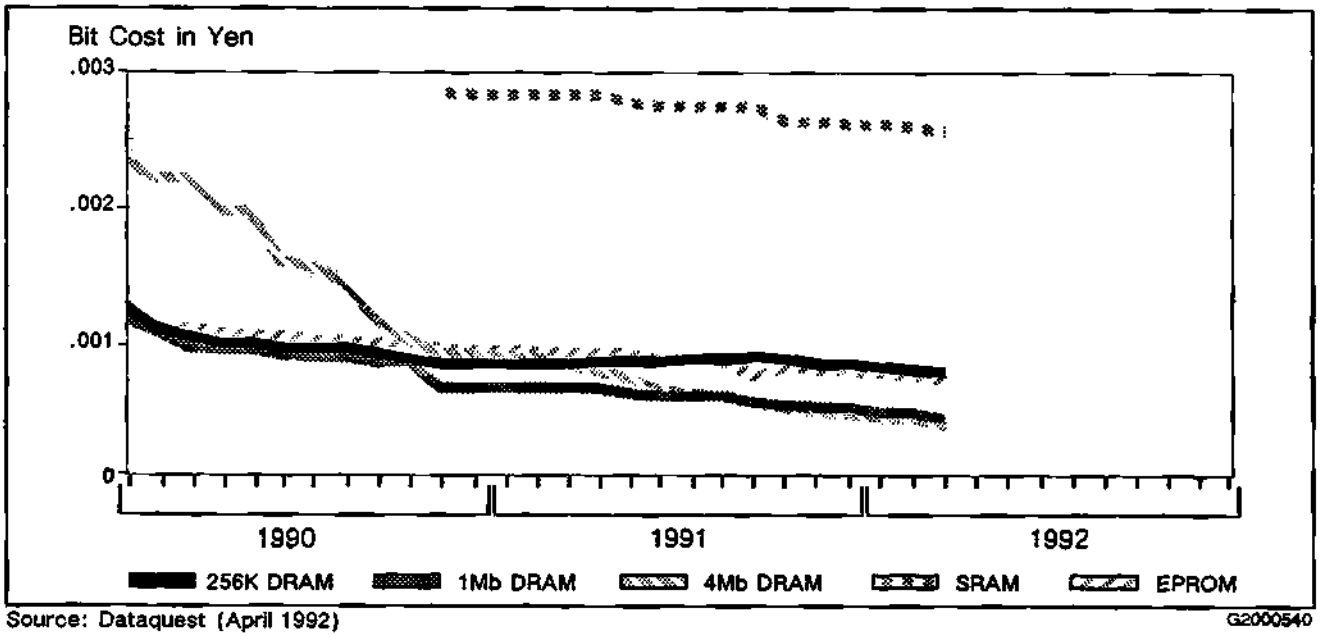
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.33	3.29	3.50	3.70	3.80	3.55
DRAM 256Kx1-8	1.10	1.54	1.60	1.20	1.29	1.10
DRAM 4Mbx1-8	12.55	11.24	14.50	14.00	15.00	12.50
EPROM 1Mb, 170ns	3.50	3.68	3.00	3.50	3.90	2.50
EPROM 2Mb, 170ns	7.13	7.05	5.65	6.00	7.90	4.80
SRAM 1Mb, 128Kx8	13.13	11.69	9.90	15.25	15.30	NA
SRAM 256K, 32Kx8	3.85	3.49	3.45	3.70	4.00	3.30
SRAM 64K, 8Kx8	1.90	1.52	1.73	1.40	1.40	1.35
68020-16	27.50	37.85	26.00	37.50	35.50	NA
80286-16	9.50	10.39	10.00	11.30	11.70	9.70
80386DX-25	125.00	136.00	139.00	125.00	152.00	98.00
80386SX-16	46.50	53.43	52.50	52.00	55.60	48.00
R3000-25	115.00	125.05	110.00	NA	NA	NA

Note: These figures correspond with the *DQ Monday Report* dated March 30, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (April 1992)

Memory Bit Price in Japan



Source: Dataquest (April 1992)
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Market Analysis

1991 Japanese Electronic Equipment Industry in Review: Facing the End of Expansion

The year 1991 would have been good for the Japanese electronics industry if it could have weathered the bottom of the silicon cycle in the semiconductor industry and benefited from a sustained economic expansion that began in December 1986. This expansion was expected to emulate the Izanagi Boom—the longest expansion period after World War II—which lasted 57 months between November 1965 through July 1970. However, signs of recession began to appear in 1991, and the fully expanded Japanese economy started to shrink.

Dataquest forecast 5.7 percent growth in electronic equipment production in Japan during 1991. In fact, the growth rate for the nine months ending with the third quarter was 6.0 percent, compared with the same period in 1990.

This article examines the Japanese semiconductor application market in 1991 and forecasts the market for 1992.

Japanese Electronic Equipment Industry in 1991

Dataquest estimates that electronic equipment production in Japan reached ¥24,655 billion in 1991, a 4.4 percent increase from the previous year (see Figures 1 and 2 for data on individual segments).

Quarterly growth was strong up to the third quarter of 1991: a 7.2 percent increase in the first quarter compared with the same period in 1990, followed by 4.9 percent in the second quarter and 6.1 percent in the third quarter. The growth rate plummeted to negative 0.6 percent in the fourth quarter, which coincided with sharp downturns in the Japanese economy and resulted in the 4.4 percent growth for the industry (see Figure 3).

The annual growth rates among major applications are as follows:

- 3.6 percent for electronic data processing (EDP) equipment
- 3.8 percent for communications equipment
- 2.8 percent for industrial equipment
- 7.4 percent for consumer equipment
- Negative 0.4 percent for automotive equipment

A major factor in the slowdown of electronic equipment production was the slump in the stock market, which limited financial sources for capital expenditure and adversely affected the industrial equipment market. In addition, major markets for electronic equipment—information systems for financial institutions and transportation equipment—were directly hit by economic downturns. Deteriorating consumer confidence contributed somewhat to the slowing growth in consumer electronic equipment, but Dataquest concludes that the consumer electronic segment showed steady growth in 1991, as fueled by domestic demand in Japan. The exception was VCRs, where demand seems to be near saturation. The following sections analyze electronic equipment production trends by major markets.

EDP Equipment Market

EDP equipment production in 1991 rose 3.6 percent from the previous year, to ¥6,977 billion (see Figure 4 for data on individual segments). Data storage equipment declined 1.4 percent, while terminals were down 8.2 percent. In the computer segment, which accounted for 40 percent of the EDP equipment market, double-digit growth was maintained on a value basis. However, production of general-purpose computers decreased by 40.1 percent on a unit basis. PC production recorded a meager 1.8 percent growth on a value basis, the lowest in the past five years and a reflection of market saturation driven by notebook PCs.

Slowdowns in notebook PCs affected the data storage equipment segment, where production of flexible disk drives was down 12.4 percent from 1990. On the other hand, hard disk drives (HDDs) grew by 32.6 percent on a unit basis because of price declines, while the value of production remained at a 2.2 percent increase. In the PC market, which has huge market potential, the further decline of HDD prices will be essential in spurring the growth of future PC systems. At the same time, the increased use of HDDs on PCs will lead to their becoming standard features, contributing to further expansion of the HDD market.

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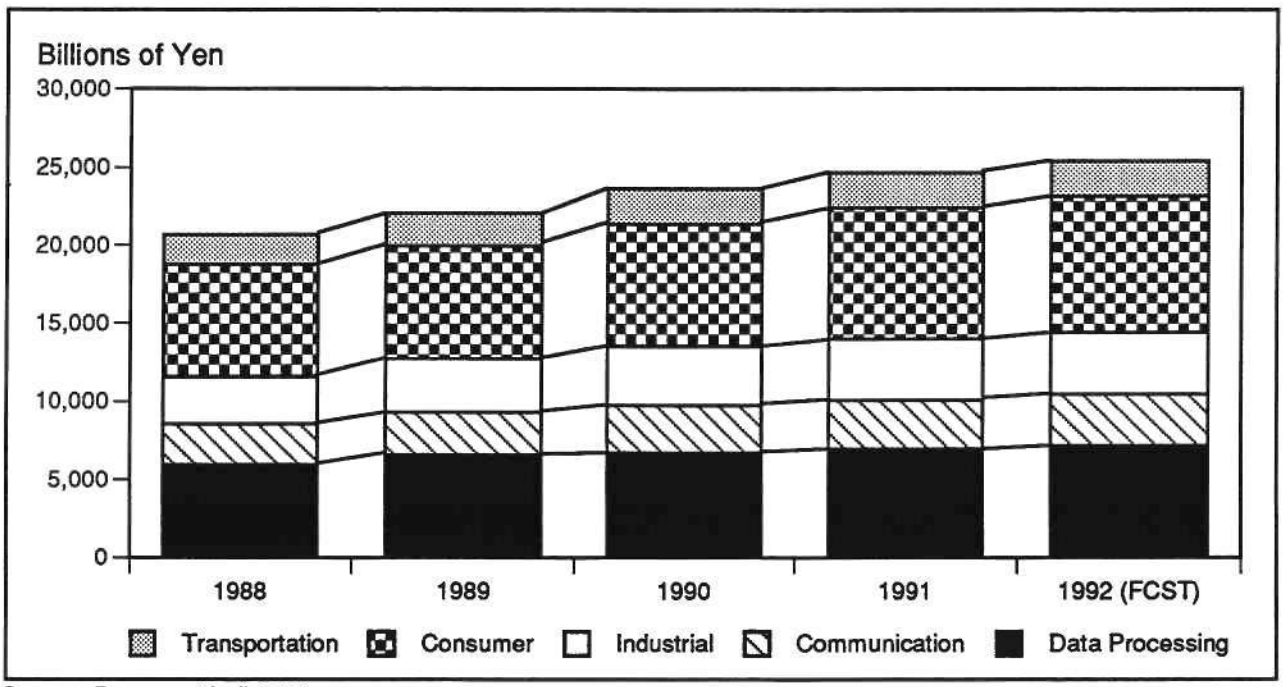
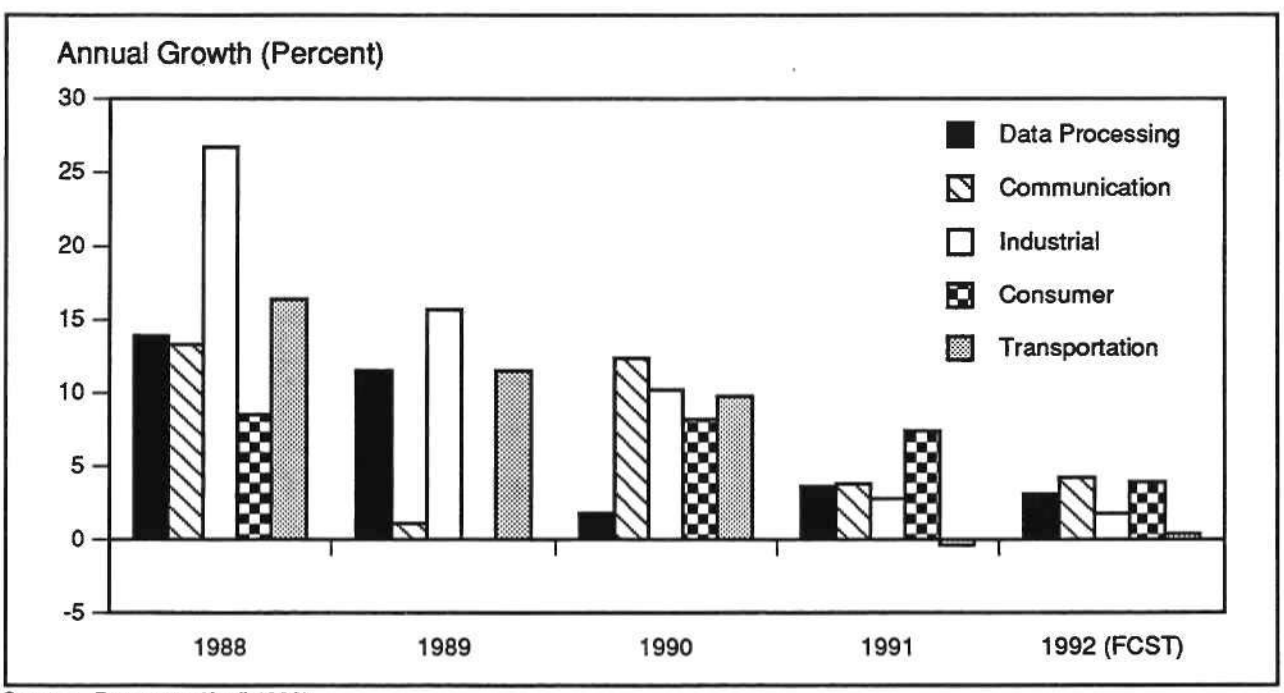
Figure 1
1991 Japanese Electronic Equipment Production



Source: Dataquest (April 1992)

Figure 2
1991 Japanese Electronic Equipment Production Growth



Source: Dataquest (April 1992)

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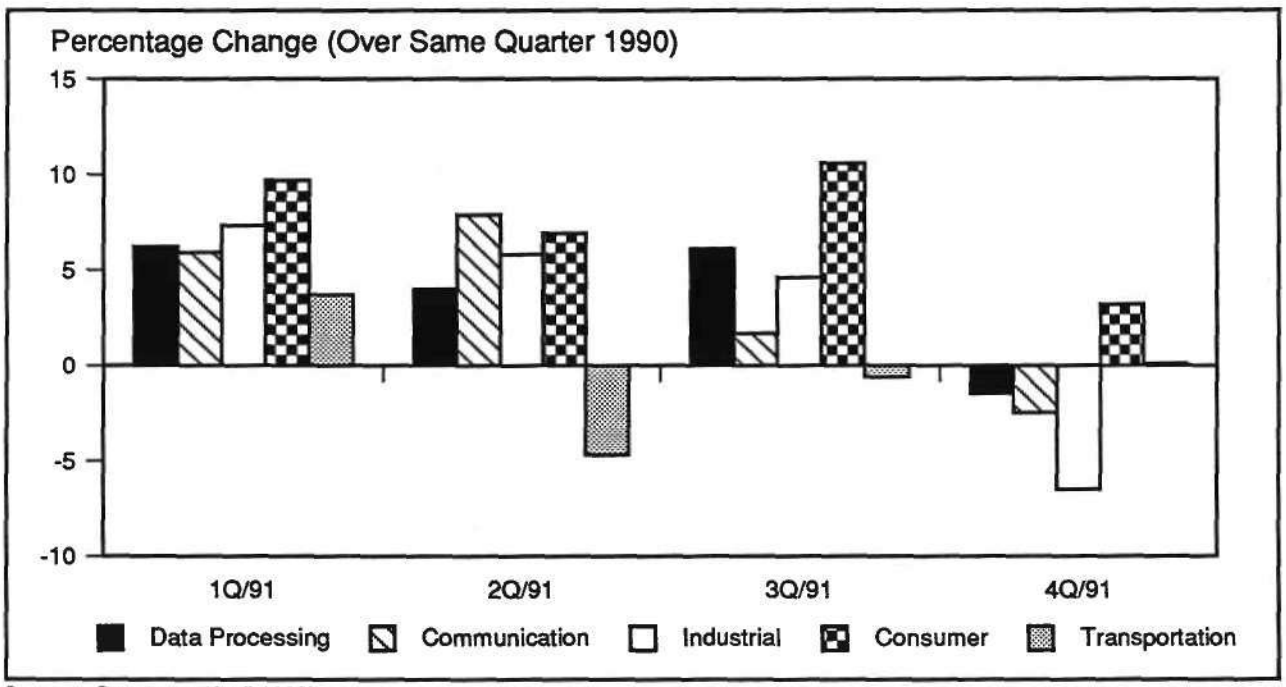
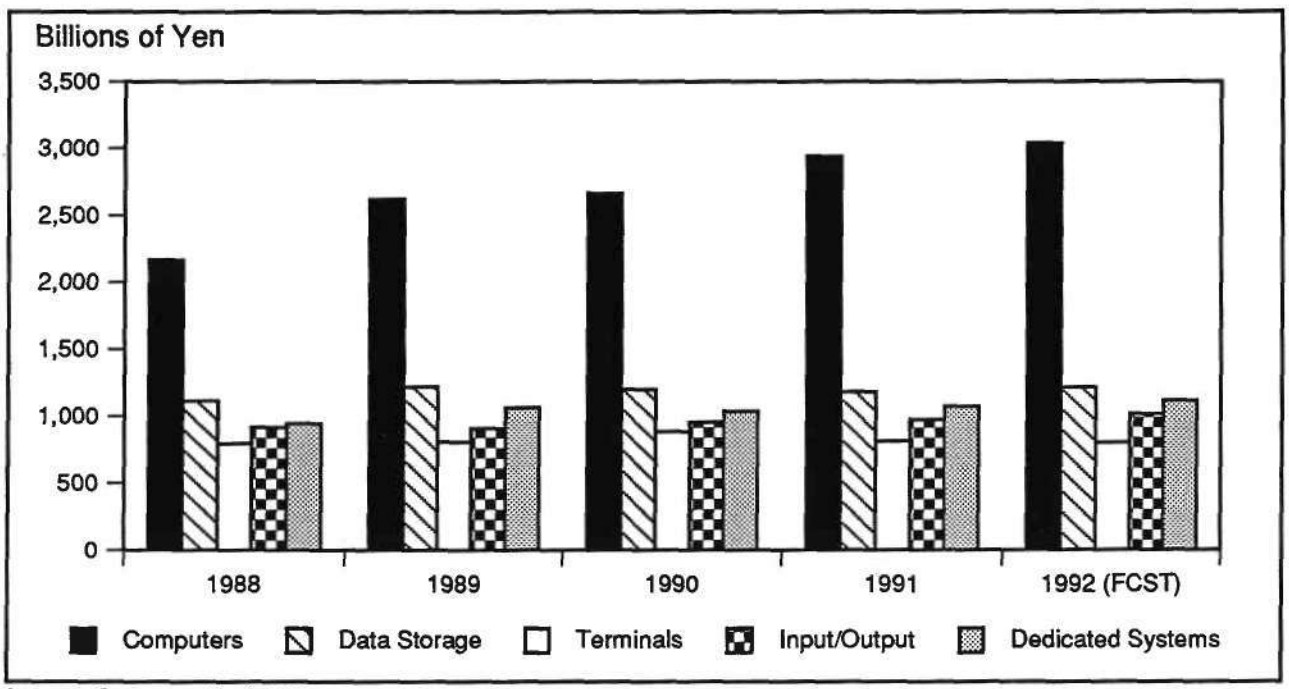
Figure 3
1991 Quarterly Japanese Electronic Equipment Production



Source: Dataquest (April 1992)

Figure 4
1991 Japanese Data Processing Equipment Production



Source: Dataquest (April 1992)

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Except for display units, which recorded a strong 12.1 percent growth on a value basis, growth in other EDP systems remained unchanged or decreased from the previous year.

Communications Equipment Market

The communications equipment market in 1991 grew by a moderate 3.8 percent to ¥3,118 billion (see Figure 5 for data on individual segments). Premises telecom and public telecom equipment showed respective negative growths of 2.7 percent and 1.1 percent from the previous year, which were more than compensated for by broadcasting and studio equipment (up 5.2 percent) and radio equipment (up 21.5 percent).

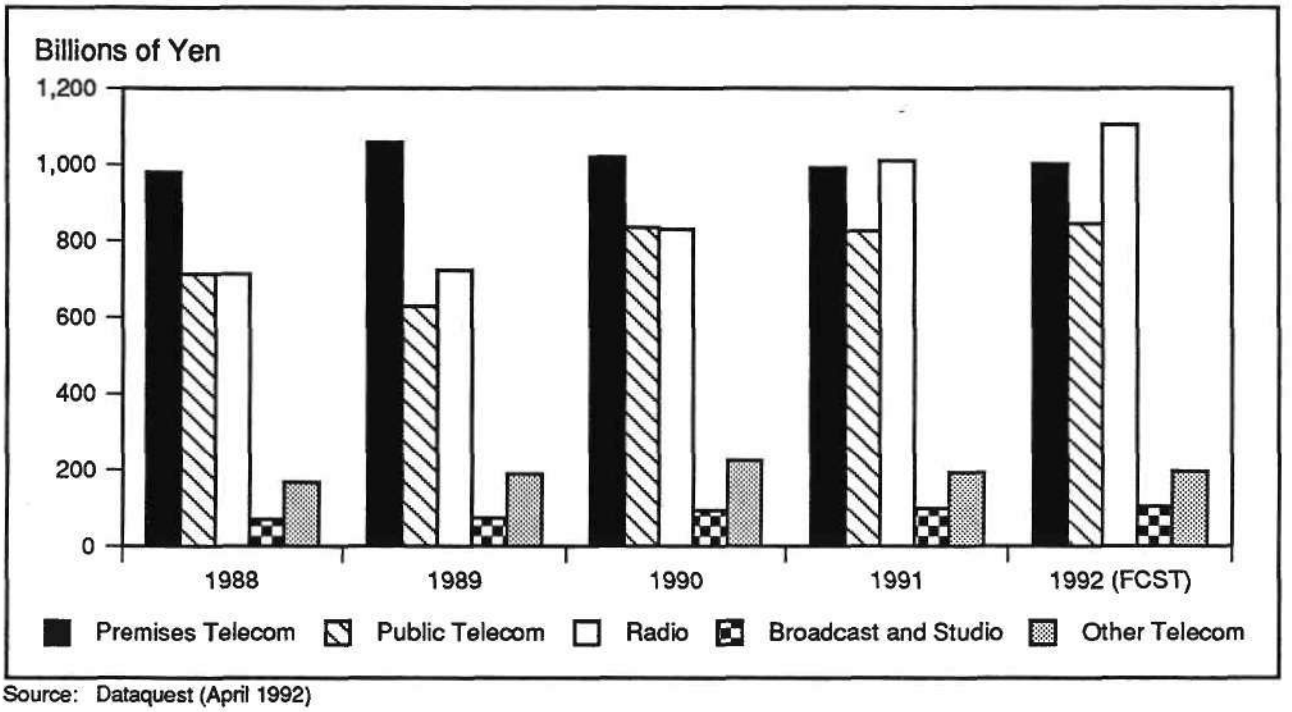
In terms of major product segments, cordless telephones—whose market size has been doubling each year in Japan—grew only 21.8 percent from 1990. Nevertheless, its contribution to a 17.8 percent growth in the entire telephone segment was great. Major growth of 33 percent over 1990 came in personal communications equipment, in particular mobile radio equipment including cellular phones. At the same time, significant growth was recorded in telephone network and other NTT-related equipment segments. The 8.9 percent growth of central office switches was typical.

The facsimile market, on the other hand, failed to grow out of the saturation stage, despite the introduction of low-cost products by many manufacturers. Good news came from G4 machines, which increased by 53.8 percent on a unit basis and thereby provided a rosy outlook for trade-up demand for higher-performance machines.

Industrial Equipment Market

Security and energy management systems recorded healthy growth of 22.1 percent in 1991 (see Figure 6). But manufacturing systems—which accounted for 35 percent of the industrial equipment market—began slowing in the second quarter and declined 18.2 percent in the fourth quarter over the previous year. Also, instrumentation and medical equipment experienced negative growth in the fourth quarter. As a result, growth in the entire industrial equipment market was negative 6.5 percent in the fourth quarter, with a mere 2.8 percent increase on an annual basis, to ¥3,888 billion. To make matters worse, the continued curtailing of capital expenditure by major industries, as well as automobile production cutbacks, portend continued sluggishness and late recovery of the industrial equipment market in 1992.

Figure 5
1991 Japanese Communications Equipment Production



Source: Dataquest (April 1992)

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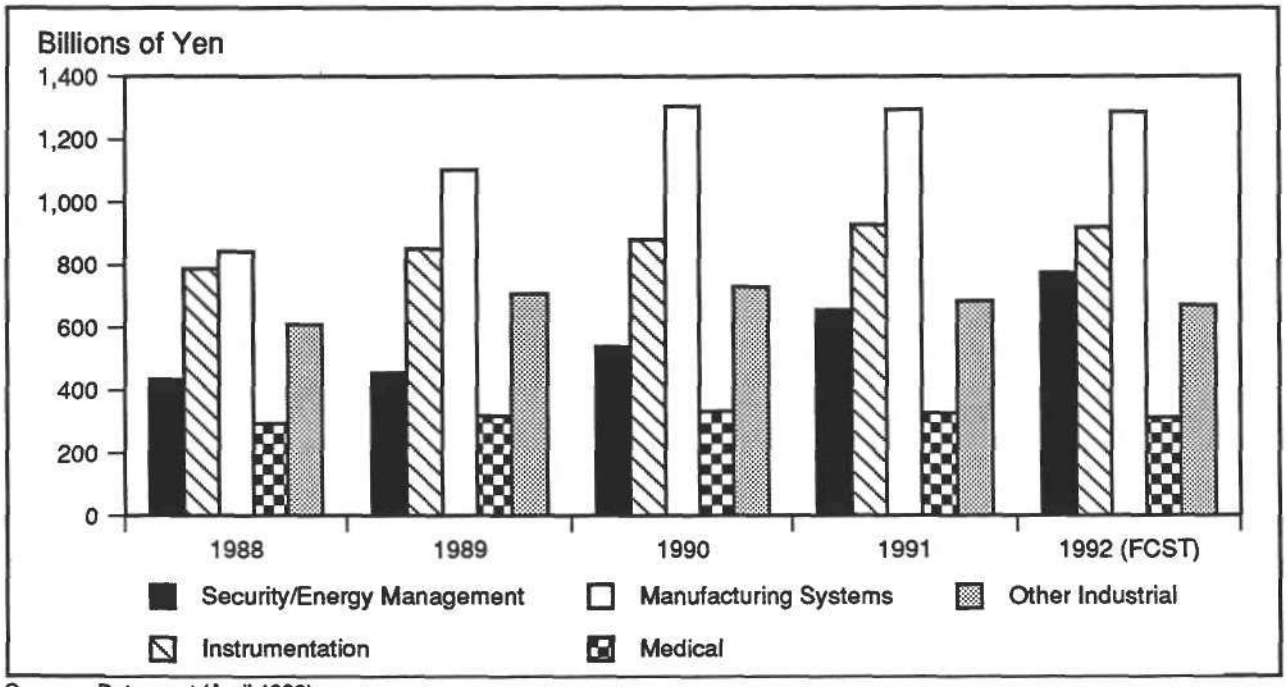
Figure 6
1991 Japanese Industrial Equipment Production



Source: Dataquest (April 1992)

Consumer Electronic Equipment Market

While production of other semiconductor applications showed moderate growth, consumer electronic equipment recorded a 7.4 percent increase from 1990 to ¥8,416 billion (see Figure 7), driven by audio equipment and household appliances, which grew 11.7 percent and 14.8 percent, respectively. Similarly, video equipment maintained 6.3 percent growth to reach ¥3 trillion, as video camera production increased 25.1 percent, compared with 1990 (despite a sharp drop to 0.7 percent growth in December 1991 over December 1990).

Audio equipment production was bolstered by the major products that included sets of stereo components (up 30.3 percent), digital audio disk (DAD) players (up 22.9 percent), and headphone stereo equipment (up 11.5 percent), which together accounted for about 50 percent of the total. The most impressive growth, however, was seen in digital audiotape (DAT) recorders, which are expected to become the recording medium for the next-generation audio system. DAT production increased by 56.3 percent from the previous year and gained a 1.3 percent share in audio equipment production, which suggests their market potential.

In the household appliance sector, air conditioners recorded 24.6 percent growth in production in 1991, expanding their share in the consumer electronic equipment market to 13 percent. In light of the sluggish housing market, robust growth in this segment seems to reflect the shift in the consumption pattern to personal use.

Notably, consumer electronic equipment production maintained a 3.2 percent increase in the fourth quarter 1991; other categories suffered negative growth. This implies that personal demand—although having passed its peak level—has not completely chilled, given the dim economic outlook.

Transportation Equipment Market

Automobile production in 1991 managed to maintain a 2.1 percent increase from the previous year, decelerating to a 1.9 percent decline on a unit basis. In particular, production of small passenger cars—a main pillar of the Japanese auto industry—was down 8.0 percent. This led to negative growth of automotive electronic equipment production after the second quarter, resulting in a 0.4 percent decline on an annual basis to ¥2,261 billion. The sluggishness

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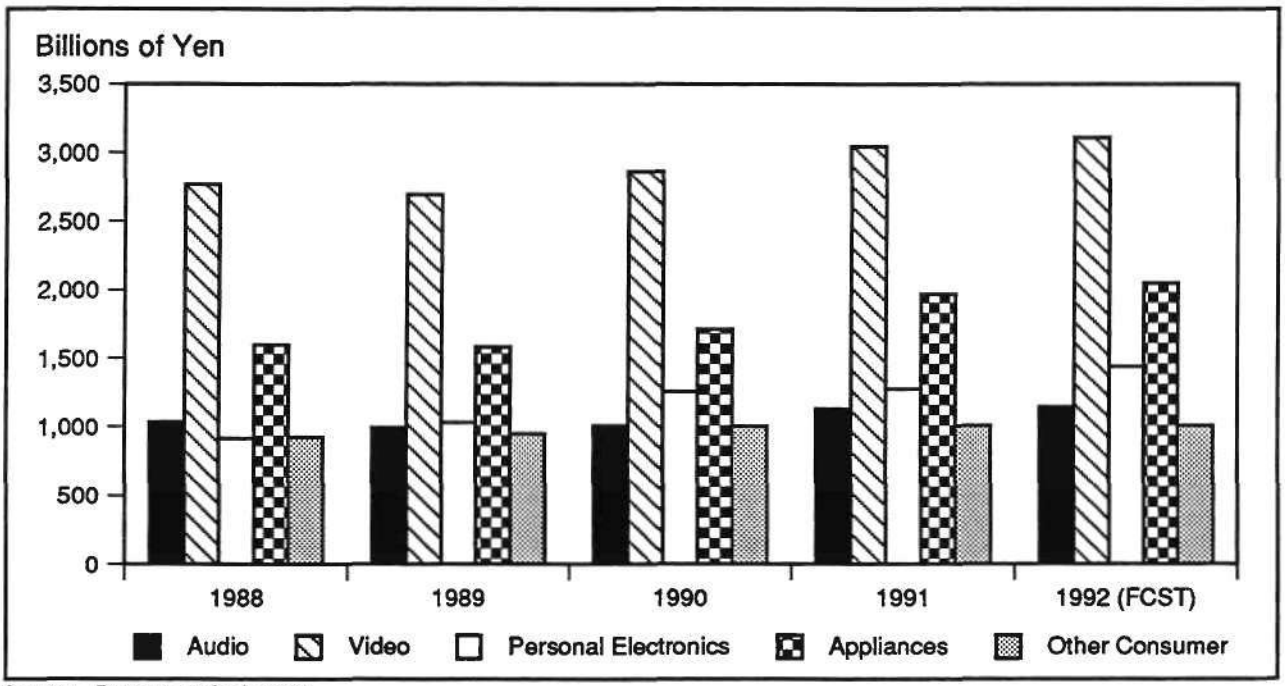
Figure 7
1991 Japanese Consumer Electronic Equipment Production



Source: Dataquest (April 1992)

further spread to audio equipment and automotive air conditioners—which are generally consumed in conjunction with automobiles without much price competition—which recorded a mere 1.4 percent increase and a 2.5 percent decrease, respectively. Clearly, the bubbling of the Japanese economy accelerated the increase in large automobiles and the use of electronics in automotive equipment and components. Thus the economic collapse, along with other unfavorable conditions in the auto industry such as the reheated issue of auto export restriction, is forcing the industry to rely on recovery of the Japanese domestic market.

Dataquest Perspective

Electronic equipment production in 1991 was robust, maintaining a 4.4 percent growth from the previous year in the midst of economic downturns that occurred in the recovery phase of the silicon cycle. The main contributing factor was the strength of consumer electronic equipment production, up 7.4 percent, which accounted for 34 percent of electronic equipment production in Japan and 40 percent of worldwide consumer equipment production. Increased production in the consumer electronic equipment sector as well as in personal radio equipment clearly indicates that consumer spending remains strong despite the dipping of the U.S. economy and the slowdown in the Japanese economy.

On the other hand, production in EDP, communication, and industrial equipment will continue to drag at least until the middle of 1992. It should be noted, however, that the slowdown in electronic equipment consumption will not necessarily lead to decreased emphasis on electronics and networking. Based on these underlying market trends, Dataquest expects electronic equipment production in Japan to grow 3.0 percent in 1992, reaching ¥25,411 billion.

Production of consumer electronic equipment, which was driven by consumer spending in 1991, continues to be a major driving force for the electronic equipment industry, although some uncertainties will exist because of absent next-generation star products. In particular, digital audio equipment such as minidisk players and digital compact cassette players is expected to have huge market potential.

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Among EDP equipment, which accounts for about 50 percent of semiconductor consumption, the PC market has reached the near-saturation stage in terms of ownership. But the increased use of the graphical user interface environment is likely to induce recovery and help the market regain its position of "memory eaters." Furthermore, a new multimedia environment frontier straddling information, consumer electronics, and communications markets will grow into a core strategic market for next-generation electronic equipment, while spurring long and sustainable growth in the computer market.

In conclusion, Dataquest believes that the computer market will gain momentum from different directions in the form of product strategies based on diverse resources, and will stimulate market demand in a variety of areas, thus returning as a major force supporting growth in the electronic equipment market.

By Naotoshi Yasuhara

Offshore Production: A Growing Trend in Japanese Semiconductor Manufacturing Strategy

Although the first offshore sites were started in the early 1970s, the 1980s witnessed a growing trend in the proliferation of offshore manufacturing as a mainstream globalization strategy for Japanese companies. This trend has continued into the 1990s.

Construction of many new offshore semiconductor facilities has been scheduled by Japanese companies during the past two years. Some of these Japanese companies are large, vertically integrated corporations with well-established foreign market presence and reputations as true multinationals. While the use of foreign-based manufacturing sites is a common criterion and standard prerequisite to qualification as a true multinational enterprise, it is rather surprising how long it has taken many of Japan's largest enterprises to set up their foreign facilities. The overall success of Japanese foreign-based semiconductor manufacturing ventures relative to their domestic plants has yet to be determined.

Table 1 shows the existing and planned Japanese semiconductor company offshore manufacturing facilities, which include, by definition, back-end assembly and testing operations.

This article will survey some of the offshore manufacturing activities of Japanese semiconductor companies that have occurred during the past two years. These activities for the most part are concentrated in three regions: the United States, Europe, and other parts of Asia. Dataquest also will provide an analysis of the probable causes for the recent rise in these types of activities.

Offshore Manufacturing Trends

The Japanese have always recognized the value of manufacturing capabilities as the root of their competitive edge and hence have been reluctant to move their traditional strengths to foreign soil. However, as the wealth of the country has risen, so has the value of its currency. Since 1986, the Japanese yen has appreciated by about 50 percent against the U.S. dollar. Although Japanese productivity has also risen to a large degree, it has become a less significant component of the business equation as fixed costs such as capital equipment continue to escalate. This has made it increasingly difficult for the Japanese to cut their production costs, compared with their foreign competitors. The strength of the yen has also made the funding of offshore facilities that much more attractive.

An important semiconductor industry trend was born during the 1980s that has had a major impact on the way that the producers and users of semiconductor products interact. The trend is toward chip customization and for the user of a chip to take a more active role in the design of the ICs they purchase. The proliferation of chip foundries and design houses, and the rising market performance of the product category known as ASICs, are all manifestations of this growing trend. This phenomenon is due largely to two engineering advances, as follows:

- The sophistication of modern design automation software tools, which have radically reduced the difficulty of designing complex customized circuits
- The capacity to create a technologically advanced semiconductor fabrication process that is both reproducible and sufficiently characterized for the design automation tools to accurately predict circuit performance prior to implementation

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Table 1
Japanese Semiconductor Company Offshore Facilities

Company	Country	Location	Open Date		Product
Fuji Electric	Scotland	Glasgow	1992	AT	Power transistor module
Fujitsu	Ireland	NA	1977	AT	1Mb DRAM, EPROM
	United States	San Diego	1981	AT	MOS memory, BIP
	Singapore		1986	AT	64/256K DRAM
	United States	Gresham (OR)	1988	F	1Mb DRAM, gate array
	Malaysia		1989	AT	256K, 1Mb DRAM, TTL
	England	Durham	1991	F	4Mb DRAM, ASIC
Hitachi	Taiwan		1967	AT	Transistor
	Malaysia	Penang	1972	AT	256K, 1/4Mb DRAM, MPU, BIP
	Germany	Landshut	1980	AT	4Mb DRAM, SRAM, DRAM, Logic
	United States	Irving (TX)	1988	F	256K, 1Mb SRAM, 1Mb DRAM, MPU, MCU
Matsushita	Singapore		1988	AT	BIP, discrete
	United States	Puyallup (WA)	1991	F,AT	1Mb DRAM, arrays, PLD
	United States	Fort Worth (TX)	1994	NA	16Mb DRAM
Mitsubishi	United States	Durham (NC)	1984	F	1Mb DRAM, arrays, MCU
	Germany	Alsdorf	1992	F,AT	1/4Mb DRAM, MPU
NEC	Ireland	NA	1976	AT	256K, 1Mb DRAM, ASIC, MPU
	Singapore		1976	AT	1/4Mb DRAM, Linear
	Malaysia		1976	AT	Linear, TR, 1Mb DRAM
	Scotland	Livingston	1982	F	256K, 4Mb DRAM, 256K SRAM, MPU
	United States	Roseville (CA)	1984	F	256K, 4Mb DRAM, ASIC
	China	Beijing	1993	F,AT	Linear IC
	United States	Hillsboro (OR)	1996	F,AT	16Mb DRAM
New Japan Radio	Thailand		1990	AT	BIP
Nihon Inter	Taiwan		1974	AT	Diode
Oki	United States	Tualatin (OR)	1990	FAT	1/4Mb DRAM, 256K SRAM, ASIC
	Thailand	Ayutaya	1991	AT	1Mb DRAM, mask ROM, micro

(Continued)

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Table 1 (Continued)
Japanese Semiconductor Company Offshore Facilities

Company	Country	Location	Open	Date	Product
Rohm	Korea		1972	AT	Discrete, opto. BIP
	Brazil	NA	1972	AT	Discrete
	Thailand		1987	AT	Bipolar IC
	Malaysia		1987	AT	Diode
Rohm/Exar	United States	Sunnyvale (CA)	1971	F	ASIC
Sanyo	Korea		1972	AT	Transistor, MOS IC
	Thailand		1976	AT	Discrete, transistor
	Taiwan		1976	AT	BIP, transistor
	China		1985	AT	Transistor, diode
Seiko Epson	United States	San Jose (CA)	1992	F,AT	ASIC
Shindengen	Thailand		1988	AT	Hybrid IC
Sony	Thailand		1990	AT	BIP
	United States	San Antonio (TX)	1992	F	1Mb SRAM, PLD, PROM
Stanley	France	NA	1984	AT	LED
	United States	NA	1986	AT	LED
	Thailand		1987	AT	LED
TDK/Silicon Systems	United States	Tustin (CA)	1972	F	MPR, CBIC, discrete, telecom
	United States	Santa Cruz (CA)	1992	F	MPR, ASIC, A/D, D/A
Tohko	Korea	Fusan	1971	AT	BIP
Toshiba	Mexico	NA	1966	AT	(terminated March 1992)
	Malaysia		1973	AT	256K, 1Mb DRAM, TR, BIP
	Germany	Braunsweig	1982	F,AT	256K,1Mb DRAM
	Thailand	Bangkok	1992	AT	Bipolar discrete
	United States	Sunnyvale (CA)	1980	AT	1/4Mb DRAM, prototype array
	United States	Hillsboro (OR)	1993	F	1/4Mb DRAM

NA = Not available
Note: F=Fabrication; AT=Assembly and testing
Source: Dataquest (April 1992)

Although these advances are driving down the cost of chip customization and hence making custom chips affordable for more applications, the process still requires a properly orchestrated team effort of chip user, designers, fabricators, and even software tool engineers.

The successful execution of the chip customization process relies on superior communication between the consumer and producer of semiconductor products. Recognition of this fact has driven semiconductor manufacturers to enter into closer business partnerships with their

customers, often in the form of alliances. Offshore facilities are virtually mandatory for success in this business scenario.

In the United States

The semiconductor trade disputes between the United States and Japan culminated in the past decade with the signing of the 1986 U.S.-Japan Semiconductor Trade Agreement. It is no coincidence that immediately following this agreement, Japanese semiconductor manufacturers began to expand their U.S.-based operations. This is a common response of large multinationals, regardless of the company's country of origin, to avoid trade conflict and to promote goodwill by employing foreign nationals.

Fujitsu, Hitachi, and NEC established or purchased their first U.S. fabrication facilities in the 1970s, while most other Japanese semiconductor companies started U.S. plants during the early 1980s. NEC recently completed a new building at its Roseville, California, site that houses a fabrication line capable of making ICs with 0.8-micron features. This facility is one of the few 4Mb DRAM fabs in the United States and is the first 4Mb front-end facility to be built by a Japanese company. Hitachi, which currently manufactures 1Mb DRAMs in its Texas factory, also has plans for construction of a state-of-the-art DRAM fabrication facility that is scheduled to begin producing 16Mb DRAMs by 1993. In addition to 1Mb DRAM production, Fujitsu has brought online a 6-inch wafer processing line capable of 0.8-micron line widths at its Gresham plant in Oregon that will produce high-density gate arrays. Fujitsu is already shipping Oregon-made gate arrays to customers in both North America and Europe in an effort to establish itself as a leading supplier of high-density gate arrays.

Fujitsu's move to pursue high-density gate arrays prior to further investments in commodity memory capacity appears to be an appropriate strategy for present conditions, as memory markets are currently both soft and crowded. Furthermore, Fujitsu would clearly wish to benefit from the close proximity to major gate array customers.

Oki opened its first offshore plant in Tualatin, Oregon, in 1991 and is assembling and testing 4Mb DRAMs there. Matsushita plans to use its plant in Puyallup, Washington, which it acquired from National Semiconductor in 1990, for front-end production of 1Mb and 4Mb DRAMs and some microcomponents. Toshiba has acquired property in Hillsboro, Oregon, and plans to build a wafer fabrication facility slated to begin producing ASICs in mid-1993. This front-end facility will provide a major boost to Toshiba's presence in the United States. Its current representation consists of a back-end plant in Sunnyvale, California, where ASICs and 1Mb and 4Mb DRAMs are packaged.

In the European Community

Europe's impending plan for unification into a common market in 1992 is expected to create a market comparable to that of either Japan or the United States. Competition to capture a share of this market has existed for some time among European, Japanese, and U.S. semiconductor manufacturers and is expected to grow. A European Community (EC) body governing semiconductor trade policy has already begun defensive moves to calculate and establish limits on foreign market share of the EC semiconductor market. An EC committee has also made rulings regarding the definition of "made in Europe" semiconductors; only those that are produced from front-end wafer fab lines on European territory will qualify. Wishing to avoid a repetition of conflict that led to the 1986 U.S.-Japan Semiconductor Trade Agreement, the Japanese have been moving quickly to build semiconductor facilities in Europe to cater to that region's market.

A major incentive for locating production in Europe is to avoid the import tariffs placed on many Japan-made semiconductors brought into the EC as stipulated by the trade agreement between Japan and the EC. NEC has elected to cease exporting Japan-made 1Mb and 4Mb DRAMs to Europe and to shift to local production to supply the EC memory markets with its products. To achieve this end, NEC has established a wafer processing line in Livingston, Scotland, and plans to upgrade its production capabilities from current 1Mb generation of DRAMs to 4Mb devices. Fujitsu has also found Great Britain an attractive place to establish semiconductor manufacturing; Durham was chosen in 1990 as a site for its 4Mb DRAM manufacturing plant, which is scheduled to be operational by the end of 1992.

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In Asia

Leading Japanese semiconductor manufacturers are preparing to boost their production in Southeast Asia. Construction of Japanese semiconductor plants in Asia began in the 1970s. Low fixed and variable costs in various parts of Asia, compared with those in Japan, historically have often meant good offshore investment opportunities for the Japanese, particularly in low-technology, labor-intensive operations such as final assembly. Recently, the governments of many of these countries have expressed the intention of following in the footsteps of the Japanese in achieving world-class semiconductor technology onshore.

In 1991, Texas Instruments announced its intention to establish a state-of-the-art 16Mb DRAM manufacturing facility in Singapore in cooperation with investing customers Hewlett-Packard and Canon, and the Singapore government. This pact is significant in that it departs from the strictly low-end technology exchanges previously characterizing transfers from the United States or Japan to other Asian countries. This trend signifies the rapid growth in electronic production capabilities throughout Asia as successful system manufacturers continue to attract semiconductor manufacturing capabilities to meet the local demand of the systems industries.

Alliance Alternatives

Many semiconductor companies have suffered from the escalating costs associated with semiconductor manufacturing. Construction of a new facility on foreign soil is frequently too expensive for even the largest Japanese semiconductor manufacturers. Alliances exist as an alternative to high-risk, sole-investor propositions.

As an example, Oki has employed a joint venture alliance as a means of entering the European memory market. Because Oki currently has no manufacturing base in Europe, it has chosen to ally itself with SGS-Thomson to produce 1Mb and 4Mb DRAMs at SGS-Thomson's factory. In this venture, Oki will infuse both technology and a monetary investment, while both companies can share the cost and risk of 4Mb technology development. Similarly, Mitsubishi and AT&T have teamed up and will share technology and manufacturing resources. In a similar manner, other foreign companies can emulate these strategies to establish a presence in the European markets without enduring excessive start-up costs or the penalties of importing their products.

Dataquest Perspective

The transfer of semiconductor technology from one location to another is an established science at most manufacturing companies, and moving offshore does not seem to pose any unusual hardships unique to the semiconductor industry. The Japanese are increasing their number of offshore sites to gain comparative advantage. These advantages exist for both traditional reasons, such as the lower costs of labor, raw materials, and other resources, but also for nonclassical free-trade forces such as import barriers and because of the increasing trend toward customization, which often requires a close proximity of chip providers to their customers.

By Junko Matsubara

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese MOS memory market forecast
- Japanese semiconductor alliance update: the first quarter of 1992

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Dataquest Perspective

Semiconductors *Japan*

SCJA-SVC-DP-9205 April 6, 1992

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Japanese IC Trade in 1991

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Changing Places in the 1990s: Memories to Micros

This article examines world semiconductor market trends in the 1980s, analyzes the impact of memory recession in 1990 and 1991 on the whole market, and discusses the future direction of the industry.

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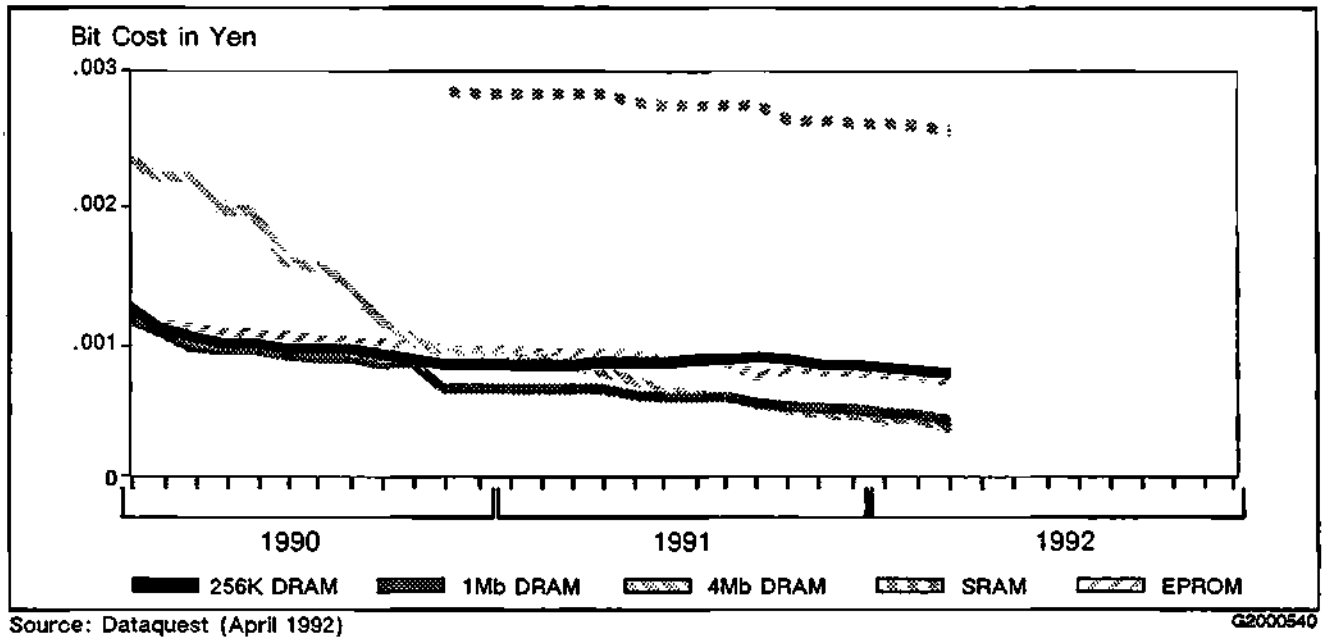
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.43	3.42	3.65	3.90	3.80	3.60
DRAM 256Kx1-8	1.10	1.56	1.58	1.35	1.30	1.10
DRAM 4Mbx1-8	12.55	11.65	14.85	15.00	15.60	12.70
EPROM 1Mb, 170ns	3.63	3.80	3.20	3.90	3.90	2.90
EPROM 2Mb, 170ns	7.28	7.25	6.10	7.85	7.90	5.70
SRAM 1Mb, 128Kx8	13.58	14.31	10.50	16.55	16.70	NA
SRAM 256K, 32Kx8	3.85	3.83	3.50	4.00	4.00	3.30
SRAM 64K, 8kx8	1.95	1.54	1.75	1.55	1.40	1.30
68020-16	27.50	39.08	26.00	42.50	35.50	NA
80286-16	9.50	10.53	10.00	11.75	11.70	9.70
80386DX-25	140.00	142.04	139.00	167.50	158.00	98.00
80386SX-16	46.50	55.25	52.50	54.00	55.60	48.00
R3000-25	119.00	130.41	110.00	NA	NA	NA

Note: These figures correspond with the *DQ Monday Report* dated March 16, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (April 1992)

Memory Bit Price in Japan



Source: Dataquest (April 1992)
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Market Analysis

Japanese IC Trade in 1991

According to trade statistics recorded on a custom-clearance basis and published by Japan's Ministry of Finance (MOF), Japanese IC exports for 1991 increased to ¥927 billion, representing a 1.4 percent growth over 1990's total. The 1991 IC imports also grew to ¥326 billion, an 8.2 percent increase over 1990's import figure. These figures added a net ¥601 billion (U.S.$4.5 million) worth of ICs to Japan's trade surplus and constituted 5.8 percent of Japan's total 1991 merchant trade surplus of ¥10,517 billion. Figure 1 shows Japan's total IC exports and imports for the past 10 years.

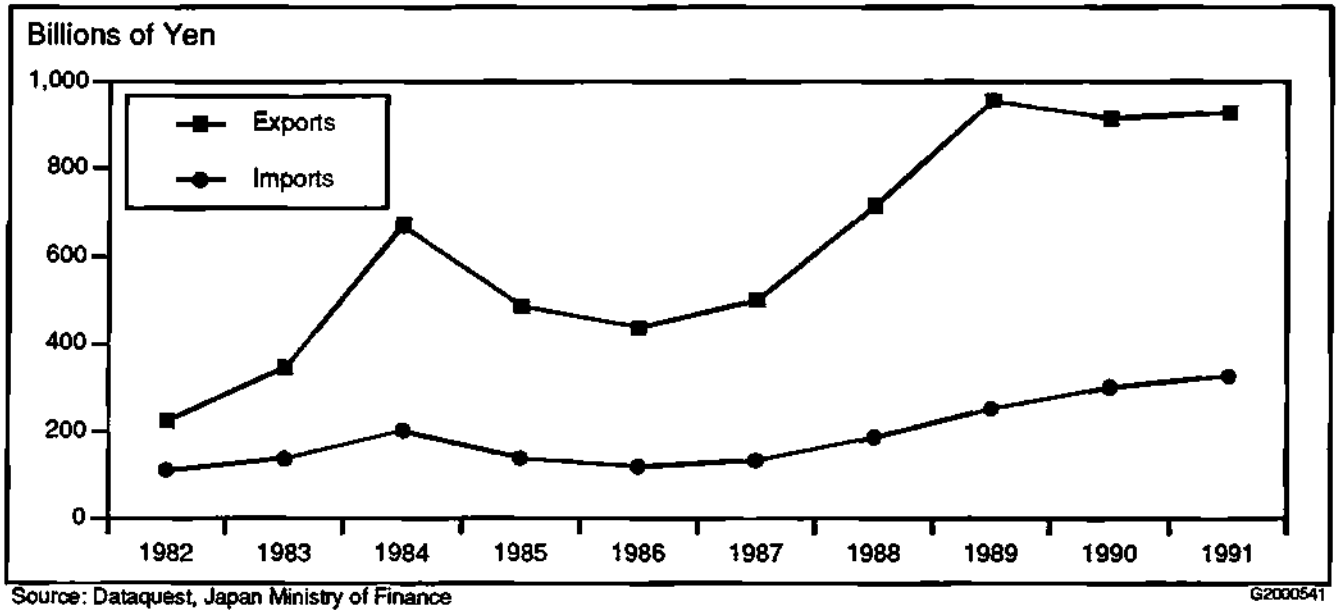
During the past 10 years of Japan's IC trade history, Japan's annual IC import and export rates generally increased or decreased in unison in a given year. The only deviation from this tracking behavior occurred in 1990, when exports declined while imports continued to increase. The positive perspective would be to interpret this trend as a sign that Japan's trade surplus was making progress toward a more balanced position as import volumes converged on export volumes and the IC trade gap dwindled. Although exports have returned to positive increases for 1991, the gap between imports and exports continues to close, though at a somewhat diminished rate when compared with the steep changes found in 1990. Having peaked in 1989, Japan's annual IC trade surplus has declined by about 20 percent during the past two years.

Japanese IC Trade by Product

Figures 2 and 3 compare 1991 IC exports and imports by major product categories with those of 1990. Total exports increased a modest 1.4 percent in 1991. Memory devices, the traditional stronghold of Japanese IC trade exports, apparently didn't contribute to the observed growth in exports. In 1991, memories accounted for 34.8 percent of Japan's IC exports, thereby continuing a downward trend that began in 1989 when 47.7 percent of exports were derived from memory product revenue. In addition, memory chip imports increased to 23.5 percent of all imported ICs to Japan during 1991, as compared with 20.7 percent of import market during the previous year. The combined effect of decreases in memory exports and increases in memory imports resulted in a ¥55.3 million drop in Japan's memory trade surplus during 1991, as compared with 1990's memory trade surplus.

Furthermore, Dataquest's 1991 preliminary market share figures indicate that, while the

Figure 1
Japanese IC Exports and Imports (Billions of Yen)



Source: Dataquest, Japan Ministry of Finance G2000541

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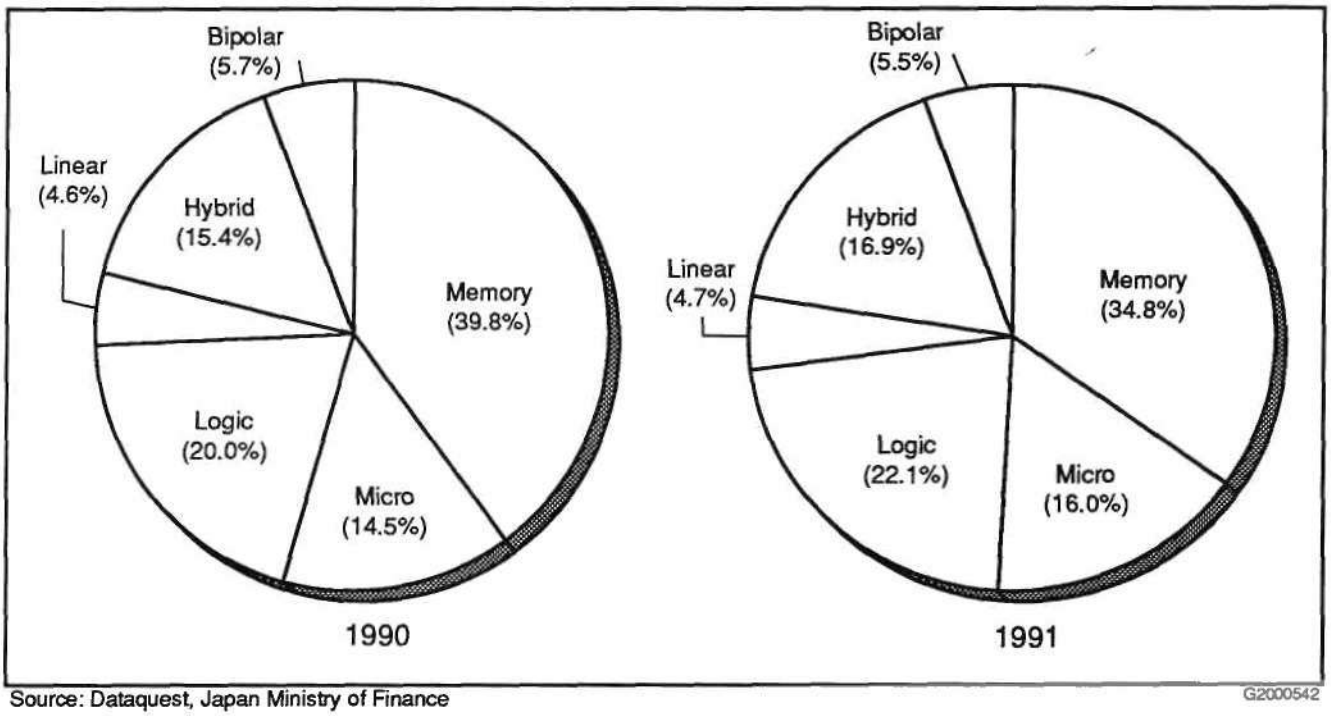
Figure 2
Japanese IC Exports by Product (1991 versus 1990)



Source: Dataquest, Japan Ministry of Finance

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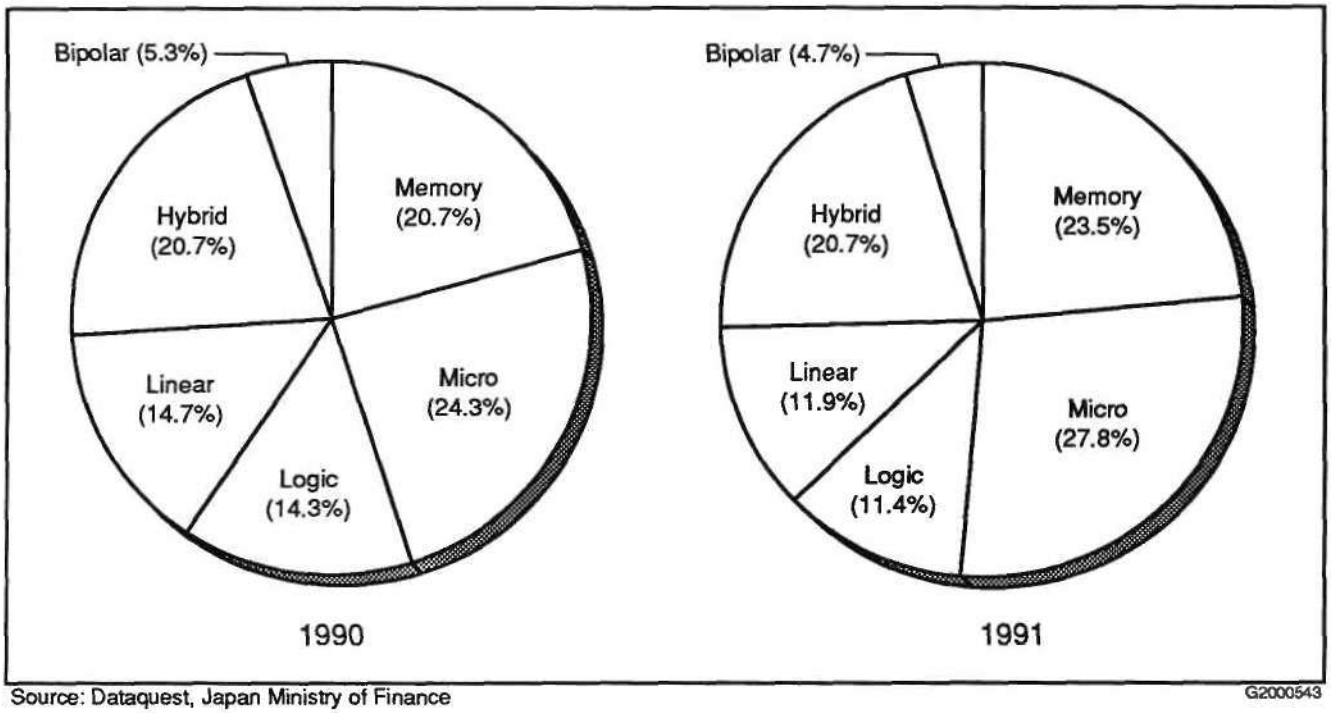
Figure 3
Japanese IC Imports by Product (1991 versus 1990)



Source: Dataquest, Japan Ministry of Finance

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Japanese domestic semiconductor market grew by 15.3 percent during 1991, the MOS memory segment grew only 5.0 percent. Of this 5.0 percent growth, about half was captured by a rise in memory imports. The repercussion was that Japanese memory suppliers experienced a drop in memory revenue during 1991 from levels attained in 1990. Within the past two years, Japan's monthly export figures have steadily declined since peaking in April 1990.

Total IC imports to Japan have grown steadily since 1986, which, coincidentally, corresponds to the beginning of the 1986 U.S.-Japan Semiconductor Trade Agreement. Extension of this trade agreement in August 1991 was intended to promote the growth of IC imports to Japan from the United States. However, the continued success of this cause and effect is critically dependent on the assumption that Japan's economy remains healthy. Signs that the Japanese economy is faltering began surfacing toward the latter half of 1991. The close coupling of the U.S. and Japanese economies is certain to be a major cause of this recent slowdown in Japan. Indeed, it would be difficult to justify sustaining expansion in the Japanese economy, with exports so heavily dependent on a U.S. economy that continues to experience recessionary contraction. Hence, though many Japanese chip manufacturers and system makers have been under pressure to purchase more U.S.-made semiconductors, IC imports from the United States grew a slight 2.3 percent.

Other factors that have had an impact on both import and export trends include an average 5.5 percent appreciation of the yen against the U.S. dollar in 1991. The steady appreciation of the yen against many foreign currencies, particularly the U.S. dollar, should place a normalizing force on the Japanese IC trade balance as foreign parts become more cost competitive and imports appear more attractive. Any resistance to this force, such as intentional or unintentional trade barriers, would disable free trade mechanisms and theoretically damage all trade participants. It is thus imperative that advances in the value of yen continue to stimulate imports, which will eventually create sufficient wealth abroad to reignite the growth of Japanese exports.

Finally, a shift in imports relative to exports is also a by-product of the increased use of offshore facilities by Japanese manufacturers. During the 1980s, Japanese companies established many offshore plants in their efforts to reduce production costs and to lessen trade friction. Although the offshore facility mechanism of multinational business has minimal impact on the balance of payments between Japan and its trading partners, which is a true measure of trade deficit, it does affect export and import figures as gauged by the MOF's customs revenue.

Japanese IC Trade by Region

Figures 4 and 5 show the falling volume of Japanese IC exports to both the United States and Europe since 1989. A subtle distinction between Japanese export trends to these two regions is that, while the drop in 1991 exports to the United States is not as severe as the 1990 decline, exports to the European community fell more during 1991 than they did during 1990. Although the U.S. economy remains sluggish, it is a positive sign that purchases from Japan are not in a free-fall.

Japanese exports to the rest of the world (ROW) grew 11.2 percent and for the first time exceeded the combined exports to the United States and Europe. While this is partially the result of many Japanese and U.S. system makers having transferred their manufacturing plants to Southeast Asia and other countries of the ROW category, emerging Asian non-Japanese industries—often with government support—are experiencing rapid growth and have helped to drive up Japanese IC exports to the ROW during 1991.

Suppliers from the United States remained dominant among chip importers to Japan by capturing 65.1 percent of total IC imports in 1991. The 1991 imports from the United States exceeded 1990 imports by ¥4.7 million. This increase, however, was less than the increase in imports to Japan from the ROW during 1991, which rose ¥20.4 million, representing a near 30 percent climb over the previous year's total. As with exports, Japanese and U.S. offshore facilities distort the ROW import trends. However, imports from Korea, Malaysia, and Taiwan also contributed to the escalating ROW imports to Japan. The influence of the 1991 extension of 1986 U.S.-Japan Semiconductor Trade Agreement on imports from the United States has yet to be determined.

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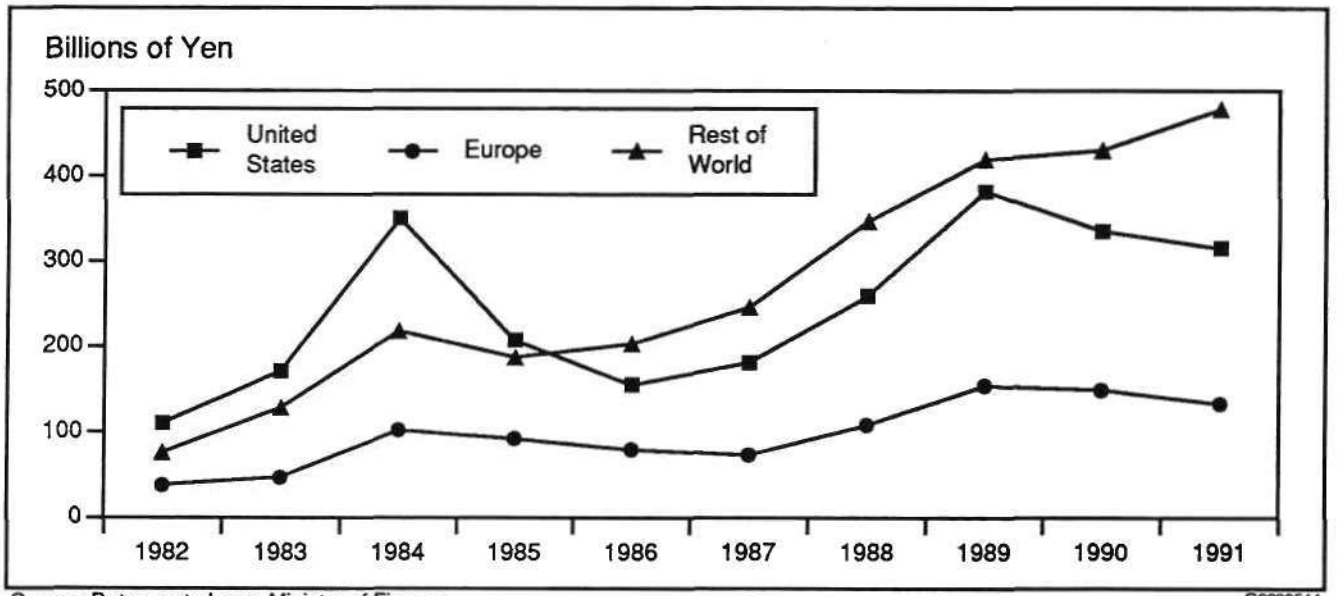
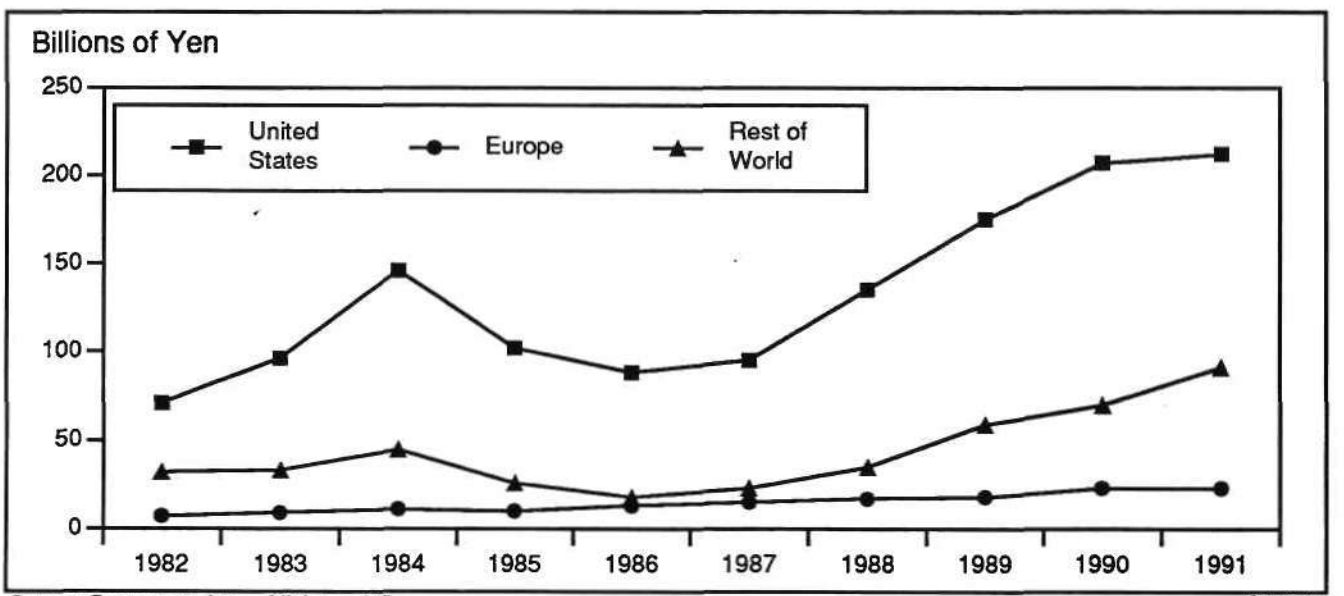
Figure 4
Japanese IC Exports by Region (1982-1991)



Source: Dataquest, Japan Ministry of Finance G2000544

Figure 5
Japanese IC Imports by Region (1982-1991)



Source: Dataquest, Japan Ministry of Finance G2000545

Dataquest Perspective

Should the Japanese economy deteriorate further, sustained growth of IC imports to Japan may not be realized in the near term. Excluding this scenario, however, accelerated offshore production, political trade issues, and foreign economies will continue to alter the profile of Japanese IC import and export trends during the current decade.

By Junko Matsubara

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Changing Places in the 1990s: Memories to Micros

In 1991, the world semiconductor market increased 11.5 percent from the previous year to $64,914 million, despite unfavorable conditions that included the sluggish U.S. economy and worldwide recession in the computer industry. The MOS memory market, which showed negative growth of 20.0 percent in 1990, recorded moderate growth of 6.4 percent in 1991. Clearly, the slack market affected Japanese makers most; combined semiconductor sales grew 7.3 percent from the previous year to ¥4.386 billion, although the dollar-based sales were up 13.6 percent to $32,246 million, which included foreign exchange gains.

Geographically, MOS memory sales in the Japanese market showed a 5.0 percent increase from the previous year. However, when adjusted for a 5.0 percent increase on the dollar basis, the figure was a 1.1 percent decrease to ¥658,600 million. This was the second consecutive year of negative growth: There was a 19.7 percent decline in 1990 (see Figure 1). According to Dataquest's preliminary estimates, the Japanese semiconductor market grew 8.9 percent in 1991 on a yen basis; the final figure is expected to be about 7 to 8 percent.

In this article, we examine 1980s trends in the world semiconductor market, analyze the impact of memory recession in 1990 and 1991 on the whole market, and take a look at the future direction of the industry.

World Semiconductor Market in the 1980s

MOS digital had the highest growth in market share for major devices in the world semiconductor market between 1980 and 1991, 33.4 percent to 56.9 percent (see Figure 2). Its compound annual growth rate (CAGR) of 20.6 percent was far above the 14.9 percent figure for all semiconductor devices. Losers in the 1980s were bipolar/digital and discrete/optoelectronic, whose shares were down from 16.8 percent and 32.4 percent in 1980 to 6.2 percent and 18.6 percent in 1991, respectively. On the other hand, analog devices managed a 15.4 percent CAGR,

Figure 1
Japanese Semiconductor Market

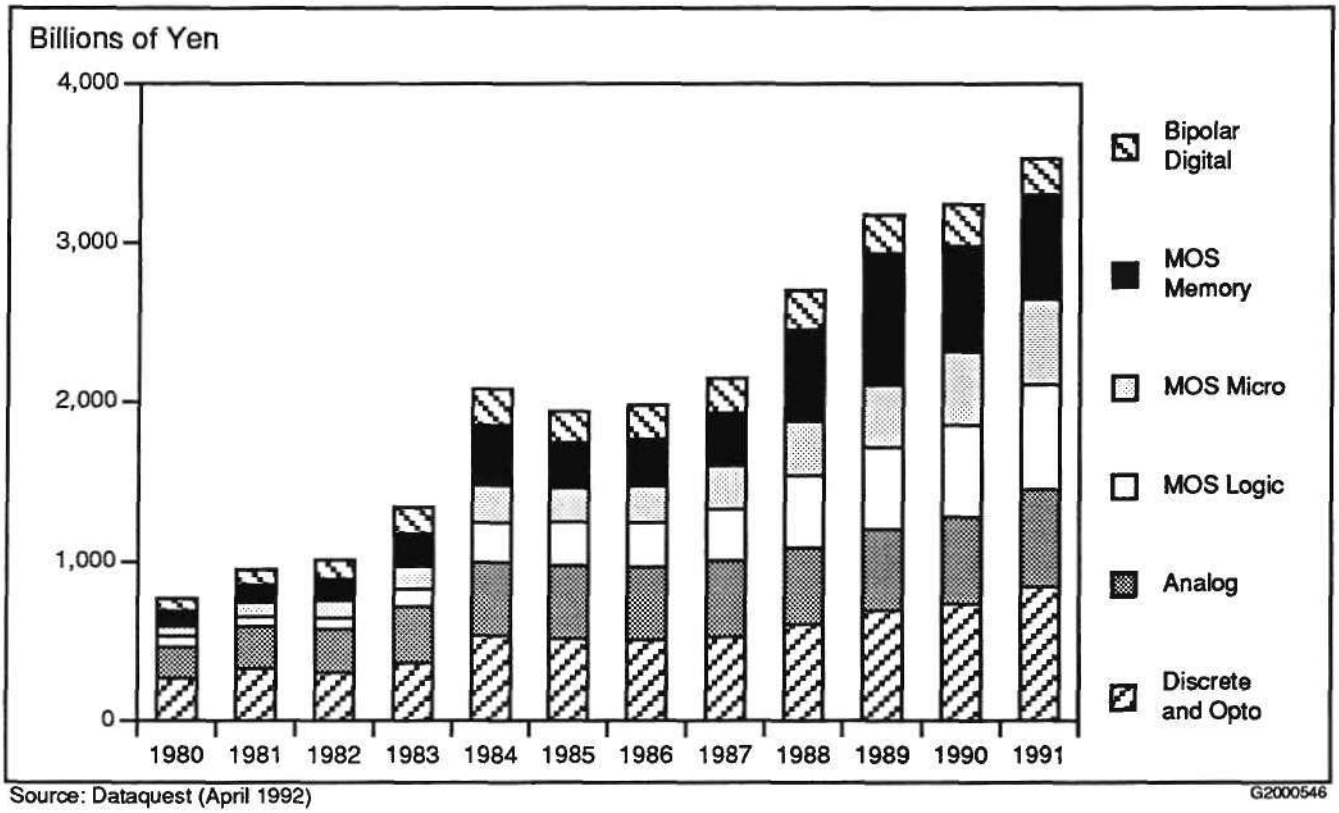

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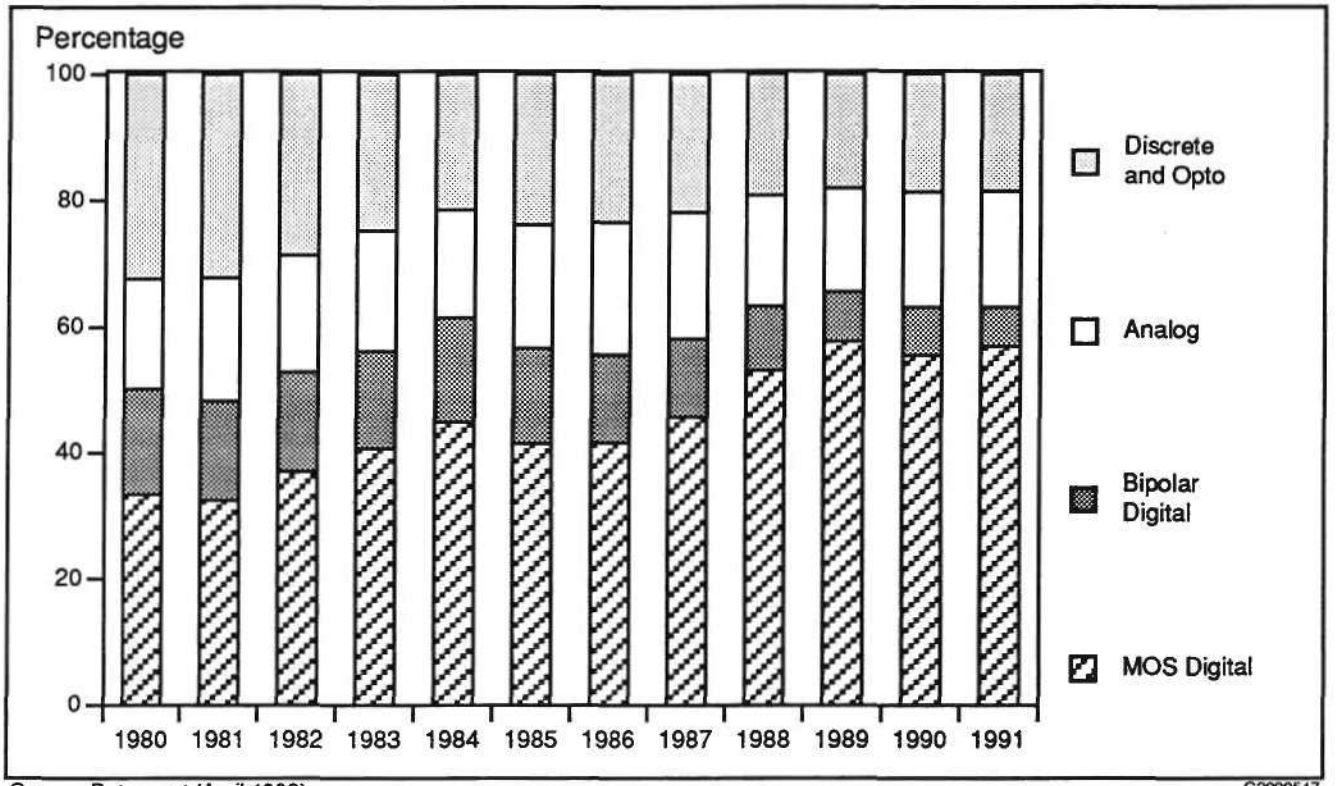
Figure 2
Worldwide Semiconductor Market



Source: Dataquest (April 1992)
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slightly above the industry average; this segment's share slightly increased from 17.4 percent to 18.3 percent during the same period.

Thus, MOS digital was the major player of the world semiconductor market in the 1980s. Stable growth patterns suggest that the importance of MOS digital will further increase in the 1990s. Its direction serves as a critical indicator for forecasting the entire semiconductor market.

World MOS Digital Market Trends

Figure 3 shows changes in market share among the major MOS digital segments—memories, micros, and logic—between 1980 and 1991. MOS micros recorded the largest gain from 18.3 percent to 33.2 percent, with 27.3 percent CAGR in the world market. MOS memories had a lower CAGR (18.1 percent) and a loss in share from 47.3 percent to 37.7 percent. MOS logic recorded below-average growth of 18.7 percent, compared with 20.6 percent CAGR in the MOS digital market; its share declined from 34.4 percent to 29.1 percent.

Despite the significant decline in share, MOS memories are still the largest segment in the MOS digital market. The segment had an 18.1 percent CAGR between 1980 and 1991 and undoubtedly was a mainstay of the semiconductor market in the 1980s.

Semiconductor recession in 1985 taught Japanese makers engaged in a never-ending battle for market shares the importance of production practices linked to actual demand. What changes will memory recession in 1990 and 1991 bring to Japanese makers? One move already visible is the shift in focus of memory production to high-value-added products by offering differentiation in terms of access time, power consumption, and packaging. Nevertheless, the present memory recession seems to be affecting the entire market and prompting the industry to review and reorganize its business strategies.

The MOS micro market has a different picture. Figure 4 shows the change in world market shares by ownership. Here Japanese makers, who achieved rapid market expansion with 32.9 percent CAGR between 1980 and 1991, have increased their share by only 13.5 percent, in contrast to the large gain in MOS memories (see Figure 5). Moreover, they actually lost share

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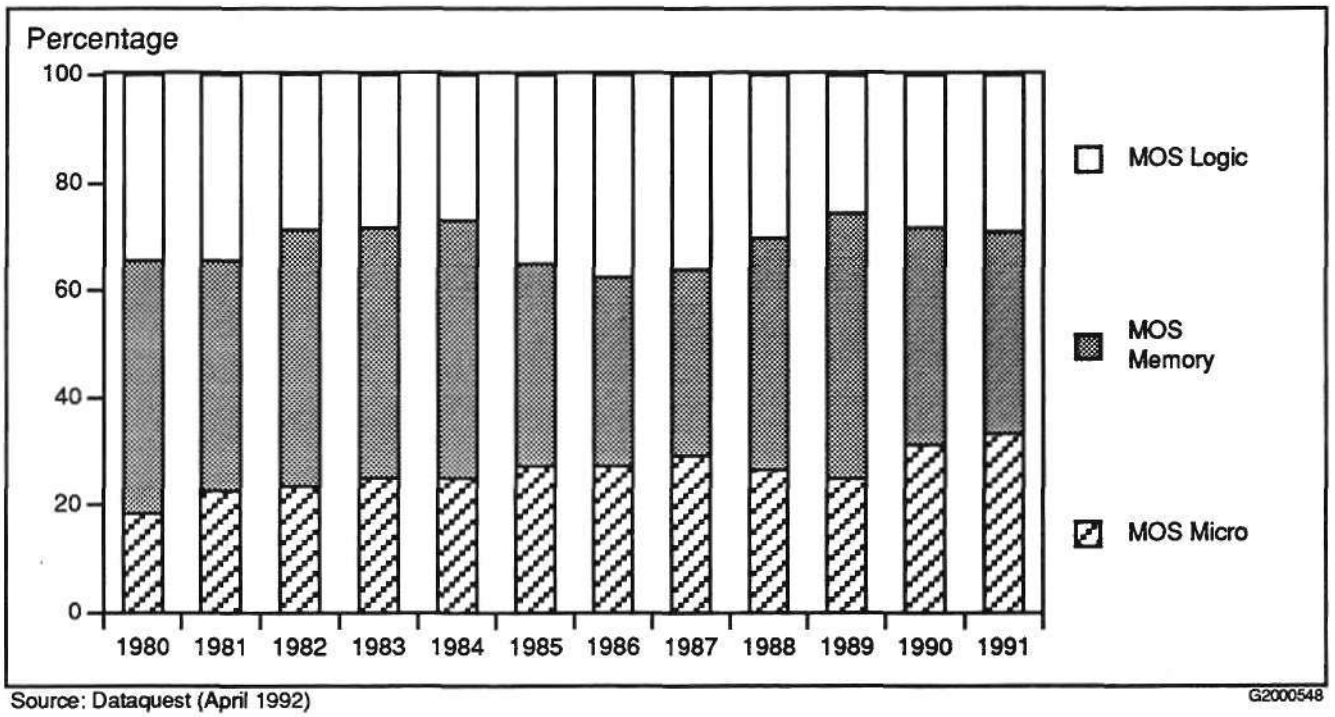
Figure 3
Worldwide MOS Digital Market



Source: Dataquest (April 1992)
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Figure 4
MOS Micro Market Share by Region

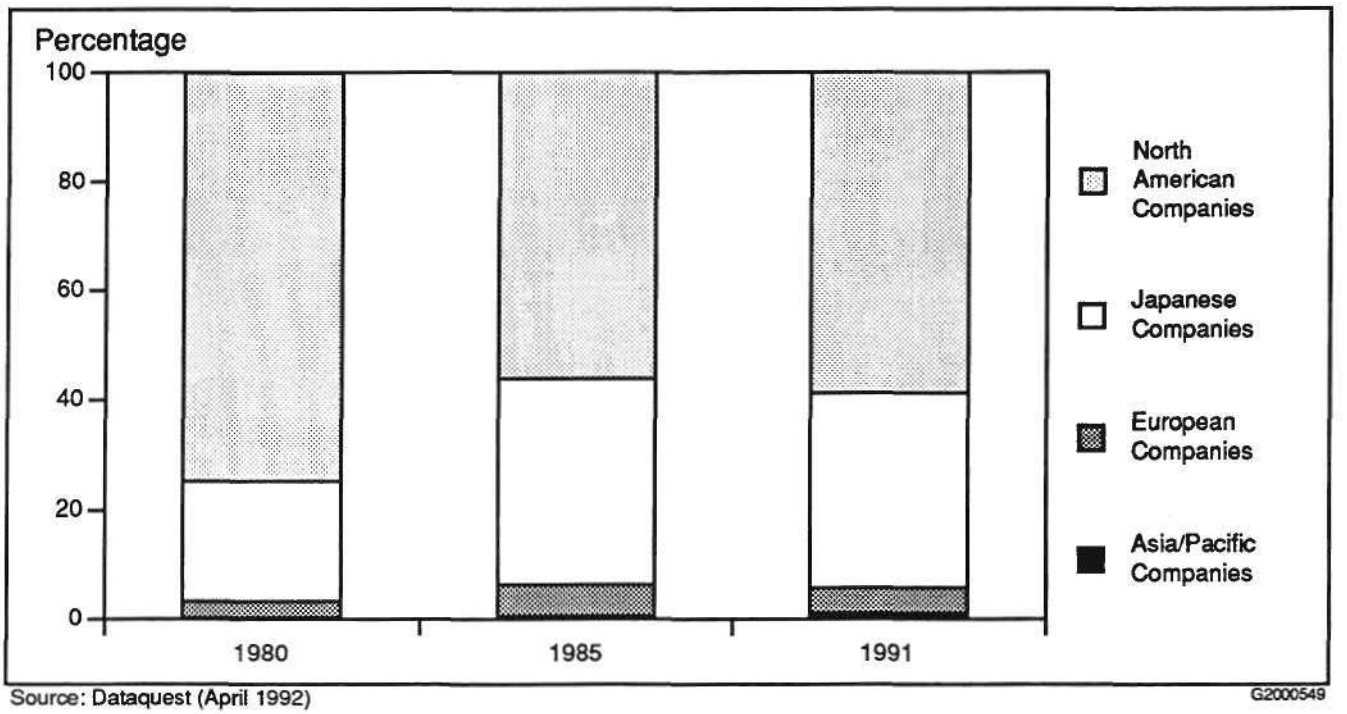

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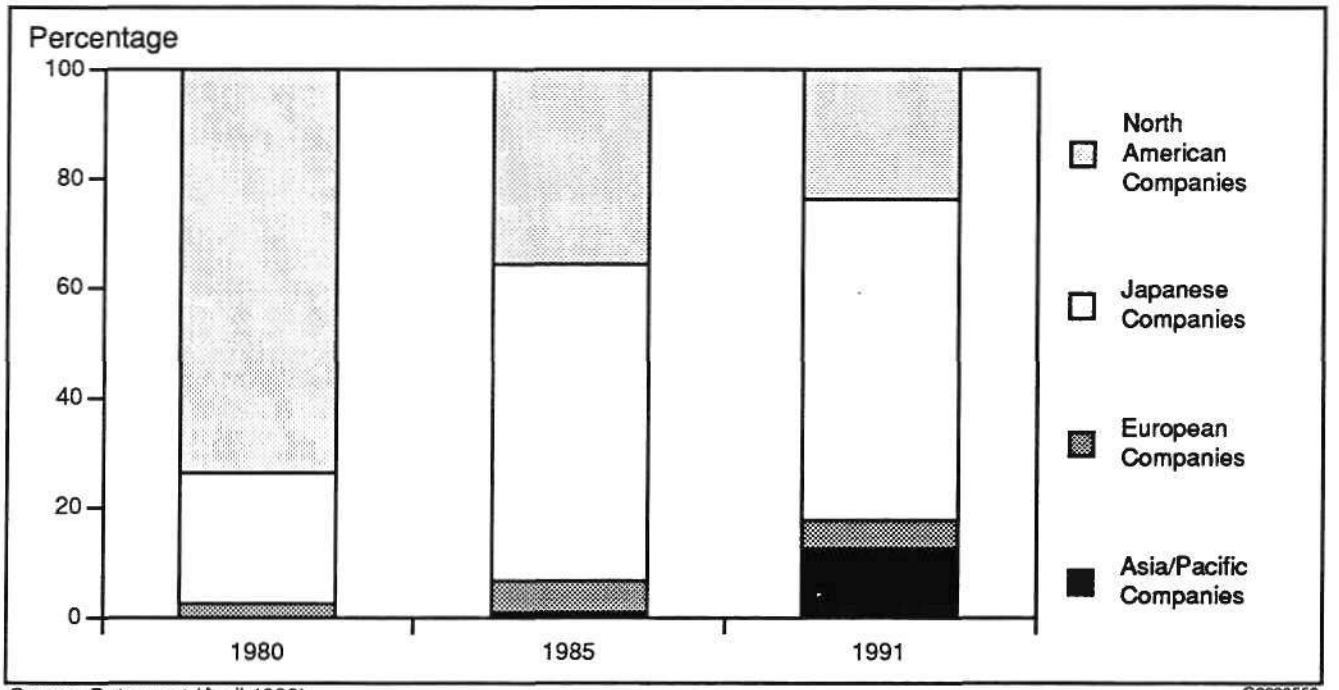
Figure 5
MOS Memory Market Share by Region



Source: Dataquest (April 1992)
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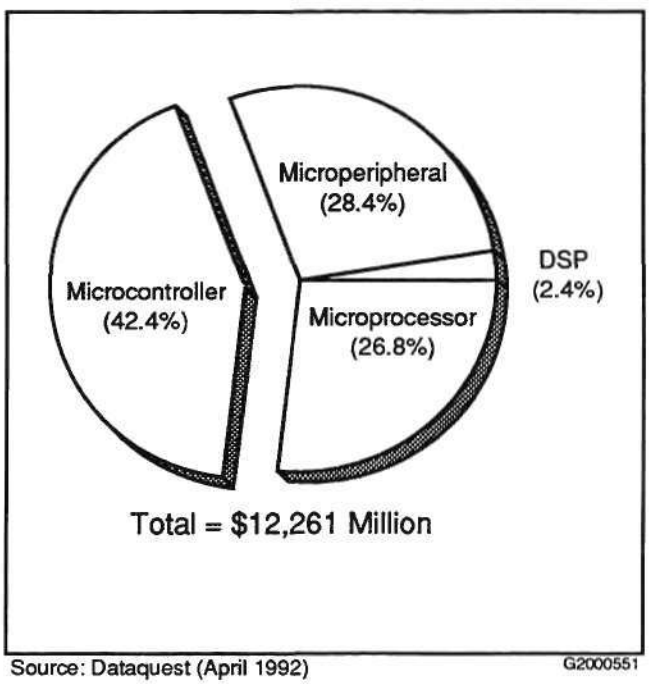
between 1985 and 1991, from 37.5 to 35.5 percent. On the other hand, U.S. makers, whose share decreased from 74.6 percent in 1980 to 58.9 percent in 1991, regained some share after 1985.

Although Japanese makers increased their share in the world semiconductor market from 28.0 percent in 1980 to 49.7 percent in 1991, lost momentum in MOS memories meant a lower share in the MOS digital market. As a result Japan's share in the world market also leveled off after 1985. U.S. makers saw their share drop from 57.0 to 35.9 percent during the same period, but they are now on the way to recovery, driven by the strong growth of MOS micros in 1990 and 1991.

MOS Micro Market Trends

In the MOS micro market, microprocessors (MPUs)—high-end products such as 32-bit RISC and CISC processors in particular—are receiving much attention. The weakness of Japanese makers without proprietary products is always the first subject brought up. In reality, however, MPUs account for only 26.8 percent of the MOS micro market, while microcontrollers (MCUs) hold an outstanding 42.4 percent (see Figure 6).

Figure 6
1991 Worldwide MOS Microcomponent Market



Source: Dataquest (April 1992)
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Japanese makers boast the largest share in the MCU market: 60.2 percent of the world market, or $3,128 million in 1991. MCUs had the second highest CAGR—29.0 percent—from 1980 to 1991, next to 33.8 percent for MPUs. Their share of the MOS micro market increased by nearly 6 percent. Dataquest expects the segment to continue growing.

When compared to MPUs, whose applications are limited to computers, particularly PCs, a major strength of MCUs is that they have a variety of applications and serve as a driver for the digitization of electronic systems. Beginning with 4-bit products, Japanese makers are now offering an array of products, including 16-bit MCUs, that cover consumer electronics to industrial equipment. They also have recently announced 32-bit MCUs using RISC CPUs as the core, under technical licensing from foreign makers.

Dataquest Perspective

If integration of semiconductor devices continues to progress at the present pace, volume production of 64Mb DRAMs is likely to start in 1995. At the same time, rapid technological advancement toward VLSIs will accelerate the development of system-on-silicon technology—implementation of an entire system on a single chip.

For instance, this technology can integrate 16 units of Intel's 80486 on a chip. Japanese makers have already introduced custom ICs that can integrate core CPUs, peripherals, logic devices, and memories, as well as analog circuits, on a single chip. Further development of the system-on-silicon technology, therefore, will make obscure present categories of semiconductor products—MOS memories, micros, and analog.

At the same time, system-on-silicon technology requires a wide range of key technologies beyond semiconductor manufacturing, including system development, processors, and software to offer total system solutions. The alliances between major semiconductor makers clearly reflect this need. While alliances in the 1980s—such as Hitachi/Texas Instruments and Toshiba/Motorola—primarily focused on development and manufacturing of next-generation memories, those in the 1990s, such as IBM/Apple/Motorola and Hewlett-Packard/TI/Canon, are viewed as efforts toward entire system development.

As MOS memory faces increasing difficulties in the 1990s, only a limited number of makers will be able to continue to operate under an ever-increasing burden of capital expenditure. Also, development of next-generation electronic equipment, such as the multimedia environment and HDTV, will require more resources than does memory. If domestic and foreign makers join hands, proprietary technologies can be used to create products that a single company cannot develop, thus allowing many makers to benefit from the synergy. This will certainly serve as another springboard for semiconductor makers into the new stage of growth.

PCs, a major force behind the rapid growth of the electronic equipment market in the 1980s, have lost their momentum and there is no market driver to take over. Dataquest believes that integrated digitization of the computer and consumer electronic industries such as multimedia and HDTV will become mainstream in the 1990s, and that system-on-silicon will be the key technology to support this development in the semiconductor industry.

Just as MOS memories shaped the semiconductor industry in the 1980s, MOS micros with system-on-silicon are expected to lead the industry in the 1990s. Dataquest believes that the MOS micro market will surpass the MOS memory market in size during this decade—changing places in the industry, rather than changing generations, as in the past.

By Susumu Kurama

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese applications market in 1991
- Japanese semiconductor offshore production strategy

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Semiconductors *Japan*

SCJA-SVC-DP-9204 March 9, 1992

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

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Market Analysis

DRAM Consumption Forecast, by Application: Will the Silicon Cycle Continue?

This article analyzes the impact of product life cycles and average sales prices on the worldwide DRAM consumption outlook for major applications. It also depicts DRAM as an industry in transition and shows the changing pattern of the silicon cycle.

By Akira Minamikawa and Kun Soo Lee *Page 3*

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

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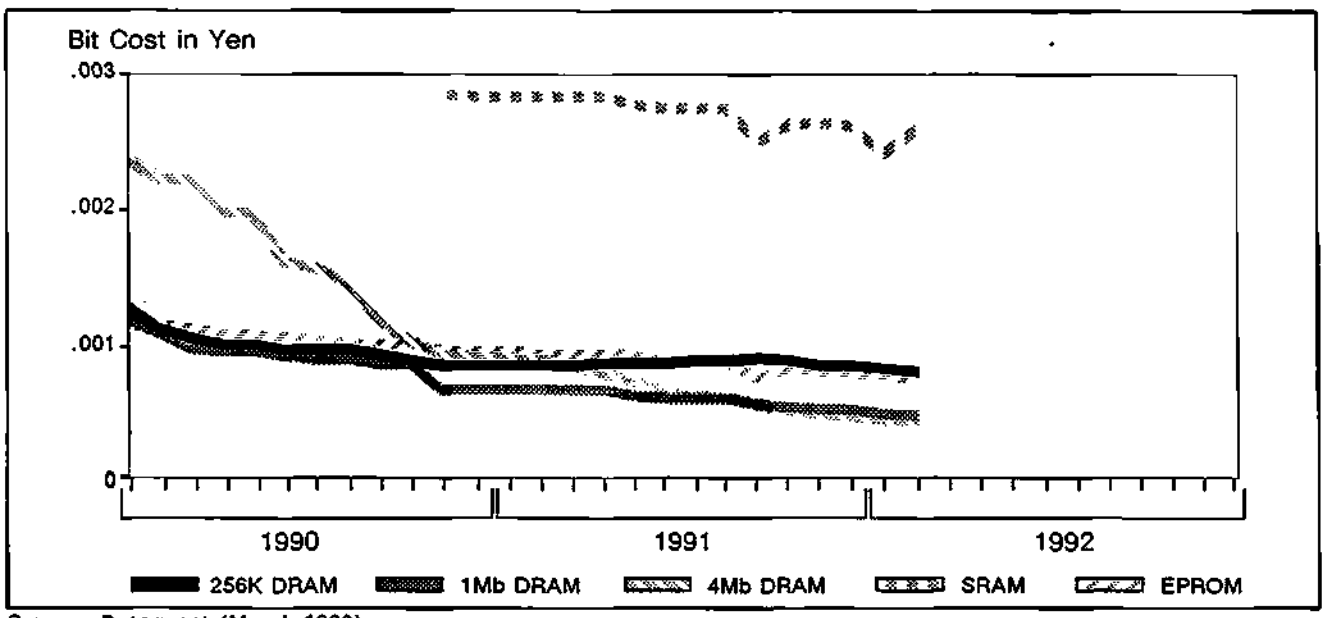
DRAM 1Mbx1-8	3.60	3.98	3.70	3.90	4.10	3.60
DRAM 256Kx1-8	1.20	1.67	1.60	1.35	1.35	1.10
DRAM 4Mbx1-8	13.25	14.51	14.90	15.00	16.00	13.20
EPROM 1Mb, 170ns	3.70	4.37	3.20	3.95	3.90	2.90
EPROM 2Mb, 170ns	7.53	8.55	6.10	7.85	7.90	5.70
SRAM 1Mb, 128Kx8	13.58	14.31	10.50	16.55	16.70	NA
SRAM 256K, 32Kx8	3.83	4.17	3.50	4.08	4.10	3.30
SRAM 64K, 8kx8	2.00	1.63	1.80	1.55	1.45	1.30
68020-16	29.00	44.52	26.00	44.00	39.00	NA
80286-16	10.00	11.73	10.00	11.75	12.80	9.70
80386DX-25	140.00	157.69	144.00	172.50	164.00	NA
80386SX-16	46.50	60.42	53.00	55.00	55.60	48.00
R3000-25	121.00	143.09	110.00	NA	NA	NA

Note: These figures correspond to the *DQ Monday Report* dated February 17, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (March 1992)

Memory Bit Price in Japan



Source: Dataquest (March 1992)

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Market Analysis

DRAM Consumption Forecast, by Application: Will the Silicon Cycle Continue?

The continued downturn in the DRAM market during 1990 and 1991 was a serious blow to the heavily DRAM-dependent Japanese semiconductor industry and suggests a dim-looking future. If this situation continues, there could be a break from the silicon cycle, which is the industry's yardstick.

Evidently technology has outgrown the 4Mb DRAM market's needs and destroyed the balance between supply and demand. DRAM suppliers are forced to bide their time and wait until the market for existing products matures before introducing new products. At the same time, they must continue efforts to reduce the time-to-market for next- and later-generation DRAMs. DRAM makers have been prospering on the strength of commodity products; now they appear to be making a strategic shift to user-specific products. Success in the DRAM business, therefore, depends on understanding future application trends and the diverse needs of DRAM users.

This article analyzes the impact of product life cycles and average sales prices on the worldwide DRAM consumption outlook for major applications. Dataquest will show that the DRAM industry is in transition and that the silicon cycle pattern is changing.

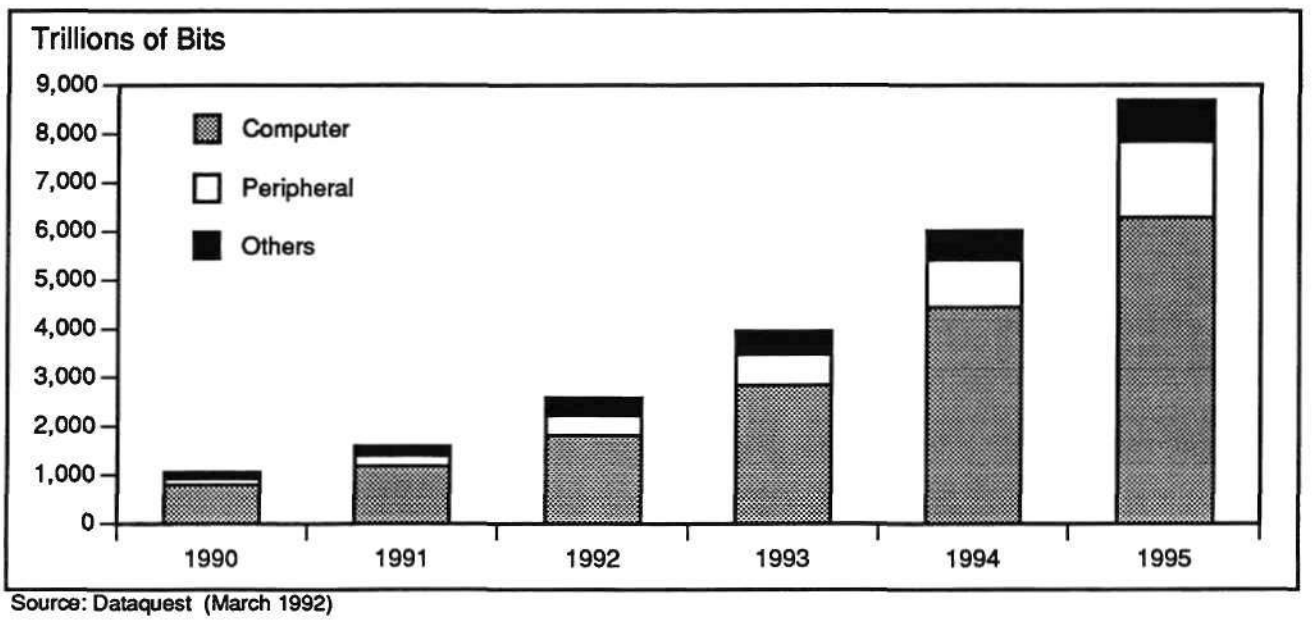
DRAM Consumption Forecast, by Application

DRAM market forecasting involves analyses of electronic system market trends and DRAM consumption per system, with some adjustment to reflect technological background. In 1990, electronic data processing (EDP) systems accounted for 89 percent of worldwide DRAM consumption. Applications including communication, consumer electronics, and industrial machinery accounted for the remaining 11 percent. This consumption pattern will not change much in the foreseeable future (see Figure 1). PCs gobbled up a majority of DRAMs supplied to the computer sector, followed by midrange computers and workstations. In 1995, however, the workstation segment's share will increase to a quarter of the total, thus eroding the share of midrange computers.

Workstations

Workstations, which are positioned as the core of distributing computing environments, are expected to show the highest growth in unit production among all computer systems. Production of workstations will jump from 386,000 units in 1990 to 2.2 million in 1995—a compound annual growth rate (CAGR) of 41.6 percent (see Table 1)—because distributed

Figure 1
1990-1995 Worldwide DRAM Consumption Forecast, by Application (December 1991)



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computing is expected to become a mainstay of future computing. Only workstations provide a truly free development environment. The advanced design concept and flexible operating environment will work as a multiplier and enable the workstation market to expand from present engineering applications to business fields.

At the same time, workstations offer great market potential for DRAMs, in terms of memory capacity. As of 1990, the average memory capacity of a workstation was estimated at about 20MB (see Figure 2), but the minimum memory capacity of standard models available at that time was 8MB. Most of these workstations were used for engineering applications, particularly graphic applications including CAD, which required 20MB main memories.

Standard models offered by leading workstation makers in 1991 were equipped with main memories that averaged 32MB. Again, because these models were used mainly for engineering purposes, it is reasonable to expect that larger memories were added to many of them. Thus, Dataquest believes that the memory capacity of workstations will increase by a CAGR of 35.1 percent between 1990 and 1995, reaching 90MB in 1995. In addition, workstations will find new applications in business areas, as relational databases, for example. Finally, flexible and decentralized development environments will further accelerate growth of the workstation market, which will create additional memory demand.

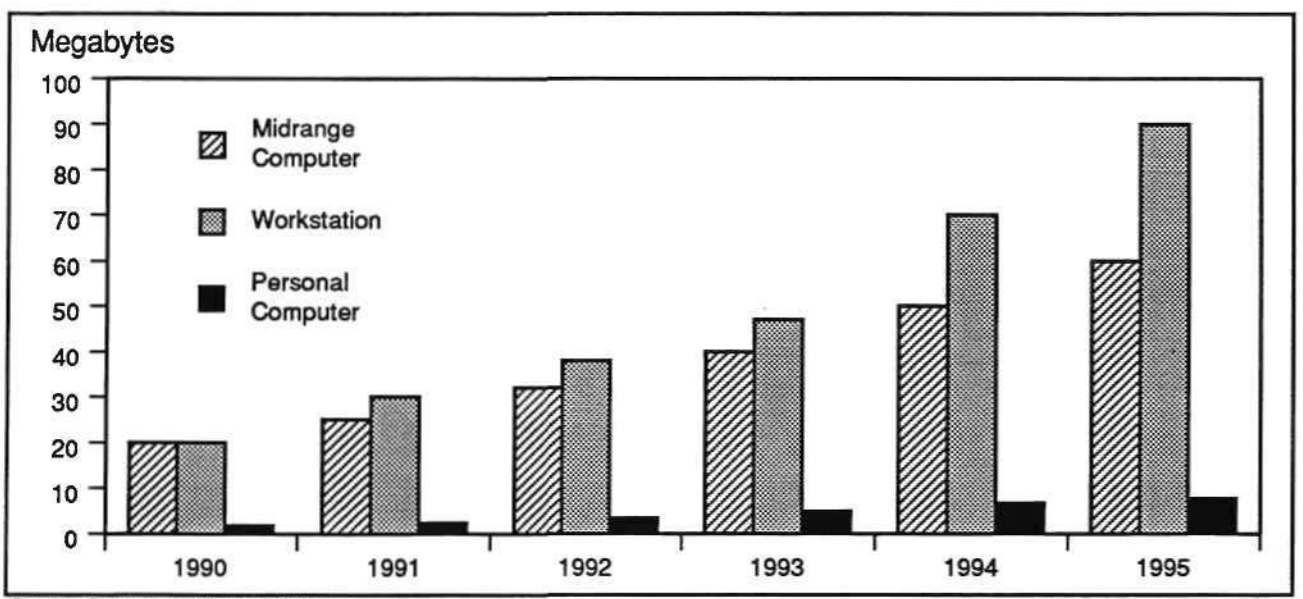
Overall evaluation of the system production forecast, memory capacity per system, and system form factors (external factors to

Table 1
Worldwide Computer Production Forecast (Thousands of Units) (December 1991)

	1990	1995	CAGR (%) 1990-1995
Mainframe	15	14	-1.6
Supercomputer	0.8	1.7	15.4
Midrange Computer	1,025	1,264	4.3
Workstation	386	2,200	41.6
Personal Computer	23,306	44,275	13.7

Source: Dataquest (March 1992)

Figure 2
1990-1995 Main Memory Forecast for Small Computers



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determine the volume) indicates that workstations will be a key product for 16Mb or larger DRAMs. In particular, personalized use of workstations at the office and introduction of personal workstations (partly competing with high-end desktop PCs) will create market opportunities for laptop workstations. Personal workstations also will use relatively small main memories compared with engineering models, which consume 4Mb DRAMs in large quantities. Dataquest expects DRAM consumption by workstations to expand rapidly from 7.7 percent of the total DRAM consumption for computers in 1990 to 25.2 percent in 1995 (see Figures 3 and 4).

Personal Computers

DRAMs consumed by PCs in 1990 accounted for 41.8 percent of the total consumption for computer systems, clearly indicating the PC's role as a driving force for the DRAM market. Although the PC market will continue to be important for the DRAM industry, it is not immune to downsizing trends. Careful analysis of major product types will be necessary to determine potential.

Today, most advanced PCs such as desktop PCs have high-performance and high-speed CPUs (80486) capable of handling tasks that required midrange computers a decade ago. These are expected to evolve into the domain of workstations. Opposite the high-end PCs are the notebook PCs with their increasing performance. These PCs are growing rapidly; their space-saving and portability features appeal to business people, to entry-level users, and to those that want to trade up to replace desktop models. They will be positioned as a minimum-size information terminal for personal users.

There is a burgeoning demand for hand-held and pen-based computers in the PC market. The saturated U.S. PC market, the largest market for DRAMs, is sluggish. But users trading up are expected to help it recover, thus accelerating the use of hand-held types as driven by downsizing trends. This will contribute greatly to an increase in unit production. Dataquest expects worldwide PC production to expand at 13.7 percent CAGR between 1990 and 1995, reaching 44.3 million units in 1995.

The average main memory capacity of an average PC in 1990 was 1.9MB for desktop models and 1.4MB for laptop models. Dataquest expects desktop models to increasingly use 16Mb DRAMs to reflect demand for higher performance. In 1995, the average memories of hand-held models will be

Figure 3
1990 Worldwide DRAM Consumption Forecast by Computer Segment—(December 1991)

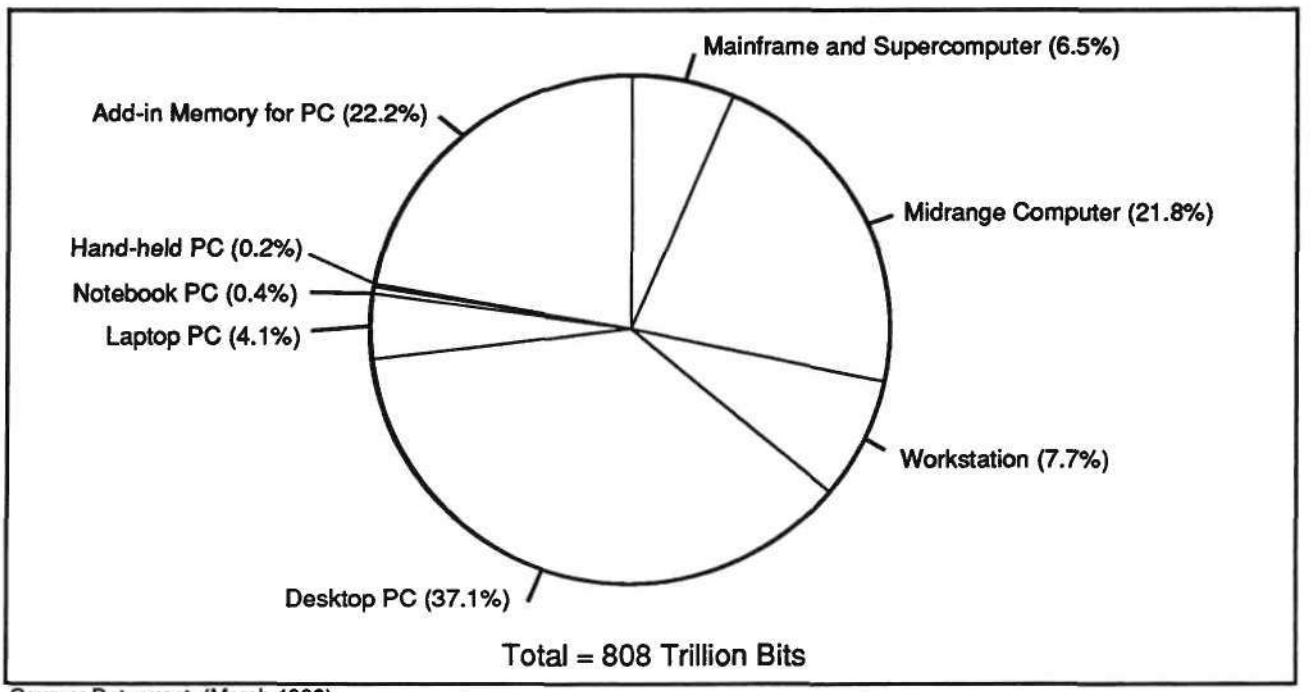

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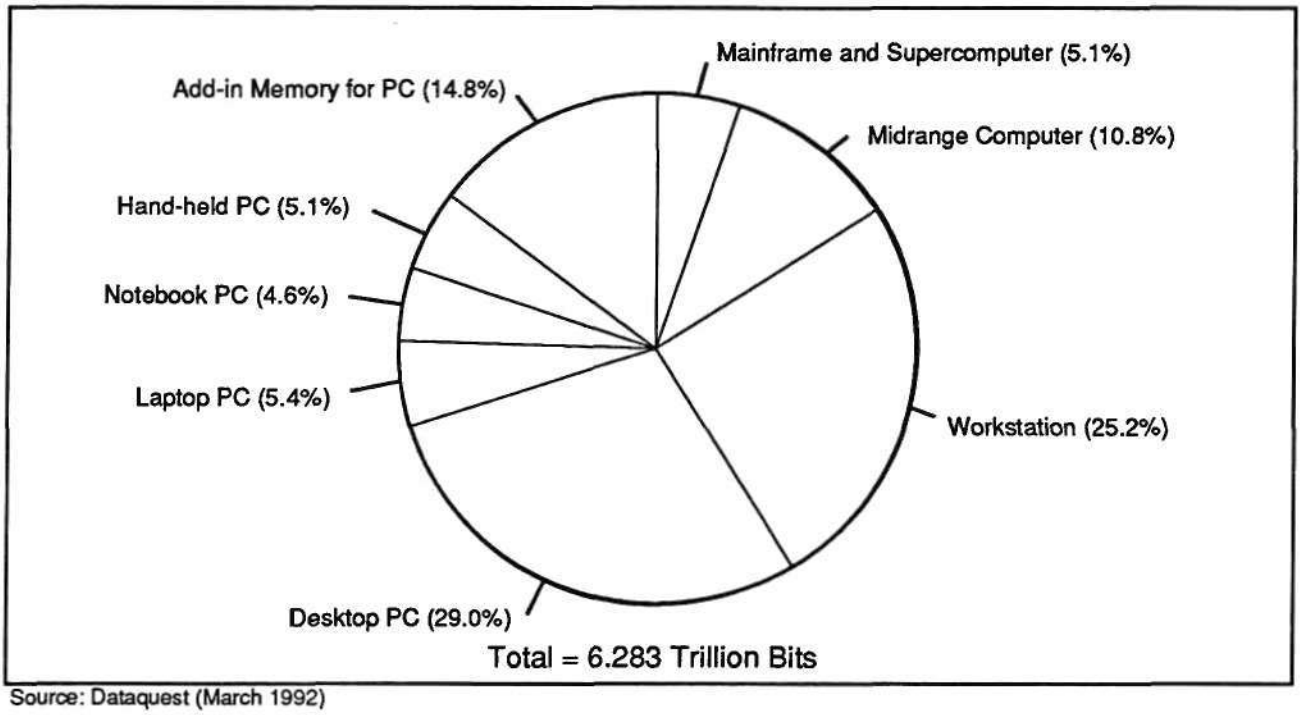
Figure 4
1995 Worldwide DRAM Consumption Forecast by Computer Segment (December 1991)



Source: Dataquest (March 1992)

2.7MB and 16Mb DRAMs; the models will be mainly used for their economy-of-scale advantages. At the same time, the memory capacity can be configured for 4Mb DRAMs. Such a configuration is likely to be used for low-end products requiring relatively small memory capacities, such as notebook and laptop PCs with 3MB main memories.

Equally important is demand for extended memory boards. In 1990, extended memory boards consumed 180 trillion bits of DRAMs, 34.8 percent of the PC's total consumption. This market segment is forecast to grow to 928 trillion bits, a 38.9 percent CAGR between 1990 and 1995. Future extended memory systems will be supplied in two forms, single in-line memory module (SIMM) and memory card, with a diverse product line to satisfy a wide range of users' needs for storage capacity. As a result, Dataquest expects 1Mb to 16Mb DRAMs to be used according to module configuration in 1995.

DRAMs consumed by PCs, including extended memories, will grow from 517 trillion bits in 1990 to 3,702 trillion bits in 1995, a CAGR of 48.3 percent. DRAM consumption by PC is principally governed by various environments affecting DRAM suppliers and demands by DRAM users. The environments include the average sales price (ASP) of each DRAM chip and the maker's strategic hardware configuration. On the other hand, user demands cover the data size of each user, memory capacity managed by application software, and operating systems that affect determination of the PC's entire specifications. Memory capacity is a realistic point of compromise between DRAM suppliers and users. As the ASP of DRAMs increases with increased storage capacity, application markets do not grow as DRAM makers expected. If this situation prevails, the entire DRAM market may follow the present path of 4Mb DRAMs.

The PC industry is about to enter a new phase. Alliances announced in 1992 between IBM, Apple Computer, and Motorola on new-generation PCs are primary examples. The PC they will design in the RISC-based graphical user interface environment, in a sense, symbolizes the direction of the PC industry toward user-oriented products.

Other Computers

Most DRAMs are used in computer systems. In 1990, 76.7 percent of worldwide DRAM

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consumption was related to computer systems, indicating that computers are dominant memory eaters among electronic systems. Nevertheless, because the computer market is sensitive to short-term technological changes, it is difficult to forecast future trends. In the 1990s, a wave of downsizing is stimulating demand for distributed computer systems, which are taking over centralized mainframes, and for midrange computers, thus necessitating the restructuring of the entire industry.

Production of mainframes will decrease from 15,100 units in 1990 to 13,900 in 1995, a CAGR of negative 1.6 percent. This will somewhat decelerate the growth of DRAM consumption to 30 percent annually, from 42 trillion bits in 1990 to 200 trillion bits in 1995, even if the increase in main memory capacity is added. More than 95 percent of memories on mainframes will use 16Mb DRAMs in 1995, with SRAMs used in some models to improve system performance.

Production of midrange computers will also grow moderately, at 4.3 percent CAGR, from 1.025 million units in 1990 to 1.264 million units in 1995. As a result, DRAM consumption will grow from 176 trillion bits to 676 trillion bits during the same period. The 16Mb DRAM will be a mainstay for midrange computers in 1995; 4Mb will be used in smaller systems.

Finally, supercomputer production will grow from 820 units in 1990 to 1,680 in 1995, a CAGR of 15.4 percent. DRAM consumption will increase from 10 trillion bits to 121 trillion during the same period. Supercomputers, which place performance over price, are likely to be the initial users of 16Mb and later-generation DRAMs.

Peripherals

DRAM consumption by the peripherals segment will increase at 64.3 percent CAGR between 1990 and 1995, reaching about 1,561 trillion bits in 1995.

Dataquest expects page printers, including laser printers, to hold the key to growth of DRAM consumption. Although copiers are the leading office equipment, page printers accounted for a majority of DRAM consumption for peripherals in 1990 and are definitely a major application. The reason is partly because laser beam printers are one of few EDP applications outside computers to use 32-bit microprocessors, and partly because the controller's data buffer requires DRAMs with a megabyte capacity, consuming a large number of DRAMs with high storage capacity.

In 1995, 4Mb DRAMs will be mainly used for 2MB to 3MB memory in page printers. At the same time, however, high-performance machines will require large memories for editing and color graphic functions, using 16Mb DRAMs.

Other Applications

Other applications consumed about 115 trillion bits of the total DRAM demand in 1990. The share is expected to remain unchanged at around 10 percent in 1995 because of the transition of information media from analog to digital and because digitization is largely affected by speed. If the order of digitization is character, voice, and video data, then communication equipment will be digitized first, followed by audio/visual systems and other consumer products. Consumer and communications areas will increase DRAM consumption, thus significantly changing the demand structure.

Worldwide DRAM Consumption Forecast (Bit Basis)

DRAM Cycle in the 1980s

In the DRAM cycle in the earlier 1980s, more than 100 percent bit growth was achieved in every year except 1981, which was the bottom of the silicon cycle. Momentum was apparently lost in the later 1980s, with the annual growth rate declining to 60 percent.

Figure 5 plots the silicon cycle in the 1980s and clearly shows that DRAMs have been a major player in boosting the cycle. The silicon cycle reached its peak in 1984 and 1988, with annual growth rates on a value basis of 97 percent and 155 percent, respectively, far above the average 42.5 percent level during the 1980s. On the other hand, bottom years occurred in 1981 and 1985, down 38 percent and 55 percent from the previous year, respectively.

Comparing these figures with the bit-based growth rates of DRAMs (see Figure 6) reveals

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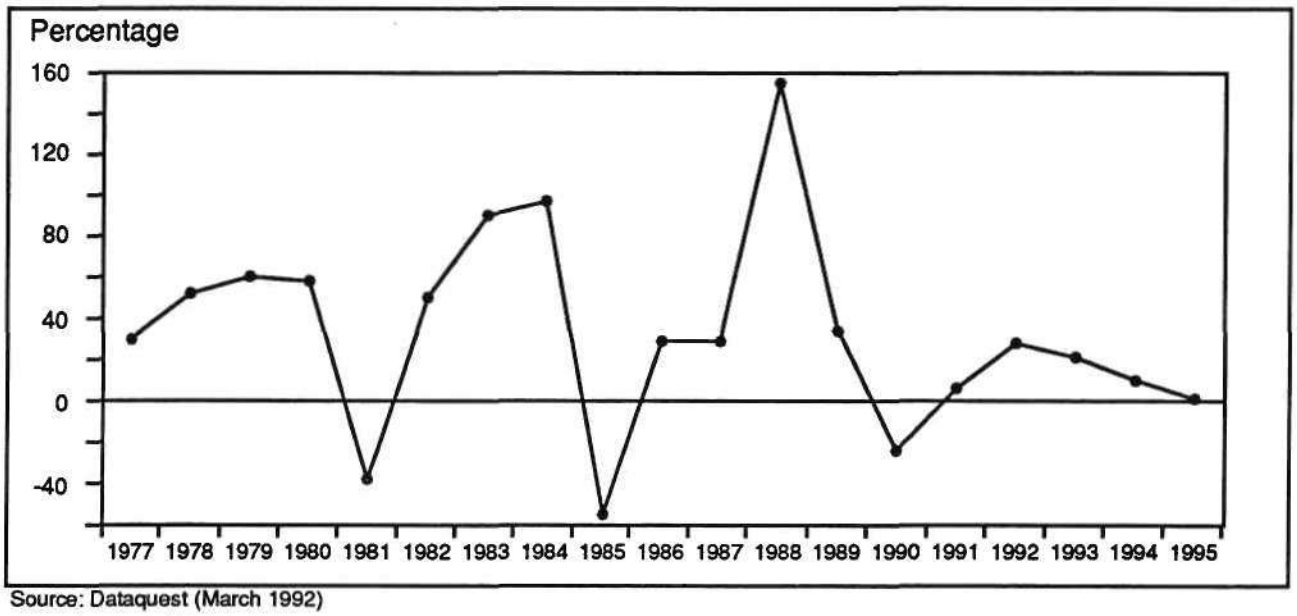
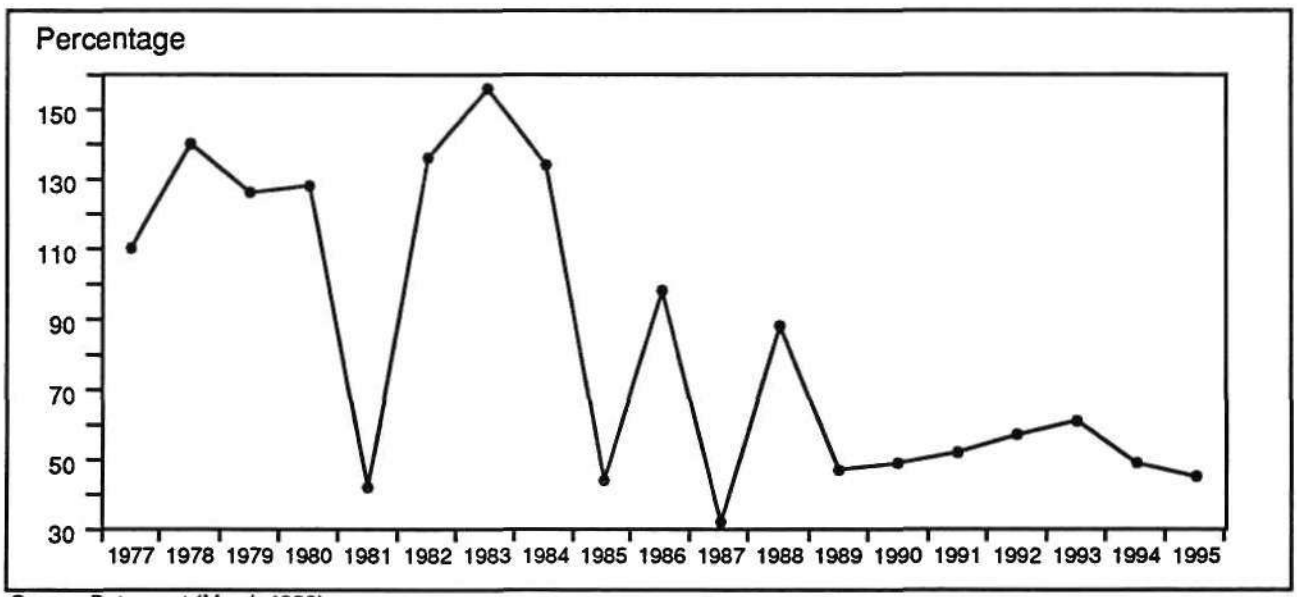
Figure 5
Worldwide DRAM Revenue Growth



Source: Dataquest (March 1992)

Figure 6
Worldwide DRAM Bit Growth



Source: Dataquest (March 1992)

that the silicon cycle does not necessarily agree with the DRAM's bit growth rate. The bit growth rate peaked in 1983 and 1986, with annual growth rates of 156 percent and 98 percent, respectively, compared with 134 percent and 88 percent in the silicon cycle. A critical factor here is ASP. Figure 7 plots yearly growth rates of ASPs, which mostly agree with the silicon cycle.

Although bit growth rates contributed significantly to the silicon cycle peaks in 1984 and 1988, ASPs are a principal factor in affecting the silicon cycle. Per-bit prices rose in 1988, breaking away from the trend, mainly because of external pressure on chipmakers by the Ministry of International Trade and Industry (MITI) to induce higher 1Mb prices. This is clearly visible in the graph plotting per-bit

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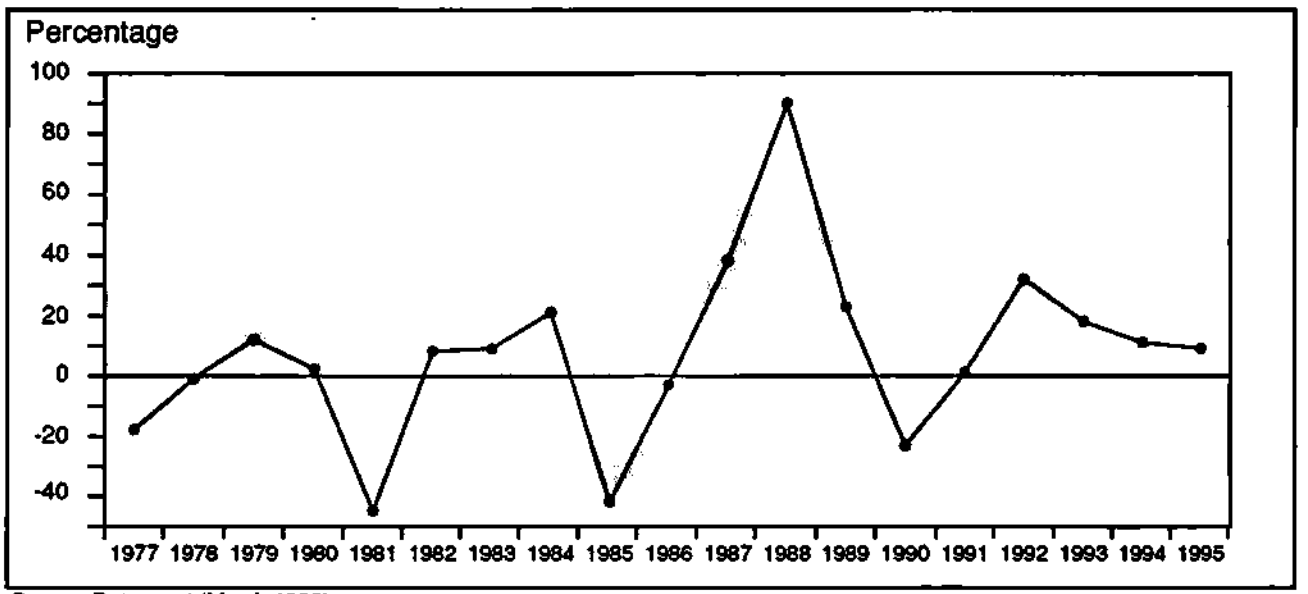
Figure 7
Worldwide DRAM ASP Growth



Source: Dataquest (March 1992)

DRAM price trends by memory capacity (see Figure 8). It is well known that Toshiba took the lead in volume production of 1Mb DRAMs and made a sizable profit and that other makers rushed to make capital expenditures for the next-generation product. However, Toshiba's huge profit was a result of price stability sustained by the external factor, which is not likely to occur again. If the 1988 peak had been at a moderate level reflecting the normal ASP trend, semiconductor makers could have made 4Mb DRAM investment in a more planned manner and the current free-fall of 4Mb prices would have been avoided.

DRAM Cycle in the 1990s

Electronic systems clearly have achieved higher performance, downsizing, and cost reduction through smaller design rules, lower cost, and higher integration of semiconductor devices. In particular, memories have been boosting integration fourfold every three years, thus serving as a process driver. The increase in integration of semiconductor memories has not only reduced the per-bit mounting area, but also brought about benefits of higher speeds and lower per-bit prices; the decline in per-bit price stimulated the increase in memory capacity on systems.

In the 1980s, DRAM consumption grew rapidly on a bit basis at 86 percent CAGR. Major applications were in computers, which experienced notable performance growth. In particular, engineering workstations doubled their performance each year by introducing RISC architecture and parallel processing. Increases in computer performance, evolution of operating systems (from MS-DOS to Windows, OS/2, and UNIX), and introduction of multimedia features have steadily increased memory capacities on systems. If the per-bit price declines at its present pace, however, the bit growth rate will be about 50 percent annually in the 1990s.

More importantly, DRAM suppliers can no longer expect demand growth corresponding to their expansion of production capacities, because the DRAM market is shifting toward application-specific memories (ASMs), including diversification of bit configurations. Thus DRAM makers will need a production plan based on accurate forecasting of demand for each application.

What is the relationship between the per-bit cost and the "bi-rule"? The bi-rule assumes that the ultimate price of DRAMs in each generation is twice that of the previous generation. Assuming that a crossover of two generations occurs every three years, the bit cost becomes half: $(0.8)^3 = 0.512$. However, some

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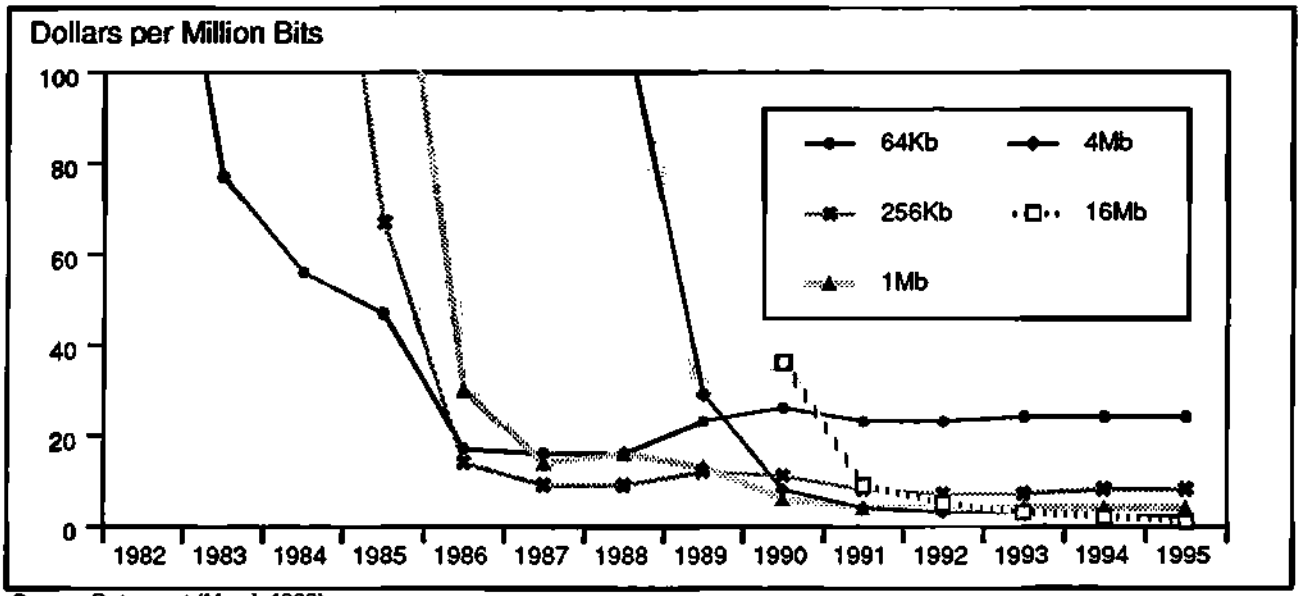
Figure 8
Worldwide DRAM Bit Price Forecast



Source: Dataquest (March 1992)

believe that this pace is too fast, in light of the decline in production efficiency and cost increases because of increased value added, which are attributed to recent increases in capital expenditure, an increased number of processes, submicron design rules, and increased product lines (including small packages and multibit products). With these factors and the lack of applications to lead the DRAM demand in mind, Dataquest expects DRAM consumption to double to $12.5 billion in 1995 and to increase eightfold on a bit basis to reach 8,700 trillion bits.

DRAM Demand Forecast

Figure 9 shows Dataquest's forecast DRAM demand by density and application in 1995, based on these considerations. 1Mb DRAMs will not be used in workstation and higher-end general-purpose systems (supercomputers, mainframes, minicomputers, and office computers). About half of the 1Mb DRAM demand (114 million units) will be used in communications and AV equipment, 24 percent (55 million units) in PC main memories and memory cards, and the remaining 27 percent in printers, display units, and other EDP systems. On the other hand, half of the 4Mb DRAM demand (397 million units) will be used in PCs, 27 percent (213 million units) in printers and display units, and 10 percent (80 million units) each in communications equipment and workstations.

At this stage, a shift to 16Mb DRAMs is expected to be complete in systems larger than midrange computing systems (supercomputers, mainframes, and midrange computers), and few 4Mb DRAMs will be used. PCs are the largest consumer of 16Mb DRAMs, representing 40 percent (122 million units), followed by workstations, which account for 25 percent (77 million units), and general-purpose computers, which account for 17 percent (54 million units). Shares for communications equipment, printers, and display units will decrease. This indicates that communications equipment, printers, and display units will not require such large storage capacity.

Per-Bit Price Demand

The annual average rate of per-bit price declines in the earlier 1980s was 40.8 percent. The figure was 11.9 percent in the latter half. The respective rates for the early and latter 1990s are 25.8 percent and 17.4 percent, according to Dataquest estimates.

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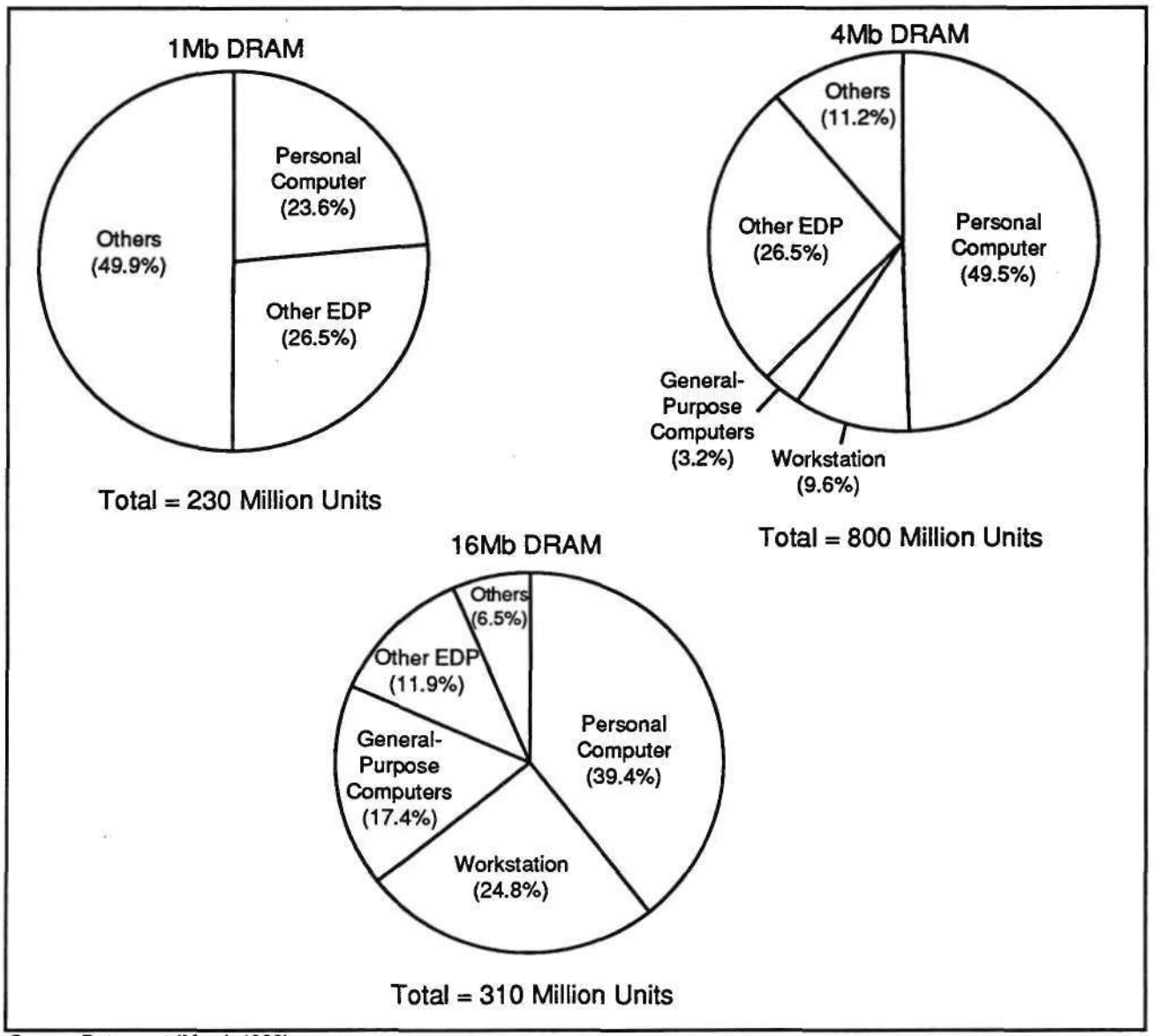
Figure 9
1995 Worldwide DRAM Consumption, by Density, by Application (December 1991)



Source: Dataquest (March 1992)

If not for the external factors mentioned earlier, the relatively small rate of decline in the latter 1980s would have been down by 20 percent. On the other hand, the DRAM demand grew rapidly in the earlier 1980s, resulting in the average bit growth rate of 102 percent, coupled with fierce competition among Japanese makers and rapid advancement of volume production technology. Problems such as the dumping dispute and the delay in commercialization of 1Mb DRAM production technology led to increased per-bit prices in the latter 1980s.

In the 1990s, technical solutions were found and the dumping issue subsided. Softened growth in the PC market, a great consumer of DRAM, and decreased demand for large memories created oversupplies and accelerated the decline in the per-bit price. Naturally, the current situation is not likely to continue. Deceleration of the rate of decline in per-bit prices will result from increased advanced fab investment, increased development costs because of increased product lines, declines in productivity, and slowdowns in bit growth.

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Dataquest Perspective

DRAM demands for EDP and other systems previously were forecast on the basis of production forecast for each system, DRAM capacity on each system, and comparison of per-bit prices (1Mb, 4Mb, and 16Mb). As a result, 1Mb, 4Mb, and 16Mb demands in 1995 will grow to 230 million, 800 million, and 310 million units, respectively, provided that DRAM prices continue to decline at the present pace.

In addition, Dataquest concludes that DRAM consumption structure will continue to change because of the following factors:

- The shift to distributed computing machines and downsizing trends in the computer industry will accelerate production of PCs and workstations, resulting in DRAM consumption patterns weighted toward these systems. More and more DRAMs will be used in workstations, which will be produced in large quantities, instead of in mainframes and midrange computers, which will be produced in small quantities. Coupled with commercialization of next-generation DRAMs and diversification of bit configuration, a major demand shift to ASMs is expected.
- Peripherals will become an indispensable market for the future DRAM industry. Currently the niche market for DRAMs, peripherals have maintained bit growth of more than 60 percent and will develop into a major DRAM consuming market of 1,561 trillion bits in 1995, accounting for 17.9 percent of the total. Furthermore, this market is expected to place a priority on prices rather than capacities, providing opportunities for older-generation products. As a result, a clear crossover will not occur in the future DRAM market, where more than two generations of DRAMs will coexist and meet diverse requirements for a variety of applications.
- DRAM production technology is required to keep its current edges in submicron processing, but it also will help achieve higher integration (storage density), faster operating speed (access time), lower power consumption, and the wide use of bits because of diversified applications.
- The recent concern about the slowdown in the rate of decline in per-bit price should be considered as a warning for the DRAM industry. The rate of decline may be critical to DRAMs for which a unit price of storage capacity is very important; they may lose their share to SRAMs, flash memories, and magnetic disk drives. Although the product line for next-generation DRAMs continues to expand, real demand exists for only a group of products.

DRAMs amplified silicon cycles in the past. However, now that the previous bit growth cannot be expected for DRAMs, it is reasonable to expect some changes in the silicon cycle. This article has revealed that empirical evidence from silicon cycles is no longer useful in the 1990s. DRAM suppliers are urged to establish a marketing strategy focusing on applications and future trends.

By Akira Minamikawa and Kun Soo Lee

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Japanese semiconductor trade
- Japanese companies' offshore production

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NEC Corporation: An Unconventional Contender

This "flash profile" of a leading Japanese semiconductor manufacturer is a brief review of the company's fiscal-year performance as well as its semiconductor operations and investments.

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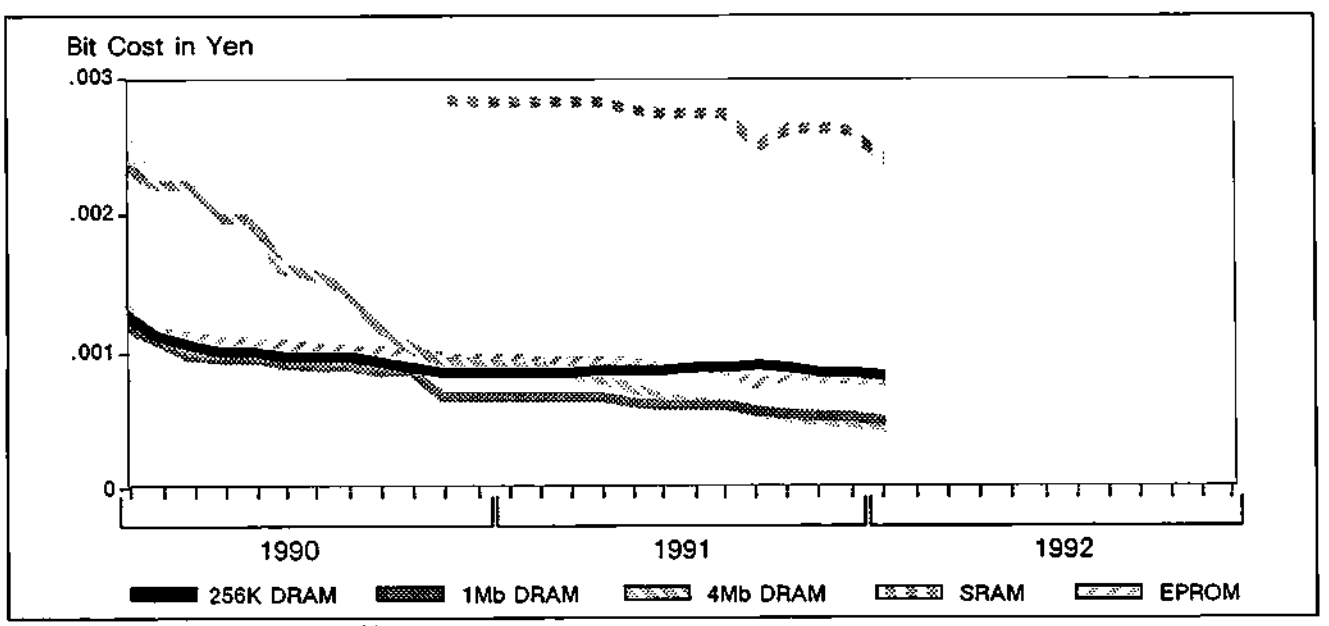
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 256K×1-8	1.35	1.67	1.60	1.43	1.30	1.10
DRAM 4Mb×1-8	13.25	14.51	15.30	17.00	17.00	13.80
EPROM 1Mb, 170ns	3.80	4.37	3.45	3.95	3.90	2.90
EPROM 2Mb, 170ns	7.55	8.55	6.70	7.75	7.90	5.70
SRAM 1Mb, 128K×8	13.63	14.31	12.70	16.55	16.50	NA
SRAM 256K, 32K×8	3.90	4.17	3.55	4.08	4.00	3.30
SRAM 64K, 8K×8	2.05	1.63	1.90	1.55	1.40	1.30
68020-16	29.00	44.52	26.00	45.50	40.80	NA
80286-16	10.00	11.73	10.00	12.00	12.65	9.70
80386DX-25	140.00	157.69	144.00	178.50	174.00	NA
80386SX-16	46.50	60.42	53.00	57.00	55.50	48.00
R3000-25	121.00	143.09	132.00	NA	NA	NA

Note: These figures correspond with the *DQ Monday Report* dated February 3, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (February 1992)

Memory Bit Price in Japan



Source: Dataquest (February 1992)

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Market Analysis

Japanese Silicon Wafer Industry Leads the World

Both the Japanese and worldwide silicon wafer markets grew about 10 percent in 1990, a healthy increase despite the year's position at the bottom of the silicon cycle. Major factors in this growth are as follows:

- The semiconductor recession in 1990 can largely be attributed to the decline of memory prices; semiconductor production did not drop on a unit basis.
- The startup in volume production of 4Mb DRAMs increased consumption of dummy wafers.
- Low yields in 4Mb DRAM production required relatively large amounts of wafers.
- The fear of shortages in wafer supplies resulted in high wafer prices.

Moreover, two factors are expected to have a significant impact on the future of the silicon wafer industry: epitaxial wafers and 8-inch wafers. This article analyzes the epitaxial wafer market by major application and predicts supply and demand trends for 8-inch wafers in the wake of slowing capital expenditure by the semiconductor industry.

World Silicon Wafer Market Trends

In 1990, the world silicon wafer market—a principal material for semiconductor production—grew 9.8 percent from the previous year to $2.68 billion (see Table 1).

Similarly, the Japanese silicon wafer market recorded a strong 9.7 percent growth, compared with a 2.1 percent decrease in semiconductor device production. This sharp contrast in performance of the two markets seems to be attributed to a combination of three factors, as follows:

- Semiconductor production did not decrease in volume and was severely affected by plummeting memory prices.
- Consumption of dummy wafers increased because of the start of volume production of 4Mb DRAMs.
- Wafer consumption grew significantly as a result of low yields in 4Mb DRAMs.

Furthermore, a shortage of wafer supplies allowed wafer makers to set prices for the first time in history. The Japanese silicon wafer market consequently grew to a massive $1.56 billion (¥225.2 billion), accounting for 58.2 percent of the world total. The U.S. market held a 26.2 percent share, Europe accounted for 10.2 percent, and rest of world (ROW) was 5.4 percent.

The ROW market showed the highest compound annual growth rate (CAGR), 27.1 percent, from

Table 1
Worldwide Silicon and Epi Wafer Market Trend (Millions of Dollars)

	1985	1986	1987	1988	1989	1990	CAGR (%) 1985-1990
United States	355.1	351.7	395.2	519.5	634.0	703.6	14.7
Change (%)		-1.0	12.4	31.5	22.0	11.0	
Japan	632.3	939.0	1,083.1	1,383.2	1,425.1	1,563.7	19.9
Change (%)		48.5	15.3	27.7	3.0	9.7	
Europe	136.9	167.6	187.9	223.0	270.0	272.9	14.8
Change (%)		22.4	12.1	18.7	21.1	1.1	
ROW	43.5	58.7	69.6	105.6	115.7	144.4	27.1
Change (%)		34.9	18.6	51.7	9.6	24.8	
Worldwide	1,167.8	1,517.0	1,735.8	2,231.3	2,444.8	2,684.6	18.1
Change (%)		29.9	14.4	28.5	9.6	9.8	

Source: Dataquest (February 1992)

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1985 to 1990. The Japanese market's CAGR was 19.9 percent. Although such high growth is natural for the ROW market, which is a newcomer to semiconductor production and had a relatively small size, it is impressive that Japan, the world's largest market, recorded 20 percent growth. This is a clear evidence that the Japanese chipmakers have made a steady recovery from the bottom of the previous silicon cycle in 1985 and lead the world semiconductor industry.

Market Breakdown, by Ownership

In terms of market share by ownership, Japanese silicon wafer makers accounted for two-thirds of the world market, with revenue of $1.82 billion (¥262.3 billion) (see Tables 2 and 3). European makers hold a 30 percent share, or $764.2 million. Thus, Japanese and European makers represent about 96 percent of the world market. In contrast, U.S. makers lost a significant portion of their share in 1989. Part of the reason was that Monsanto Electronic Materials—the largest silicon wafer maker in the United States at that time—was bought by Huels of Germany, thus adding a sizable share to European makers.

Finally, ROW makers hold only a 1.5 percent share, but the burgeoning semiconductor industry in the region is likely to result in the development of related industries. It is reasonable to expect a fostering of the silicon wafer business until its capacity grows to a level capable of satisfying local consumption.

In any case, dominance by Japanese and European makers indicates their strong influence in the world silicon wafer market, whose growth rate (9.8 percent) is practically a weighted average of those of Japanese makers (9.0 percent)

Table 2
Worldwide Silicon and Epi Wafer Market Trend by Regional Ownership
(Millions of Dollars)

	1985	1986	1987	1988	1989	1990	CAGR (%) 1985-1990
U.S. Companies	249.9	251.9	252.4	319.4	48.6	59.8	-24.9
Change (%)		0.8	0.2	26.5	-84.8	23.0	
Japanese Companies	703.3	1,037.2	1,223.5	1,535.3	1,671.6	1,821.4	21.0
Change (%)		47.5	18.0	25.5	8.9	9.0	
European Companies	214.1	226.6	252.0	340.7	690.8	764.2	29.0
Change (%)		5.8	11.2	35.2	102.8	10.6	
ROW Companies	0.5	1.3	7.9	35.9	33.8	39.2	139.3
Change (%)		160.0	507.7	354.4	-5.8	16.0	
Total	1,167.8	1,517.0	1,735.8	2,231.3	2,444.8	2,684.6	18.1
Change (%)		29.9	14.4	28.5	9.6	9.8	

Source: Dataquest (February 1992)

Table 3
Worldwide Silicon and Epi Wafer Market Trend (Ownership Basis)

	1985	1986	1987	1988	1989	1990
U.S. Companies (%)	21.4	16.6	14.5	14.3	2.0	2.2
Japanese Companies (%)	60.2	68.4	70.5	68.8	68.4	67.8
European Companies (%)	18.3	14.9	14.5	15.3	28.3	28.5
ROW Companies (%)	0	0.1	0.5	1.6	1.4	1.5
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0

Source: Dataquest (February 1992)

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and European makers (10.6 percent). Although U.S. makers recorded the highest growth, 23 percent over the previous year, their minimal share could not affect the entire market.

Ranking of Wafer Makers, by Revenue

Shin-Etsu Handotai maintained a dominant 25.9 percent share in the 1990 world market (see Table 4), followed by Huels, which took over Monsanto's share, and then Osaka Titanium, Wacker Chemitronic, Mitsubishi Materials (Japan Silicon), Komatsu Electronic Metals, and Toshiba Ceramics. It is notable that the highest share in each of the three major markets (Japan, Europe, and the United States) is held by a maker based in that region, suggesting the need for a close relationship between suppliers and users in each market.

In the Japanese market, Shin-Etsu Handotai boasts a near 34 percent share, while foreign makers hold minimal shares. There is fierce competition among the second-tier Japanese makers: Komatsu Electronic Metals (16.9 percent), Mitsubishi Materials (16.5 percent), and Osaka Titanium (16.0 percent). Notably, Komatsu's No. 6 rank in the world market, compared with its No. 2 rank in the Japanese market, indicates a very small percentage of exports.

1991 Epitaxial Wafer Market

One headline in the semiconductor industry concerns the uprising of the epitaxial equipment market, which is expected to stimulate the epitaxial wafer market. Epitaxial equipment demand is responding to an increasing move among wafer makers to boost their production capacities. Major projects include construction of a Chitose plant by Mitsubishi Materials and respective capacity increases by Toshiba Ceramics and Shin-Etsu Handotai at the Tokuyama Ceramics (subsidiary) and Isobe plants. Other capacity increases are at Osaka Titanium (Saga plant), Komatsu Electronic Metals (Nagasaki plant), and Wacker Chemitronic (Wasserburg plant).

. . . wafer makers have been steadily building up volume production capacities for 8-inch wafers and are ready for competition.

Such moves seem to reflect the belief that epitaxial wafers will be used for advanced devices including DRAMs. However, Dataquest's survey on applications of epitaxial wafers in 1991 showed significant variance among the regions (see Table 5).

In the United States, epitaxial wafers are largely used for CMOS devices. Intel and Motorola use them for microprocessors, IBM for DRAMs, and Texas Instruments (TI) for MOS devices. On the other hand, discrete and bipolar are major applications in the Japanese epitaxial wafer market.

Table 4
1991 Worldwide Silicon and Epi Wafer Supplier Ranking (Millions of Dollars)

Rank		Worldwide Sales	Market Share (%)	Japan Sales	Market Share (%)
1	Shin-Etsu Handotai	696.1	25.9	527.5	33.7
2	Huels AG	403.7	15.0	54.4	3.5
3	Osaka Titanium	346.0	12.9	250.5	16.0
4	Wacker	338.6	12.6	30.0	1.9
5	Mitsubishi Materials	317.4	11.8	258.0	16.5
6	Komatsu Electronic Metals	279.0	10.4	265.0	16.9
7	Toshiba Ceramics	129.7	4.8	127.4	8.1
	Others	174.1	6.5	50.9	3.3
	Total	2,684.6	100.0	1,563.7	100.0

Source: Dataquest (February 1992)

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Table 5
1990 Epitaxial Wafer Sales by Process Technology (Percentage)

Region	CMOS	BiCMOS	Bipolar	Discrete	CCD/Others	Total
United States	75	1	8	16	0	100
Japan	13	2	27	52	6	100
Europe	53	5	20	20	2	100
ROW	10	0	45	45	0	100

Source: Dataquest (February 1992)

The relatively small consumption for CMOS applications is mainly because Japanese makers do not use epitaxial wafers for DRAMs. Unlike IBM, which produces DRAMs for captive use only, Japanese DRAM makers face intensive price competition and cannot afford expensive epitaxial wafers. At the same time, Japanese makers have improved process technology and can do without epitaxial wafers, which are used for bipolar devices to form buried/diffused layers for the purpose of decreasing collector resistance.

However, epitaxial wafers are used for MOS devices to prevent latchup and soft errors caused by alpha-rays, thus improving high crystal structure. For CCD, improved gettering and uniformity is expected, while uniformity is the sole reason to use epitaxial wafers for discrete devices.

Another reason for the increased use of epitaxial wafers in the Japanese market today is notable growth in the power IC market to withstand high-voltage and large-current applications, in response to increased performance and size reductions in consumer electronic equipment as well as information and communications systems. They also are being used in inverters to control the speed of AC motors by varying current frequency, in switching devices, and in insulated gate bipolar transistors (IGBTs). These devices use a thick layer of epitaxy. A relatively large amount of epitaxial equipment is required because of low throughput. Therefore, growth of the epitaxial wafer market depends entirely upon whether epitaxial wafers will be used for DRAMs. Dataquest believes that they will not be used until required for 256Mb DRAMs. The production cost of epitaxial wafers has not reached a target level—30 percent above that of silicon wafers—because of low throughput of epitaxial equipment.

Another factor delaying the use of epitaxial wafers for DRAMs is the use of high energy ion implantation technology recently introduced by Mitsubishi Electric. This technology is designed to improve latchup characteristics and soft error resistance by forming retrograde wells by ion implantation. Although the same effect can be obtained by using epitaxial wafers, the mask process is reduced by two steps by using ion implanters—which cost ¥450 million each—that offer significant benefits.

Dataquest Perspective

The generation shift of DRAMs has progressed within the scheduled time frame and sample shipment of 16Mb DRAMs started in fall 1991. The best solution to maximizing productivity at a volume production stage—while also meeting requirements for higher integration and larger chip size—is the increase in wafer size. Device makers have announced plans to introduce the 8-inch wafer process.

However, deterioration of the industry's performance because of recession in the U.S. computer industry resulted in scaledown, postponement, or freezing of capital expenditure by semiconductor makers during the second half of 1991. Construction of 8-inch fab lines has not been immune to this.

Dataquest believes that collaborative efforts by device makers and equipment/material makers for a balanced market will be necessary to ensure healthy growth of the semiconductor industry.

In contrast, wafer makers have been steadily building up volume production capacities for

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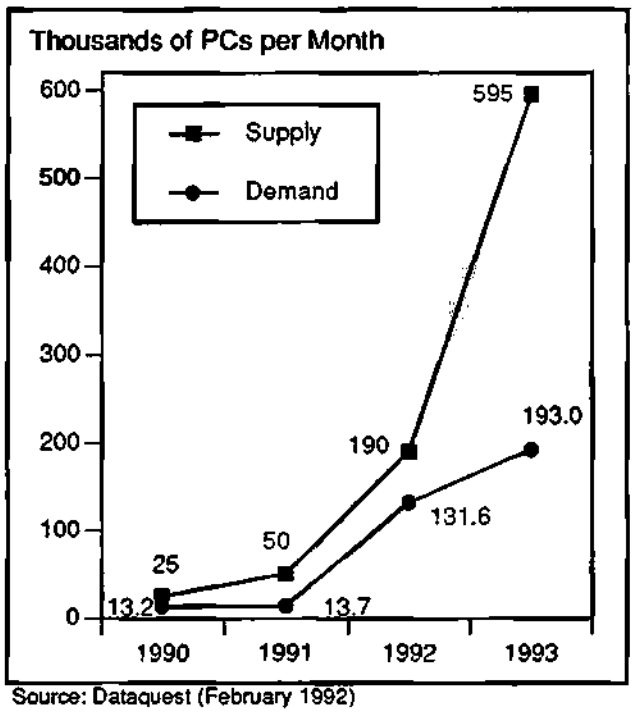
Figure 1
Supply and Demand for 8-Inch Wafers



Source: Dataquest (February 1992)

8-inch wafers and are ready for competition. Thus it is inevitable that the 8-inch wafer supply capacity will exceed actual demand, but persisting overcapacity needs to be avoided. Ordinarily, supply and demand balance can be regained as new semiconductor fab lines are added each year.

Dataquest's estimated annual demand for 8-inch wafers and supply capacity in 1990 through 1993 are shown in Figure 1. While demand is expected to increase from 13,200 wafers per month in 1990 to 193,000 wafers in 1993, supply capacity will increase from 25,000 wafers to 595,000 during the same period. Thus demand will be exceeded; the situation will continue in the foreseeable future. Wafer shortages undoubtedly have a large impact on device makers, but overcapacity severely affects wafer makers by increasing a burden of capital investment. Therefore, Dataquest believes that collaborative efforts by device makers and equipment/material makers for a balanced market will be necessary to ensure healthy growth of the semiconductor industry.

By Kunio Achiwa

Fab Plans Are Reconsidered in Japan

When major semiconductor manufacturers rushed to announce plans for new production lines one after another in early 1991, it seemed that 1992 would see construction of large fabs for volume production of 16Mb DRAMs and could possibly be the first booming year for 8-inch fab lines. As it turned out, however, most plans were put off until 1993 or later because of the slow start in 4Mb DRAM demand (contrary to high expectations), the sluggish U.S. economy, and the end of the "bubble" economy in Japan.

In the 1980s, a high level of capital investment in the semiconductor industry was directed to meet rapidly growing demand. In turn, semiconductor investment in the 1990s will emphasize the development of future fab lines.

This article reviews the semiconductor market in 1991 and analyzes new fab line trends in relation to the semiconductor market.

Worldwide Semiconductor Production Facilities

As of November 1991, there were more than 878 semiconductor production lines worldwide: 388 in the United States, 260 in Japan, 138 in Europe, and 92 in the rest of world (ROW) region. The term "production line" refers to front-end processes. The number of lines for a region represents those lines operated by all semiconductor makers in the region; fab lines in the United States include those operated by Japanese manufacturers as well. Note that R&D lines and assembly lines are not included.

Calculated from worldwide semiconductor production and the number of fab lines in 1991, production per line amounted to nearly $81.8 million. Regionally, Japan shows dominantly high production of $129 million. As for memory production, there are 109 lines in Japan, 82 in the United States, 30 in Europe, and 28 in ROW; Japan accounts for 44 percent of the 249 lines worldwide. Dataquest estimates that memory shipments in 1991 were 3.1 billion units worldwide. From these numbers, shipments of memories per line are estimated at aproximately 12.5 million units. Assuming an average 6-inch wafer fab line, which produces 170 chips from each wafer and has a 20,000-wafer capacity every four weeks and an average yield of 85 percent, then 90 fab lines are enough to produce 3.1 billion units of memories, which

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Dataquest estimates to be the total memory volume in 1991. Compared with this requirement, the present 249 memory production lines worldwide are clearly overcapacity. In addition, 24 lines were scheduled to come on stream in 1991: 3 in the United States, 5 in Europe, 12 in ROW, and 4 in Japan.

A notable trend in recent years, in addition to rapidly increasing fab investment, is the increase in the number of fabless manufacturers. This increase reflects the changing concept of production lines—including foundry production—for companies trying to survive in an atmosphere of diverse needs and requirements for semiconductor devices and ever-increasing capital expenditure.

Analysis of Japanese Fab Lines

In Japan, 260 fab lines are in operation; 40 percent of these produce memories. Of the memory lines, approximately 70 percent or 74 lines produce DRAMs only—one characteristic peculiar to Japanese fab lines. As for the most advanced lines (with design rules of less than 1.0 micron), 91 are in Japan, 111 in the United States, 24 in Europe, and 14 in ROW, for a total of 240. In particular, the U.S. advanced fab lines account for 46 percent of advanced fab lines worldwide and 29 percent of the 388 fab lines operated in the United States. In Japan, the advanced fab lines account for 35 percent of total. This distribution clearly distinguishes dominance of small-lot fab lines in the United States from volume-production lines in Japan. Furthermore, the 0.8-micron process lines represent 50 percent of 1.0-micron or smaller lines in Japan, reflecting DRAM-based production strategies.

Dataquest analyzed both domestic and offshore capacity expansion plans of Japanese semiconductor manufacturers for 1991. At present, capital investment plans in Japan have been revised considerably, compared with early 1991. Originally, major companies planned construction of 16Mb DRAM production lines in addition to expansion of existing lines, supposedly marking the beginning of the 8-inch age. However, most 8-inch lines scheduled to start operation in 1991 were postponed until after 1992 in response to uncertainties in the U.S. and Japanese economies as well as sluggishness of 4Mb DRAM production compared with past trends. As a result, fab lines newly constructed in Japan are limited to Fab B of Matsushita's Uozu Plant, which mainly produces microcomponents, and Oki Electric's Miyazaki Fab M3, which produces 4Mb and 16Mb DRAMs. Other than MOS ICs, Fujitsu is building a GaAs IC line at Fujitsu Quantum Devices.

Nevertheless, Japanese semiconductor manufacturers are active in overseas investment. NEC's Roseville fab in the United States has started volume production of 4Mb DRAMs, and Matsushita has purchased National Semiconductor's factory. In Europe, Fujitsu has commenced production of 1Mb and 4Mb DRAMs at its fab in Durham in the United Kingdom. In ROW, Oki Electric is building a memory assembly line in Thailand.

Dataquest Perspective

Today's DRAM production process is characterized by the use of the next-generation device technology for production of the current-generation device, as the 16Mb DRAM manufacturing technology is being used for 4Mb production. This approach is intended for accelerated supply of low-cost DRAMs, quick recouping of investment in 0.5-micron fab lines, and reduction of 16Mb production costs.

Postponement of production plans in 1991 means a delay in the startup of 16Mb DRAM production. Thus, 4Mb production should be reconsidered by taking into account a major change in the industry, where two or more generations of products continue to be available in the same marketplace. In terms of bit growth, Japanese device makers recorded an annualized 50 percent increase in 1991 and more than a 26 percent increase in 1990. At the same time, production plans made far in advance of actual demand—certainly creating price-cutting expectations by users—do not necessarily stimulate replacement of old-generation products.

Clearly, the semiconductor market in the 1990s is showing a different picture from the 1980s, when sales and production plans could be estimated by examining past experience. Although the addition of fab lines continues to be a key element supporting the semiconductor industry, Dataquest believes that the changing nature of the industry presents an urgent need for reconsideration of the increasingly complex process and the semiconductor fab lines themselves.

By Kazunori Hayashi

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Company Analysis

NEC Corporation: An Unconventional Contender

NEC Corporation was founded in 1899 as a manufacturer of telecommunications hardware. Although original capitalization came from abroad, the largest block of NEC stock is currently controlled by the Sumitomo Group.

NEC has 11 operating groups and 51 consolidated subsidiaries. These divisions focus on four primary business categories: Communications Systems and Equipment, Computers and Industrial Electronic Systems, Electron Devices, and Home and Miscellaneous Electronics Products. The Electron Devices area includes all semiconductor devices, passive components, panel displays, and various related peripheral equipment.

Overall Business Strategy and Performance in FY 1990

NEC had revenue totaling ¥3,699 billion in fiscal year (FY) ending March 31, 1991. Although this sales figure was 7.4 percent higher than total sales in FY 1989, net income was only ¥54 billion representing a 36.6 percent decline over the previous year's net revenue. This decrease in profitability was more severe than the drop sustained by any of the other major competitors in the electronics industry. NEC's lack of profit growth can be attributed to several factors. The recession in the United States coincided with the bottom of the silicon cycle and had some impact on most major Japanese electronics firms. NEC has been particularly susceptible to the current downturn because of its heavy involvement in commodity DRAM markets. This market saw lower than projected demand for 4Mb DRAMs, which resulted in overcapacity and price erosion during much of 1990. Despite the significant impact of the economic climate, however, NEC's decline in net revenue relative to other top Japanese electronics companies may be resolved simply by noting that NEC's R&D expenditure, expressed as a percentage of sales, is significantly larger than that of its competitors. NEC devoted 7.6 percent of its FY 1990 sales to R&D; the remaining four of the top five Japanese electronics companies invested just 6.0 percent of their sales. A high R&D investment rate is consistent with the operation of a company that is committed to supplying high-density MOS products. In many other respects, however, NEC's financial results mirror those of the typical top Japanese electronics firm. For example, NEC's productivity, measured by gross revenue per employee, was only slightly above the average of the other top five Japanese electronics companies.

NEC's own forecast of FY 1991 revenue is not promising as FY 1991 sales are expected to fall below the FY 1990 figure; this would almost certainly mean little or no gain in net income for FY 1991. Similar results are expected at other major Japanese electronics firms.

Of NEC's nonsemiconductor component businesses, the largest revenue-generating businesses—the Communications Systems and Equipment and Computers and Industrial Systems units—grew by 11.6 and 10.5 percent, respectively, during FY 1990. In particular, NEC has been a dominant player in PC markets and is also becoming a factor in the worldwide supercomputer market with its competitive SX-3.

Japanese electronics firms typically can maintain a financially healthy state and stock value with smaller current and quick ratios than can their U.S. counterparts. However, even by Japanese standards, NEC has established itself as a nonconformist. NEC's liquidity ratios are possibly the lowest in the industry. Commensurate with these liquidity ratios, the company's leverage debt-equity ratio stands at 1.07 for FY 1990. Although NEC appears to have an impaired capacity to service its debt, the confidence of banks and shareholders has not sufficiently declined to lead to measurable instability. Perhaps it is NEC's close ties to the Sumitomo Group of banks that have helped to reinforce trust in NEC's ability to determine and maintain a reasonable and effective balance sheet.

NEC Semiconductor

According to Dataquest's semiconductor market share estimates, NEC has ranked as a top semiconductor manufacturer in the world market since 1985. In calendar year 1991, NEC was first among global competitors in worldwide market share, a status the company achieved by scoring a top-five ranking in four major product categories: MOS memories, MOS microcomponents, MOS logic, and discrete devices.

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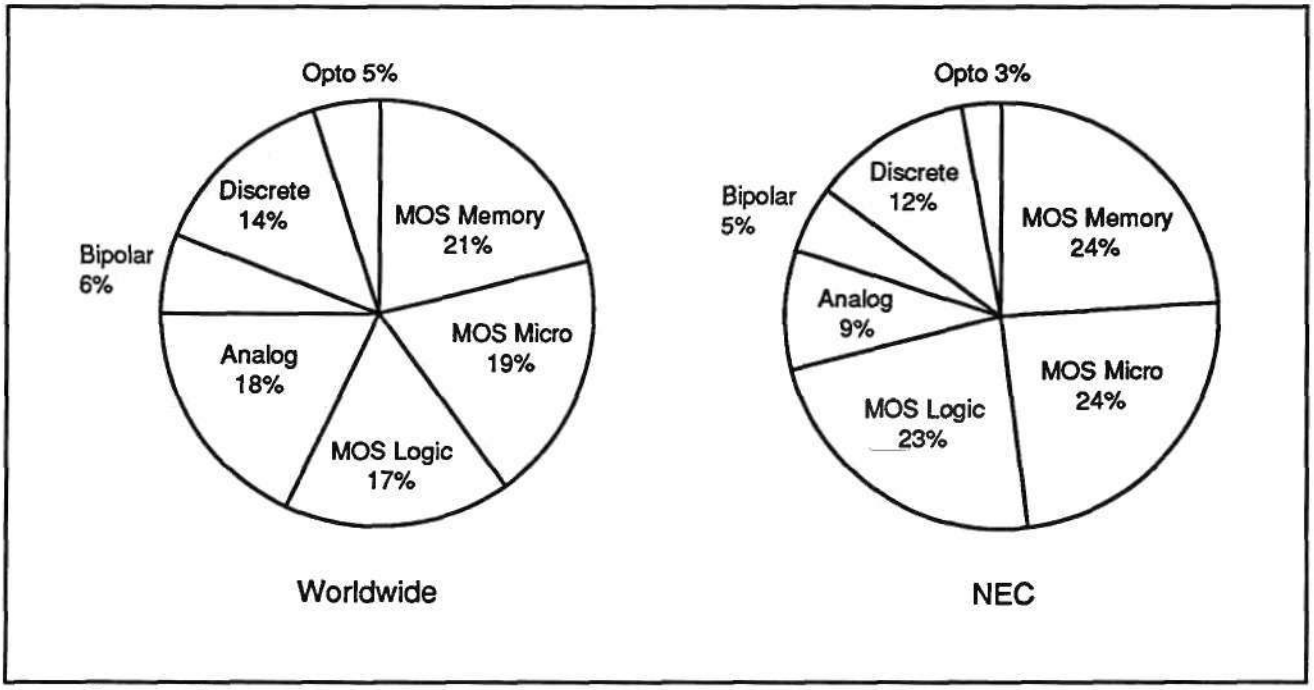
Figure 1 is an illustration of both NEC's semiconductor product mix revenue and the worldwide product mix revenue recorded in 1991. NEC's most productive product lines, MOS memories, microcomponents, and logic, each contributed roughly one-quarter of NEC's total semiconductor sales. A remarkable aspect of NEC's semiconductor portfolio is that its product categories contribute to NEC's total semiconductor revenue at nearly the same rates that those product categories contribute to the global semiconductor market. This makes NEC an especially well-balanced semiconductor supplier, putting the company in a good position to capitalize on shifts in the markets. In MOS microcomponents, one of the highest growth areas of the chip industry during 1991, NEC's revenue ranked second only to Intel. In terms of growth in this segment, NEC's MOS microcomponents revenue outpaced the growth of the worldwide market of microcomponents as illustrated in Figure 2.

In the microprocessor arena, attention has been focused on the growing market competition between CISC and RISC designs. The projections that RISC-based CPUs will exceed one-half of the worldwide 32-bit microprocessor market by 1995 has resulted in a surge of alliances pertaining to RISC design licensing and technology exchanges. As a participant in this trend, NEC has aligned itself with the MIPS Computer architecture and is also a member of the Advanced Computing Environment (ACE) group, which promotes MIPS-based machines. NEC is also one of the earliest suppliers of Intel 80X86-compatible CISC designs and could potentially surface as a supplier of i80386-compatible CPUs, joining AMD and others in creating an alternative to the Intel monopoly. Microprocessors are clearly an important element in NEC's strategy to maintain both leading-edge manufacturing and its current position as Japan's PC market leader.

NEC is highly globalized for a Japanese semiconductor manufacturer. The company began overseas production in the late 1970s. It owns state-of-the-art front-end facilities in both Europe (Livingston, Scotland) and the United States (Roseville, California). The Roseville plant investment has reached $600 million, which has endowed the new fab line with the capacity to produce 4Mb DRAMs as of January 1991, and 16Mb DRAM production is slated for the future.

Figure 1
1991 Semiconductor Market Share Product Mix



Source: Dataquest (February 1992)

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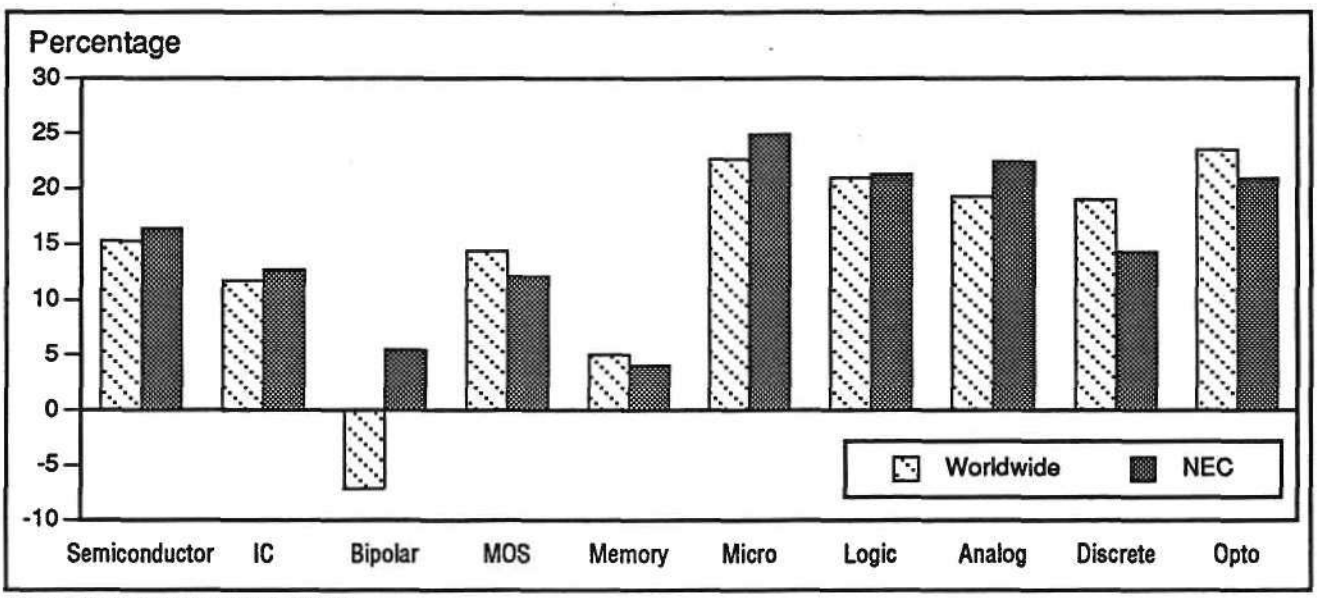
Figure 2
NEC's 1991 Growth Rate Compared with Worldwide Market

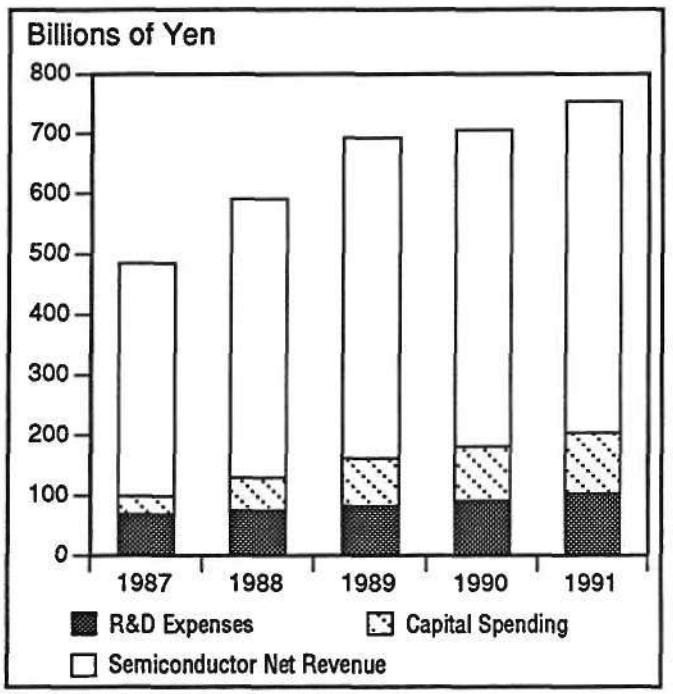


Source: Dataquest (February 1992)

Semiconductor Investments

NEC's industry-leading semiconductor capital spending and R&D expense trends against overall semiconductor revenue for the past five years are shown in Figure 3. Capital spending and R&D costs have been steadily increasing; NEC has reinvested over one-quarter of its semiconductor revenue during the past two years. Although it took an early lead in the 256Kb DRAM race, NEC cut its capital spending to ¥30 billion or 6.2 percent of revenue because of the semiconductor downturn of 1986 and 1987. This action resulted in a loss of NEC's market-leading position to Toshiba and Hitachi in the 1Mb DRAM race. Subsequently, NEC has invested heavily to reestablish itself as a leading supplier of 4Mb parts, but the 4Mb race has virtually stalled as of the end of calendar 1991 with little or no return on investments.

Figure 3
NEC's Semiconductor Revenue and Investment



Source: Dataquest (February 1992)

Dataquest Perspective

NEC is well positioned to maintain a leadership role in many semiconductor, computer, and communications markets. The company has leveraged its future with investments in technological sophistication and aggressive financial strategies that should pay off in the long term as world economies rebound from the current slowdown.

By Junko Matsubara

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In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- Changing DRAM demand: analysis from DRAM applications
- Japanese companies' offshore production

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Semiconductors *Japan*

SCJA-SVC-DV-9202 February 3, 1992

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Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest online *DQ Monday Report* notes the difference in regional semiconductor prices.

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Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

By Dataquest's Japan Office *Page 2*

Market Analysis

Another Case of Premature Birth: Are 16Mb DRAMs Following the Path of 4Mb DRAMs?

This article analyzes the current state of DRAM production by Japanese manufacturers and the futures of 4Mb DRAMs and 16Mb DRAMs on the way to premature birth.

By Akira Minamikawa *Page 3*

Growing Semiconductor Investment and 16Mb DRAM Production Cause Some Concern in Japan

This article analyzes semiconductor investment in 1991 and strategies of Japanese manufacturers facing major uncertainty and deterioration of investment productivity in the midst of a moderately growing semiconductor market.

By Kazunori Hayashi *Page 7*

Company Analysis

Japanese Semiconductor Alliance Update: The Fourth Quarter of 1991

Dataquest reports Japanese semiconductor alliance trends and analyses on a quarterly basis. During the fourth quarter of 1991, we recorded 13 semiconductor-related strategic alliances.

By Junko Matsubara *Page 10*

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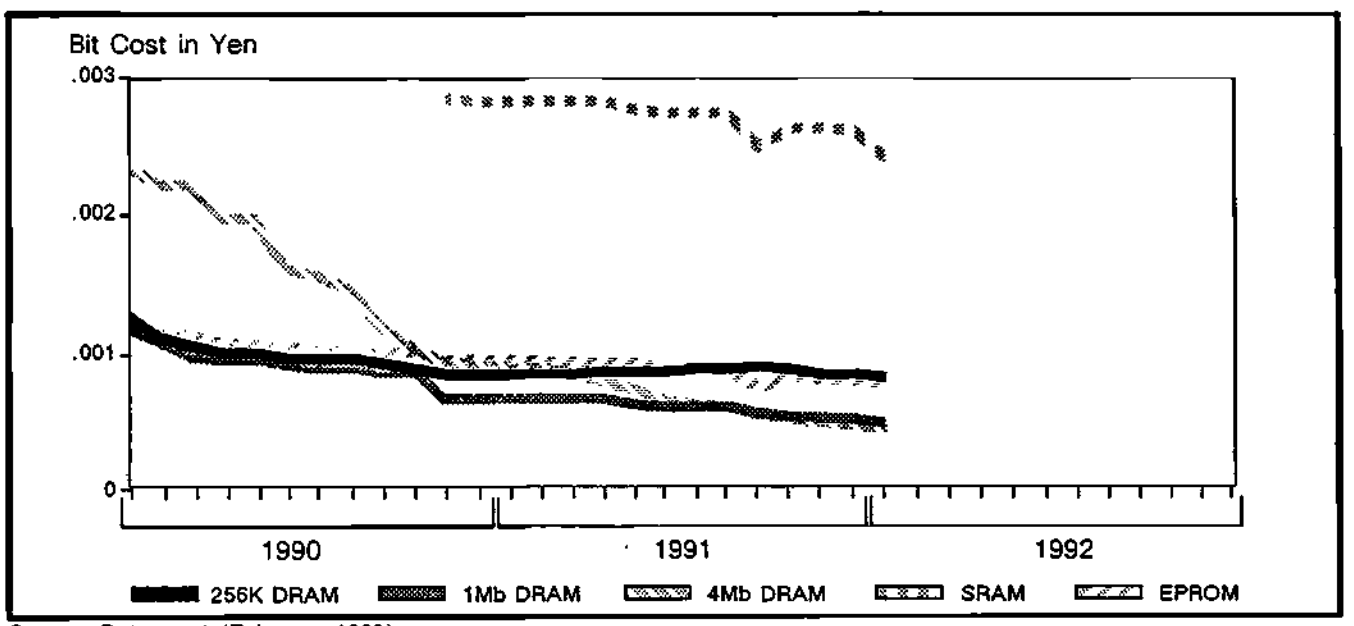
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.63	3.99	3.85	4.10	4.00	3.70
DRAM 256Kx1-8	1.55	1.71	1.60	1.43	1.30	1.10
DRAM 4Mbx1-8	13.25	14.75	15.30	17.00	17.00	13.80
EPROM 1Mb, 170ns	3.83	4.46	3.45	3.95	3.90	2.90
EPROM 2Mb, 170ns	7.60	8.77	6.70	7.75	7.90	5.70
SRAM 1Mb, 128Kx8	13.83	14.94	12.70	16.55	16.50	NA
SRAM 256K, 32Kx8	3.93	4.26	3.55	4.08	4.00	3.30
SRAM 64K, 8Kx8	2.15	1.63	1.90	1.55	1.40	1.30
68020-16	30.00	48.61	26.00	45.75	40.80	NA
80286-16	6.25	13.55	10.00	12.00	12.65	9.70
80386DX-25	140.00	164.15	144.00	178.50	174.00	NA
80386SX-16	46.50	64.15	53.00	57.00	55.50	48.00
R3000-25	121.00	147.43	132.00	NA	NA	NA

Note: These figures correspond with the *DQ Monday Report* dated January 20, 1992, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (February 1992)

Memory Bit Price In Japan



Source: Dataquest (February 1992)

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Market Analysis

Another Case of Premature Birth: Are 16Mb DRAMs Following the Path of 4Mb DRAMs?

Continuing a trend from 1990, the Japanese DRAM market presented another gloomy picture in 1991 by recording negative growth due to the sluggishness of the U.S. PC industry and a drop in DRAM prices resulting from overproduction. Thus, 1991 was a disappointing year despite high expectations for it to mark the beginning of a silicon cycle that was supposed to peak in 1992. This situation is clearly evident in 4Mb DRAMs, production of which is undergoing a period of adjustment; major suppliers including Hitachi Ltd. and Toshiba Corporation—originally planning to boost monthly production to 5 million by the end of 1991—are currently revising their production plans downward in response to the slow rise in demand.

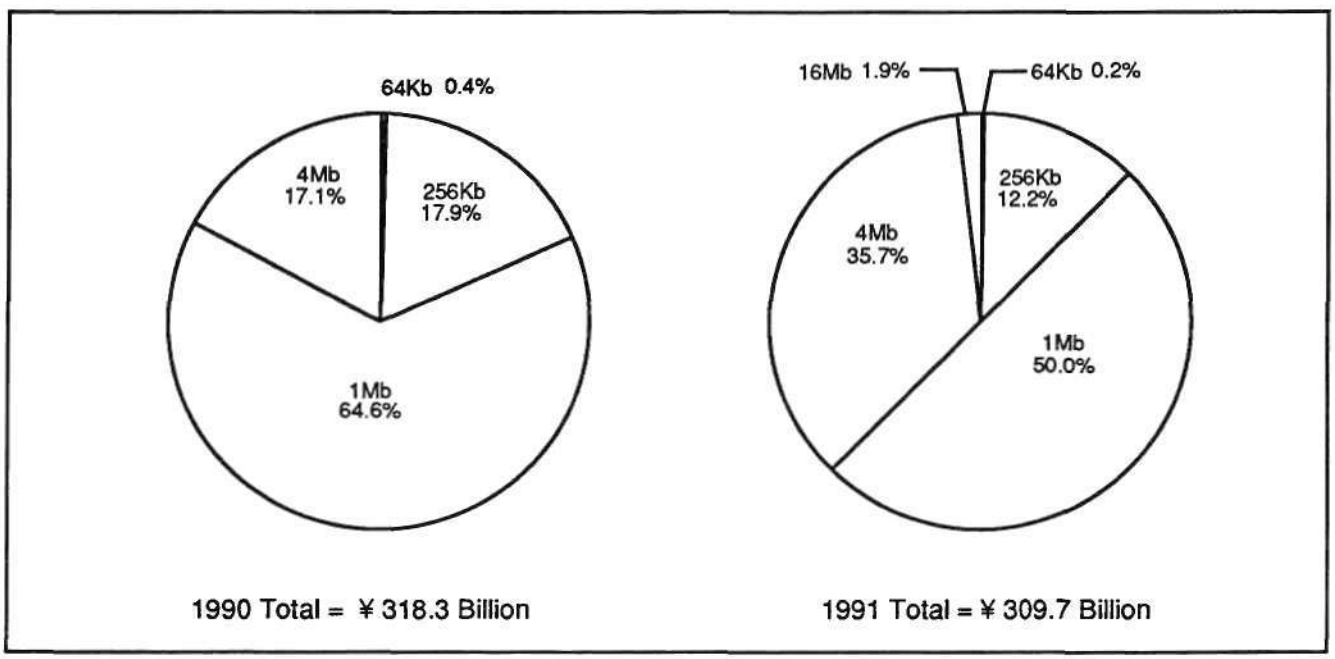
This article analyzes the current state of DRAM production by Japanese manufacturers and examines the futures of 4Mb DRAMs—some speculate a short life before full-fledged growth of demand—and 16Mb DRAMs on the way to premature birth.

Japanese DRAM Market in Perspective

The Japanese DRAM market in 1990 registered unit shipments of 392.05 million, amounting to ¥318.3 billion in revenue and representing a decline of 25.4 percent from 1989. In terms of bit growth, the 26.0 percent increase to 293 trillion bits was the lowest in history. Although bit growth regained an annual rate of 41.3 percent in 1991, Dataquest estimates that the plummeting of 1Mb and 4Mb prices, much faster than expected, pushed revenue back to ¥309.7 billion for a 2.7 percent decrease from 1990. Also, the rapid decline in 1Mb DRAMs seems to have put off the generation shift to 4Mb DRAMs expected in early 1991.

Figure 1 breaks down the Japanese DRAM market by density in 1990 and 1991. In 1990, 1Mb DRAMs accounted for 64.6 percent of the total market, while 4Mb DRAMs represented 17.1 percent; the 4Mb share grew to 35.7 percent in 1991. Dataquest believes that the Japanese DRAM market posted negative growth in 1991, in terms of both units and value, if transition to 4Mb DRAMs is taken into account. So 1991 marks the second consecutive year of negative growth on a unit basis for the first time since volume production of DRAMs started.

Figure 1
Japanese DRAM Market by Density



Source: Dataquest (February 1992)

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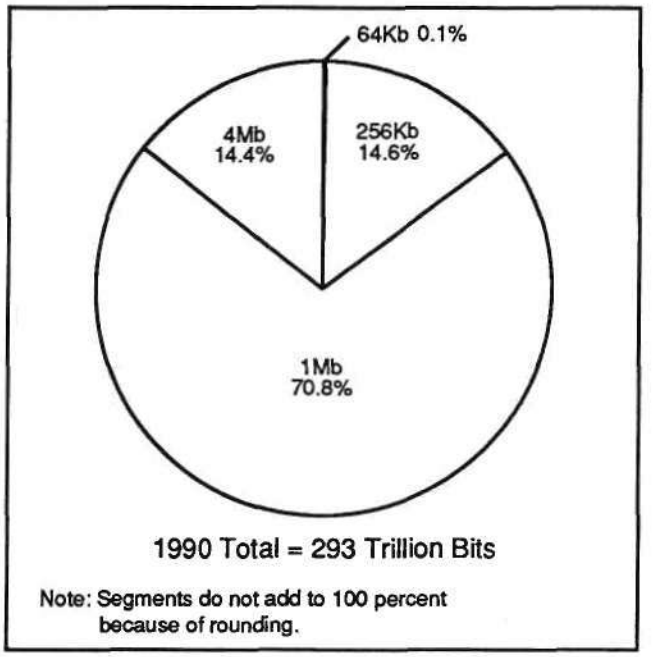
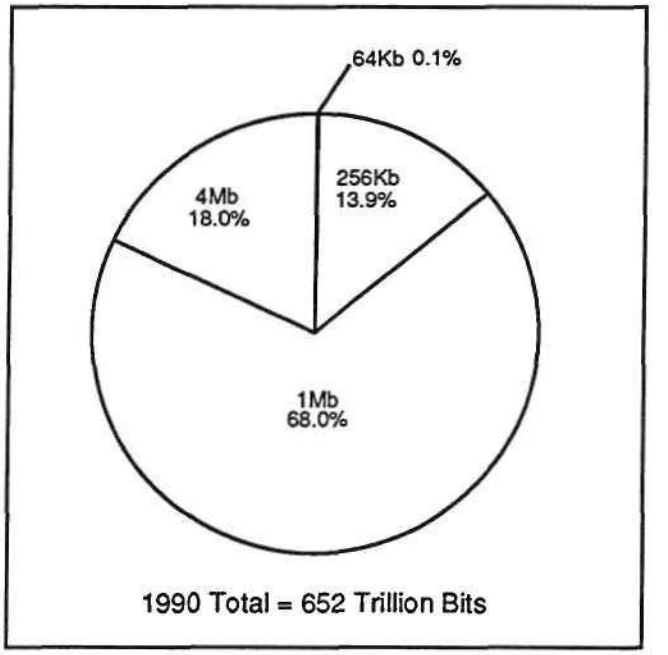
Figure 2
1990 Japanese DRAM Consumption by Density
(Trillions of Bits)



Source: Dataquest (February 1992)

Figure 3
1990 Japanese DRAM Production by Density
(Trillions of Bits)



Source: Dataquest (February 1992)

Obviously, an increasing gap between supply capacity and actual demand is penalizing DRAM suppliers.

Figures 2 and 3 indicate DRAM consumption and DRAM units produced by Japanese companies in 1990. The amount of DRAM production by Japanese makers reached 652 trillion bits in 1990.

Changes in DRAM production by Japanese makers, by generation, are examined in Figures 4 and 5. The figures indicate that there is no significant difference between generations in terms of accumulated production from the start of volume production (the period when total DRAM production by Japanese makers reached 1 million units per month) to the eighth quarter; 4Mb DRAM production shows a similar start-up pattern. Thus, the alleged sluggishness of 4Mb DRAM business seems to be exaggerated by a perception gap originating in high expectations of chipmakers and dramatic growth of the previous generation (1Mb DRAMs). Another factor is the rapid decline of 4Mb DRAM prices, which served as a major obstacle to the high profitability traditionally seen in the start-up period. In fact, shipments of 4Mb DRAMs on a bit basis refute the allegation by exceeding Dataquest's forecast of September 1990.

DRAM Shipments by Maker

Most Japanese DRAM manufacturers cut 256Kb production drastically in 1990, with the exception of Oki Electric Industries Company Ltd. and NMB Semiconductor. These two companies boosted production slightly. Interestingly, this approach represents a difference in DRAM strategy among Japanese suppliers. In 1990, NEC Corporation ranked first in sales of 256Kb DRAMs, Toshiba in 1Mb, and Hitachi in 4Mb. Toshiba led overall DRAM sales by ¥177 billion, followed by NEC (¥113 billion) and Hitachi (¥111 billion). Total sales by Japanese DRAM makers were ¥678 billion in 1990 and ¥680 billion in 1991, according to Dataquest's estimate.

In terms of the newest generations (4Mb and 16Mb), Japanese makers shipped 29.32 million units of 4Mb DRAMs in 1990, accounting for 92.4 percent of the worldwide total. In 1991, 4Mb shipments are estimated to have reached

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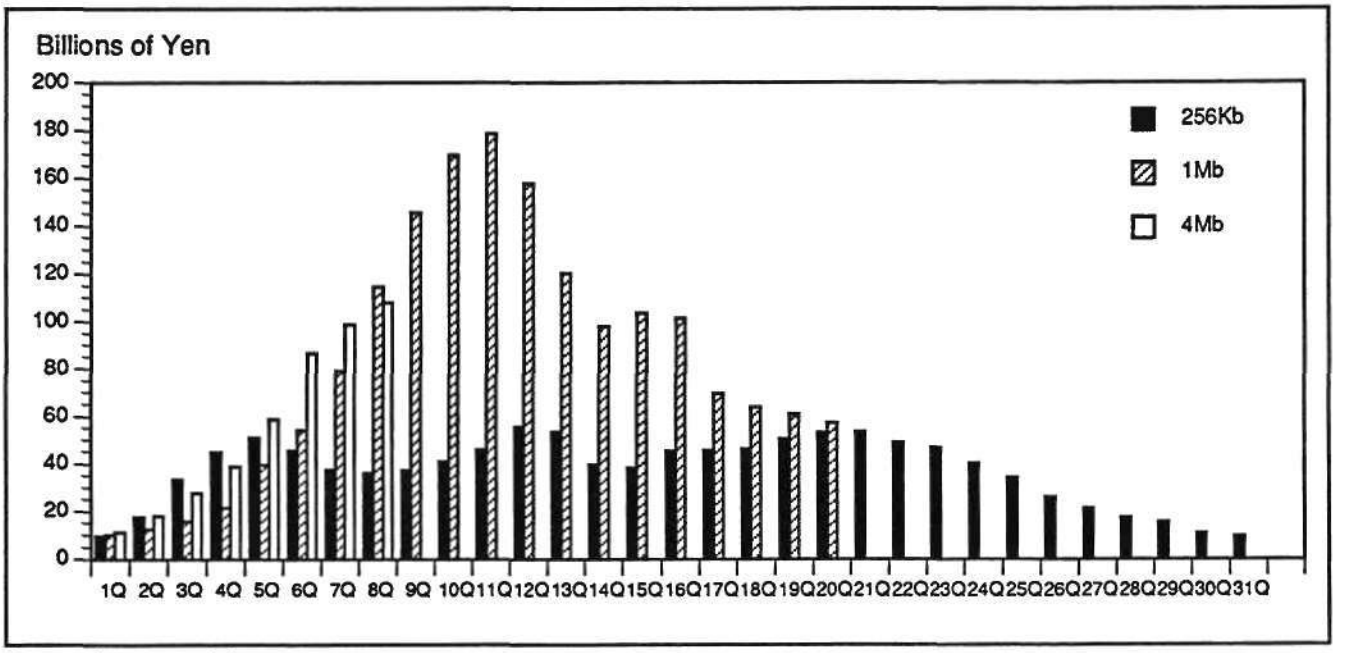
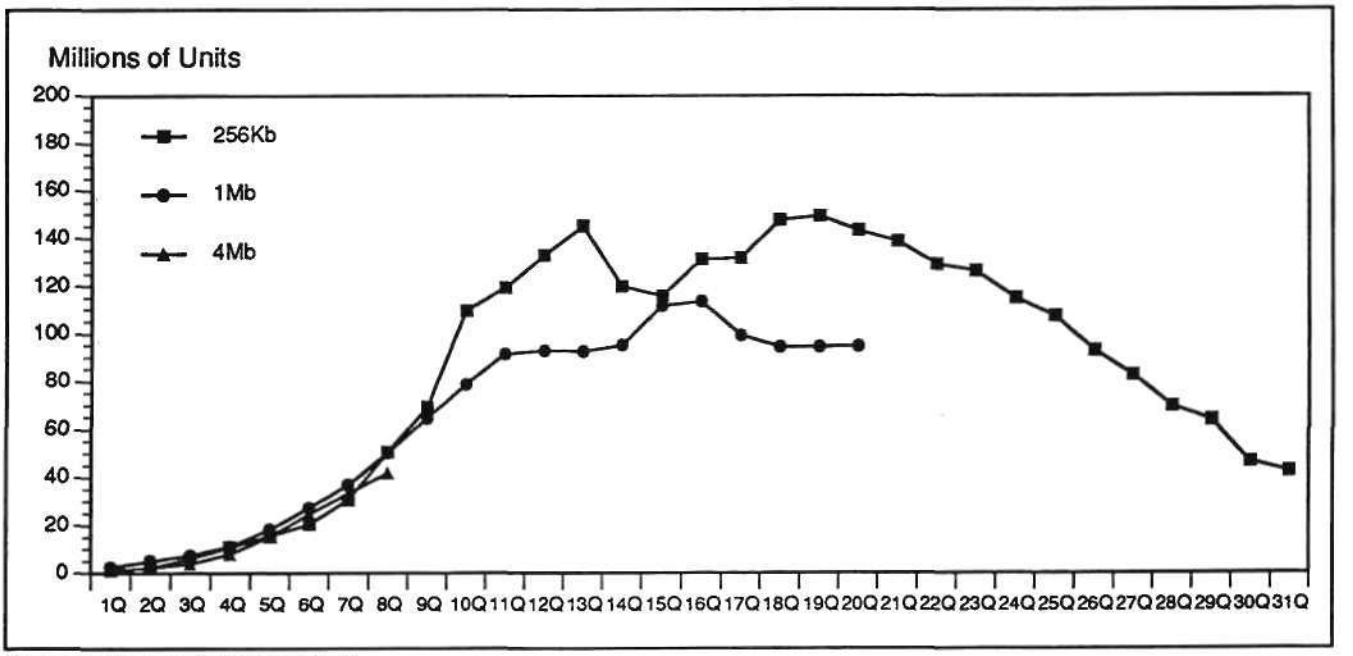
Figure 4
Japanese DRAM Manufacturer Revenue by Density



Source: Dataquest (February 1992)

Figure 5
DRAM Production by Japanese Manufacturers



Source: Dataquest (February 1992)

125.12 million units and 16Mb are estimated at 200,000 units. Currently, Hitachi takes a lead in 4Mb monthly production by 3.2 million units, followed by Toshiba (2.9 million), NEC (2.2 million), Fujitsu Ltd. (2.1 million), and Mitsubishi Electric (1.6 million). On the other hand, Fujitsu

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leads the 16Mb production race—volume production was started in the second quarter of 1991—by 10,000 units monthly, followed by Hitachi and Toshiba, each producing 5,000 units. Because the race has just started, it is difficult to say which company will win.

Changing DRAM Cycle

In 1988, Japanese makers produced 179.45 million units of 1Mb DRAMs, 41.3 percent of which (74.1 million units) were consumed in Japan. Three years later, they are estimated to have produced 125.12 million units of 4Mb DRAMs; domestic consumption accounted for 31.9 percent, or 40 million units. In the Japanese market, the major consumers of DRAMs are data processing (EDP) equipment (75 percent), telecommunications equipment (10 percent), and other electronic equipment (15 percent). Among EDP applications, PCs are the largest segment, accounting for approximately 26 percent of the total. However, it is no longer true that the PC market gobbles up DRAMs with higher densities, as seen in 256Kb and 1Mb. To make matters worse, the longer product life cycle for recent generations has led to an increase in overall DRAM production.

Another new and notable trend is that the product life cycle is prolonged to keep pace with the increase in applications as well as the advancement of electronic systems, although a peak production level has dropped for each generation. This means that the technological advance in DRAMs has passed that of electronic systems; therefore, DRAMs have to be supplied longer to wait for development of suitable systems. Dataquest believes that this situation also applies to 16Mb DRAMs, as illustrated by the relationship between DRAM prices and the generation shift.

In 256Kb and 1Mb devices, the crossover occurred when the new generation's price fell to a level about five times that of the previous generation, and it was further accelerated as the price difference narrowed to four times. Currently, the 4Mb price has fallen to less than four times that of 1Mb, but PC makers still consume large quantities of 1Mb devices.

Currently, 4Mb DRAM makers are expanding their product lines by adding multibit products, including x8 and x16, in an attempt to widen applications. In fact, although 4Mb DRAMs are increasingly used in workstations, they are not widely adopted by the major consumer (PCs) because 4Mb is not offering much of DRAM's traditional advantage (scale advantage) in implementing smaller PCs with high performance by housing highly integrated memories in a high density. When 64Kb and 256Kb devices were used for PC main memories, consuming 20 to 30 units each, introduction of larger memories brought significant economy of scale. In contrast, today's main memory (2MB) requires only one 16Mb DRAM, so that the use of 16Mb is not currently under consideration by many PC designers. Thus, introduction of 16Mb devices with high per-bit cost is not likely to cause a generation shift.

Nevertheless, one thing remains unchanged: The PC market will continue to be the largest consumer of DRAMs in years to come. Dataquest believes that the PC market is currently facing difficulties after its rapid growth period and is in the middle of transition to a larger market—home-use PCs. Unlike the United States, Japan has no social climate to accelerate the use of PCs by general households. One major opportunity is introduction of PCs into education, which also would demand more user-friendly features.

In 1991, the PC market took a decisive step toward a truly user-friendly environment. Windows 3.0, Macintosh System 7.0, Netware 386 V3.1J, and LAN Manager 2.0 marked the beginning of operating systems emphasizing utilities and operability, and Dataquest predicts that they will serve as an impetus for future growth of the PC market.

4Mb and 16Mb DRAMs Meet PC/Workstation Markets

Dataquest believes that the peak production level for 1Mb DRAMs is lower than for 256Kb and that the 4Mb will be even lower. One reason for our assumption is the net decrease in the number of DRAM makers. In Japan, there were 10 manufacturers competing in the 256Kb DRAM business. After 1Mb DRAMs became a mainstay of the market, 2 companies virtually stopped production for the merchandise market. And in 4Mb DRAMs, 6 companies account for 99 percent of total production.

As mentioned earlier, the Japanese DRAM market as measured by bit growth rate increased at an annual 41.3 percent in 1991 and is expected to record a compound annual growth rate (CAGR) of 50.1 percent between 1990 and 1995. Approximately 240,000 workstations and 4.2 million PCs will be produced in 1995. Most of these workstations will use 16Mb DRAMs, amounting to 9.6 million units, as Dataquest estimates that each workstation will consume an average 80MB of DRAM. Based on these

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figures, 4Mb and 16Mb markets in Japan will reach 184 million units and 72 million units, respectively, in 1995. Thus, Dataquest expects market segmentation in the coming years; the PC market will be dominated by 4Mb DRAMs, but 16Mb DRAMs will be mainly used in workstations and other high-end machines.

Dataquest Perspective

As DRAMs assume a role of technology driver for the semiconductor industry, R&D in DRAM technology is indispensable and its results need to be commercialized. However, if such technological advancement is implemented only to increase the number of processes as well as chip area, DRAM makers face the issues of ever-increasing capital investment and lower yield.

Generally speaking, after 256Kb DRAMs, the chip area has been increasing by 1.5 times and the number of photoetching processes by 1.3 times for each new generation. Furthermore, submicron-level process technology, superclean rooms, high vacuum, and ultrapure water all add to production costs.

The use of these technologies for 16Mb DRAMs has resulted in a gigantic investment that can be a heavy burden on a single company, even for a leading semiconductor manufacturer. Therefore, future R&D efforts related to DRAM technology should be directed to process simplification for lower capital expenditure and yield improvement. Forecast of the 16Mb DRAM market would take into account, in addition to conventional factors, changes in technological aspects, including demand shift due to price fluctuation, 3V specifications adopted from 16Mb DRAMs, and increasing application-specific design.

Nevertheless, market acceptance of 16Mb DRAMs will be delayed, in comparison with 4Mb DRAMs. Dataquest believes that 16Mb production capacity has already exceeded demand and may soon reach an oversupply level. If the situation continues, the 16Mb market will face price erosion due to overproduction—just as the 4Mb market is experiencing now—running the risk of losing an opportunity to recover initial investment. The time has come to recognize that premature introduction of a new product will deteriorate profitability for semiconductor manufacturers. Their future success lies in their ability to make a timely shift of focus in sales strategy from revenue to profitability.

By Akira Minamikawa

Growing Semiconductor Investment and 16Mb DRAM Production Cause Some Concern in Japan

Growth of capital spending by Japanese semiconductor makers has continued into 1991. This growth is related to development of production capacity for the next-generation 16Mb DRAMs and R&D on 64Mb DRAMs. At the same time, Japanese makers are active in offshore investment. Parallel to aggressive domestic investment toward 1992—the peak year of the silicon cycle. However, a slowdown in growth of the semiconductor market is projected to cause serious concern about this seemingly nonstop expansion of capital investment. Today, 19 fab lines are already capable of 16Mb DRAM production, which portends overproduction in the future.

This article analyzes semiconductor investment in 1991 and some strategies of Japanese manufacturers facing major uncertainty and deterioration of investment productivity in the midst of a moderately growing semiconductor market.

Trends in Capital Spending by Japanese Makers

Yearly changes in investment by Japanese semiconductor makers between 1988 and 1992 are shown in Figure 1. As seen here, the compound annual growth rate (CAGR) of capital spending between 1988 and 1992 is 8 percent. Significant is the increase in offshore capital spending, which has accelerated since 1988 as a result of establishment of offshore production bases by Japanese semiconductor manufacturers. The CAGR of domestic capital spending for the period from 1988 to 1992 is 5 percent, and the CAGR of offshore capital spending during the same period is 41 percent. In 1991, capital spending by Japanese semiconductor makers grew 1.4 percent from the previous year; domestic capital spending increased by 1.5 percent and offshore capital spending by 0.9 percent. Domestic capital spending was largely poured into the next-generation memory, 16Mb DRAMs. Major purposes of offshore capital spending were the construction or addition of production lines, particularly in the United States and Europe.

Major characteristics of capital spending—both domestic and overseas—by Japanese makers are analyzed in the following sections.

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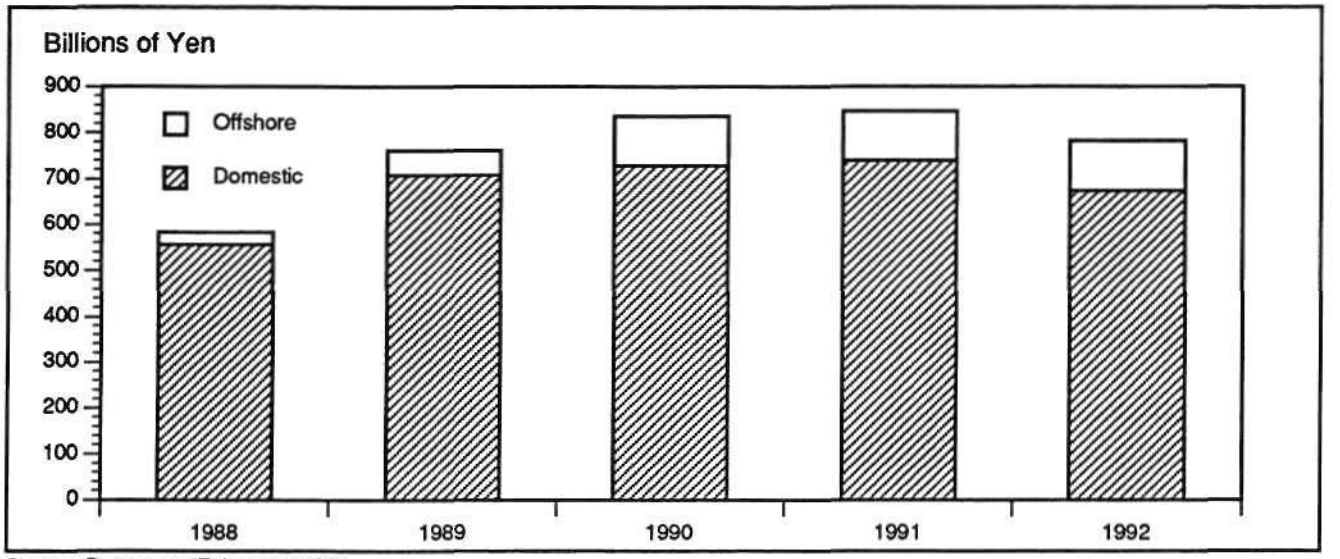
Figure 1
Capital Spending by Japanese Companies



Source: Dataquest (February 1992)

Domestic Capital Spending: Weight on 16Mb DRAMs

Capital spending related to next-generation 16Mb DRAMs has been on the increase. Volume 16Mb production relies on process technology based on 0.5- to 0.6-micron rules and introduction of the 8-inch wafer process, which is the key to expanded production capacity. In Japan, there are 19 fab lines capable of producing 16Mb DRAMs, including those under construction or planned (see Table 1). Hitachi Ltd. was the first to announce 16Mb volume production capability. The Hitachi fab is also equipped with 64Mb capability for the future. The process line is capable of implementing 0.5-micron and then 0.3-micron design rules.

Hitachi's major competitors are also ready to start volume production. NEC Corporation plans to start 16Mb production at NEC Hiroshima and NEC Kyushu in addition to the pilot line at its Sagamihara fab in Kanagawa Prefecture. NEC Kyushu will introduce an 8-inch wafer process line. Toshiba will produce 16Mb DRAMs at Toshiba Oita—a memory production base—and at its newly constructed Yokkaichi fab in Mie Prefecture. Considering that construction of a 16Mb DRAM fab is estimated to cost ¥100 billion in the initial phase and an additional ¥100 billion in the second and third phases to add new lines, Dataquest believes that it is about time to make efforts to stop further deterioration of productivity in capital spending related to semiconductors.

Offshore Capital Spending: Focusing on 4Mb DRAMs

Japanese semiconductor manufacturers started offshore production in the 1970s and have expanded operations since then, driven by trade friction and the appreciation of the yen. Dataquest estimates that offshore capital spending in 1991 grew approximately 0.9 percent from the previous year, reaching ¥107 billion. Among other regions, construction of production lines is a major focus in Europe, with an eye to the unification of the European Community (EC) this year. Hitachi and Mitsubishi are building 4Mb DRAM fabs in Germany, while Fujitsu Ltd. is also constructing a 4Mb DRAM fab in the United Kingdom.

In the United States, Matsushita is equipping a fab acquired from National Semiconductor with a submicron process for 4Mb DRAM production. Sony plans to start production of SRAMs at a San Antonio, Texas, fab acquired from Advanced Micro Devices. In Southeast Asia, assembly lines are increasing in response to relocation of system makers. Also, Canon

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Table 1
16Mb DRAM Fab Lines in Japan

Company	Location	Plant Name	Fab Name	Operating Year	Wafer Size
Fujitsu	Mie	Mie	No. 3	1989	6
Fujitsu	Iwate	Iwate	NA	1993	8
Hitachi	Yamanashi	Kofu	K-2	1990	6
Hitachi	Ibaragi	Naka	N-2	1992	8
Matsushita	Toyama	Tonami	Fab 2	1993	8
Matsushita	Toyama	Uozu	NA	1992	6
Mitsubishi	Ehime	Saijo	NA	1993	8
NEC	Kumamoto	NEC Kyushu	No. 8	1992	8
NEC	Hiroshima	NEC Hiroshima	Phase 2	1995	8
NEC	Hiroshima	NEC Hiroshima	Phase 3	1994	8
NEC	Hiroshima	NEC Hiroshima	Phase 4	1995	8
Oki	Miyagaki	Oki Miyazaki	M3	1992	6
Oki	Miyagi	Oki Miyagi	No. 2	1994	8
Sanyo	Niigata	Niigata	No. 5	1993	6
Sanyo	Niigata	Niigata	No. 6	1994	8
Sharp	Hiroshima	Fukuyama	Fab 3	1993	8
Toshiba	Oita	Oita	Step 4	1992	6
Toshiba	Oita	Oita	Step 5	1994	8
Toshiba	Mie	Yokkaichi	Phase 2	1993	8

NA: Not available
Source: Dataquest (February 1992)

plans to start 16Mb DRAM production jointly with Hewlett-Packard Company and Texas Instruments at the invitation of the government of Singapore. Such joint production, we believe, indicates a future direction for the industry.

Dataquest Perspective

Dataquest estimates that domestic capital spending by Japanese semiconductor makers in 1992 amounted to ¥675 billion, most of which was directed to production of 16Mb DRAMs. Currently, there are 19 fab lines known to be capable of 16Mb production, excluding pilot lines. Assuming that all of these lines are operated for 24 hours per day, processing an average of 18,000 8-inch wafers per month to produce 200 chips each, the current maximum production capacity of 16Mb DRAMs is 820.8 million units. However, Dataquest predicts that the peak demand for 16Mb DRAMs will be 600 million units in 1996, clearly indicating that the current capacity already exceeds the expected demand. This would force DRAM makers to adjust their capital spending strategies, particularly regarding 16Mb DRAMs.

Finally, the end of the bubble economy and the securities scandal are virtually prohibiting corporate financing at low interest rates. This situation significantly affects the semiconductor industry, which has sizable financial requirements for capital spending. Most device manufacturers are expected to report reduced profits; therefore, it is inevitable that they will adjust their capital spending plans downward. All in all, Dataquest estimates that capital spending in Japan in 1992 will be reduced 8 percent from the previous year.

By Kazunori Hayashi

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Company Analysis

Japanese Semiconductor Alliance Update: The Fourth Quarter of 1991

During the fourth quarter of 1991, which ended on December 31, Dataquest recorded 13 new alliance agreements involving Japanese semiconductor companies (see Table 1).

Dataquest classifies strategic alliances into the following major categories, as applied in Table 1.

- LA—Licensing agreement
- SS—Second-source agreement
- SA—Sales agency agreement
- FA—Fab agreement
- AT—Assembly and testing agreement
- TE—Technology exchange
- JV—Joint venture
- JD—Joint development
- IV—Investment
- CO—Coordination of standard
- PC—Procurement agreement
- OT—Other

HDTV Cooperative Effort

High-definition TV (HDTV) is expected to become a $2.5 billion market by the year 2000, which would make it a major semiconductor application market by volume alone. Because HDTV will combine and upgrade today's TV technology with aspects of what is now referred to as multimedia technology, there is support for the perception that HDTV technology is the logical evolution of both TV and personal computers as we currently define these separate technologies. This perception of HDTV makes involvement in its development more than an investment toward producing a sophisticated consumer electronics product. For both consumer electronics and computer companies, HDTV will encompass most or all of their technologies. HDTV is thus expected to play a significant role as a system-level driver of building block technologies such as chip and display panel manufacturing. In turn, these building blocks will drive fabrication technologies as leading-edge DRAM or microprocessor circuits have in the past.

Therefore, many electronics companies worldwide, including Japan's major corporations, regard HDTV as an integral part of their long-term strategies. These strategies have manifested themselves by the increased participation in joint

Table 1
Japanese Semiconductor Alliances (Fourth Quarter of 1991)

Company 1	Company 2	Product	Agreement Type	Date
Oki	Bull	IC cards	LA	10/91
Asahi Kasei Microsystems	Int'l Microelectronics	Programmable filters	SA, JD	10/91
Fujitsu	Cadence	ASIC design tools	JD	10/91
Kobe Steel	Texas Instruments	ASICs	SA	10/91
Toshiba	Siemens/IDT	RISC MPUs	SA, JD	10/91
Mitsubishi	Benz Group	Bipolar analog ICs	JD	10/91
Toshiba	Photon Dynamics/InSystems Applied Materials	LCD process equipment	JD	11/91
Shibasoku	Credence	Semiconductor test equipment	SA, JV, JD	11/91
Eight Japanese Companies	LSI Logic/VLSI Technology	MUSE decoder chip	JD	11/91
Hitachi	Texas Instruments	64Mb DRAM	JD	11/91
Toshiba	Siemens	MIPS RISC MPUs	JD	11/91
Matsushita	Philips/Signetics	Consumer CMOS ICs	FA	12/91
Kokusai Electric	BTU International	Thermal processing system	JV	12/91

Source: Dataquest (February 1992)

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ventures directed at HDTV-related projects by Japanese companies. This is not surprising, as establishing a universal HDTV standard by definition necessitates cooperation or at least consensus. Furthermore, as Dataquest frequently emphasizes, joint ventures offer diversification of risk, which is particularly true for projects requiring large R&D expenditure over extended periods. Many new HDTV alliances are also formed out of a need to gain access to complementary and/or enabling technologies that can yield chip set implementations of complete HDTV subsystems. Finally, the participation of Japanese corporations in alliance agreements involving U.S. companies offers the added benefit of demonstrating a politically correct response to the U.S.-Japan Semiconductor Trade Arrangement renewed in August 1991.

Eight Japanese companies, together with two U.S. companies, formed an alliance to codevelop a MUSE decoder originally proposed by NHK (Japan Broadcasting Corporation) that has become Japan's current HDTV standard. Prior to this alliance, two separate teams were formed during the third quarter of 1991 to address HDTV technology development: Sanyo allied itself with LSI Logic, and Fujitsu, Hitachi, Sony, and Texas Instruments entered into a joint development agreement. During the fourth quarter, Shibasoku and Credence Systems agreed to jointly develop semiconductor test equipment specifically designed for testing HDTV chips. Also during that period, Matsushita, NHK, Oki, and Dainippon Printing formed a team to develop a color plasma display for HDTV applications.

Promising Multimedia Alliances

During the fourth quarter of 1991, large Japanese electronics companies formed several alliances in areas not specifically related to their semiconductor businesses but that would certainly have an impact on this segment of their business. Sony has allied itself with Apple and Motorola to develop multimedia PCs. In a competing effort, Matsushita announced that the company had agreed to jointly develop multimedia workstations with Sun Microsystems. Prior to these multimedia ventures, Fujitsu and NEC invested in a joint program initiated by software giants Microsoft and AT&T to develop multimedia standards. Hitachi and IBM have also joined forces to mutually produce and market each other's PCs.

Although these alliances are not yet explicitly related to semiconductor chip development efforts, multimedia platforms have implicit hardware requirements that are sure to lead to multimedia application-specific chip designs. Because many Japanese electronics companies are both vertically and horizontally integrated, semiconductor chip design efforts will probably be exploited to gain competitive advantage in manufacturing systems with performance and cost differentiations.

Dataquest Perspective

The number of semiconductor alliance involving Japanese companies reached 87 during 1991. Although this total was one short of the number recorded in the previous year, it shows that the formation rate during the past three years has been basically constant. Dataquest maintains that the strategic alliance has established itself as an essential and effective business practice. Alliances involving HDTV and multimedia will flourish during 1992. These partnerships will be used to codevelop chip sets, display technologies, standards, and complete systems.

Strategic Alliances

The following paragraphs briefly summarize some strategic alliances recorded by Dataquest during the fourth quarter.

Toshiba/Photon Dynamics/InSystems/Applied Materials
Toshiba will cooperate with three U.S. companies to jointly develop diagnostic and manufacturing equipment for TFT LCD production.

Eight Japanese Companies/LSI Logic/VLSI Technology
Two U.S. companies, LSI Logic and VLSI Technology, will participate in an alliance to develop an HDTV MUSE decoder chip set in Japan. The eight Japanese participants are Matsushita Electric Industrial, Matsushita Electronics, Mitsubishi Electric, NEC, NEC Home Electronics (NEC HE), Pioneer, Sharp, and Victor Company of Japan (JVC).

LSI Logic will work on audio chips, while VLSI Technology will handle color processing ICs. Matsushita Electric Industrial will develop frame memory and motion detection circuitry with its affiliate Matsushita Electronics. Mitsubishi will design and produce input/output (I/O) processing chips. NEC and its sister

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organization NEC HE will create other signal processing circuits. Finally, Pioneer, Sharp, and JVC will work on the chips governing digital signals and picture quality.

Hitachi/Texas Instruments
Hitachi and TI signed a 64Mb DRAM development agreement. The two companies also agreed to extend their contract for 16Mb DRAM development until the end of 1994. Hitachi and TI will jointly design 64Mb DRAMs by setting up a design team at TI Japan's Miho plant. They will also develop a design automation environment, 0.35-micron processing technology, reliability and evaluation standards, and packages.

Toshiba/Siemens
Toshiba agreed with Siemens to cooperate in RISC microprocessor development. The two companies will jointly design RISC MPUs based on the MIPS Computer Systems' R3000/4000 MPUs and peripheral LSIs and will mutually supply the MPUs by OEM. Both companies have R3000/4000 manufacturing and sales contracts with MIPS.

Matsushita/Philips/Signetics
Signetics, a subsidiary of Philips Electronics NV, will manufacture and assemble significant quantities of IC for Matsushita. Under the agreement, Signetics will build consumer-oriented CMOS digital ICs for Matsushita in its New Mexico fab and will assemble the parts in its plant in Thailand. With the link-up, the Matsushita group aims to give a lift to the microchip operations of Philips, the Dutch electronics giant that is in a slump. Signetics will produce 9,000 wafers per month for Matsushita.

By Junko Matsubara

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- New semiconductor fab lines
- Japanese silicon wafer industry

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Dataquest Perspective

Semiconductors *Japan*

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In This Issue...

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

The volume contract pricing taken from the latest on-line *DQ Monday* notes the difference in regional semiconductor prices.

By Dataquest Regional Offices *Page 2*

Memory Bit Price in Japan

The figure illustrates current memory bit prices in the Japanese market.

By Dataquest Japan Office *Page 2*

Market Analysis

Preliminary 1991 Japanese Semiconductor Market Shares

According to Dataquest's preliminary 1991 worldwide semiconductor market share estimates, global semiconductor sales totaled $64,914 million. The Japanese market represented $25,951 million, or 40 percent of the total market.

By Junko Matsubara *Page 3*

Product Analysis

Structural Changes in DRAM Demand

DRAM demand is changing its face and deviating from the traditional life cycle. This article examines what is changing in DRAM demand now by looking at the electronic data processing equipment market.

By Akira Minamikawa *Page 11*

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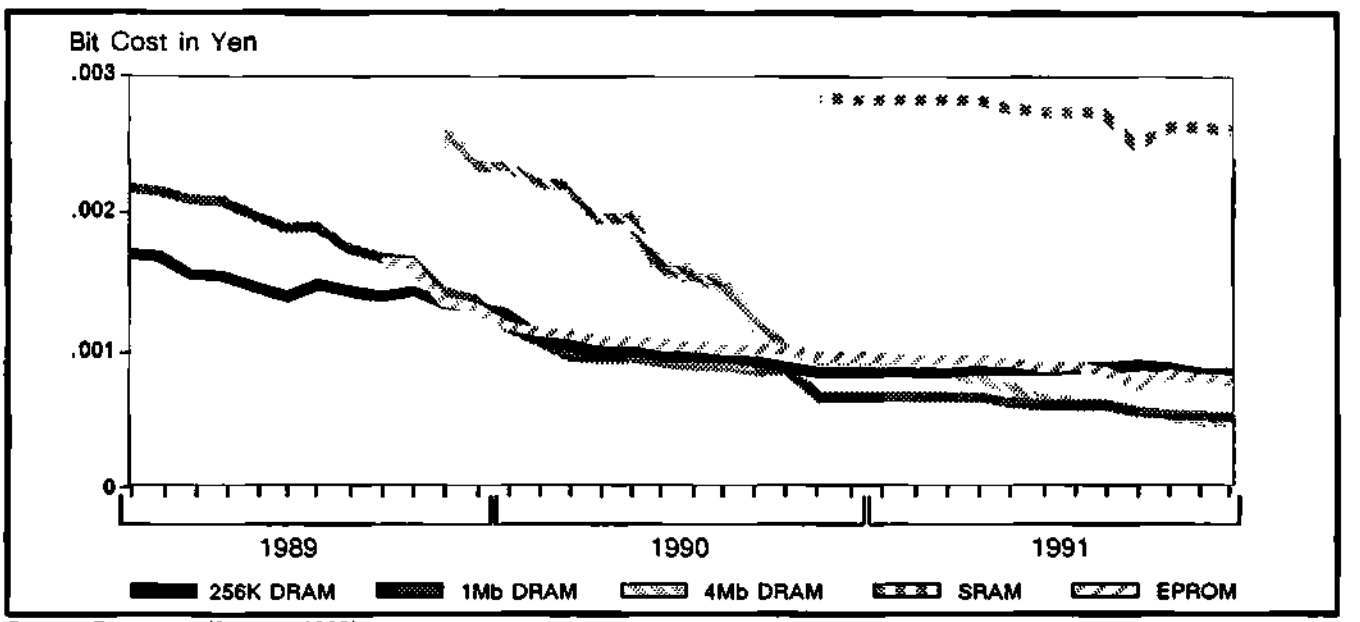
Regional Pricing Update

DQ Monday Report: Volume Mean Pricing

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
DRAM 1Mbx1-8	3.70	4.00	3.80	4.25	4.10	3.75
DRAM 256Kx1-8	1.65	1.66	1.70	1.43	1.40	1.10
DRAM 4Mbx1-8	14.05	14.66	16.00	17.35	17.20	13.80
EPROM 1Mb, 170ns	3.85	4.44	3.60	4.25	4.00	3.80
EPROM 2Mb, 170ns	7.68	8.49	7.00	7.80	8.00	7.00
SRAM 1Mb, 128Kx8	14.00	14.86	13.30	17.10	17.80	NA
SRAM 256K, 32Kx8	3.93	4.13	3.60	4.25	4.30	3.30
SRAM 64K, 8kx8	2.13	1.59	1.85	1.60	1.50	1.30
68020-16	31.00	46.24	26.00	45.75	42.00	NA
80286-16	11.75	13.45	12.00	12.00	12.80	12.70
80386DX-25	147.50	164.74	160.00	178.50	181.00	NA
80386SX-16	48.25	64.14	55.00	57.00	57.00	55.00
R3000-25	125.00	143.91	132.00	NA	NA	NA

Note: These figures correspond with the *DQ Monday Report* dated December 16, 1991, and reflect prices in U.S. dollars.
NA = Not available
Source: Dataquest (January 1992)

Memory Bit Price in Japan



Source: Dataquest (January 1992)

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Market Analysis

Preliminary 1991 Japanese Semiconductor Market Shares

Dataquest's preliminary 1991 worldwide semiconductor market share figures for all corporate entities with a significant share of any major worldwide market have been compiled. On the basis of these figures, total worldwide semiconductor sales are now estimated to be $64,914 million for the year, representing an 11.5 percent increase over 1990 sales.

As the single largest entity of the worldwide semiconductor market, the Japanese market is gauged at $25,952 million, or about 40.0 percent of the total market. The North American market is the next largest at $18,158 million, or 28.0 percent of the worldwide market. The Japanese and Rest of World (ROW) markets expanded during 1991, while the U.S. and European markets shrank (see Table 1).

In terms of suppliers to all markets, Japanese companies captured 49.7 percent of 1991 worldwide semiconductor sales. Compared with last year's final figure of 48.7 percent, Japanese suppliers increased their worldwide market share by 1 percent. Although Japanese suppliers lost market share in their home market in 1991, they maintained a clear dominance in the Japanese semiconductor market with an 87.8 percent market share (see Table 2).

The Markets

Worldwide Market

Despite slow economies in much of the world, worldwide semiconductor revenue grew 11.5 percent in 1991, primarily because of robust Japanese and ROW markets. In contrast, the North American market grew just 4.4 percent.

For nearly a decade, Japanese semiconductor companies have steadily increased their share of the worldwide semiconductor market. In 1986, U.S. and Japanese suppliers experienced a role reversal in worldwide semiconductor market share leadership; this turning point led to intensified U.S.-Japan trade friction. Trade tension again mounted when, in 1988, Japanese suppliers' market share exceeded half of the worldwide market. Although Japanese companies experienced their first decline in worldwide market share in 1990, 1991 saw Japanese corporations reestablish a market share growth trend of approximately 1 percent per year.

Table 1
Worldwide Semiconductor Market by Region (Millions of Dollars)

	1989	1990	1991*	1990-1991 Percent Change	Percent of 1991 Worldwide Market
North America	17,937	17,386	18,158	4.4	28.0
Japan	22,997	22,508	25,951	15.3	40.0
Europe	9,755	10,661	11,366	6.6	17.5
Asia/Pacific-ROW	6,524	7,670	9,439	23.1	14.5
Total	57,213	58,225	64,914	11.5	

*Preliminary
Source: Dataquest (January 1992)

Table 2
Suppliers' Market Share of Japanese Semiconductor Market (Millions of Dollars)

				Market Share (%)		
Supplier	1989	1990	1991*	1989	1990	1991*
North America	2,162	2,402	2,816	9.4	10.7	10.9
Japan	20,628	19,825	22,789	89.7	88.1	87.8
Europe	130	164	181	0.6	0.7	0.7
Asia/Pacific-ROW	77	117	165	0.3	0.5	0.6
Total	22,997	22,508	25,951			

*Preliminary
Source: Dataquest (January 1992)

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Japanese Market

A statistical history demonstrates that the Japanese economy can be described by a cyclic function, which has expansion periods characterized by a positive derivative of GNP with respect to time and is now officially referred to as "Heisei Boom." Most of the Japanese economy in 1991 coincided with the conclusion of the longest-running Heisei Boom recorded. Although the boom was forecast to conclude near the beginning of 1991, it lasted until the third quarter. This period of boom buoyed semiconductor revenue as Japanese consumer spending and corporate investments showed a positive response to the economic indicators that are also used to monitor the Heisei Boom.

The Japanese market constituted $25,951 million, or 40 percent of the worldwide market in 1991, which clearly ranked it as the single largest semiconductor market. On the basis of a dollar value computation, the Japanese market grew 15.3 percent relative to the previous year's market. A substantial amount of this apparent growth may be a reflection of the strong 5.6 percent appreciation of yen against the U.S. dollar during 1991.

This distortion might occur for two reasons. The first is that foreign market share of the Japanese market has not increased as substantially as would be expected from the pricing advantages posed by the appreciation of the yen relative to other currencies. The second reason is that because Japanese companies hold so much of their own market, their reported yen cost per unit probably has not been affected by yen appreciation. This is particularly true of the high percentage of captive sales consumed internally by many of the large, vertically integrated Japanese companies. These two factors, under worst case conditions, could conceivably contribute 5 percent to the overall growth rate percentage based on a dollar value computation. Indeed, a yen-based calculation yields a Japanese market growth rate of just 8.9 percent for 1991.

On the basis of a supplier's country of origin, North American companies increased their share of the Japanese market to 10.9 percent, up from 10.7 percent in 1990 (see Table 2). The U.S.-Japan Semiconductor Trade Arrangement was renewed in August 1991, and Japanese companies have been under growing pressure to purchase more foreign-made chips. Some measure of response to this pressure is indicated by the combined North American, European, and ROW market share, which rose to 12.2 percent of the Japanese market in 1991. This figure is still far short of the 20 percent level specified in the new agreement.

Not surprisingly, the top 10 positions in the rankings of suppliers to the Japanese market were all occupied by Japanese companies. Within the top 10, Matsushita and Mitsubishi exchanged positions from their 1990 rankings as semiconductor suppliers. This probably resulted from Mitsubishi's 10.6 percent decline in growth in its MOS memory product line, which limited total MOS digital growth to just 4.6 percent. On the other hand, Matsushita achieved a 38.2 percent growth rate in its MOS product lines, which gave it a 25.8 percent overall growth in semiconductor sales to help propel the company past Mitsubishi in the rankings.

Breakdown by Product

Table 3 shows the preliminary 1991 Japanese market broken down by product. Figure 1 gives the 1991 product growth rates, expressed as a percentage change with respect to 1990 rates, occurring in both the worldwide and Japanese markets.

From Figure 1, it appears that Japanese companies have improved their growth rates in the worldwide and Japanese markets relative to 1990 growth rates in all product categories except in MOS memories and bipolar products. Bipolar product lines are possibly dying as a category as many previously pure bipolar products are evolving into more sophisticated BiCMOS circuits with improved speed to power consumption performance. MOS memory sales recorded $4,842 million for the year, a modest 5.0 percent growth rate.

Price erosion, which started in 1989, continued throughout 1991. Most Japanese semiconductor manufacturers are heavily dependent on these memory products, especially DRAMs, for revenue. Sales of laptop and notebook computers, which can consume a large volume of memory units, have slowed since the beginning of the third

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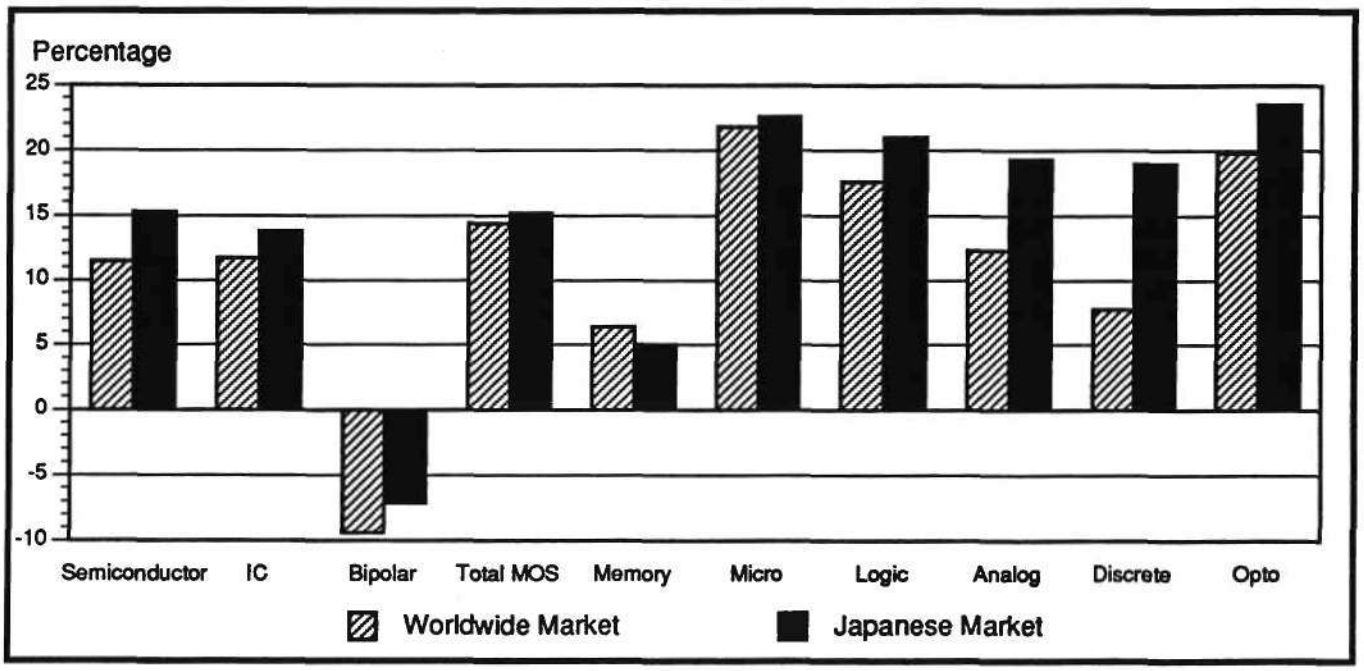
Table 3
Preliminary 1991 Japanese Semiconductor Market by Product
(Millions of Dollars)

Product	1989	1990	1991	Percent Change
Total Semiconductor	22,997	22,508	25,951	15.3
Total Integrated Circuit	17,946	17,387	19,781	13.8
Bipolar Digital	1,750	1,800	1,673	-7.1
MOS Function	12,497	11,799	13,590	15.2
MOS Memory	5,992	4,612	4,842	5.0
MOS Microcomponent	2,828	3,210	3,934	22.6
MOS Logic	3,677	3,977	4,814	21.0
Analog	3,699	3,788	4,518	19.3
Total Discrete	3,321	3,392	4,035	19.0
Total Optoelectronics	1,730	1,729	2,135	23.5

Source: Dataquest (January 1992)

Figure 1
Preliminary 1991 Market Segment Growth Rate
(Worldwide Market versus Japanese Market)



Source: Dataquest (January 1992)

quarter of 1991. In addition, Korean companies have accelerated the pricing pressure on memory products. This aggressiveness led to Samsung's slight gain in its ranking among memory suppliers in Japan.

MOS microcomponents and logic, together with optoelectronic products, appear to be the highest growth areas for the near future. Many Japanese vendors have recently licensed a variety of competing RISC architectures and appear to be poised for major pushes into both the RISC chip and systems markets.

Tables 4 through 11 list market share rankings by product category in the Japanese market.

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Dataquest Perspective

The preliminary 1991 market share figures continue to support the hypothesis that the worldwide silicon slowdown hit bottom last year. The prospects for continued growth through 1992 look promising, with the outlook best for microcomponents, logic, and optoelectronic devices. In particular, semiconductors as applied to RISC-based applications could be the star performers of the upcoming decade as RISC systems mature in scalable architectures ranging from desktop PCs to massively parallel supercomputers.

By Junko Matsubara

Table 4
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—Total Semiconductor (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	NEC	3,614	4,207	16.4	16.2
2	2	Hitachi	2,717	2,991	10.1	11.5
3	3	Toshiba	2,650	2,938	10.9	11.3
4	4	Fujitsu	2,041	2,253	10.4	8.7
5	6	Matsushita	1,572	1,977	25.8	7.6
6	5	Mitsubishi	1,583	1,770	11.8	6.8
7	7	Sharp	1,080	1,270	17.6	4.9
8	8	Sanyo	1,033	1,170	13.3	4.5
9	9	Sony	890	1,115	25.3	4.3
10	10	Rohm	633	820	29.5	3.2
11	12	Texas Instruments	614	744	21.2	2.9
12	11	Oki	620	655	5.6	2.5
13	13	Motorola	438	492	12.3	1.9
14	14	Intel	367	447	21.8	1.7
15	15	Fuji Electric	313	360	15.0	1.4
16	16	Sanken	281	341	21.4	1.3
17	17	Shindengen Electric	189	222	17.5	0.9
18	18	Seiko Epson	172	194	12.8	0.7
19	19	New JRC	149	194	30.2	0.7
20	20	National Semiconductor	143	164	14.7	0.6
21	22	Yamaha	138	150	8.7	0.6
22	21	Advanced Micro Devices	139	147	5.8	0.6
23	23	Ricoh	96	109	13.5	0.4
24	26	Samsung	60	89	48.3	0.3
25	24	Rockwell	80	84	5.0	0.3
26	25	Philips	77	80	3.9	0.3
27	27	LSI Logic	58	73	25.9	0.3
28	29	Burr-Brown	49	56	14.3	0.2
29	30	Analog Devices	42	54	28.6	0.2
30	32	SGS-Thomson	40	49	22.5	0.2
31	40	Exar	19	44	131.6	0.2
32	28	Toko	53	41	-22.6	0.2
33	31	Harris	41	34	-17.1	0.1
34	34	Hewlett Packard	24	28	16.7	0.1
35	35	Silicon Systems	23	26	13.0	0.1
36	33	ITT	25	25	0	0.1
37	36	General Instrument	23	25	8.7	0.1
38	38	Siemens	21	25	19.0	0.1
39	53	MOSel	9	25	177.8	0.1
40	41	Chips & Technologies	19	22	15.8	0.1
		Total Market	22,508	25,951	15.3	100.0

Source: Dataquest (January 1992)

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Table 5
Preliminary Estimated 1991 Japanese Semiconductor Market—Japan Bipolar Digital (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	2	Hitachi	387	447	15.5	26.7
2	1	Fujitsu	487	390	-19.9	23.3
3	3	NEC	238	251	5.5	15.0
4	4	Texas Instruments	184	148	-19.6	8.8
5	5	Mitsubishi	96	106	10.4	6.3
6	6	Toshiba	94	104	10.6	6.2
7	7	National Semiconductor	61	56	-8.2	3.3
8	9	Motorola	55	55	0	3.3
9	10	Oki	47	48	2.1	2.9
10	11	Advanced Micro Devices	47	33	-29.8	2.0
11	12	Philips	22	14	-36.4	0.8
12	13	Matsushita	13	14	7.7	0.8
13	14	GEC Plessey	4	2	-50.0	0.1
14	17	New JRC	1	1	0	0.1
15	18	Goldstar	1	1	0	0.1
16	19	Chips & Technologies	1	1	0	0.1
17	16	Raytheon	1	1	0	0.1
18	133	Applied Micro Circuits Corp.	0	1	NA	0.1
		Total Market	1,800	1,673	-7.1	100.0

Source: Dataquest (January 1992)

Table 6
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—MOS Memory (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	Hitachi	776	835	7.6	17.2
2	2	NEC	750	780	4.0	16.1
3	4	Fujitsu	587	699	19.1	14.4
4	3	Toshiba	611	554	-9.3	11.4
5	6	Sharp	392	438	11.7	9.0
6	5	Mitsubishi	417	373	-10.6	7.7
7	8	Texas Instruments	152	171	12.5	3.5
8	7	Matsushita	158	160	1.3	3.3
9	9	Oki	133	140	5.3	2.9
10	10	Sony	120	127	5.8	2.6
11	11	Motorola	103	84	-18.4	1.7
12	13	Samsung	55	79	43.6	1.6
13	12	Sanyo	80	63	-21.3	1.3
14	15	Advanced Micro Devices	47	56	19.1	1.2
15	16	Intel	30	38	26.7	0.8
16	14	Seiko Epson	47	28	-40.4	0.6
17	21	MOSel	9	25	177.8	0.5
18	18	SGS-Thomson	17	22	29.4	0.5
19	24	Rohm	7	21	200.0	0.4
20	19	Goldstar	14	20	42.9	0.4
		Total Market	4,612	4,842	5.0	100.0

Source: Dataquest (January 1992)

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Table 7
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—MOS Microcomponents (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	NEC	770	962	24.9	24.5
2	2	Hitachi	408	447	9.6	11.4
3	3	Mitsubishi	360	431	19.7	11.0
4	4	Intel	332	403	21.4	10.2
5	5	Toshiba	267	306	14.6	7.8
6	6	Matsushita	233	295	26.6	7.5
7	7	Fujitsu	190	210	10.5	5.3
8	8	Motorola	124	160	29.0	4.1
9	9	Sharp	117	133	13.7	3.4
10	11	Sony	49	100	104.1	2.5
11	10	Oki	77	92	19.5	2.3
12	15	Ricoh	23	70	204.3	1.8
13	12	Texas Instruments	45	68	51.1	1.7
14	13	Sanyo	39	37	-5.1	0.9
15	14	National Semiconductor	27	34	25.9	0.9
16	19	Rohm	17	25	47.1	0.6
17	18	Advanced Micro Devices	18	22	22.2	0.6
18	17	Chips & Technologies	18	21	16.7	0.5
19	16	Cirrus Logic	23	19	-17.4	0.5
20	21	Seiko Epson	11	16	45.5	0.4
		Total Market	3,210	3,934	22.6	100.0

Source: Dataquest (January 1992)

Table 8
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—MOS Logic (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	NEC	941	1,132	20.3	23.5
2	2	Fujitsu	466	555	19.1	11.5
3	3	Toshiba	455	522	14.7	10.8
4	6	Matsushita	237	413	74.3	8.6
5	4	Hitachi	289	325	12.5	6.8
6	5	Oki	285	288	1.1	6.0
7	7	Sharp	217	261	20.3	5.4
8	10	Texas Instruments	112	208	85.7	4.3
9	11	Sony	110	169	53.6	3.5
10	9	Yamaha	131	140	6.9	2.9
11	12	Seiko Epson	104	139	33.7	2.9
12	8	Sanyo	145	137	-5.5	2.8
13	14	Mitsubishi	67	79	17.9	1.6
14	13	Motorola	69	75	8.7	1.6
15	15	LSI Logic	56	68	21.4	1.4
16	17	Rohm	33	39	18.2	0.8
17	18	New JRC	31	33	6.5	0.7
18	19	Fuji Electric	25	27	8.0	0.6
19	20	National Semiconductor	19	25	31.6	0.5
20	16	Ricoh	44	23	-47.7	0.5
		Total Market	3,977	4,814	21.0	100.0

Source: Dataquest (January 1992)

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Table 9
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—Analog (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	2	Sanyo	370	474	28.1	10.5
2	1	Mitsubishi	389	454	16.7	10.0
3	3	Toshiba	362	436	20.4	9.7
4	4	NEC	344	421	22.4	9.3
5	5	Matsushita	314	363	15.6	8.0
6	6	Hitachi	288	331	14.9	7.3
7	7	Sony	275	305	10.9	6.8
8	8	Rohm	221	287	29.9	6.4
9	9	Fujitsu	150	187	24.7	4.1
10	12	New JRC	103	138	34.0	3.1
11	10	Sanken	113	126	11.5	2.8
12	11	Texas Instruments	111	116	4.5	2.6
13	13	Rockwell	80	84	5.0	1.9
14	15	Motorola	64	84	31.3	1.9
15	14	Sharp	69	74	7.2	1.6
16	21	Shindengen Electric	33	66	100.0	1.5
17	18	Fuji Electric	43	57	32.6	1.3
18	16	Burr-Brown	49	56	14.3	1.2
19	19	Analog Devices	39	51	30.8	1.1
20	22	National Semiconductor	33	44	33.3	1.0
		Total Market	3,788	4,518	19.3	100.0

Table 10
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—Total Discrete (Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	Toshiba	625	747	19.5	18.5
2	2	Hitachi	522	551	5.6	13.7
3	3	NEC	461	528	14.5	13.1
4	4	Matsushita	314	364	15.9	9.0
5	5	Rohm	258	331	28.3	8.2
6	7	Mitsubishi	224	291	29.9	7.2
7	6	Fuji Electric	243	274	12.8	6.8
8	8	Sanyo	185	237	28.1	5.9
9	10	Sanken	149	198	32.9	4.9
10	9	Shindengen Electric	156	156	0	3.9
11	12	Fujitsu	62	97	56.5	2.4
12	11	Sony	76	90	18.4	2.2
13	13	Motorola	23	34	47.8	0.8
14	14	General Instrument	23	25	8.7	0.6
15	15	International Rectifier	14	18	28.6	0.4
16	18	Toko	5	17	240.0	0.4
17	17	ITT	10	15	50.0	0.4
18	16	Oki	10	12	20.0	0.3
19	24	New JRC	3	8	166.7	0.2
20	20	Korean Electronic Co.	5	5	0	0.1
		Total Market	3,392	4,035	19.0	100.0

Source: Dataquest (January 1992)

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Table 11
Preliminary Estimated 1991 Japanese Semiconductor Market Share Ranking—Total Optoelectronic
(Millions of Dollars)

Rank			Revenue		Percent	Market Share
1991	1990	Company	1990	1991	Change	1991 (%)
1	1	Matsushita	303	368	21.5	17.2
2	2	Sharp	285	364	27.7	17.0
3	3	Sony	260	324	24.6	15.2
4	4	Toshiba	236	269	14.0	12.6
5	5	Sanyo	154	222	44.2	10.4
6	6	NEC	110	133	20.9	6.2
7	8	Rohm	96	117	21.9	5.5
8	7	Fujitsu	99	115	16.2	5.4
9	9	Hitachi	47	55	17.0	2.6
10	10	Oki	33	36	9.1	1.7
11	11	Mitsubishi	30	36	20.0	1.7
12	15	Texas Instruments	10	33	230.0	1.5
13	12	Hewlett-Packard	21	25	19.0	1.2
14	13	Sanken	19	17	-10.5	0.8
15	14	New JRC	11	14	27.3	0.7
16	17	Korean Electronic Co.	2	2	0	0.1
		Total Market	1,729	2,135	23.5	100.0

Source: Dataquest (January 1992)

Product Analysis

Structural Changes in DRAM Demand

DRAM demand is changing and deviating from the traditional life cycle in which a new generation with quadrupled circuit density takes over every four years. Although demand for 4Mb DRAMs (which in 1989 triggered the volume production that is now supposed to be in its full-growth phase) is low despite high expectations, the 4Mb DRAM's predecessor—the 1Mb DRAM—still enjoys strong demand. Furthermore, next-generation 16Mb DRAMs will be available earlier than expected. The sluggish 4Mb DRAM demand appears to represent a significant departure from the empirical rule of product cycle, serving as a major factor in causing structural changes in DRAM demand. This article examines what is changing in DRAM demand now by examining the electronic data processing (EDP) equipment market, which consumes approximately 70 percent of DRAM products.

Relationship between Sluggish PC and 4Mb DRAM Demands

The major reason for sluggish 4Mb DRAM demand is slow growth of consumption of these products by PCs. Traditionally, compact and high-performance PCs were a direct outcome of highly integrated memories until 4Mb DRAMs, which offer little "space-saving effect," came along. This effect is clearly seen in the generation shift from 256K DRAMs to 1Mb DRAMs. The standard size of PC main memory is 1MB, which consumes 32 pieces of 256K DRAMs, which in turn take up about 10cm x 10cm in board space. It takes only 8 pieces of 1Mb DRAMs to do the same by using a 5cm x 5cm space, a 75 percent savings in board space. This offered a great advantage to PC makers, which rushed to use 1Mb DRAMs.

Now it takes only two pieces of 4Mb DRAMs to realize the further reduction in board size, but the benefits are not significantly different from 1Mb DRAMs. Many designers believe that 1Mb DRAMs will suffice for now. In other words, 4Mb DRAMs cannot sell for the traditional advantage of saving space, suggesting that sluggish 4Mb DRAM sales are instead the consequence of the DRAM demand structure in transition.

Changes for the better will come once Windows 3.0 is widely accepted as backed up by development of application software. PCs' main memory will be enhanced dramatically. Also, the

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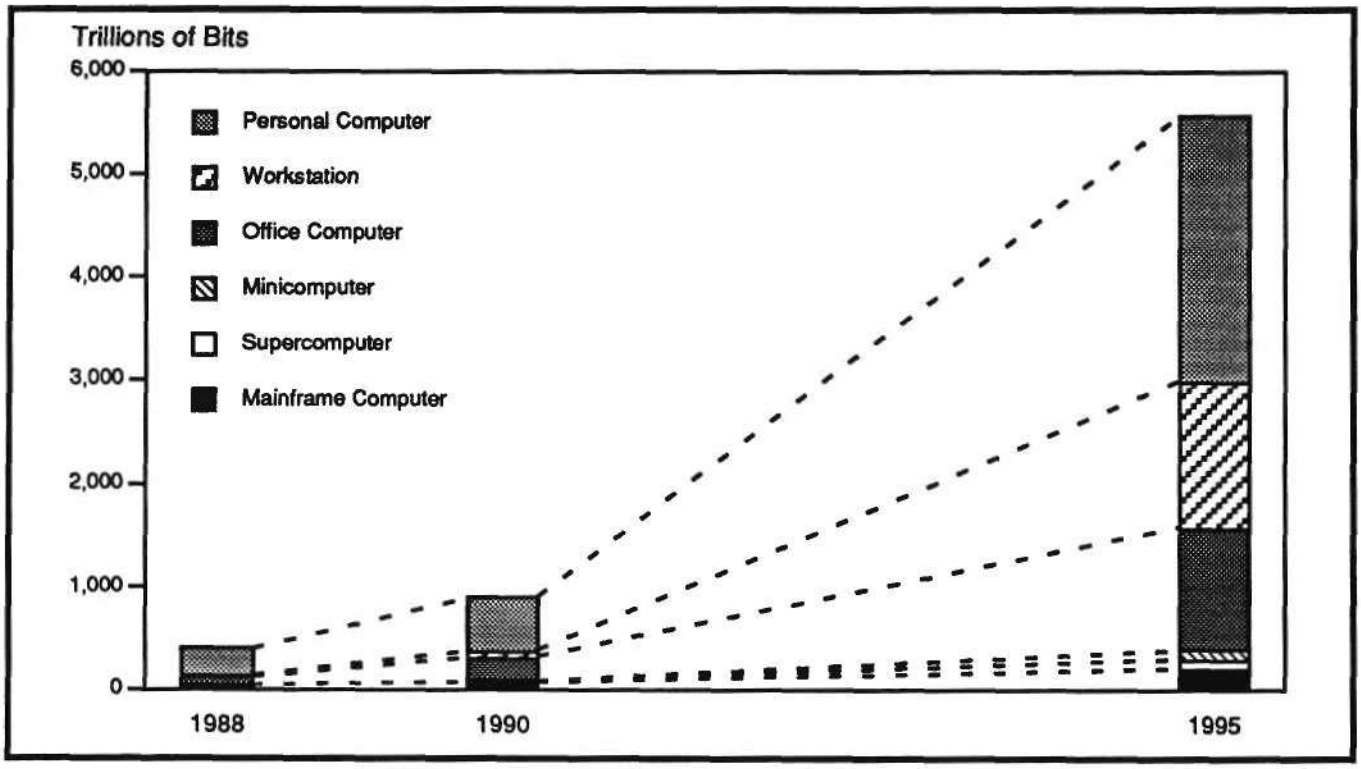
Figure 1
Worldwide Forecast DRAM Consumption by Computers



Source: Dataquest (January 1992)

Integrated Services Digital Network (ISDN) will prompt the use of digital communications equipment that handles and stores voice and image data in large quantities. These capabilities point to a large demand for 4Mb or larger memories.

Downsizing Changes DRAM Demand Structure

Rapid growth of small computers and terminals as a result of downsizing has accelerated diversion of users from mainframe computers in 1991, another factor in changing the DRAM demand structure. Downsizing demands multibit DRAMs, which leads to reduction of DRAMs per system accompanied by unit cost reduction and improving system reliability. This is evidenced by a steady growth of DRAM consumption for PCs and workstations, and Dataquest expects further increase in multibit products.

In the 1990s, mainframe computers will be increasingly used as file servers, while database processing and communications will be done by dedicated machines using high-performance microprocessors. This is because upgrading microprocessor performance does not keep up with user needs, so that a mainframe cannot handle all tasks by itself. The most widely adopted solution is to enhance system performance by using multiprocessors. Last year, major computer makers announced new products, most of which adopted the multiprocessor system and successfully improved the entire system performance. Nevertheless, multiprocessor use would be limited to eight units if efficiency is considered.

Dataquest believes that small and midrange computers will face strong competition from workstations. Many manufacturers are reportedly developing RISC machines that offer performance equivalent to the small and midrange computers, such as NCR Corporation's System 3000. Against this background, shipments of general-purpose and other computers in the 1990s suggest a rosy picture for future DRAM consumption. Shipments of mainframe computers in the worldwide market amounted to 15,000 units in 1990 and should remain more or less at the same level in 1995 (see Figure 1). Workstation shipments are forecast to grow from 386,000 units in 1990 to 2.2 million units in 1995, becoming major DRAM users.

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Similarly, shipments of PCs will increase from 23.3 million in 1990 to 44.27 million in 1995. Changes in bit configuration of DRAMs are another important factor of the increase.

Mainframe computers have primarily used ×1 versions of the most advanced DRAMs. Recently, however, some machines, such as Fujitsu's M-1800, use SRAMs in their main memories to match ever faster MPUs. This reflects an increasing difference in speed between CPUs and memories, which will continue in the foreseeable future.

In addition, ×1 DRAMs have been losing their traditional applications since 1988. This move will be accelerated as memory IC capacities increase. Given the shrinking market for ×1 versions, it is critical for DRAM manufacturers to introduce multibit products as quickly as possible. The future outlook for computer markets clearly portends that while mainframe, supercomputer, and minicomputer markets show only moderate growth prospects and therefore do not promise strong demand for ×1 DRAMs, workstations and PCs have high growth potential to drive demand for multibit products.

Dataquest Perspective

In 1990, worldwide DRAM consumption by workstations and PCs amounted to 430 trillion bits, accounting for about 61 percent of aggregate DRAM consumption. Dataquest expects bit consumption by PCs and workstations to reach 3,993 trillion in 1995, which is 72 percent of total consumption. In the process, the use of multibit versions will increase significantly, lowering the share of ×1 versions to less than 20 percent. One worry is that the increase in multibit products will push unit prices of memories upward. Memory manufacturers have to find a solution to overcome the increase in chip area of multibit DRAMs.

Dataquest's analysis depicts the changing face of the DRAM demand. DRAM manufacturers have to realize that they can no longer enjoy the traditional favorable cycle in which the use of new DRAMs in new products created a new round of demand. And they must learn about self-control to avoid overcapacity and plummeting prices in the midst of ever-increasing capital investment.

By Akira Minamikawa

In Future Issues

The following topics will be addressed in future issues of Semiconductors Japan *Dataquest Perspective:*

- DRAM forecast
- 16Mb DRAM investment
- Japanese semiconductor alliance update: the fourth quarter of 1991

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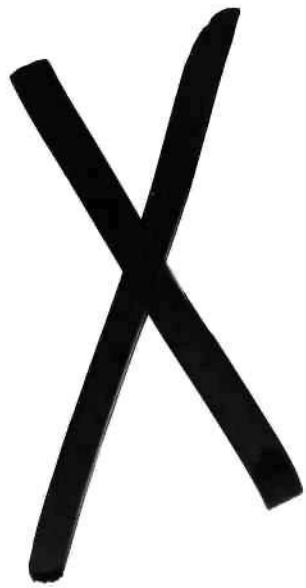

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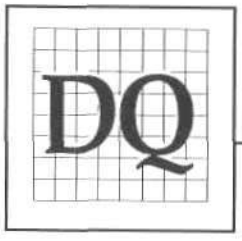

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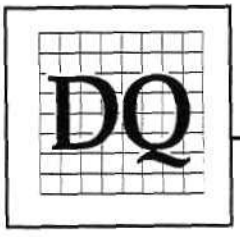

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Semiconductor Market Definitions

October 1992

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Chapter 1

Market Share Survey Overview

Each year, Dataquest surveys semiconductor vendors to estimate their annual sales. The survey covers about 160 semiconductor vendors worldwide (this varies according to mergers, acquisitions, liquidations, start-ups, and so on) by 59 individual semiconductor product categories (excluding subtotals), 6 application segments, and 5 world regions (Europe is split into further subregions). This exercise helps Dataquest maintain its dynamic database of semiconductor supply by company, and semiconductor shipments by world region and product. The information gained is supplemented by, and cross-checked with, Dataquest's various other information sources.

The semiconductor market share survey takes place twice each year. The first survey is to prepare preliminary estimates for the calendar year. This is followed by a second survey of the same companies three months later to finalize estimates for the same calendar year. The first survey takes place during October and November. Our preliminary estimates are completed by the end of the calendar year under review, and the results are summarized in several Dataquest reports. Preliminary vendor rankings are featured in a Dataquest press release shortly after the beginning of the new year.

The second survey takes place during March. Our final semiconductor market share estimates are published in greater depth in a reference report (a *Source: Dataquest* document) by May 31. There is usually minimal difference between preliminary and final rankings, as Dataquest makes every effort to ensure that preliminary estimates are as accurate as possible. However, there will be occasions when some company results are revised according to unexpected late billings or order cancellations in the final months of the calendar year being reported.

The categories for which semiconductor revenue is reported are defined comprehensively for the purpose of clarity and guidance to survey participants. These definitions may occasionally be revised, altered, or expanded to reflect changes in the industry. To support these definitions, Dataquest will issue an annual survey guide to all participants in its semiconductor market share survey program. This document comprises the 1992 survey guide.

Chapter 2

Semiconductor Companies Surveyed Worldwide 1992

North American Companies

ACC Microelectronics
Actel
Acumos
Advanced Micro Devices
Allegro MicroSystems
Altera
Analog Devices
Appian Technology
Applied Micro Circuits
AT&T
Atmel
Brooktree
Burr-Brown
California Micro Devices
Catalyst
Cherry Semiconductor
Chips & Technologies
Cirrus Logic
Comlinear
Cypress Semiconductor
Cyrix
Dallas Semiconductor
DSP Group
Elantec
Electronic Designs
ETEQ Microsystems
Exar
General Instrument
Gennum
Gould AMI
Harris
Hewlett-Packard
Honeywell
Hughes
IMI
Integrated Device Technology
Integrated Information Technology
Intel
International Microelectronic Products
International Rectifier
ITT
Kulite
Lattice
Linear Technology
Logic Devices
LSI Logic
Maxim
Micrel
Micro Linear
Micro Power Systems
Microchip Technology
Micron Technology
Microsemi
Mitel
Motorola
National Semiconductor
NCR
Novasensor
Oak Technology
Optek
OPTi
Performance Semiconductor
Powerex
Quality Semiconductor
Quality Technologies
Raytheon
Rockwell
SEEQ Technology
Semtech
Sierra Semiconductor
Silicon General
Silicon Systems
Siliconix
Sipex
Solitron
Standard Microsystems
Supertex
Symphony Laboratories
Teccor Electronics
Tektronix
Teledyne
Texas Instruments
Trident Microsystems
TRW

Tseng Labs
Unitrode
Universal
VLSI Technology
VTC
WaferScale Integration
Weitek
Western Digital
Xicor
Xilinx
Zilog

Japanese Companies

Fuji Electric
Fujitsu
Hamamatsu Photonics
Hitachi
Matsushita Electronics
Mitsubishi Electric
Mitsumi Electric
NEC
New Japan Radio
Nihon Inter Electronics
Nippon Precision Circuits
Nippondenso
NMB Semiconductor
Oki Electric Industry
Ricoh
Rohm
Sanken Electric
Sanyo Electric
Seiko Epson
Sharp
Shindengen Electric Manufacturing
Sony
Stanley Electric
Toko
Toshiba
Yamaha

European Companies

ABB-HAFO
ABB-IXYS
Austria Mikro Systeme
Dialog Semiconductor
Ericsson
EM Microelectronic
Eupec
European Silicon Structures
Eurosil
Fagor
GEC Plessey
Matra-MHS
MEDL
Micronas
Mietec
Philips Semiconductors
Semikron
SGS-Thomson
Siemens
STC
TAG
Telefunken Electronic
TMS
Westcode Semiconductors
Zetex

Asia/Pacific Companies

Daewoo
Dongsung Semiconductor
Goldstar
Hualon Microelectronics
Hyundai
Korean Electronics
Macronix
MOSel/Vitelic Corporation
Samsung
Silicon Integrated Systems
United Microelectronics
Winbond Electronics

Summary

95 North American Companies
26 Japanese Companies
25 European Companies
12 Asia/Pacific Companies
158 Worldwide Companies

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Chapter 3

General Sales Definitions

1. **Sales to customer.** All sales are reported according to customer location, that is, the shipping destination. The five regions that Dataquest recognizes are North America, Japan, Europe, Asia/Pacific, and Rest of World (ROW).
2. **Finished semiconductor products.** Defined as assembled and tested semiconductor products. *Only count sales of finished semiconductor products to distributors and equipment manufacturers.* Do not include sales of finished semiconductors to other semiconductor vendors for value-added resale. Resale revenue will be estimated separately for these companies. Also, only count sales made by an overseas subsidiary to a distributor or equipment manufacturer as opposed to counting sales from headquarters to an overseas subsidiary.
3. **Unfinished semiconductor products.** Defined as wafer and die foundry products. *Only count sales of unfinished semiconductor products to distributors and equipment manufacturers.* Do not include sales of unfinished semiconductors to other semiconductor vendors for resale. Resale revenue will be estimated separately for these companies. Also, only count sales made by an overseas subsidiary to a distributor or equipment manufacturer as opposed to counting sales from headquarters to an overseas subsidiary.
4. **Internal semiconductor sales.** Includes in-house and captive semiconductor sales that are differentiated as follows:
   - **In-house semiconductor sales.** Defined as revenue from finished or unfinished semiconductor products from intracompany (internal) transfers to divisions of your company and/or subsidiaries of your parent company that manufacture end equipment. *Include only those products also sold on the merchant market.* **Include all in-house semiconductor sales at market price.** Market price is defined as the price at which the same product is sold to equipment manufacturers.
   - **Captive semiconductor sales.** Defined as revenue from finished or unfinished semiconductor products from intra-company (internal) transfers to divisions of your company and/or subsidiaries of your parent company that manufacture end equipment. *Includes only those products* not *sold on the merchant market.* **Do not include captive semiconductor sales.**
5. **Hybrid products.** Defined as products that comprise a number of active semiconductor die and/or passive components in a single package. *Only count sales of hybrid products that conform with definition 2 or 3.*
6. **Modules and board-level products.** Defined as products that comprise a number of active semiconductor and/or passive components mounted on a single printed circuit board (PCB). Only count sales of modules and board-level products that conform with definition 2 or 3. *Only include the market price of the active semiconductors in the module or board-level product.*
7. **System-level products.** Defined as products that comprise a number of module and/or board-level products amounting to a single system or subsystem. Examples include development systems, hardware platforms, and box-level products. *Do not include any sales from such system-level products.*
8. **NRE charges.** Defined as nonrecurring engineering charges made to customers as the result of costs incurred during the design or customizing of a semiconductor device for that customer. Only count NRE charges when they occur in the following product areas:
   - Design charges for ASICs including gate arrays, cell-based ICs, and full-custom ICs.
   - Mask charges that result from the customizing of a programmable array logic

(PAL), when the customer's fuse pattern is masked into it to produce a hard-wired array logic (HAL).

- Mask charges that result from the customizing of ROMs.
- Mask charges that result from the storage of the customer's program in a microcontroller.

Only count revenue from NRE charges on active semiconductor products that conform with definition 2 or 3. Include these NRE charges as part of the revenue received from associated semiconductor product. Do not include revenue from NRE charges incurred during research, feasibility studies, or facility rental to third parties.

9. **Electronic design automation (EDA) software.** EDA software is used to automate the design of semiconductors. Dataquest includes revenue from ASIC semiconductor vendors that also sell their own EDA software. *Include any revenue derived from EDA software in the appropriate ASIC product category.* The applicable categories are PLD, gate array, and cell-based IC.

10. **IPR income.** Defined as intellectual property rights, income from royalties, licensing agreements, technology transfers, and dispute settlements. *Do not include any such IPR income.*

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Chapter 4

Exchange Rate Definitions

When converting a company's local currency sales into U.S. dollars, or vice versa, it is important to use the preliminary 1992 exchange rates provided below. This will prevent inconsistencies in the conversion of offshore sales between each company. The preliminary 1992 exchange rate estimate uses actual exchange rates through September 1992, and assumes that the September rate applies throughout the months of October through December. The annual rate is estimated as the arithmetic mean of the 12 monthly rates. Exchange rates for historical years are available on request.

Average 1992 Exchange Rates per U.S. Dollar

Country	1991 Rate	1992 Estimate	U.S.$ Expected Appreciation (%)
Austria (Schilling)	11.67	10.68	-8.4
Belgium (Franc)	34.13	31.26	-8.4
China (Renminbi)	5.33	5.49	2.8
Denmark (Krone)	6.39	5.87	-8.2
ECU	0.81	0.75	-7.6
Finland (Markka)	4.04	4.24	5.1
France (Franc)	5.64	5.14	-8.8
Germany (Mark)	1.66	1.52	-8.5
Great Britain (Pound)	0.57	0.54	-4.6
Greece (Drachma)	181.89	183.48	0.9
Hong Kong (Dollar)	7.77	7.74	-0.4
India (Rupee)	22.72	27.96	23.1
Ireland (Punt)	0.62	0.57	-7.9
Italy (Lira)	1,238.93	1,171.01	-5.5
Japan (Yen)	136.00	125.95	-7.4
Malaysia (Ringgit)	2.75	2.54	-7.8
Netherlands (Guilder)	1.87	1.71	-8.5
Norway (Krone)	6.49	5.99	-7.6
Portugal (Escudo)	144.02	130.55	-9.4
Singapore (Dollar)	1.73	1.62	-6.2
South Korea (Won)	730.90	784.00	7.3
Spain (Peseta)	103.81	97.86	-5.7
Sweden (Kroner)	6.04	5.54	-8.4
Switzerland (Franc)	1.43	1.36	-5.2
Taiwan (Dollar)	26.50	24.89	-6.1
Thailand (Baht)	25.52	25.36	-0.6

Source: Dataquest (October 1992)

Chapter 5

Semiconductor Product Category Hierarchy

The following semiconductor product category hierarchy begins with total semiconductor, and indents each subcategory in the left-hand column according to its position in the hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Any level in the hierarchy that does not depend on any subcategories is marked as a "Data Point."

Total Semiconductor:	**Total Integrated Circuit + Total Discrete + Total Optoelectronic**
Total Integrated Circuit:	Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog IC
Bipolar Digital IC:	1. Bipolar Digital ECL IC + Bipolar Digital TTL/Other IC—*technology split* 2. Bipolar Digital Memory IC + Bipolar Digital Microcomponent IC + Bipolar Digital Logic IC—*function split*
Bipolar Digital ECL IC:	Data Point
Bipolar Digital TTL/Other IC:	Data Point
Bipolar Digital Memory IC:	Data Point
Bipolar Digital Microcomponent IC:	Data Point
Bipolar Digital Logic IC:	Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC
Bipolar Digital Logic ASIC:	Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC + Bipolar Digital Full-Custom IC
Bipolar Digital GA:	Data Point
Bipolar Digital PLD:	Data Point
Bipolar Digital CBIC:	Data Point
Bipolar Digital FCIC:	Data Point
Bipolar Digital Standard Logic IC:	Data Point
Other Bipolar Digital Logic IC:	Data Point
MOS Digital IC:	1. CMOS Digital IC + BiCMOS Digital IC + NMOS/Other Digital IC—*technology split* 2. MOS Memory IC + MOS Microcomponent IC + MOS Logic IC—*function split*
CMOS Digital IC:	Data Point
BiCMOS Digital IC:	Data Point
NMOS/Other Digital IC:	Data Point

MOS Digital Memory IC:	DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC
DRAM:	Data Point
SRAM:	Data Point
EPROM:	Data Point
EEPROM:	Data Point
Flash Memory:	Data Point
Mask ROM:	Data Point
Other MOS Memory IC:	Data Point
MOS Digital Microcomponent IC:	MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + MOS Digital Signal Processor
MOS Digital MPU:	Data Point
MOS Digital MCU:	Data Point
MOS Digital MPR:	Data Point
MOS DSP:	Data Point
MOS Digital Logic IC:	MOS Digital Logic Application-Specific IC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC
MOS Digital Logic ASIC:	MOS Digital Gate Array + MOS Digital Programmable Logic Device + MOS Digital Cell-Based IC + MOS Digital Full-Custom IC
MOS Digital GA:	Data Point
MOS Digital PLD:	Data Point
MOS Digital CBIC:	Data Point
MOS Digital FCIC:	Data Point
MOS Digital Standard Logic IC:	Data Point
Other MOS Digital Logic IC:	Data Point
Analog IC:	Monolithic Analog IC + Hybrid IC
Monolithic Analog IC:	Monolithic Linear IC + Monolithic Mixed-Signal IC
Linear IC:	Amplifier IC + Voltage Regulator IC + Voltage Reference IC + Comparator IC + Special Consumer IC + Special Automotive IC + Other Special Function IC + Linear Array ASIC
Amplifier IC:	Data Point
Voltage Regulator IC:	Data Point
Voltage Reference IC:	Data Point
Comparator IC:	Data Point
Special Consumer IC:	Data Point
Special Automotive IC:	Data Point
Other Special Function IC:	Data Point
Linear Array ASIC:	Data Point
Mixed-Signal IC:	Data Converter IC + Telecom IC + Interface IC + Switch/Multiplexer IC + Disk Drive IC + Mixed-Signal ASIC

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Data Converter IC:	Data Point
Telecom IC:	Data Point
Interface IC:	Data Point
Switch/Multiplexer IC:	Data Point
Disk Drive IC:	Data Point
Mixed-Signal ASIC:	Data Point
Hybrid IC:	Data Point
Total Discrete:	Transistor + Diode + Thyristor + Other Discrete
Transistor:	Small-Signal Transistor + Power Transistor
Small-Signal Transistor:	Data Point
Power Transistor:	Bipolar Power Transistor + MOS Power Transistor + Power Insulated Gate Bipolar Transistor (IGBT)
Bipolar Power Transistor:	Data Point
MOS Power Transistor:	Data Point
Power IGBT:	Data Point
Diode:	Small-Signal Diode + Power Diode
Small-Signal Diode:	Data Point
Power Diode:	Data Point
Thyristor:	Data Point
Other Discrete:	Data Point
Total Optoelectronic:	LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optoelectronic
LED Lamp/Display:	Data Point
Optocoupler:	Data Point
CCD:	Data Point
Laser Diode:	Data Point
Photosensor:	Data Point
Other Optoelectronic:	Data Point

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Chapter 6

Semiconductor Product Category Definitions

The following semiconductor product category definitions begin with total semiconductor, and continue through each subcategory in the same order as shown in the preceding semiconductor product category hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Comprehensive definitions are given at every level.

Total Semiconductor:	(Total Integrated Circuit + Total Discrete + Total Optoelectronic.) Defined as an active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide, but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.
Total Integrated Circuit:	(Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog IC.) An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package. A monolithic IC is one in which discrete circuits are integrated onto a single die, while a hybrid IC is one in which discrete circuits are integrated onto a small number of die.
Bipolar Digital IC:	1. *Technology split*—(Bipolar Digital ECL IC + Bipolar Digital TTL/Other IC.) 2. *Function split*—(Bipolar Digital Memory IC + Bipolar Digital Microcomponent IC + Bipolar Digital Logic IC.) A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data-carrying signals vary in discrete values.
ECL IC:	Defined as a bipolar digital IC manufactured using emitter-coupled logic (ECL) semiconductor technology.
TTL/Other Bipolar Digital IC:	Defined as a bipolar digital IC manufactured using transistor-transistor logic (TTL) semiconductor technology. Other bipolar technologies include resistor-transistor logic (RTL) and diode-transistor logic (DTL).

Bipolar Digital Memory IC:	Defined as a bipolar digital semiconductor product in which binary data are stored and electronically retrieved. Includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, and first-in/first-out (FIFO) memory. Not included are products made with mixed bipolar CMOS (that is, BiCMOS) with TTL or ECL outputs, which are classified as MOS.
Bipolar Digital Microcomponent IC:	Defined as a bipolar digital semiconductor product that contains a data processing unit or serves as an interface to such a unit. Includes both complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) architectures. Includes bipolar digital microprocessor (MPU), bipolar digital microcontroller (MCU), and bipolar digital microperipheral (MPR), where applicable.
Bipolar Digital Logic IC:	(Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC.) Defined as a bipolar digital semiconductor product in which more than 50 percent of the die area performs logic functions. Excludes bipolar digital microcomponent ICs.
Bipolar Digital Logic ASIC:	(Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC + Bipolar Digital Full-Custom IC.) Defined as a single-user bipolar digital logic IC that is manufactured using vendor-supplied tools and/or libraries. Do not include bipolar digital ASICs incorporating microcontroller cells, as these should be reported in the bipolar digital microcomponent IC category.
Bipolar Digital GA:	Bipolar Digital Gate Array is defined as an ASIC device that is customized by the vendor to end-user specification using layers of interconnect. Included in this category are generic or base wafers with embedded functions, such as SRAM and EEPROM.
Bipolar Digital PLD:	Bipolar Digital Programmable Logic Device is defined as an ASIC device that is customized by the end user after assembly. Included in this category are bipolar field-programmable logic (bipolar FPL), bipolar field programmable gate array (bipolar FPGA), bipolar programmable array logic (bipolar PAL), bipolar programmable logic array (bipolar PLA), bipolar electrically programmable logic device (bipolar EPLD), and bipolar programmable multilevel logic device (bipolar PMD).
Bipolar Digital CBIC:	Bipolar Digital Cell-Based IC is defined as an ASIC device that is produced from a library of standard circuits/cells to a single-user specification. This process involves automatic routing and placement of cells. Included in this definition is bipolar standard cell IC. Excluded from this definition are cell-based ICs with processor cores. These should be reported under bipolar digital microcomponent IC.

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Bipolar Digital FCIC:	Bipolar Digital Full-Custom IC is defined as an ASIC device that is produced for a single user using a full set of masks. This manufacturing process involves manual routing and placement of cells.
Bipolar Digital Standard Logic IC:	Defined as commodity bipolar family logic with less than 150 gates. Sometimes referred to as glue logic. Examples include TTL, ECL and the following other family logic: TTL-compatible SSI, MSI, LSI; standard, AS, FAST, LS, ALS lines; and ECL-compatible SSI, MSI, LSI. Also included are RTL and DTL.
Other Bipolar Digital Logic IC:	Defined as all other bipolar digital logic ICs not accounted for in the preceding categories. Includes bipolar commodity family logic with 150 or more gates, and bipolar digital general-purpose logic not belonging to any families.
MOS Digital IC:	1. *Technology split*—(CMOS + BiCMOS + NMOS/Other.) 2. *Function split*—(MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC.) A MOS digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, any portion of the die area that is manufactured using metal-oxide semiconductor (MOS) technology. A digital function is one in which data-carrying signals vary in discrete values. Includes mixed technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.
CMOS Digital IC:	Defined as a MOS digital IC manufactured entirely in complementary metal-oxide semiconductor (CMOS) technology.
BiCMOS Digital IC:	Defined as a MOS digital IC manufactured using bipolar and complementary metal-oxide semiconductor (CMOS) technologies.
NMOS/Other Digital IC:	Defined as a MOS digital IC manufactured entirely in N-channel metal-oxide semiconductor (NMOS) technology. Other MOS technologies include P-channel metal-oxide semiconductor (PMOS).
MOS Digital Memory IC:	(DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC.) Defined as a MOS digital IC in which binary data are stored and electronically retrieved.
DRAM:	Defined as a Dynamic RAM, Multiport-DRAM (M-DRAM), and Video-DRAM (V-DRAM). DRAMs have memory cells consisting of a single transistor, and require regular externally cycled memory cell refreshes. These are volatile memories and addressing is multiplexed.

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SRAM:	Defined as a Static RAM, Multiport-SRAM (M-SRAM), Battery Backed-Up SRAM (BB-SRAM), and Pseudo SRAM (PSRAM). SRAMs have memory cells consisting of a minimum of four transistors, except PSRAM, which has a memory cell consisting of a single transistor and is similar to a DRAM. SRAMs do not require externally cycled memory cell refreshes. These are volatile memories and addressing is not multiplexed (except in the case of PSRAM). Note that color palette DACs are included in the mixed-signal data converter category.
EPROM:	Defined as Erasable Programmable Read-Only Memory. This product classification includes Ultraviolet EPROM (UV EPROM) and One-Time Programmable Read-Only Memory (OTP ROM). EPROMs have memory cells consisting of a single transistor, and do not require any memory cell refreshes. These devices are considered nonvolatile memories.
EEPROM:	Defined as Electrically Erasable Programmable Read-Only Memory. Includes Serial EEPROM (S-EEPROM), Parallel EEPROM (P-EEPROM), and Electrically Alterable Read-Only Memory (EAROM). EEPROMs have memory cells consisting of a minimum of two transistors, and do not require memory cell refreshes. Also includes Nonvolatile RAM (NV-RAM), also known as Shadow RAM. These semiconductor products are a combination of SRAM and EEPROM technologies in each memory cell. The EEPROM functions as a shadow backup for the SRAM when power is lost. These devices are considered nonvolatile memories.
Flash Memory:	Defined as nonvolatile products designed as Flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/chip erase. Flash memory can only erase data by bulk/chip, not by byte.
Mask ROM:	Defined as Mask-Programmable Read-Only Memory. Mask ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step. Mask ROM is programmed in hardware rather than software. These devices are considered nonvolatile memories.
Other MOS Digital Memory IC:	Defined as all other MOS digital memory not already accounted for in the preceding categories. Includes MOS digital content addressable memory (CAM), MOS digital cache-tag RAM, MOS digital first-in/first-out memory (FIFO), MOS digital last-in/first-out (LIFO) memory, and ferroelectric memory.
MOS Digital Microcomponent IC:	(MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + MOS Digital Signal Processor.) Defined as a MOS digital IC that contains a data processing unit or serves as an interface to such a unit. Includes both complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) architectures.

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MOS Digital MPU:	MOS Digital Microprocessor is defined as a semiconductor product serving as the central processing unit (CPU) of a system. Consists of an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. An MPU performs general-purpose computing functions by executing external instructions and manipulating data held in external memory. Includes MOS digital MPUs incorporating or originating from an ASIC design.
MOS Digital MCU:	MOS Digital Microcontroller is defined as a semiconductor product serving as a dedicated or embedded controller in a system. Consists of an integral MPU, nonvolatile memory for use as Program Store, and volatile memory for temporary storage of code or data. MCUs typically contain microperipherals and as a result, an MCU can perform basic computing functions without support from microperipheral (MPR) products. Includes MOS digital MCUs incorporating or originating from an ASIC design.
MOS Digital MPR:	MOS Digital Microperipheral is defined as a semiconductor product serving as a logical support function to an MPU in a system. An MPR provides enhancement of system performance and/or interface with external systems. Includes MOS digital MPRs comprising more than one device, such as PC chip sets. Examples of a MOS digital MPR include: memory and bus controllers (for example, PC logic chip sets, DRAM controllers, memory management units (MMU), and DMA controllers; peripheral interface controllers (for example, graphics controllers, LAN controllers, UARTs, keyboard controllers, and mass storage controllers); and coprocessors (for example, math coprocessors—or FPUs—and other coprocessors).
MOS DSP:	Defined as a high-speed general-purpose arithmetic unit used for performing complex mathematical operations such as Fourier transforms. DSPs embedded into an MPU or MCU are classified as either an MPU or MCU, respectively.
MOS Digital Logic IC:	(MOS Digital Logic Application-Specific IC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC.) Defined as a MOS digital IC in which more than 50 percent of the die area performs logic functions. Excludes MOS digital microcomponent ICs.
MOS Digital Logic ASIC:	(MOS Digital Gate Array + MOS Digital Programmable Logic Device + MOS Digital Cell-Based IC + MOS Digital Full-Custom IC.) Defined as a single-user logic IC that is manufactured using vendor-supplied tools and/or libraries. Do not include ASICs incorporating microprocessor or microcontroller cells, which should be included in microprocessor or microcontroller revenue.
MOS Digital GA:	MOS Digital Gate Array is defined as an ASIC device that is customized by the vendor to end-user specification using layers of interconnect. Included in this category are generic or base wafers with embedded functions, such as SRAM and EEPROM.

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MOS Digital PLD:	MOS Digital Programmable Logic Device is defined as an ASIC device that is customized by the end user after assembly. Included in this category are MOS field-programmable logic (MOS FPL), MOS field-programmable gate array (MOS FPGA), MOS programmable array logic (MOS PAL), MOS programmable logic array (MOS PLA), MOS electrically programmable logic device (MOS EPLD), and MOS programmable multilevel logic device (MOS PMD).
MOS Digital CBIC:	MOS Digital Cell-Based IC is defined as an ASIC device that is produced from a library of standard circuits/cells to a single-user specification. This process involves automatic routing and placement of cells. Included in this definition is MOS standard cell IC. Excluded from this definition are cell-based ICs with processor cores. These should be reported under MOS digital microcomponent IC.
MOS Digital FCIC:	MOS Digital Full-Custom IC is defined as an ASIC device that is produced for a single user using a full set of masks. This process involves manual routing and placement of cells.
MOS Digital Standard Logic IC:	Defined as commodity MOS family logic with less than 150 gates. Sometimes referred to as glue logic. Examples include: HC, HCT, AC, ACT, FACT, and 74BC BiCMOS family logic.
Other MOS Digital Logic IC:	Defined as all other MOS digital logic ICs not accounted for in the preceding categories. Includes MOS commodity family logic with 150 or more gates, and MOS digital general-purpose logic not belonging to any families.
Analog IC:	(Monolithic Analog IC + Hybrid IC.)
Monolithic Analog IC:	(Monolithic Linear IC + Monolithic Mixed-Signal IC.) A monolithic analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes all monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package.
Monolithic Linear IC:	(Amplifier IC + Voltage Regulator IC + Voltage Reference IC + Comparator IC + Special Consumer IC + Special Automotive IC + Other Special Function IC + Linear Array ASIC.) A monolithic linear IC is defined as an analog device that has 100 percent analog I/O, therefore its characteristics are inherently linear.

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Amplifier IC:	Defined as a general-purpose linear IC that provides a voltage or current gain to an input signal. Includes operational amplifiers (mono, dual, and quad, among others), instrumentation amplifiers, buffer amplifiers, and power amplifiers. Consumer-dedicated amplifier ICs are counted in special consumer IC. Amplifier ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Voltage Regulator IC:	Defined as a general-purpose linear IC that outputs a variable current at a regulated DC voltage to other circuits from a variable current and voltage input. Regulator ICs are either linear regulators in which the device provides an input-to-output voltage drop, or switching regulators, in which the device provides switched quantities of power to a smoothing circuit to gain higher efficiency and reduce power dissipation. Voltage regulator ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Voltage Reference IC:	Defined as a general-purpose linear IC that outputs a precise reference voltage to other circuits from a variable voltage input. A reference IC differs from a regulator IC in that it is not expected to power other circuits. In fact, voltage regulator ICs incorporate a voltage reference circuit. Voltage reference ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Comparator IC:	Defined as a general-purpose linear IC that compares two analog signal inputs and provides a single logic bit output. Although the output could be considered digital, these products are classed as linear ICs because they are specialty high-gain amplifiers, used in an open-loop mode, and for which the output is constrained to only two states. By using a comparator, an unknown voltage can be compared with a known reference voltage. Comparator ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Special Consumer IC:	Defined as a general-purpose linear IC that is dedicated to general consumer applications but is not application-specific. Includes analog ICs implemented in audio, video, radio, speech synthesis and recognition, electronic games, personal and home appliances, and electronic cameras. Consumer ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Special Automotive IC:	Defined as a linear IC that is used in the following applications: entertainment, engine control, safety, traction, and in-car electrical and suspension systems. Special automotive ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.

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Other Special Function IC:	Defined as either general-purpose linear ICs that do not fit into the other categories, or market/application-specific linear ICs for which a category does not yet exist. The main products that fall into this category include timers, phase-locked loops (PLLs), voltage-controlled oscillators (VCOs), signal/function generator ICs, and analog multipliers. Other special function ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.
Linear Array ASIC:	Defined as a single-user linear IC that is manufactured using vendor-supplied tools and/or libraries. Linear arrays fall into one of three types, as follows: 1. Arrays of discrete-level cells such as transistors and diodes 2. Arrays of discrete device combinations referred to as tiles 3. Arrays of higher level functional macro cells such as operational amplifiers, comparators, VCOs, references, and other analog functions These arrays are interconnected with a metal mask or by means of some user-programmable interconnect scheme. Unlike cell-based designs, they do not have a unique set of masks for all layers.
Mixed-Signal IC:	(Data Converter IC + Telecom IC + Interface IC + Switch/Multiplexer IC + Disk Drive IC + Mixed-Signal ASIC.) Defined as an analog IC that carries information in both digital (numeric) and signal/power forms. An IC is considered mixed-signal if it has both analog I/O and digital I/O pins. This definition is not based on the comparative size of the IC's analog and digital circuitry. It is a definition based on external pin functionality. ICs that are mainly digital but have some nominal, analog housekeeping functions such as voltage monitors, power-on reset, or clock oscillators are not considered to be mixed-signal because there is no analog signal being received by or sent from the active component.
Data Converter IC:	Defined as a general-purpose mixed-signal IC that converts an analog signal into a digital signal, or vice versa. Includes analog-to-digital converters (ADCs), digital-to-analog converters (DACs), comparators, sample-and-hold circuits (SHCs), voltage-to-frequency circuits (VFCs), frequency-to-voltage circuits (FVCs), synchro-to-digital circuits (SDCs), and digital-to-synchro circuits (DSCs). All these are general-purpose data converter ICs. Also included in this category are color-palette DACs. Consumer-dedicated data converter ICs are counted in special consumer IC. Data converter ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.

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Telecom IC:	Defined as a general-purpose mixed-signal IC used for voice band communication or data communication over voice band media. This category includes CODECs, combos and SLACs, SLICs, modem and fax/modem ICs, dialer and ringer ICs, repeaters, cellular communications ICs, ISDN ICs, telecom filter ICs, and other telecom-specific circuits. Telecom ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.
Interface IC:	Defined as a general-purpose mixed-signal IC that serves as an interface between a digital system and other external nonsemiconductor systems. Includes line drivers, peripherals drivers, display drivers, keyboard encoders, receivers, transmitters, and transceivers. Interface ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.
Switch/Multiplexer IC:	Defined as a mixed-signal IC that digitally controls analog transmission gates. These products connect or disconnect the analog signal path in analog circuits. Analog switches operate in a mode where each switch is operated independently by a single logic bit. Multiplexers are multiple analog switches that are connected in a dependent manner, where only one signal path is connected through to the output depending on the state of a digital address word (greater than one bit). Thus, analog multiplexers are really addressable signal selector switches that select one-out-of-many signals for further analog processing. Because these addressable analog switches were the key element in time-division multiplexing, the term "multiplexer" has remained. They are an important part of the data conversion product family in that they are used to provide time-division multiplexing of signal inputs to a fast analog-to-digital converter. Switch/multiplexer ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.
Disk Drive IC:	Defined as a mixed-signal IC that is designed specifically for the rotating mass storage market. Applications include the read/write path from preamp up to the ENDEC, head positioning controller, and spindle motor control. Disk drive ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.
Mixed-Signal ASIC:	Defined as a mixed-signal analog IC that is manufactured for a single user, using vendor-supplied tools and/or libraries.
Hybrid IC:	Defined as a semiconductor product consisting of more than one die contained in a single package. A hybrid IC may perform 100 percent linear, 100 percent digital, or mixed-signal (both linear and digital) functions. Includes hybrid implementation of all monolithic IC functions described in the preceding categories. Includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies.

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Total Discrete:	(Transistor + Diode + Thyristor + Other Discrete.) A discrete semiconductor is defined as a unit building block performing a fundamental semiconductor function.
Transistor:	(Small-Signal Transistor + Power Transistor.)
Small-Signal Transistor:	Defined as signal transistors, RF microwave transistors, dual transistors, MOS field-effect transistors (MOS-FETs), conductivity modulated field-effect transistors (COMFETs), insulated gate bipolar transistors (IGBTs), and MOS-bipolar transistors (MBTs). All rated below 1W power dissipation.
Power Transistor:	(Bipolar Power Transistor + MOS Power Transistor + Power IGBT.) All rated 1W power dissipation and above.
Bipolar Power Transistor:	Defined as bipolar Darlington transistor, bipolar microwave transistor, and bipolar radio frequency (RF) transistor.
MOS Power Transistor:	Defined as MOS field-effect transistor (MOS-FET), MOS Darlington transistor, MOS microwave transistor, and MOS radio frequency (RF) transistor.
IGBT Power Transistor:	Defined as insulated gate bipolar transistor (IGBT). Also includes conductivity modulated field-effect transistor (COMFET), MOS-bipolar transistor (MBT), and GEMFET.
Diode:	(Small-Signal Diode + Power Diode.)
Small-Signal Diode:	Defined as signal diodes, Schottky diodes, zener diodes, switching diodes, voltage reference diodes, voltage regulator diodes, and rectifier diodes. All are rated below 0.1A.
Power Diode:	Defined as zener diodes and rectifier diodes. All are rated 0.1A and above.
Thyristor:	Defined as thyristors, silicon-controlled rectifiers (SCRs), diacs, and triacs. Also includes solid-state relays (SSRs) incorporating triacs, thyristors, resistors, and capacitors.
Other Discrete:	Defined as all other discrete semiconductor products not accounted for in the preceding categories. Includes microwave diodes, varactors, tuning diodes, tunnel effect diodes, and selenium rectifiers. Does not include thermistors and varistors.
Total Optoelectronic:	(LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optoelectronic.) Defined as a semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

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LED Lamp/Display:	(LED Lamp + LED Display.) An LED lamp is defined as a light-emitting diode: a semiconductor product consisting of a single die in which photons are emitted at frequencies dependent upon the semiconductor material employed. An LED display is defined as an array of LEDs: a semiconductor product consisting of more than one die in which photons are emitted at frequencies dependent upon the semiconductor material employed.
Optocoupler:	Defined as an optocoupler or optoisolator. A semiconductor product consisting of an LED separated from a photosensor by a transparent, insulating, dielectric layer. These are mounted inside an opaque package. Includes optointerrupters, in which the separation between LED and photosensor is large enough to allow external physical systems to influence the device.
CCD:	Defined as a charge-coupled device. A semiconductor product consisting of an array of photodiodes, an analog CCD shift register, and an output circuit. Includes linear array CCDs with serial shift registers and area array CCDs with parallel shift registers. Includes charge injection device (CID), charge-coupled photodiode (CCP), charge-priming device (CPD), and self-scanning photodiode (SSP).
Laser Diode:	Defined as a diode that produces coherent light. A semiconductor product in which the heterojunction structure stimulates light amplification by stimulated emission of radiation (laser), resulting in coherent light. Includes Fabrey-Perot laser diodes, pulsed laser diodes, and phase-shifted laser diodes.
Photosensor:	(Photodiode + Phototransistor.) Defined as a diode or transistor in which photons are used to affect current flow or electric potential.
Other Optoelectronic:	Defined as all other optoelectronic devices not accounted for in the preceding categories. Includes solar cells and optical thermal piles.

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Chapter 7

Worldwide Geographical Region Definitions

North America

Includes Canada, Mexico, and the United States.

Japan

Japan is the only single-country region.

Europe

Western Europe

Includes Austria, Belgium, Denmark, Eire, Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Rest of Western Europe (Cyprus, Iceland, Malta, Turkey, and Others).

Eastern Europe

Includes Albania, Bulgaria, Czech and Slovak republics, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Republics of the former Yugoslavia, Republics of the former USSR (including Belorussia, Russia, and Ukraine), and Others.

Asia/Pacific

Includes Asia/Pacific's Newly Industrialized Economies (NIEs) and the Rest of Asia/Pacific regions. Newly Industrialized Economies include Hong Kong, Singapore, South Korea, and Taiwan. The Rest of Asia/Pacific region includes Australia, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Philippines, Thailand, and Vietnam.

Rest of World

Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America.

Chapter 8

Semiconductor Application Segment Definitions

Data Processing

Defined as computer systems, data storage devices, terminals, input/output devices, and dedicated systems:

- *Computer systems* include supercomputers, mainframe computers, midrange computers (also known as superminicomputers and minicomputers) workstations, and personal computers (including portable computers).
- *Data storage devices* include flexible/removable disk drives, fixed/rigid disk drives, optical disk drives, and tape drives (streamers).
- *Terminals* include alphanumeric terminals, graphics terminals, and funds transfer terminals.
- *Input/output devices* include printers, media-to-media data conversion, magnetic ink character recognition, monitors, optical scanning equipment, plotters, voice recognition/synthesizer equipment, mice, keyboards, and digitizers.
- *Dedicated systems* include electronic copiers, electronic calculators, smart cards, dictating/transcribing equipment, electronic typewriters and dedicated word processors, banking systems and funds transfer systems and terminals, point-of-sale terminals and electronic cash registers, and mailing/letter-handling/addressing equipment.

Communication

Defined as premise telecom equipment, public telecom equipment, mobile/radio communications equipment, broadcast and studio equipment, and other telecom equipment:

- *Premise telecom equipment* includes image and text communication such as facsimile and video teleconferencing; data communications equipment such as modems, statistical multiplexers, T-1 multiplexers, front-end processors, DSU/CSU, protocol converters, local area networks (LANs), internetworking, network management and packet data switching/wide area networks (WANs); premise switching equipment, such as PBX telephone equipment, and key telephone systems; call processing equipment, such as voice messaging systems, interactive voice response systems, call accounting and automatic call distributors (ACDs); and desktop terminal equipment such as telephone sets/pay telephones and teleprinters.
- *Public telecom equipment* includes transmission equipment, such as multiplexers, carrier systems, microwave radio, laser and infrared transmission equipment, and satellite communications equipment; and central office switching equipment.
- *Mobile/radio communications equipment* includes mobile radio systems such as cellular telephones, mobile radios and mobile radio base station equipment; portable radio receivers and transmitters; radio checkout equipment; and other RF communications equipment.
- *Broadcast and studio equipment* includes audio equipment, video equipment, transmitters and RF power amplifiers, studio transmitter links, cable TV equipment, closed circuit TV equipment, and other equipment such as studio and theater equipment.
- *Other telecom equipment* includes intercom equipment and electrical amplifiers, and communications equipment not elsewhere classified.

Industrial

Defined as security/energy management systems, manufacturing systems and instruments, medical equipment, and other industrial equipment:

- *Security/energy management systems* include alarm systems, such as intrusion detection and fire detection systems, and energy management systems.

- *Manufacturing systems and instruments* include semiconductor production equipment, controllers and actuators, sensor systems, management systems, and robotics; and semiconductor-dedicated automatic test equipment (ATE), all other ATE, oscilloscopes and waveform analyzers, nuclear instruments, and other test and measurement equipment.
- *Medical equipment* includes X-ray equipment, ultrasonic and scanning equipment, blood and body fluid analyzers, patient monitoring equipment, and other diagnostic and therapeutic equipment.
- *Other industrial equipment* includes vending machines, power supplies, traffic control equipment, and industrial equipment not elsewhere classified.

Consumer

Defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment:

- *Audio equipment* includes compact disc players, radios, stereo components, musical instruments, tape recorders, and other audio equipment such as tuners and headphone stereos.
- *Video equipment* includes videocassette recorders (VCRs), video cameras and camcorders, videodisk players, and color, monochrome, and LCD televisions.
- *Personal electronics* include electronic games and toys, cameras, watches, and clocks.
- *Appliances* include air conditioners, microwave ovens, washers and dryers, refrigerators, dishwashers, and ranges and ovens.
- *Other consumer equipment* includes automatic garage door openers and consumer equipment not classified elsewhere.

Military and Civil Aerospace

Defined as military electronic equipment and civil aerospace.

- *Military electronic equipment* includes military electronics, such as radar and sonar, missiles and weapons, space-related electronics, communications and navigation equipment, electronic warfare, aircraft systems, military computer systems, military simulation systems, and military electronics not classified elsewhere.
- *Civil aerospace* includes civilian aerospace electronics, such as radar, space-related electronics, communications and navigation equipment, flight systems, and simulation systems.

Transportation

Defined as in-car entertainment systems, body control electronics, driver information systems, power train systems, and safety and convenience systems:

- *In-car entertainment systems* include AM/FM radio, cassette, compact disc player, radio cassette combination systems, two-way radio communications systems, and CB radio.
- *Body control electronics* include vehicle controls such as four-wheel steering control and 2WD/4WD control; multiplex systems such as driver's door, auto-climate control, door locks, windshield wipers, heated rear windows, memory seats, remote security systems, steering wheel, suspension control and traction control; lighting controls including automatic headlight systems, timers, reminders, and sequential signal controls; and other body control electronics including aerodynamic aid control and power roof/window controls.
- *Driver information systems* include electronic dashboard/instrument clusters, analog or digital clusters, electronic analog/digital clocks and compasses, electronic thermometers, head-up displays, navigation and location systems, and signal and warning lights.
- *Power train systems* include engine management systems, power train sensors, ignition control, fuel injection systems, fuel flow, engine temperature, air temperature, coolant level, and wheel speed sensors.
- *Safety and convenience systems* include air conditioners, air purifier systems, air bag control systems, antilock braking systems, active suspension, collision avoidance systems, collision warning systems, and cruise control.

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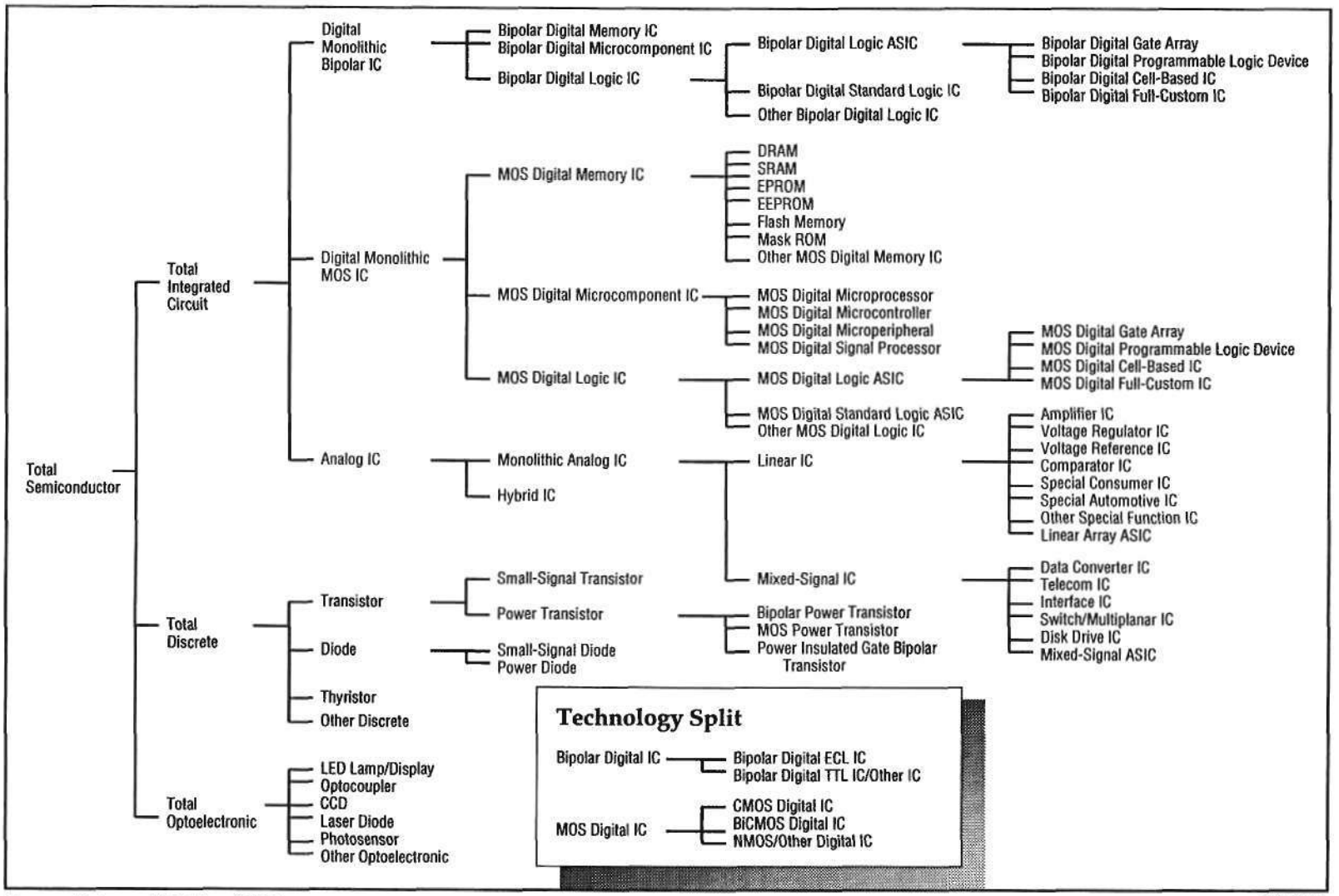
Appendix A

Semiconductor Product Hierarchy

Figure A-1
Semiconductor Product Hierarchy



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Dataquest Index

Semiconductors *Worldwide*

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How to Use This Index

Dataquest has decided to print the index for *Market Statistics* (MS) separately. Therefore, the index for each service is in two parts. This should make it easier and quicker to identify the items of interest to you. For *Market Statistics* documents, only table titles are indexed. A key at the bottom of each page indicates the product abbreviations. Entries are followed by the date of publication and the page number(s). A Table of Contents for 1992 Dataquest *Market Statistics* publications is included at the end of the index.

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Note: The following abbreviations identify products associated with the Semiconductors Worldwide group.

SCWW-COR	Semiconductors Worldwide	GAAS-SEG	Gallium Arsenide Worldwide
SCWW-PMT	Products, Markets, and Technologies	SAWW-SVC	Semiconductor Application Markets Worldwide
SCWW-MKT	Market Summary (Extra Editions)	SPWW-SVC	Semiconductor Procurement
MMRY-SEG	Memories Worldwide	SEMM-SVC	Semiconductor Equipment, Manufacturing, and Materials
ASIC-SEG	ASICs Worldwide	SCEU-SVC	Semiconductors Europe
ANLG-SEG	Analog: Linear/Mixed-Signal ICs Worldwide	SCJA-SVC	Semiconductors Japan
MCRO-SEG	Microcomponents Worldwide	SCAP-SVC	Semiconductors Asia

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Semiconductors *Worldwide*

January - December 1992 — February 22, 1993

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This is a cumulative index of key industry terms, companies, and products for 1992 core and segment issues of *Dataquest Perspective* (DP), *MarketTrends* (MT), *IndustryTrends* (IT), *Inquiry Summary* (IS), *User Wants and Needs* (UW), *Focus Report (FR), and Vendor Profile* (VP) documents. The *Market Statistics* (MS) index is printed separately and accompanies this index. A key at the bottom of each page indicates the product abbreviations. Entries are followed by the date of publication and the page number(s). Product names are listed under the company that manufactures or publishes the product. General information about a company itself is found under the full company name. Each citation indicates only the beginning page of a discussion of a topic (the range of page numbers is not cited). A Table of Contents for 1992 Dataquest publications listing each issue number, title, and date is included at the end of the index. Article titles are listed for the *Dataquest Perspective.*

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SCWW-PMT	Products, Markets, and Technologies	SAWW-SVC	Semiconductor Application Markets Worldwide
SCWW-MKT	Market Summary (Extra Editions)	SPWW-SVC	Semiconductor Procurement
MMRY-SEG	Memories Worldwide	SEMM-SVC	Semiconductor Equipment, Manufacturing, and Materials
ASIC-SEG	ASICs Worldwide	SCEU-SVC	Semiconductors Europe
ANLG-SEG	Analog: Linear/Mixed-Signal ICs Worldwide	SCJA-SVC	Semiconductors Japan
MCRO-SEG	Microcomponents Worldwide	SCAP-SVC	Semiconductors Asia

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Segmentation and Glossary

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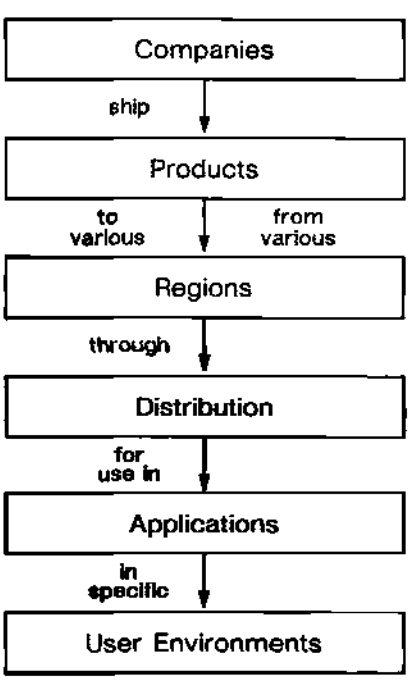
High–Technology Guide

The *High–Technology Guide* provides a reference for Dataquest research, analysis, and publications. The segments and terms found in this guide are used consistently in our research and methodology and throughout Dataquest products.

The *High–Technology Guide* is divided into two parts: segmentation and glossary. The segmentation section provides a comprehensive listing of the classifications used in our research. This segmentation is broken into different dimensions including companies, products, regions, distribution, applications, and user environments. These dimensions are illustrated below (see Figure 1). The glossary is an alphabetical list defining the terms found in the segmentation section.

Figure 1
Research Dimensions



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Segmentation

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Companies

The companies section contains more than 3,500 companies on which Dataquest conducts research. These companies are studied because of their concentration or emphasis in technology markets and industries. The company segmentation shows the breadth and depth of collective coverage that Dataquest maintains. Because of the extensive nature of the company list, it is not published in this guide but can be provided upon request.

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Products

The products section lists high-technology products. This section presents the segmentation of the technology as defined by Dataquest.

The major categories of products are as follows:

- Materials
- Components
- Boards and Subsystems
- Equipment
- Software
- Consumables
- Services
- Other Products

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Products

MATERIALS

- Wafer
  - Silicon Wafer
  - Epitaxial Wafer
- Gas
  - Bulk Gas
    - Nitrogen
    - Oxygen
    - Hydrogen
    - Argon
  - Specialty Gas
    - Silicon Precursor
    - Dopant
    - Plasma Etchant
    - Reactant Gas
    - Atmospheric/Purge Cylinder Gas and Other
  - Plastics

COMPONENTS

- Semiconductor
  - Integrated Circuit
    - Bipolar Digital (by Technology)
      - TTL/Others
      - ECL
    - Bipolar Digital (by Function)
      - Bipolar Digital Memory
        - Bipolar RAM
        - Bipolar Nonvolatile Memory
        - Other Bipolar Memory
      - Bipolar Digital Microcomponents
      - Bipolar Digital Logic
        - Bipolar ASIC
          - Bipolar Gate Array
          - Bipolar PLD
            - Bipolar PLA
            - Bipolar PMD
            - Bipolar FPGA

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COMPONENTS

- Bipolar ASIC (Continued)
  - Bipolar Cell-Based IC
- Bipolar Custom IC
- Bipolar Standard Logic
- Other Bipolar Logic

MOS Digital (by Technology)
- NMOS/PMOS
- CMOS
- BiCMOS

MOS Digital (by Function)
- MOS Memory
  - DRAM
    - 16K DRAM
    - 32K DRAM
    - 64K DRAM
    - 128K DRAM
    - 256K DRAM
    - 1Mb DRAM
    - 4Mb DRAM
    - 16Mb DRAM
  - SRAM
    - Slow SRAM
      - 1K SRAM
      - 4K SRAM
      - 8K SRAM
      - 16K SRAM
      - 64K SRAM
      - 256K SRAM
      - 1Mb SRAM
      - 4Mb SRAM
    - Fast SRAM
      - 1K SRAM
      - 4K SRAM
      - 8K SRAM
      - 16K SRAM
      - 64K SRAM
      - 256K SRAM
      - 1Mb SRAM
      - 4Mb SRAM

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COMPONENTS

- Nonvolatile Memory IC
  - ROM
    - 4K ROM
    - 8K ROM
    - 16K ROM
    - 32K ROM
    - 64K ROM
    - 128K ROM
    - 256K ROM
    - 1Mb ROM
    - 2Mb ROM
    - 4Mb ROM
    - 8Mb ROM
    - 16Mb ROM
  - EPROM
    - 16K EPROM
    - 32K EPROM
    - 64K EPROM
    - 128K EPROM
    - 256K EPROM
    - 1Mb EPROM
    - 2Mb EPROM
    - 4Mb EPROM
    - 8Mb EPROM
  - EEPROM
    - 1K EEPROM
    - 2K EEPROM
    - 4K EEPROM
    - 8K EEPROM
    - 16K EEPROM
    - 32K EEPROM
    - 64K EEPROM
    - 128K EEPROM
    - 256K EEPROM
    - 512K EEPROM
    - 1Mb EEPROM
  - Other MOS Memory
- MOS Microcomponents
  - MOS Microprocessor (by Word Length)
    - 8-bit MOS MPU

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COMPONENTS

- MOS Microprocessor (by Word Length) (Continued)
  - 16-bit MOS MPU
  - 16/32-bit MOS MPU
  - 32-bit MOS MPU
  - 32/64-bit MOS MPU
  - 64-bit MOS MPU
- MOS Microprocessor (by Technology)
  - CISC MOS MPU
  - RISC MOS MPU
- MOS Microcontroller
  - 4-bit MOS MCU
  - 8-bit MOS MCU
  - 16-bit MOS MCU
  - 32-bit MOS MCU
  - Digital Signal Processor
    - DSP Microprocessor (DSMPU)
    - Microprogrammable DSP (MPDSP)
    - Special-Function DSP (SFDSP)
- MOS Microperipheral
  - System Support Peripheral
    - Traditional Peripheral
      - Counter/Timer
      - DMA
      - Interrupt Controller
      - Memory Management
      - Real-Time Clock
      - Others
    - General-Purpose I/O
    - DRAM Controller
    - Cache Controller
    - PC Logic Chip Set
  - Display Peripheral
    - Alphanumeric CRT Controller
    - Graphics Controller
    - Keyboard Controller
    - Printer Controller
    - Others
  - Mass Storage Peripheral
    - Floppy Disk Controller
    - Hard-Disk Controller
    - Optical Disk Controller
    - Others

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COMPONENTS

- Communications Peripheral
  - LAN
  - ISDN
  - Modem
  - Serial I/O
  - UART/USART
  - Others
- Floating-Point Coprocessor
  - 16-bit
  - 32-bit
- MOS Logic
  - MOS ASIC
    - MOS Gate Array
    - MOS PLD
      - MOS PLA
      - MOS PMD
      - MOS FPGA
    - MOS Cell-Based IC
  - MOS Custom IC
  - MOS Standard Logic
  - Other MOS Logic
- Analog Integrated Circuit
  - Monolithic Analog IC
    - Linear IC
      - Amplifier IC
      - Voltage Regulator
      - Voltage Reference IC
      - Comparator IC
      - Special-Function IC
      - Special Consumer IC
      - Special Automotive IC
      - Linear Array/ASIC
    - Mixed Signal IC
      - Data Converter IC
      - Telecommunication IC
      - Interface IC
      - Switch/Multiplexer IC
      - Disk Drive IC
      - Mixed Signal ASIC
  - Hybrid Analog IC

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COMPONENTS

- Discrete Semiconductor
  - Transistor
    - Small Signal Transistor
    - Power Transistor
      - Bipolar Power Transistor
      - MOS Power Transistor
      - Insulated Gate Bipolar Transistor
  - Diode
    - Small Signal Diode
    - Power Diode/Rectifier
  - Thyristor
  - Other Discrete Semiconductor
- Optoelectronic Semiconductor
  - Light-Emitting Diode/Display
  - Optocoupler
  - CCD
  - Laser Diode
  - Photosensor
  - Solar Cell
- III-V Semiconductor
  - GaAs Digital IC
  - GaAs Analog IC
  - III-V Discrete Transistor
  - Optoelectronic IC
- Passive Component
  - Cable
  - Capacitor
  - Cathode Ray Tube (CRT)
  - Connector
  - Inductor
  - Potentiometer
  - Relay
  - Resistor
  - Socket
  - Splice (Optical)
  - Transducer
  - Liquid Crystal Display
  - Switch

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BOARDS AND SUBSYSTEMS

- Graphic Board
  - Mac-Type Add-On Graphic Board
  - IBM-Type Add-On Graphic Board
- Imaging Subsystem
  - Add-On Memory Board
  - Controller Board
    - Storage Controller Board
    - Printer Controller Board
  - Magnetic Recording Head
  - Board-Level Computer
- Storage Subsystem

EQUIPMENT

- Data Processing Equipment
  - Computer Systems by Product Segment
    - General-Purpose Computer System
      - Supercomputer
        - Corporate Supercomputer
        - Departmental Supercomputer
        - Research Supercomputer
      - Mainframe Computer
      - Midrange Computer
        - Superminicomputer
        - Minicomputer
        - Microcomputer
      - Workstation Computer
        - Graphic/Project Supercomputer
        - Superworkstation
        - Traditional Workstation
        - Entry-Level Workstation
      - Personal Computer
        - Desktop Personal Computer
        - Desk-Side Personal Computer
        - Transportable Personal Computer
        - Laptop A/C Personal Computer
        - Laptop D/C Personal Computer
        - Notebook D/C Personal Computer
        - Pen-Based Personal Computer

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EQUIPMENT

- Hand-Held Personal Computer
- Special-Purpose Computer System
- Data Storage Device
  - Flexible Disk Drive
    - Fixed Media
      - Sub-3.5-Inch Disk Drive
        - 0 to 30MB
        - 31 to 60MB
        - 61 to 100MB
        - 101 to 200MB
        - 201 to 500MB
        - 501+MB
      - 3.5-Inch Disk Drive
        - 0 to 30MB
        - 31 to 60MB
        - 61 to 100MB
        - 101 to 200MB
        - 201 to 500MB
        - 501 to 1,000MB
        - 1,001+MB
      - 5.25-Inch Disk Drive
        - 0 to 30MB
        - 31 to 60MB
        - 61 to 100MB
        - 101 to 200MB
        - 201 to 500MB
        - 501 to 1,000MB
        - 1,001+MB
      - 8 to 10.5-Inch Disk Drive
        - 0 to 30MB
        - 31 to 60MB
        - 61 to 100MB
        - 101 to 200MB
        - 201 to 500MB
        - 501 to 1,000MB
        - 1,001+MB
      - 14-Inch Disk Drive
        - 0 to 30MB
        - 31 to 60MB

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EQUIPMENT

14-Inch Disk Drive (Continued)
61 to 100MB
101 to 200MB
201 to 500MB
501 to 1,000MB
1,001+MB

Rigid Disk Drive
Fixed Media
Sub-3.5-Inch Disk Drive
0 to 30MB
31 to 60MB
61 to 100MB
101 to 200MB
201 to 500MB
501+MB

3.5-Inch Disk Drive
0 to 30MB
31 to 60MB
61 to 100MB
101 to 200MB
201 to 500MB
501 to 1,000MB
1,001+MB

5.25-Inch Disk Drive
0 to 30MB
31 to 60MB
61 to 100MB
101 to 200MB
201 to 500MB
501 to 1,000MB
1,001+MB

8 to 10.5-Inch Disk Drive
0 to 30MB
31 to 60MB
61 to 100MB
101 to 200MB
201 to 500MB
501 to 1,000MB
1,001+MB

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EQUIPMENT

14-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

Removable Media

Sub-3.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501+MB

3.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

5.25-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

8 to 10.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

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EQUIPMENT

14-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

Dual Media

Sub-3.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501+MB

3.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

5.25-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

8 to 10.5-Inch Disk Drive
- 0 to 30MB
- 31 to 60MB
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

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EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- Optical Disk Drive
  - CD-ROM
  - WORM Optical Disk Drive
    - 5.25 Inch
    - 8 to 12 Inch
    - 14 Inch
  - Rewritable Optical Disk Drive
    - 2 to 5.25 Inch
    - 8 to 12 Inch
  - Optical Jukebox
- Tape Drive
  - 1/4-Inch Tape Drive
    - Start-Stop
    - Streamer
      - 8 Inch
      - 5.25 Inch
      - 3.5 Inch
  - 1/8-Inch Tape Drive
    - Cassette
    - Cartridge
  - 1/2-Inch Tape Drive
    - 1/2-Inch Vacuum Column
    - 1/2-Inch Tension Arm
    - 1/2-Inch Streaming
    - 1/2-Inch Cartridge
  - Reel-to-Reel Tape Drive Recap
  - Helical Scan Tape Drive
    - VHS
    - DAT
    - 8mm
    - Others
- Input/Output Device
  - Terminal
    - Alphanumeric (CRT) Terminal
      - Minicomputer-Based Terminal

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EQUIPMENT

- Alphanumeric (CRT) Terminal (Continued)
  - Non-IBM, Protocol-Specific Terminal
  - IBM 3270 Protocol Terminal
  - Host/Vendor-Independent Terminal
  - Processing Terminal
- Graphics Terminal
- Point-of-Sale Terminal
- Funds Transfer Terminal (ATMs)
- Smart Card
- Other Specialized Terminal

Electronic Printer
- Serial Printer
  - Serial, Impact, Dot Matrix Printer
    - Dot Matrix Printer by Speed
      - 0 to 180 cps
      - 181 to 250 cps
      - 251 to 399 cps
      - 400+ cps
    - Dot Matrix Printer by Size
      - Total < 9 Wire (Pin)
      - Total 9 Wire (Pin)
      - Total 18 Wire (Pin)
      - Total 24 Wire (Pin)
  - Serial, Impact, Fully Formed Printer
    - 0 to 30 cps
    - 31+ cps
  - Serial, Nonimpact, Direct Thermal Printer
  - Serial, Nonimpact, Thermal Transfer Printer
    - Wax-Based
    - Sublimation
    - Dry Silver
  - Serial, Nonimpact, Ink Jet Printer
- Line Printer
  - Line, Impact, Dot Matrix Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651+ lpm
  - Line, Impact, Fully Formed Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651 to 1,050 lpm

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EQUIPMENT

Line, Impact, Fully Formed Printer (Continued)
1,051 to 1,250 lpm
1,251+ lpm

Line, Nonimpact, Direct Thermal Printer
Line, Nonimpact, Thermal Transfer Printer

Page Printer
0 to 6 ppm
7 to 10 ppm
11 to 15 ppm
16 to 20 ppm
21 to 30 ppm
31 to 50 ppm
51 to 80 ppm
81 to 150 ppm
151+ ppm

Other Input/Output Devices
Monitor
Remote Batch, Job-Entry, and Output
Key Entry Equipment
Media-to-Media Data Conversion
Magnetic Ink Character Recognition (MICR)
Optical Scanning Equipment
Computer Plotters
Small Format Pen Plotter
Large Format Pen Plotter
Small Format Electrostatic Plotter
Large Format Electrostatic Plotter
Ink Jet Plotter
Thermal Plotter
Photosensitive Plotter
Laser Plotter
Voice Recognition Computer Device
Voice Synthesizer
Mouse
Keyboard
Digitizer

Office Equipment
Copier and Duplicator
Personal Copier (Up to 12 cpm)
Segment 1 (Up to 20 cpm)

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EQUIPMENT

- Copier and Duplicator (Continued)
  - Segment 2 (21 to 30 cpm)
  - Segment 3 (31 to 44 cpm)
  - Segment 4 (45 to 69 cpm)
  - Segment 5 (70 to 90 cpm)
  - Segment 6 (91+ cpm)
- Full-Color Copiers
- Electronic Calculator (without Alpha Keyboard)
- Dictating, Transcribing Machine
- Electronic Typewriter
- Word Processor
- Banking System
  - Check-Handling System
- Cash Register
- Mailing, Letter-Handling, Addressing Equipment
- Other Office Equipment

Communications
- Telecommunicatons
  - Image Communications
    - Facsimile
      - Classification by Type
        - Standalone Systems
        - PC Facsimile Cards
        - LAN to Fax Gateways
      - Classification by Technology
        - Group I
        - Group II
        - Group III
        - Group III Bis
        - Group IV
      - Classification by Feature
        - Ultra Low End
        - Low End
        - Midrange
        - High End
      - Classification by Price
        - <$1,000
        - $1,000 to $1,499
        - $1,500 to $1,999
        - $2,000 to $2,499
        - $2,500 to $2,999
        - $3,000 or More

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EQUIPMENT

- Classification by Printing Technology
  - Thermal
  - Thermal Transfer
  - Plain Paper (Laser, LED, etc.)
- ISDN Terminals
- Servers
- Teleconferencing
  - Audio
  - Video
    - Captured Image
    - Near-Full Motion
    - Codecs
    - PX64
  - Telex
    - Machines
    - Black Boxes
    - Gateways
    - Message Switches
  - Videotex
    - Terminals

Personal Communications

- Mobile Radio
  - Cellular Handsets
    - Classification by Type
      - Car-Mounted
      - Transportable
      - Portable
    - Classification by Technology
      - Analog
        - C450
        - NMT450
        - NMT900
        - TACS
        - ETACS
        - Radiocom 2000
        - AMPS
        - RTMS-Italy
      - Digital
        - GSM
        - Others

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EQUIPMENT

- Cordless Handsets
  - CT0
  - CT1
  - CT2
  - CT3
  - DECT
  - GSM
  - Base Stations
- Global Positioning Systems
- Mobile Infrastructure
  - Base Stations
- Personal Communications Networks (PCN)
  - Mininetworks
- Public Mobile Radio (PMR)
- Paging Systems

Networking

- Cable (Private)
- Data PBX
- Encryption Units
- Front-End Processors
  - IBM and IBM-Compatible
  - Proprietary
- ISDN
- Local Area Networks (LANs)
  - Terminal Servers
    - Ethernet
    - Token Ring
    - Others
  - PC Network Operating Software
  - PC LANs
  - Classification by Type
    - IBM PC/Compatible
    - Apple Macintosh
  - Classification by Technology
    - 802.3
    - 802.5
    - Arcnet
    - FDDI
    - Others
  - Classification by Media
    - Coaxial
    - Unshielded Twisted Pair (UTP)
    - Fiber-Optic
    - Datagrade

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EQUIPMENT

- Local Operating Network Systems (LONs)
- Modems
  - Classification by Standards
    - U.S. Standards
      - 212 A
      - V.22 Bis
      - 201 B/C
      - 208 A/B
      - V.29
      - V.32
      - V.33
      - 16.8 Kbps
      - 19.2 Kbps
      - V.35
      - V.36
        - Proprietary Dial-Up 9.6 Kbps
    - European Standards
      - V.21/23
      - V.21/23 PC
      - V.22
      - V.22 PC
      - V.22 Bis
      - V.22 Bis PC
      - V.26
      - V.27
      - V.29 Basic
      - V.29 Premium
      - V.32
      - V.32 PC
      - Proprietary Dial-Up 9.6 Kbps
      - V.33
      - 16.8 Kbps
      - 19.2 Kbps
      - Proprietary Baseband
      - Proprietary DOVE
- Multiplexers
  - Classification by Technology
    - Time Division (TDM)
      - Low-End Point-to-Point/Dual Trunk
      - Low-End Networking
      - Channels Banks/Primary MUX
      - T1/E1 Point-to-Point/Dual Trunk

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EQUIPMENT

- Time Division (TDM) (Continued)
  - T1/E1 Network Access
  - High-End Networking
  - Greater than T1/E1
- Statistical Time Division (STDM)
  - Classification by Size
    - Low End (Up to 16 Channels)
    - Midrange (Up to 48 Channels)
    - High End (More than 48 Channels)

Network Management Systems
- Public
  - Carrier
  - Local
  - Long Distance
- Private
  - LANs
  - T1/E1
  - X.25
  - Modems
  - Voice (Call Accounting)
  - Switch and Patch
  - Matrix
  - Mini/Mainframe-Based
  - Test Equipment
    - Analyzers
  - Operator Support Systems

Network-Terminating Devices

Operator Support Systems

Other Datacom Equipment
- Fiber-Optic Multiplexers

Public Data Network Systems (Equipment)
- X.21 Switches

Servers

Value-Added Networks (Equipment)

X.25
- Classification by Type
  - Packet Assemblers/Disassemblers (PADs)
    - Asynchronous Only
    - Synchronous Only
    - Multiprotocol
  - Packet Switches (Nodes)

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EQUIPMENT

- Classification by Capacity
  - Low End (Up to 100 Packets per Second)
  - Midrange (Up to 1,000 pps)
  - High End (More than 1,000 pps)
- Public Network Equipment
- Cable
  - Coaxial
  - Fiber-Optics
    - Monomode
    - Multimode
  - Multipair
- Cable TV
- Carrier Equipment
- Central Office
  - Classification by Type
    - Local
    - Trunk
    - Gateway
  - Classification by Technology
    - Analog
    - Digital
      - ISDN
        - Basic Rate Interface (BRI)
        - Primary Rate Interface (PRI)
    - Others
  - Classification By Size
    - Less than 2K Lines
    - 2K to 10K Lines
    - More than 10K Lines
- Digital Access Crossconnect Systems (DACS)
  - Classification by Type
    - 1/0 DCS
    - 1/1 DCS
    - 3/1 DCS
    - 3/1/0 DCS
    - 3/3 DCS
    - 4/1 DCS
    - 4/3 DCS
    - 4/4 DCS
    - OCN/OCN

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EQUIPMENT

- Classification by Capacity
  - Low End
  - Midrange
  - High End
- Fiber-Optic Terminal (FOTs)
- Line Conditioners
- Main Distribution Frame (MDF)
- Connectors
- Microwave
  - Classification by Type
    - Systems
    - Antenna
    - Accessories
    - Electronics
  - Classification by Usage
    - Short Haul
    - Long Haul
  - Classification by Technology
    - Analog
    - Digital
- Multiplexers
  - Classification by Type
    - Multiplexers
    - Fiber-Optic Terminals
  - Classification by Technology
    - Analog
    - Digital
  - Classification by Standards
    - European/CEPT Standard
      - 2 Mbps
      - 8 Mbps
      - 34 Mbps
      - 140 Mbps
      - 565 Mbps
      - 2.4 Gbps
    - U.S. Standard
      - 1.5 Mbps
      - 6 Mbps
      - 45 Mbps
      - 90 Mbps
      - 135 Mbps
      - 1.2 Gbps

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EQUIPMENT

- SONET
- Synchronous Digital Hierarchy (SDH)
- Asynchronous Transfer Mode (ATM)
- Fast Packet Switching
- Frame Relay

Network Termination Units
- ISDN
- DSU/CSU
- NTU

Operating Support Systems
Pay Phones
Public Paging Systems
Local Loop Equipment
- Analog
  - PCM Repeaters
  - Digital
- Twisted Pair
- SLC-96 and Compatibles
- Others
- Fiber Optics
  - Universal Digital Line Carrier (UDLC)
  - Integrated Digital Line Carrier (IDLC)
  - Flexible Access System (FAS)
  - SONET
  - 802.6 Metropolitan Area Network (MAN)
  - Others
- Wireless
  - Basic Exchange Telephone Radio Service (BETRS)
  - Cordless

Satellite Communications
- Space Stations
- Earth Stations
  - VSAT
  - Master—Hub
  - Remote
    - Receive Only—Data Broadcast
    - Interactive
- Direct Broadcast
- Teleport
- Television Receive Only
- Video Distribution

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EQUIPMENT

- Satellite Communications (Continued)
  - Home
  - Intelsat
  - Eutelsat
  - Others
- Signaling
- Telex
  - Low End (Less than 20 Ports)
  - Midrange(20 to 80 Ports)
  - High End (More than 80 Ports)
- X.25
  - Classification by Size
    - Low End
    - Midrange
    - High End

- Voice Communication
  - Answering Machines
  - Attendant Consoles
  - Automatic Call Distributors (ACDs)
    - Classification by Type
      - Standalone
      - Integrated
      - Analog
      - Digital
    - Classification by Capacity
      - 1 to 8 Agent Positions
      - 9 to 24 Agent Positions
      - 25 to 48 Agent Positions
      - 49 to 100 Agent Positions
      - More than 100 Agent Positions
  - Business Communications Systems
    - Classification by Type
      - Private Branch Exchange (PBX)
      - Key Telephone System (KTS)
    - Classification by Technology
      - Analog
      - Digital
      - ISDN
        - Terminals
        - ISDN
        - Proprietary
        - Servers
      - Network
        - BRI

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EQUIPMENT

- Network (Continued)
  - PRI
  - Proprietary
  - Gateways
- Basic

- Classification by Capacity
  - 1 to 8 Lines
  - 9 to 24 Lines
  - 25 to 48 Lines
  - 49 to 100 Lines
  - 101 to 400 Lines
  - 401 to 1,000 Lines
  - More than 1,000 Lines
- Cable (Private)
- Call Management Systems
  - Centrex
  - KTS
  - PBX
- Integrated Voice/Data Workstations (IVDT)
- Intercom Systems
- ISDN Terminals
  - Voice
  - Data
  - Video
  - Integrated
- Private Paging Systems
- Trading Turrets/Dealer Boards
- Voice-Messaging Systems
  - Classification by Capacity
    - 1 to 4 Ports
    - 5 to 8 Ports
    - 9 to 16 Ports
    - 17 to 32 Ports
    - 33 to 64 Ports
    - 65 to 128 Ports
    - More than 128 Ports
- Voice Response Units (VRUs)
  - Classification by Capacity
    - 1 to 4 Ports
    - 5 to 8 Ports
    - 9 to 16 Ports
    - 17 to 32 Ports
    - 33 to 64 Ports
    - 65 to 128 Ports
    - More than 128 Ports

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EQUIPMENT

- Voice Terminals
  - Classification by Type
    - Corded
    - Cordless
  - Classification by Technology
    - Analog
    - Digital
      - Pulse Dial
      - Tone Dial (DTMF)

- Industrial Electronic Equipment
  - Security/Energy Management
    - Alarm System
      - Intrusion Detection Alarm System
      - Fire Detection Alarm System
        - Discrete Device, Security/Energy Management
  - MPU Load Programmer
  - Computerized Energy Control System

  - Manufacturing System
    - Wafer Fabrication Equipment
      - Lithography Equipment
        - Proximity/Contact Aligners
        - Projection Aligner
        - Steppers
        - Direct-Write E-Beam
        - Maskmaking E-Beam
        - X Ray

      - Automatic Photoresist Processing Equipment
      - Etch-and-Clean Equipment
        - Wet Process
        - Dry Strip
        - Dry Etch
        - Ion Milling

      - Deposition Equipment
        - Chemical Vapor Deposition
        - Physical Vapor Deposition
        - Silicon Epitaxy Deposition
        - Metalorganic CVD Deposition
        - Molecular Beam Epitaxy Deposition
        - Diffusion
        - Rapid Thermal Processing

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EQUIPMENT

- Ion Implantation
  - Medium Current Ion Implantation
  - High-Current Ion Implantation
  - High-Voltage Ion Implantation
- Optical CD/Wafer Inspection
- Other Process Control Equipment
- Factory Automation Equipment
- Other Water Fabrication Equipment

Test Equipment
- ATE (Automatic Test Equipment)
  - Discrete Component Tester
  - Semiconductor Tester
  - Interconnect/Bare PCB Tester
  - In-Circuit PCB Tester
  - Functional PCB Tester
  - Combined PCB Tester
  - Manufacturing EATE N/A
- General Test Equipment

Process Control System
- Process Control System, Controller
- Process Control System, Recorder
- Process Control System, Indicator
- Process Control System, Auxiliary Station
- Process Control System, Nonunified System
- Process Control System, Industrial Process

Programmable Machine Tool
- Boring Programmable Machine Tool
- Drilling Programmable Machine Tool
- Grinding Programmable Machine Tool
- Horizontal Turning Programmable Machine Tool
- Vertical Turning Programmable Machine Tool
- Milling Programmable Machine Tool
- Machining Center Programmable Machine Tool
- Other Cutting Programmable Machine Tool
- Punch/Shear/Bend Programmable Machine Tool
- Flexible Manufacturing System Programmable Machine Tool

Mechanical Assembly Equipment

Plastic Processing Machinery

Robot System
- Robotic Electronic Assembly
- Robotic Nonelectronic Assembly

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EQUIPMENT

- Robot System (Continued)
  - Material-Handling/Loading Robot System
  - Painting Robot System
  - Spot-Welding Robot System
  - Arc-Welding Robot System
  - Machining Robot System
  - Other Robot System
- Automated Material Handling
  - Guided Vehicle
  - Programmable Conveyor
  - Storage/Retrieval Automatic Material-Handling System
  - Programmable Monorail
  - Warehousing
  - Programmable Overhead Crane
  - Other Automated Material-Handling Equipment
- Instrumentation
  - Integrating and Totalizing Meter for Gas
  - Counting Device
  - Digital Panel Meter
  - Analog Panel Meter
  - Panel Type Instrument
  - Elapsed-Time Meter
  - Portable Electronic Measuring Instrument
  - Electronic Recording Instrument
  - Physical Property Test, Inspection, and Measurement
  - Commercial Meteorological and General-Purpose Instrument
  - Nuclear Radiation Detection and Monitoring
  - Surveying and Drafting Instrument
  - Ultrasonic Cleaners, Drill
  - Meteorological Instrument
  - Geophysical Instrument
  - Analytical and Scientific Instrument
- Medical Equipment
  - Diagnostic Medical Equipment
    - Automatic Blood Analyzer
    - CAT Scanner
    - Digital Radiography
    - Electrocardiograph
    - Electroencephalograph
    - Magnetic Resonance Imaging

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EQUIPMENT

- Medical Equipment (Continued)
  - Respiratory Analysis
  - Ultrasonic Scanner, Medical
  - X Ray, Medical
  - Other Diagnostic Medical Equipment
- Patient-Monitoring
- Prosthetic Medical Equipment
  - Hearing Aid
- Surgical Support
- Therapeutic
  - Defibrillator
  - Dialysis, Diathermy
  - Electrosurgical
  - Pacemaker
  - Ultrasonic Generator
  - Other Therapeutic Medical Equipment
- Other Industrial Electronic Equipment
  - Vending Machine
  - Laser System (Excluding Communication)
  - Power Supply
  - Traffic Control
  - Particle Accelerator
  - Industrial and Scientific X Ray
  - Laboratory and Scientific Apparatus
  - Teaching Machine and Aid
  - Scientific Not Elsewhere Classified
- Consumer Electronic Equipment
  - Audio Consumer
    - Audio Amplifier
    - Compact (Disc) Player, Music
    - Consumer Radio
    - Stereo (Hi-Fi) Component
    - Stereo Headphone
    - Electronic Musical Instrument
    - Tape Recorder, Consumer
  - Video, Consumer
    - Video Camera, Consumer
    - VTRs (VCRs)
    - Videodisc Player

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EQUIPMENT

- Video, Consumer (Continued)
  - Color Television
  - Black-and-White Television
  - HDTV
  - Remote Control
  - LCD Television
- Personal Electronic
  - Game
  - Camera
  - Watch
  - Clock
  - Toy
  - Sewing Machine
  - Other Personal Electronic
- Appliance
  - Air Conditioner
  - Microwave Oven
  - Washer and Dryer
  - Refrigerator
  - Dishwasher, Disposal
  - Range and Oven, Consumer
  - Rice Cookers
  - Fans
  - Heaters
  - Vacuum Cleaners
  - Food Processors
  - Other Consumer Appliance
- Other Consumer Electronic
  - Automatic Garage Door Opener
  - Residential Smoke Alarm
  - Consumer Electronic Equipment Not Elsewhere Classified
- Military/Aerospace Electronic Equipment
  - Military Electronic Equipment
    - Radar, Military
    - Sonar, Military
    - Missile-Weapon
    - Space Military Equipment
    - Navigation, Military
    - Communication, Military
    - Electronic Warfare

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EQUIPMENT

- Military Electronic Equipment (Continued)
  - Reconnaissance
  - Aircraft System
  - Military Computer System
  - Simulation and Training, Military
  - Miscellaneous Military Equipment
- Civil Aerospace
  - Radar, Civilian
  - Civilian Space
  - Civil Navigation/Communication
  - Civil Aircraft Flight System
  - Civil Simulation and Training
- Transportation Electronic Equipment
  - Entertainment, Transportation
  - Body Controls
  - Driver Information
  - Powertrain
  - Safety and Convenience
- Other Electronic Equipment

SOFTWARE

- Application Software (See Applications Segmentation)
- System Software
  - Operating System Software
    - Database
      - Document Management
      - Data Acquisition and Control
      - Storage Management
      - Database Administration
      - On-Line Transaction Processing
    - Development Tools
    - Editors
    - Language
      - Compilers
      - Assemblers
      - Translators
      - Data Translator
      - Query Languages

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SOFTWARE

- Interactive Languages
  - Fourth-Generation Languages
  - Visual Programming Languages
- Graphic
- Communication Management
  - User Interface
  - Device Interface
- Protocol
- Security
- Operating Environment
- Operating System
  - Proprietary
    - IBM/VM/MVS
    - DEC VMS
    - Others
  - Open
    - UNIX
      - OSF1
      - Sun OS
      - System V/BSD
      - Mach
      - XENIX
      - Others
        - Pick
        - Theos
        - Others
    - Real-Time
  - PC
    - DOS
    - OS/2
    - Macintosh
    - Others
  - Operating Utilities
    - Peripheral I/O Management
    - System Subroutine Libraries
    - Data Center and System Management
    - Information Resource Management
    - Information Center
    - System Utilities

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CONSUMABLES

- Paper
  - Cut Sheet
  - Form
  - Label
- Toner and Developer
- Print Ribbon
- Photoreceptor
- Print Element
  - Printwheel
  - Golf Ball
  - Thimble
- Computer Storage Media
  - Flexible Disk
  - Rigid Disk
  - Computer Storage Tape
  - Optical Media
- Transparency
- Other Consumable

SERVICES

- Telecommunications Services
  - Core Services
    - Classification by Type
      - Local Telephone Services
      - Long Distance Services
      - International Services
    - Classification by Technology
      - Analog
      - Digital
        - ISDN
          - HO
          - BRI
          - PRI
        - Others
    - Classification by Product
      - Toll Revenue
      - WATS Outgoing
      - WATS Incoming (800 Service)
      - 900 Service
      - Switched Digital Services
        - Switched 56 Kbps
        - X.21

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SERVICES

- Classification by Product (Continued)
  - Analog Private Lines
    - Conditioned
    - Unconditioned
  - Digital Private Lines
    - Classification by Capacity
      - 0 to 19.2 Kbps
      - 19.2 Kbps to 64 Kbps
      - 64 Kbps to H11
      - H11 to 772 Kbps
      - T1
      - E1
      - 8 Mbps
      - T3
      - 34 Mbps
      - More than T3
  - Centrex
    - Classification by Type
      - ETN
      - ACD
      - CLASS
      - Routing
      - Billing
      - Network Management
    - Classification by Size
      - 1 to 8 Lines
      - 9 to 24 Lines
      - 25 to 48 Lines
      - 49 to 100 Lines
      - 101 to 400 Lines
      - 401 to 1,000 Lines
      - More than 1,000 Lines
  - B-ISDN
  - Operator Services
- Enhanced Services
  - Audiotex Access Services
  - Voice Mail
  - Cable TV
  - Directory Inquiry
  - Electronic Messaging
    - X400
    - EDI
    - Others

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SERVICES

- ISDN
- Public Data
- Satellite
  - VSAT
  - Others
- Teleconferencing
- Teleport Services
- Telex Services
- Facsimile Services
- Value-Added Networks (VANs)
- VideoConferencing
  - Ad Hoc
  - Carrier Provided
- Virtual Private Network Services
- Videotex Access Services
- X.25
- Voice Messaging

Mobile Services
- Cellular
  - Classification by Technology
    - Analog
      - C450
      - NMT450
      - NMT900
      - TACS
      - ETACS
      - Radiocom 2000
      - AMPS
      - RTMS-Italy
    - Digital
      - GSM
      - Others
- Cordless
  - Portable
    - CT2
    - CT3
    - DECT
  - Mobile
    - GSM
- Global-Positioning Systems
  - Location Identification Systems

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SERVICES

- Personal Communications Networks (PCN)
  - SubGSM
- Public Mobile Radio (PMR)
  - Data Services
- Public Paging Systems
- Messaging Services
- Hardware Maintenance
  - Contract Maintenance
  - Time and Materials
- Parts
- Software Support
- Customer Training/Education
- Network Support
- Professional
  - Systems Integration
  - Facilities Management

OTHER PRODUCTS

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Geographic Regions

The geographic regions segmentation shows the classification scheme used by Dataquest to define the regions of the world. Dataquest classifies the world into the following regions:

- North America
- Europe
- Japan
- Rest of Asia—Rest of World

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Geographic Regions

Worldwide

North America
Europe
Japan
Rest of Asia—Rest of World

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North America

North America

United States

East North Central Division
- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin
- East North Central Other

East South Central Division
- Alabama
- Kentucky
- Mississippi
- Tennessee
- East South Central Other

Mountain Division
- Arizona
- Colorado
- Idaho

Mountain Division (Continued)
- Montana
- Nevada
- New Mexico
- Utah
- Wyoming
- Mountain Other

Middle Atlantic Division
- New Jersey
- New York
- Pennsylvania
- Middle Atlantic Other

New England Division
- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont
- New England Other

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United States (Continued)

Pacific Division
- Alaska
- California
- Hawaii
- Oregon
- Washington
- Pacific Other

South Atlantic Division
- Delaware
- District of Columbia
- Florida
- Georgia
- Maryland
- North Carolina
- South Carolina
- Virginia
- West Virginia
- South Atlantic Other

West North Central Division
- Iowa
- Kansas
- Minnesota
- Missouri
- Nebraska
- North Dakota
- South Dakota
- West North Central Other

West South Central Division
- Arkansas
- Louisiana
- Oklahoma
- Texas
- West South Central Other

Puerto Rico Division
- Puerto Rico

United States Other

Canada

North America Other

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Europe

Western Europe

Western Europe Major

- France
- Germany
- Italy
- Netherlands
- Spain
- Sweden
- United Kingdom

Western Europe Other

- Austria
- Belgium
- Cyprus
- Denmark
- Finland
- Gibraltar
- Greece
- Iceland
- Ireland
- Liechtenstein
- Luxembourg
- Malta
- Monaco
- Norway
- Portugal
- San Marino
- Switzerland

European Community (EC)

- Belgium
- Denmark
- France
- Germany
- Greece
- Ireland
- Italy
- Luxembourg

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European Community (EC) (Continued)
- Netherlands
- Portugal
- Spain
- United Kingdom

European Free Trade Association (EFTA)
- Austria
- Finland
- Iceland
- Norway
- Sweden
- Switzerland

Eastern Europe
- Albania
- Bulgaria
- Czechoslovakia
- Hungary
- Poland
- Romania
- Union of Soviet Socialist Republics
- Yugoslavia

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Japan

Japan

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Rest of Asia—Rest of World

Rest of Asia—Rest of World

Four Tigers

- Hong Kong
- Korea
- Singapore
- Taiwan

Other Asia

- Bangladesh
- Brunei
- Burma
- Cambodia
- China
- East Timor
- India
- Indonesia
- Laos
- Macau
- Malaysia
- Maldives
- Nepal
- Pakistan
- Philippines
- Sri Lanka
- Thailand
- Vietnam

Rest of World

Australia/New Zealand

- Australia
- Christmas Island
- Cocos Islands
- New Zealand
- Norfolk Island

Oceania

- American Samoa
- Canton and Enderbury Islands
- Cook Islands
- Fiji
- French Polynesia

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Oceania (Continued)
- Guam
- Johnson Island
- Kiribati
- Midway Islands
- Nauru
- New Caledonia
- Niue
- Pacific Islands
- Papua New Guinea
- Pitcairn
- Samoa
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu
- Wake Island
- Wallis and Futuna Islands

Africa
Central America
Caribbean
Middle East
South America
Atlantic
Inner Asia

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Distribution

The distribution segmentation outlines the path by which a product moves from the manufacturer to the ultimate end user. This segmentation is used by Dataquest to analyze markups, discounts, and buyer behavior.

Dataquest defines the major distribution classifications as follows:

- Distribution channel
- Distribution method

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Distribution

DISTRIBUTION CHANNEL

- Direct
- Indirect
  - Value-Added Reseller/Systems Integrator
  - Original Equipment Manufacturer
  - Distributor
    - Regional Bell Operating Company (RBOC)
      - Independent Telephone Company
      - Telephone Interconnect Supplier
  - Dealer
  - Mass Merchandiser
  - Manufacturers' Representatives/Agents

DISTRIBUTION METHOD

- Direct Sales Force
- Telemarketing
- Mail Order
- Company-Owned Store

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Applications

The applications segmentation describes the use to which a product is put or the function it performs. Sometimes there are one-to-one relationships between products and their applications and the actual functions that a product performs.

The major applications as defined by Dataquest are as follows:

- General productivity
- Organizational
- Entertainment
- Industry specific

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Applications

GENERAL PRODUCTIVITY

- Document/Media Creation and Editing
  - Computer-Aided Printing and Publishing
    - Electronic Publishing
    - Technical Publishing
  - Graphics
    - Chart and Map Generation
    - Image Generation
    - Graphic Design Art
      - Image Editing
      - Draw/Paint
      - Image Capture
      - Clip Art
      - Illustration
    - Presentation Graphics
    - Color Prepress
      - Input
      - Image Processing
        - Image Manipulation
        - Color Correction
        - Color Pagination
      - Composition and Translation
      - Color Separation
    - Page Composition and Page Makeup
      - Page Description
      - Page Imaging
      - Document Architecture
      - Desktop Publishing
      - Scientific Visualization/Simulation
    - Multimedia
      - Animation
      - Desktop
        - Video
          - Compression
          - Digitizer
          - Full-Motion
          - Real-Time
        - Videodisc

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GENERAL PRODUCTIVITY

- Holography
- Photo Realism
- Information Retrieval

- Forms

- Publishing Utilities
  - Tagging
  - PostScript Printing
  - Compression/Decompression
  - File Translation/Data Conversion

- Document Management
  - Author/Editor
  - Image Processing
  - Scanning
    - Text
    - Image
  - Word Processing
  - Typography

- Communication
  - Electronic Mail

- Spreadsheet/Decision Support/Executive Information Systems
  - Spreadsheet
  - General-Purpose Simulation
  - Modeling
  - Forecasting

- Learning/Education/Training
  - Instructional
    - Computer Training/Assisted Instruction
  - Educational Simulation
  - Learning

- Project Management
  - Calendaring
  - Scheduling
  - Ticketing
  - Library Management

- Time Management
  - Application Utilities
  - Integrated Applications
  - Relational Database Management System

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ORGANIZATIONAL

- Management and Administration
  - Accounting
    - Accounts Payable
      - Checkbook Management
    - Accounts Receivable
      - Billing/Invoicing
    - General Ledger
    - Payroll
    - Tax Accounting
    - Personal Finance
  - Capital Assets
    - Fixed Assets
    - Lease Accounting
  - Human Resource/Personnel Management
    - Benefits Administration
    - Employment Administration
  - Finance
    - Financial Planning
    - Budgeting
    - Cost Accounting
    - Investment/Portfolio Management
    - Cash/Money Management
    - Deposit/Loan Management
    - Treasury/Stocks/Bonds
  - Purchasing
    - Contract Administration
    - Vendor Management
  - Planning
    - Business Planning
    - Strategic Planning
    - Command, Control, Communications, and Intelligence
  - Facilities Management
    - Facility Planning
    - Facility Simulation
    - Equipment/Maintenance Management
    - Property/Real Estate Management
    - Facility Security Management

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ORGANIZATIONAL

- Sales and Marketing
  - Marketing Research
  - Advertising and Promotional
  - Public Relations
  - Order Entry/Processing
    - Customer/Prospect Management
      - Credit Management
    - Sales Support/Administration
- Research, Engineering, and Development
  - Industrial Automation
    - Shop Floor Plan and Control
    - CAM/Automated Assembly
    - Manufacturing Engineering Tools
    - Other Planning and Control
    - Test and Measurement
    - Others
  - Design Automation
    - CAD/CAM/CAE
      - Modeling
        - Two-Dimensional
        - Three-Dimensional
        - Solid
      - Mechanical
        - Documentation/Drafting
          - Detail Drafting
          - Document Management
          - Schematics
          - Technical Illustration
          - Charts
        - Conceptual Design
          - Industrial Design
          - Design Layout
          - Styling
        - Functional Design
          - Component
          - Assembly Verification
          - Linkage/Mechanism
        - Analysis
          - Fatigue
          - Structural

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ORGANIZATIONAL

- Analysis (Continued)
  - Thermal
  - Vibrational
  - Magnetic
  - Composite
  - Mass Property
- Manufacturing Engineering
  - Tool Design
  - Fixture Design
  - Part-Processing Design
- Manufacturing Process Simulation
  - NC Part Programming
  - Coordinate Measuring Machines
  - Off-Line Robotics
  - QC Analysis
- AEC (Architectural, Engineering, and Construction)
  - Architectural
  - Civil
  - Facility Design
  - Process Plant Design
- Geographical Information Systems
  - GIS/Mapping
  - Raster-Based GIS Systems
- Electronic Design Automation
  - Electronic Computer-Aided Engineering
    - Digital Design
      - Design Entry
        - Schematic Entry
        - Libraries
      - Design Verification
        - Simulation
        - Simulation Acceleration
        - Hardware Modeling
        - Static Timing Analysis
      - Logic Synthesis
      - Test Automation
        - Automatic Test Vector Generation
        - Design for Testability/Test Synthesis
        - Fault Simulation

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ORGANIZATIONAL

- Analog Design
  - Design Entry
    - Schematic Capture
    - Libraries
  - Design Verification
    - Circuit Simulation
    - Mixed Signal Simulation
- IC Layout and Verification
  - Editing
  - Layout
  - Verification
  - Module Generation
- PCB Layout

Software Development
- Computer-Aided Software Engineering
- Artificial Intelligence
- General Software Development

Earth Resources
- Seismic Analysis
  - Geophysical Seismic Imaging
- Oil Field Services
- Remote Sensing

Technical Data Analysis
- General Scientific
  - Scientific Research/Analysis
  - Scientific Visualization
  - Scientific Simulation
- Chemistry
  - Crystallography
  - Modeling
  - Analysis
- Simulation
- Laboratory
- Analytical Instruments
- Instrument Automation
- Quality Control/Assurance
- Research and Laboratory Analysis
- Others

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ORGANIZATIONAL

- Medical
  - Body Scanning
  - Patient Monitoring
  - Others
- Diagnostic
- Therapeutic

Manufacturing and Distribution
- Distribution Planning and Control
  - Transportation/Fleet Management
    - Route Planning
    - Dispatching
  - Warehouse Management
    - Automated Warehousing and Materials Handling
  - Inventory and Distribution Management and Control

Manufacturing Planning and Control
- Material/Process Requirements Planning, Production and Process Management
- Shop Floor Planning and Control
- CAM/Automated Assembly
- Manufacturing Engineering Tools
- Other Planning and Control
  - Simulation
    - Robot Programming and Simulation
  - Quality Assurance
    - Detection and Tracking
  - Fault Management/Adaptive Control
- Test and Measurement
- Inspection
  - Machine Vision

Others
- Real-Time Data Acquisition and Control
  - Simulation
  - C^3i
  - Others
- Building Automation

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ORGANIZATIONAL

Others (Continued)
- Traffic Control
- Railroad Control
- Power Grid Control
- Water Quality and Sewage Control
- Atmospheric Monitoring

ENTERTAINMENT

INDUSTRY SPECIFIC

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User Environment

The user environment segmentation is based on industry classifications derived from a format that reflects the United States Department of Commerce's Standard Industrial Classification (SIC) code scheme and the International Standard Industrial Classification of all economic activities used by the United Nations.

Environments are a description of where a product is used ultimately. The major user environments as defined by Dataquest are as follows:

- Home
- Business
- Education
- Government

Dataquest has a classification scheme available at the two-, three-, and four-digit SIC levels, which can be provided on request.

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User Environment

HOME

BUSINESS

Natural Resources and Construction
- Agricultural Production—Crops
- Agricultural Production—Livestock
- Agricultural Services
- Forestry
- Fishing, Hunting, and Trapping
- Metal Mining
- Coal Mining
- Oil and Gas Extraction
- Nonmetallic Minerals, except Fuels
- General Building Contractors
- Heavy Construction, except Building
- Special Trade Contractors

Process Manufacturing
- Food and Kindred Products
- Tobacco Products
- Textile Mill Products
- Lumber Wood Products
- Paper and Allied Products
- Printing and Publishing
- Chemicals Allied Products
- Petroleum and Coal Products
- Rubber and Miscellaneous Plastics Products
- Leather and Leather Products
- Stone, Clay, and Glass Products
- Primary Metal Industries

Discrete Manufacturing
- Apparel and Other Textile Products
- Furniture and Fixtures
- Fabricated Metal Products
- Industrial Machinery and Equipment
- Electronic and Other Electric Equipment
- Instruments and Related Products

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BUSINESS

Discrete Manufacturing (Continued)
- Miscellaneous Manufacturing Industries
- Transportation Equipment

Transportation
- Railroad Transportation
- Local and Interurban Passenger Transit
- Trucking and Warehousing
- Water Transportation
- Transportation by Air
- Pipelines, except Natural Gas
- Transportation Services

Communication
- Communication

Utilities
- Electric, Gas, and Sanitary Services

Wholesale Trade, Durable Goods
- Wholesale Trade—Durable Goods

Wholesale Trade, Nondurable Goods
- Wholesale Trade—Nondurable Goods

Retail Trade
- Building Materials and Garden Supplies
- General Merchandise Stores
- Food Stores
- Automotive Dealers and Service Stations
- Apparel and Accessory Stores
- Furniture and Home Furnishings Stores
- Eating and Drinking Places
- Miscellaneous Retail

Finance
- Depository Institutions
- Nondepository Institutions
- Security and Commodity Brokers

Insurance
- Insurance Carriers
- Insurance Agents, Brokers, and Service

Real Estate
- Real Estate
- Holding and Other Investment Offices

Hotels And Other Lodging
- Hotels and Other Lodging

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BUSINESS

Business Services
- Business Services
- Legal Services

Health Care
- Health Services

Other Services
- Personal Services
- Auto Repair, Services, and Parking
- Miscellaneous Repair Services
- Motion Pictures
- Amusement And Recreation Services
- Social Services
- Museums, Botanical, Zoological Gardens
- Membership Organizations
- Engineering and Management Services
- Services, NEC

EDUCATION

Elementary
Secondary
Higher Education
Four-Year Institution
Two-Year Institution
Public
Private

GOVERNMENT

Government by Function
- Executive, Legislative, and General
- Justice, Public Order, and Safety
- Finance, Taxation, And Monetary Policy
- Administration of Human Resources
- Environmental Quality and Housing
- Administration of Economic Programs
- National Security and International Affairs

Government
- Federal
- State
- Local

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SIZE (BUSINESS, EDUCATION, GOVERNMENT)

Revenue (Millions of U.S. dollars)
- 0 to 99.9
- 100 to 499.9
- 500 to 999.9
- 1 to 4.9
- 5 to 9.9
- 10 to 49.9
- 50+

Employees
- Small
  - 0 to 9
  - 10 to 19
  - 20 to 49
- Medium
  - 50 to 99
  - 100 to 249
- Large
  - 250 to 499
  - 500 to 999
  - 1,000+

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Research Items

The research items segmentation is a listing of general terms used by Dataquest to organize, describe, and analyze data for technology markets and industries. A typical use of research items is to describe market data in terms of shipments, retirements, and installed base.

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Research Items

Application
Assembler
Average Selling Price
Average Usage
Average Volume
Balance of Trade
Bit
Byte
Capital Spending
Captive Production
Compound Growth Rate
Consumption
Conversion Revenue
Cost
End User
End-User Average Selling Price
End-User Revenue
Environment
Export
Factory Average Selling Price
Factory Revenue
Gross Lease Additions
If-Sold Value
Import
Industry
Input/Output (I/O) Ratio
Installed Base
Internal Transfer
Inventory
Joint Venture
Lease
Lease/Rental Conversions
List Price
Manufacturer
Manufacturer's Suggested Retail Price
Market
Market Share
Markup
Merchant Production
Net Additions
New Placement Demand
Placement
Product
Product Category
Production
Replacement Demand
Research and Development
Residual Value
Retirement
Return
Revenue
Shipment
Subsidiary
Tie Ratio
Unit
Useful Life
Users per System
Year-Average Population

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Glossary

This glossary includes definitions of the major terms associated with Dataquest's segmentation of the high-technology marketplace.

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III-V discrete semiconductor. 1: A semiconductor device with low noise, low power, and high power in the range of one-half watt to one watt. 2: A device of gate structures based on D-MESFET and E/D MESFET devices.

A

academic support. College expenditures that include expenditures for support services that are an integral part of the institution's primary missions of instruction, research, or public service. Includes expenditures for libraries, galleries, audio/visual services, academic computing support, auxiliary support, academic administration, personnel development, and course and curriculum development.

accounting software. 1: A software application that supports a system of recording and summarizing business and financial transactions and analyzing, verifying, and reporting results. 2: A software application used to manage an organization's money and/or assets. This type of software includes general ledger, accounts payable/receivable, and inventory control.

accounts payable (AP). An application that supports the accounts payable function, which is the amount owed by a business to its suppliers and other regular trading partners.

accounts receivable (AR). An application that supports the accounts receivable function, which is the amount owed to a business by its customers.

ACD. See **automatic call distributor.**

adaptive control. 1: The property of a control system that allows it autonomously to maintain a manufacturing or process environment within predetermined control limits. 2: A device with parameters that adjust automatically to compensate for changes in the dynamics of the process to be controlled.

add-on graphics board. A graphics board that is added to a basic computer to enhance the computer's current graphic capability.

add-on graphics board, Mac-type. Personal computers that were designed to run applications exclusively through a graphical user interface (i.e., windows, menus, and icons). Mac-type systems include Apple's Macintosh series (512E, Plus, SE, and II), Atari's ST series (524 and 1024), and Commodore's Amiga. This term also refers to peripherals intended for use in Mac-type systems.

add-on memory board. A printed circuit board populated with memory integrated circuits (IC), usually DRAMs or SRAMs, that plugs into personal computers via connectors on the central processing unit bus. These boards are used to increase central processing unit storage capacity.

AEC. See **architecture, engineering, and construction.**

aerial. See **antenna.**

AGVS. See **automatic guided vehicle system.**

AI. See **artificial intelligence.**

air conditioner. 1: An apparatus for controlling the temperature and humidity of air. 2: A broad field including numerous processes, among which are refrigeration, heating, ventilation and humidification, and electronic air filtering.

aircraft system (military). Electronic power devices used in airplanes to perform functions like flight control, communication and navigation, lighting computer system (including air data, mission and fire control), engine control, instrumentation, integral targeting system, associated test system, and integrated system.

alarm system. A system designed to warn of an intrusion, a fire, or other undesired occurrence. Alarm systems have three functions in common: detection, control, and annunciation signaling.

alphanumeric CRT controller. A character set of both letters and numbers that is used to control electron beams, which are used to present data in a visual form.

alphanumeric CRT terminal. A display terminal that provides character information to the operator.

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amateur radio. A radio used for two-way radio communications by private individuals. It is not used for enterprise activity.

AMH. See **automated materials handling.**

amplifier IC. A linear IC that provides a voltage or power gain to an applied signal.

analog. 1: Representation of data by means of continuously variable physical quantities, such as voltage, current, or frequency. 2: A circuit or system in which the output signals bear a continuous relationship to the input signals. 3: A representation of an event in another form, e.g., the representation of voice sounds as continuously variable electrical signals.

analog design verification. A software application that includes analog simulation, analog synthesis, monte carlo analysis, worst-case analysis, and parametric plotting.

analog loop. A nondigital portion of the telecommunications network.

analog panel meter. 1: An electrical switchboard or instrument board with continuously variable electrical signals known as analog signals. 2: A mounting plate for the controls and/or other parts of equipment, utilizing analog signals.

analysis. Separation of a whole into its parts; proof of a mathematical proposition by assuming the result and deducing a valid statement by a series of reversible steps. Includes mass properties, kinematic and dynamic mechanism analysis, structural, thermal, composite, fluids, and vibration analysis. Finite element and finite difference are common analysis technologies used.

analytical and scientific instrument. Instruments used to measure, access, control, and monitor objects and systems.

animation. A software application to present either continuous pictures or images or to present them in rapid succession.

answering machine. A device, hooked to a telephone, that can record and play messages as they pass through a phone when a user is unable to pick up the telephone.

antenna. 1: A conductor or system of conductors that serves to radiate or intercept energy in the form of electromagnetic waves. 2: A device for transmitting or receiving radio waves. Also called aerial.

AP. See **accounts payable.**

appliance. 1: An instrument or device designed for a specific household or office purpose. 2: A piece of equipment for adapting a tool or machine to a special purpose.

application. The use to which a product is put; the function it performs.

application software. A software program or set of programs designed for a specific application, such as inventory control or linear programming.

application-specific integrated circuit (ASIC). A single-user IC that is manufactured using vendor-supplied tools and/or libraries. (May be sold by an ASIC or standard-product group.)

application utilities. A software application that enhances the operation of other standalone applications; Typically operates concurrently with these standalone applications.

AR. See **accounts receivable.**

architectural. Computer-aided tools intended for use in design and drafting of facilities' architectural aspects.

architecture, engineering, and construction (AEC). The use of computer-aided tools by architects, contractors, plant engineers, civil engineers, and others associated with these disciplines to aid in designing and managing buildings, industrial plants, ships, and other types of nondiscrete entities.

arc-welding robot systems. A system in which a robot carries an arc-welding torch to produce welds.

argon. An inert gas extensively used in discharge tubes.

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artificial intelligence (AI). The ability of a machine to perform functions normally associated with human intelligence, such as learning, adapting, reasoning, self-correcting, and improving automatically.

ASCII. Standardized coding for alphanumeric and other standard keyboard characters.

ASIC. See **application-specific integrated circuit.**

ASP. See **average selling price.**

AS/RS. See **automated storage/retrieval system.**

assembler. A company that adds manufacturing value to a product.

assembly. 1: A group of subassemblies and/or parts that, when put together, create a major subdivision of the final product. When two or more components or subassemblies are put together by the application of labor and machine hours, it is called an assembly. An assembly may be an end product or a component for a higher-level assembly. 2: The semiconductor manufacturing steps of mounting a die in a package, bonding the pads to the package leads, and sealing the package.

assembly verification. The integration of various component designs into an assembly to test size/shape and functional characteristics.

asynchronous telecommunications software. A software application that emulates a standard computer terminal (e.g., DEC VT-100) and performs file transfer between asynchronously connected computers and/or provides remote operation of another computer.

ATE. See **automatic test equipment.**

ATM. See **automated teller machine.**

atmospheric monitoring. A real-time software application that monitors weather-related data from satellites and other monitoring sites around the world.

atmospheric/purge cylinder gas. A specialty gas; a cylinder gas for purging certain processing systems and equipment when manufacturers are concerned about possible back contamination of the house lines.

attendant console. A specialized telephone instrument that allows fast and efficient answering and routing of telephone calls.

audio amplifier. A device that uses transistors or vacuum tubes to obtain voltage, current, or power to amplify sound.

audio conferencing. The ability to communicate among more than two people at one time via a speakerphone or the telephone system/network.

audio equipment. Amplifiers, preamplifiers, control consoles, and other equipment used in studio, broadcast, and home environments. Equipment interprets frequencies corresponding to audible sound waves.

automated assembly system. The assembly of parts into subassemblies and/or complete assemblies using programmable equipment that may include robots. In discrete piece manufacturing, this system includes spot- and arc-welding and adhesives. In electronics, this system includes component placement and printed board component insertion. Usually, these automated assembly systems include sensors.

automated guided vehicle system (AGVS). An unmanned mobile transporter under programmable control that moves materials and tooling throughout a factory and/or warehouse. Includes towing vehicles, pallet trucks, light-load transporters, unit-load transporters, and self-loading and unloading vehicles.

automated materials handling (AMH). The automated handling of discrete or bulk materials in manufacturing systems. Materials handling includes the movement, storage, identification, and controlling of materials.

automated storage/retrieval system (AS/RS). All computer hardware, software, and equipment that are used together for mechanical hoists and carriages and that interface with racks and bins for automatic storage and retrieval of unit loads, pallets, and individual parts. An AS/RS moves materials from inventory to operations and back to inventory, frequently for work-in-process inventory.

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automated teller machine (ATM). A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **funds transfer terminal.**)

automatic blood analyzer. Equipment used to analyze, detect, and decipher blood types and blood-related diseases.

automatic call distributor (ACD). A computer-based system located at a customer's premises that: (1) provides real-time monitoring of a telephone system's work load; (2) distributes calls to the agent who is idle longest; and (3) uses a queuing or waiting list assignment that holds the callers in queue until an agent is available, averages the random flow of traffic, and decreases peak traffic load. An ACD also contains features known as gates or agent split groups that provide functional divisions within the routing scheme and allow calls to be directed to a specific group or agent.

automatic photoresist processing equipment (colloquial: track). Equipment used to dispense and process photoresist material onto a wafer. Track equipment, as this equipment is usually called, includes wafer clean/bake, wafer prime, wafer coat/bake, wafer develop/bake, and resist stabilization equipment.

automatic test equipment (ATE). Computer-controlled equipment that inspects electronic devices, both active and passive. ATE usually includes analytical and statistical data-reduction capabilities and can document test results by display, hard copy, and electronic storage. ATE can perform printed circuit board (PCB) inspection by mechanical, electrical, and visual means in an automatic, programmable mode. ATE includes both bare boards and boards that have been loaded with electronic devices. In the latter case, diagnostic capabilities are included as a part of the system definition if they are part of the equipment.

automatic warehousing system (AWS). A dedicated storage and retrieval system that is used not on the factory floor but in a warehouse that may or may not be located within a manufacturing facility. An AWS includes a control system and associated material-handling equipment and structures, but excludes the building unless it is a structural part of the automated system. The control system includes both hardware and software.

automation. The system or technique of the production process that minimizes human intervention. Self-controlled machines are used to accomplish human tasks or tasks not able to be accomplished by human intervention.

average selling price (ASP). The average price of a product, inclusive of any discounts. (See also **end-user ASP** and **factory ASP.**)

average usage. The average number of units of product used per unit of time.

average volume. The average number of units of product produced per unit of time.

awarded contract. A binding agreement granted to a specific company.

AWS. See **automatic warehousing system.**

B

balance of trade. 1: The difference between the value of a country's exports and imports of tangible goods over a given period, usually one year. 2: The difference between the value of a country or region's exports of tangible goods to and imports of tangible goods from a second country or region.

banking system. Systems used in the banking/finance industries to facilitate the transmission of funds to improve efficiencies. Systems include: payroll allocation and deduction; demand deposit accounting; savings, both regular and certificates of deposit; and loan processes.

baseband modem. A type of modem that utilizes all of the available analog bandwidth on a line.

basic exchange telecommunications radio system (BETRS). A radio system network that provides cost-effective basic telephone service within remote areas.

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benefits administration. A software application with the primary function of administering and aiding in managing an organization's employee benefits.

BETRS. See **basic exchange telecommunications radio system.**

BiCMOS. Bipolar complementary metal oxide semiconductor. See **BiMOS.**

BiMOS (BiCMOS). Bipolar metal oxide semiconductor (MOS). An integrated circuit (IC) manufactured with both bipolar and MOS processes that yields a component with the benefits of both technologies.

bipolar. 1: A semiconductor technology employing two junction transistors. 2: A device in which both majority and minority carriers are present. A transistor structure with electrical properties determined within the silicon material.

bipolar application-specific IC. See **application-specific integrated circuit.**

bipolar cell-based IC. See **cell-based integrated circuit.**

bipolar custom IC. See **custom integrated circuit.**

bipolar digital logic. See **logic circuit.**

bipolar digital microcomponent. See **microcomponent.**

bipolar FPGA. See **field-programmable gate array.**

bipolar gate array. See **gate array.**

bipolar memory. See **memory.**

bipolar nonvolatile memory. See **nonvolatile memory.**

bipolar PLA. See **programmable logic array.**

bipolar PLD. See **programmable logic device.**

bipolar PMD. See **programmable multilevel logic device.**

bipolar standard logic. See **standard logic.**

bipolar transistor. A transistor that uses positive- and negative-charge carriers. Bipolar transistors provide current gain—that is, a current input results in a larger current output.

bit. Abbreviation for binary digit. A unit of information equal to one binary decision, or the designation of one of two possible and equally likely values or states of anything used to store or convey information.

black-and-white television. Television in which the reproduced picture is displayed in shades of gray between black and white. Also known as monochrome television.

board-level computer. A single, or multiple, board-level CPU that is sold individually or incorporated in systems-level products (boxes). Typically, these are products that are not considered complete packaged systems. Prices range from the low hundreds to the low thousands of dollars. Frequently, software is bundled with the board for a specific application.

body control. Electronic equipment used to direct, manage, or guide an automobile or truck. Examples include electronic suspension, cruise control, intermittent wipers, load-sensitive braking, antitheft devices, electronic steering, and electronic mufflers.

book publishing software. Software with the main purpose/use of printing books or written or printed literary works.

boring programmable machine tool. A factory tool designed to machine internal work such as cylinders, holes, and castings.

broadband communications. Communications that utilize a bandwidth greater than a voice-grade circuit.

broadcast. 1: The transmission of packets on a contention bus where all data are heard by all devices on the channel and are selected by each device through address-recognition techniques. 2: To send messages or to communicate simultaneously with many or all points on a circuit. 3: The transmission of radio frequencies from a source to all devices that are capable of receiving the signal. Microwave transmission is one method of transmission. 4: Radio or television transmission intended for public reception.

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broadcast and studio equipment. Equipment used to make information public by means of radio or television.

broadcast transmitter antenna. An electronic device for generating and amplifying a radio-frequency carrier for transmission through space from an antenna.

bubble memory. A storage medium that allows information to be stored on magnetically charged crystal chips. Bubble memories can hold data without electricity to sustain them; blackouts, changes in current, and static charges do not affect them. Such memories process material 75 times as fast as disk memories. However, bubble memory processors cannot handle multiprogramming, i.e., performing parallel operations with several programs.

budgeting. An application that supports future resource planning.

building automation. A software application with the primary functions of managing the operations of a facility, including fire detection, energy management, and alarm systems. Large manufacturing plants and skyscrapers use real-time computers to control and monitor conditions. This may include fire detection and control systems; security systems; clocking, documenting, and energy management for heating, ventilation, and air conditioning.

bulk gas. A discrete delivery of gas in a liquid state.

bundled distribution and warehouse package. Hardware and/or software modules used for planning and control of warehouse or product distribution systems. These packages are not available separately from the total warehouse or distribution system.

business. A commercial or mercantile environment usually referred to as a vertical market. See "User Environment" section.

byte. 1: A single group of eight bits processed together. 2: The number of bits that a computer processes.

C

C³I. See command, control, communications, and intelligence.

cable. An assembly of one or more conductors within an enveloping protective sheath, constructed to permit the use of the conductors singly or in groups.

cable television equipment. All equipment for both the head and subscriber ends of a cable television system.

cache. A fast, small memory (typically SRAM) used to enhance CPU performance, separate from main processor memory.

cache controller. A device that governs the area of a system that stores only data the system may need in the immediate future.

CAD. See computer-aided design, drawing, or drafting.

CAE. See electronic computer-aided engineering and mechanical computer-aided engineering.

CAGR. See compound annual growth rate.

calculator. A device capable of performing logical and arithmetical digital operations of any kind.

calendaring. 1: An application to support the scheduling of meetings and other events. It is usually a tickler file, reminding people of upcoming commitments. 2: In the papering industry, paper with a hard, smooth finish.

call management systems. The equipment and service that records the calling activity of a centrex, PBX, or key telephone system in order to generate reports that support telephone cost allocation and other telephone management information needs.

call processing equipment. Call processing equipment provides additional functions and capabilities beyond traditional call processing. This classification includes add-on products such as voice-messaging systems, call accounting systems, and automatic call distributors.

CAM. See computer-aided manufacturing.

capacitor. A commonly used component that stores electrical energy. It is sometimes referred to as a condenser.

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capital assets. An application that assists a company in managing its capital assets, which are any physical property or right that is owned and has a money value.

capital spending. The purchase of a capital asset or an asset that is needed to create a product and is acquired with the intention of keeping (rather than being resold).

captive production. The sale of a good to a division within the manufacturing company.

carrier equipment. A cable-based system that provides transmission of multiple signals over a common metallic or fiber-optic cable. This segment includes subscriber carrier systems, trunk carrier systems, Basic Exchange Transmission Radio (BETR) systems, and repeaters.

cartography. An application that supports map production and/or resource management. May contain a spatially indexed data structure.

cartridge tape drive. A tape drive that uses a special metal and plastic protective device for the tape, which can be used for 1/4-inch or 1/2-inch tape products.

CASE. See **computer-aided software engineering.**

cash register. A device that automatically registers visibly the amount of a specific sale. Many are used to trace inventory and other product information through the sale of the product.

cassette tape drive. A tape drive that uses a small container of tape similar to that used for commercial audio recording purposes.

cathode ray tube (CRT). A television-like display screen which, on receipt of information bearing electronic signals, produces a visual display of the information (text, graphics). The CRT consists of a vacuum tube display in which a beam of electrons is projected onto a fluorescent surface of phosphors, producing a visual display. Used in most computer display terminals. Also referred to as video display terminal/visual display tube (VDT).

CAT scanner. A computerized axial tomography—frequently shortened to CT. A reconstructive imaging technique employing an X-ray source and array of detectors rotated about the body of the patient. The host computer calculates an image based on the appearance of a thin volume in the plane of the rotation.

CBIC. See **cell-based integrated circuit.**

CCD. See **charge-coupled device.**

CCIT. A French acronym for the International Telegraph and Telephone Consultative Committee, a committee of the international standards organization made up of telecommunication authorities of member countries. The committee's primary purpose is to develop and produce standards for telecommunication networks.

CCME. See **computational chemistry/molecular engineering.**

CCTV. See **closed circuit television.**

CD. See **critical dimension** and **compact disc.**

CD-ROM (compact disc read-only memory). See **CD-ROM disc drive.**

CD-ROM disc drive. All CD-ROM discs are 4.7 inches (12cm) in diameter, have a 1.6-microinch-pitch single-spiral track, and have 2.048 data bytes per sector.

cell-based integrated circuit (CBIC). An ASIC device that is customized using a full set of photomasks and uses automatic placement of cells and automatic routing.

cellular handset. See **cellular telephone.**

cellular service. One type of mobile communications, where a low-power radio is used between limited-distance "cells."

cellular telephone. Mobile radio equipment associated with cellular radio services.

central office (CO). 1: The physical location that contains the equipment that supports the telephone network. 2: The switching equipment that connects local access lines to toll circuits.

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central office switching equipment. Equipment comprised of electronic systems that interconnect local telephone lines (loops) and connect local telephone lines to long distance trunk lines.

central processing unit (CPU). A microprocessor or microcontroller. Central processing unit of a computer.

centrex. An optional service that provides voice/data switching by using the utility's central office.

charge-coupled device (CCD). ICs that combine charge-coupled signal transfer with arrays of photosensors to provide image sensing. CCDs are available as linear or area arrays.

chart. Any table, graph, or drawing depicting a range of technical data.

chart and map generation. A graphics software application that is designed specifically for charts and predefined maps.

check-handling system. A system to improve the speed and accuracy of check-handling processes within the banking and finance industries.

chemical vapor deposition (CVD). A formation of a stable compound on a heated substrate by thermal reaction or decomposition of gaseous compounds. A process that chemically isolates and deposits a specific material on a wafer. CVD equipment includes atmospheric-pressure CVD (APCVD), plasma-enhanced CVD (PECVD), and low-pressure CVD (LPCVD) techniques. Historically, the CVD market was split into APCVD, PECVD, and LPCVD technologies, because each had its own applications. Now, because of advanced reactors that are crossing application boundaries, it makes more sense to divide the market by film application rather than by equipment technology.

chemistry. 1: An application to support the science dealing with the composition structure and properties of substances and with the transformations that they undergo. 2: Chemical processes and phenomena.

circuit. 1: The electrical path between two or more points. 2: A means of two-way communication between two points, consisting of a sending and a receiving channel or a combined sending and receiving channel. 3: A transmission path between two or more points.

CISC MPU. See complex-instruction-set computing microprocessor.

citizens band: mobile and base. A frequency band allocated for private individual radio service (460 to 470 megahertz or 26.965 to 27.405 megahertz).

civil aerospace. Civilian travel in space.

civil aircraft flight system. Same as military aircraft, except related to civilian activity.

civil application. A software application used for civil engineering tasks, typically for design and drafting of sites for buildings, streets, highways, bridges, dams, airports, and utilities.

civilian space. Equipment used by civilians to explore the earth's atmosphere. Includes satellites, reconnaissance equipment, and ground control equipment.

civil navigation/communication. Same as military navigation/communications, except related to civilian activity.

civil radar. Same as military radar, except related to civilian activity.

civil simulation and training. Same as military simulation and training, except related to civilian activity.

closed circuit television (CCTV). A television system where television signals are not broadcast, but are transmitted over a closed circuit and received by interconnected receivers.

CMOS. See complementary MOS.

CO. See central office.

coaxial cable. Type of transmission cable with one or more central conductors, surrounded by an insulator.

CODEC. See coder/decoder circuit.

coder/decoder circuit. An integrated circuit that codes a voice signal into a binary waveform or decodes a binary waveform into a voice signal. Such circuits now are used in digital communications applications.

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college. A postsecondary school that offers general or liberal arts education, usually leading to an associate, bachelor's, master's, doctor's, or first professional degree. Junior colleges and community colleges are included under this category.

color prepress. A process that converts visual material to electronic signals.

color separation. A process of photographing objects using three filters, each corresponding in color and light transmission to one of the additive primary colors; analogous to seeing.

color television. An electronic system that transmits signals to a visual image that can be viewed in an array of colors on a screen.

combined elementary and secondary school. A school that encompasses instruction at both the elementary and secondary levels. Examples of combined elementary and secondary school grade spans would be 1 through 12 or 5 through 12.

combined PCB tester. Testing equipment that combines functional and in-circuit test techniques and capabilities that result in a test strategy to suit any given board's production history and fault spectrum to achieve the highest board fault coverage at the lowest cost.

command, control, communications, and intelligence (C^3I). Systems used to display the ongoing status of tactical or strategic operations in dynamic scenarios for rapid decision making.

commercial antenna. See **antenna.**

commercial meteorological and general-purpose instrument. Equipment used to obtain quantitative information about the weather.

communication. 1: The transmission of information from one point or person or equipment to another. 2: The sensing of a measurement signal or phenomenon for display, recording, amplification, transmission, computing, or processing into useful information.

communication management. The organization of stations, peripherals, and devices capable of intercommunications but not necessarily on the same channel.

communication peripheral. An interface device for machine-to-machine connections.

compact disc (CD). A disc from which data are read optically by means of a laser.

compact disc player. 1: A recording and playback system used to play recorded music by means of a small plastic optical disc similar to multiplex stereo broadcast and reception. Each wall of the record groove carries a single channel of information. 2: A recording device in which the sounds are mechanically impressed onto a disc.

comparator. A type of amplifier that produces a logic output (1 or 0) based on comparison of an input voltage with a fixed reference voltage. A widely used form of linear integrated circuit.

compiler. 1: Computer routine that translates symbolic instructions to machine instructions and replaces certain items with subroutines. 2: An automatic coding system in a computer that generates and assembles a program from instructions written by a programmer. 3: A computer language system consisting of various subroutines that have been evaluated and computed into one routine handled by a computer. 4: Software used to convert application programs from computer language to machine language.

complementary MOS. A semiconductor technology that uses both P-channel and N-channel transistors on the same silicon substrate to gain the primary advantages of very low power and high noise immunity.

complex-instruction-set computing (CISC) microprocessor. The number of instructions a microprocessor runs for a specific application. Known as a general-purpose processor.

component. An assembly, device, or piece of equipment that is part of a larger assembly or system.

component design. Design of the individual components in an assembly.

composite analysis. The analysis of composite materials (such as carbon fiber) as they change in the manufacturing process and are used in the final assembly.

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compound annual growth rate (CAGR). The average rate of growth compounded over a specified period. The formula used to calculate CAGR is:

$$\left(\frac{\text{Value in period 1+n}}{\text{Value in period 1}}\right)\left(\frac{1}{n}\right) - 1$$

computational chemistry/molecular engineering (CCME). The use of computers to model molecular structures, to predict physical properties of molecules, and to design new compounds for specific purposes.

computer-aided design (CAD). Systems that function as tools to expedite mechanical and electronic design. Most CAD systems consist of a graphics computer terminal linked with a computer and a software package with features that aid in design and drafting, keep track of parts, run simulations, and provide illustrated parts or circuit diagrams. Programs complete the layout, geometric transformations, projections, rotations, magnifications, and interval (cross-sectional) views of a part and its relationship with other parts.

computer-aided manufacturing (CAM). The use of computers to program, direct, and control production equipment in the fabrication of manufactured items.

computer-aided software engineering (CASE). A combination of artificial intelligence and structured programming techniques used to aid in the development of large software programs.

computerized energy control system. A system with the resources for producing heat, electricity, and/or power and the capability of running on computers.

computer plotter. A visual display on which a dependent variable is graphed by an automatically controlled pen or pencil or other image development device/technique as a function of one or more variables. See also **plotter.**

computer storage media. The substance upon which data are stored electronically. Media may be flexible disks, rigid disks, tape, or optical disks.

computer storage tape media. Long, thin, flexible tape appropriate for digital magnetic recording and storage of computer data.

computer system. A combination of hardware, software, firmware, and peripheral components that has been assembled to satisfy a particular goal or set of goals.

computer systems performance segments. The following are Dataquest segments for computer systems performance: Level I—low-performance minicomputers, microcomputers, and personal computers; Level II—medium-performance minicomputers and microcomputers, very low end workstations, and high-end personal computers; Level III—low-performance superminis, midrange workstations, and high-performance minicomputers; Level IV—midrange superminis, low-end mainframes, and high-end workstations; Level V—high-performance superminis and midrange mainframes; Level VI—low-end supercomputers and very high performance superminis; and Level VII—supercomputers and high-end mainframes.

computer to PBX interface/digital multiplex interface (CPI/DMI). Two different standards for communication between systems.

computer to plate. A process that merges type and black-and-white images and combines the functions of typesetting, camera photography, and contact platemaking.

conceptual design. An application that supports styling, industrial design, and other design applications emphasizing visualization, aesthetic, and ergonomic considerations.

connector. A device used to join or fasten transistors, establishing a relationship between active and passive devices.

consortium. An international business agreement; an association or society.

consumable. Material that is capable of being consumed.

consumer electronics. The application of electronics in consumer equipment.

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consumer integrated circuit (IC). An analog circuit that meets specific consumer end-market applications. These circuits are dedicated to specific applications, such as audio or radio, and would not be used for general purpose.

consumer N.E.C. Consumer equipment not elsewhere classified.

consumer radio. A device used by the general public for communication by electromagnetic waves transmitted through space to produce sound.

consumption. The markets' purchase and use of goods and services, including lease or rental.

contract administration. The management of agreements between a company and its vendors and/or customers.

contract maintenance service. Ongoing repair services based on agreed upon terms and conditions (such as hours of coverage and level of services) as stipulated in a written agreement between the customer and the service provider.

controller. A device or group of devices that serve to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

controller board. A printed circuit board that provides programmable logic that controls the sequence of operations of the functional stages of a peripheral device.

conversion revenue. The revenue generated by changing from an equipment rental contract to a purchase or lease contract.

coordinate measuring machine. Machine used to measure the physical dimensions of a part.

copier. A reproduction device designed to produce replicas of hard-copy originals. Copiers may use either an analog or a digital scanning system.

coprocessor. A logic device that operates in association with a microprocessor to enhance system performance. Coprocessors are not capable of independent operation.

cordless telephony. The transmission of speech or other information via radio, enabling two persons to converse over almost any distance without a connecting cord to a base unit.

corporate publishing. Publishing that supports the main business of an organization or person; printed and published products are produced in the normal course of operations, but not as a primary source of revenue.

corporate supercomputer. An information system priced at more than $2 million. Performance speed is more than 200 mflops; current upper limit is approximately 2 Gflops. Currently used mainly for batch applications, but the trend is toward interactive use. Optimized for very heavy, numerically intensive applications. Requires special environmental controls and cooling techniques.

cost. The expenditure necessary to produce a product.

cost accounting. An application that supports a branch of accounting that is concerned with the collection, determination, and control of costs, particularly those costs associated with producing products or services.

counter/timer circuit. A circuit that receives uniform pulses representing units to be counted and provides a voltage proportional to their frequency.

counting device. A device register or location in computer storage for storing numbers or number representations in a manner that permits these numbers to be increased or decreased by the value of another number or to be changed or reset to zero or to an arbitrary value.

CPE. See customer premise equipment.

CPI/DMI. See computer to PBX interface/digital multiplex interface.

CPU. See central processing unit.

critical dimension (CD). Refers to a line, element, or feature that must be manufactured and controlled to very tight specifications.

CRT. See cathode ray tube.

CT2. See digital cordless telephone.

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custom/contract programming. Programming services that include applications development and software systems conversions.

customer management. A software application used to maintain lists of purchasers of a company's products and services.

customer premise equipment (CPE). Telecommunication equipment used at an end user's location, as compared with use at the local telephone utility.

customer training/education service. Activities designed to instruct customers in the installation, usage, programming, management, and maintenance of hardware, software, and networking products.

custom integrated circuit. A handcrafted, single-user integrated circuit that is customized using a full set of photomasks and requires manual placement and routing. Can be either bipolar or MOS technology process.

CVD. See **chemical vapor deposition.**

D

daisywheel. See **printwheel.**

DAT. See **digital audiotape.**

data acquisition and control. See **real-time data acquisition and control.**

database. The entire body of data that has to do with one or more related subjects. Typically, it consists of a collection of data files stored in a computer system.

database administration. A control program function that provides access to data sets, enforcement of data storage conventions, and regulation of the use of input/output devices.

database management system (DBMS). 1: A software application that provides storage maintenance functions for data stored in sequential, hierarchical, relational, or object format. Example of DBMS products include FOCUS (hierarchical), Ingres (relational), and GBASE (object oriented). 2: A systematic approach to storing, updating, and retrieving information stored as data items, commonly referred to as data files.

database publishing. A system with the main purpose/use of printing the ordered collections of data.

data capture. A process that takes possession or control of information.

data center. A program designed primarily to acquire, analyze, process, store, retrieve, and disseminate one or more types of data.

data center construction/relocation services. Services in which a vendor performs or manages the contracting of site management services including the design and building of a customer's data center and/or the relocation and installation of customer's equipment.

datacom equipment. See **data communications equipment (DCE).**

data communications equipment (DCE). Equipment used for transmitting data between points of origin and reception. It includes products such as modems, statistical multiplexers, T-1 multiplexers, front-end processors, data PBX systems, data network management systems, DSU/CSU equipment, local area networks, and private packet data switching equipment.

data converter. An integrated circuit that changes alternating current to direct current or direct current to alternating current.

data creation. The process of producing or originating information.

data network management system. A product or device that diagnoses, isolates, reinstates, or accumulates information for network components or provides reports and analysis of network performance.

data PBX system. A digital private branch exchange system that allows terminals to switch and contend for computer ports by providing RS-232-C connections. This system does not provide voice switching. Data PBX base units and add-on channels also are included in this classification.

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data processing (DP). 1: The preparation of source media that contain data or basic elements of information and the handling of such data according to precise rules of procedures to accomplish such operations as classifying, sorting, calculating, summarizing, recording, and computing. 2: The handling of information in a sequence of reasonable operations.

data service unit (DSU) and channel service unit (CSU). These provide an interface to digital services, such as the AT&T Dataphone Digital Service (DDS).

data storage device. A product designed to hold data until needed. Storage devices are rated by technology (rigid, flexible, and optical disk drives and tape drives), physical size in inches (diameter for rigid and flexible disk drives, width for tape drives), and capacity in bytes. (See also **disk drive, tape drive.**)

data translation. 1: A device that transforms computer information to data from one language to another language without affecting the meaning. 2: To change one binary word to another.

DBMS. See **database management system.**

DCE. See **data communications equipment.**

dealer. 1: Independent businesses selling products under contract to one or more vendors. 2: A product reseller selling to end users. A dealer's primary added value is distribution; secondary added values are service, training, and support.

defibrillator. An electronic instrument used for stopping spontaneous, local contraction of muscle fibers (fibrillation) during a heart attack by applying controlled electronic pulses to the heart muscles.

departmental supercomputer. An information system with price ranging from $100,000 to $2 million. Performance speed ranges from 10 to 200 mflops. Acquired usually by users who need heavy number-crunching capabilities but cannot afford a full-scale supercomputer costing more than $2 million. This computer is a vector processor and thus uses a fundamentally different execution technique from scalar processors, such as mainframe computers and superminicomputers, and is typically configured as a uniprocessor rather than a parallel processor. Typical environment is a "cool room" with a raised floor and/or an ordinary office with no special environmental controls. Number of concurrent users typically ranges from 10 to 50.

deposition. The layering of various chemicals on a wafer. The introduction of dopant to wafers in high-temperature furnaces, chemical vapor deposition (CVD), sputtering, and implant.

deposit/loan management. An application that facilitates the control and earning potential of loans and deposits.

design layout. An initial design process in which the major components and part interfaces are defined.

desk-side personal computer. The desk-side personal computer meets all the qualifications listed for desktop personal computers but is further defined as being a personal computer that has been specifically designed to be placed next to or under the computer operating or desk surface, including foot/stand on bottom of system.

desktop personal computer. The desktop computer classification includes all personal computers except those products that are designed and sold as local area network servers, desk-side personal computers, and all forms of portable computers. Further, these systems are based on keyboard input devices.

desktop publishing. 1: Generalized computing platforms used to perform electronic publishing tasks as one of many applications. 2: The formatting of text and graphics into publishing-quality printed output.

desktop terminal equipment. Telecommunications equipment that is actually used on a desktop. This segment includes products such as single-line telephone equipment and integrated voice/data workstations.

desktop video. Tabletop televised images.

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detail drafting. The representation of a part in standard geometric drafting format. This representation will include all part geometry dimension and notations describing mechanical/structural, functional, and material characteristics.

detection and tracking. A real-time application that detects, tracks, and controls various systems and processes. (See also **data acquisition and control.**)

device interface. 1: An electronic device that enables one piece of gear to communicate or control another. 2: A device linking two incompatible devices. 3: A card containing circuits that allow a device to interface with other devices.

diagnostic. 1: Pertaining to the detection, discovery, and further isolation of a malfunction or mistake. 2: Medical applications that aid in diagnosing medical problems. X-rays, CAT scans, and ultrasound are examples.

dialysis. The separation of substances in solutions by means of their unequal diffusion through semipermeable membranes.

diathermy. The therapeutic use of high-frequency electric currents to produce localized heat in body tissue.

dictating/transcribing machine. A device that automatically records human speech onto a form of magnetic tape that can be played back for transcription.

diffusion. 1: A process used in the production of semiconductors that introduces minute amounts of impurities into a substrate material. 2: The movement of particles away from regions of higher concentration caused by the random thermal motion of atoms and molecules to areas of lower concentration.

digital. 1: Pertaining to the class of devices or circuits in which the output varies in discrete steps. 2: Circuitry in which data-carrying signals are restricted to either of two voltage levels, corresponding to logic 1 or 0.

digital access cross-connect system. A system that is composed of multiplex equipment that allows digital lines to be remapped electronically at a different digital level.

digital audiotape (DAT). A 4mm helical scan device (i.e., data recorded at an angle rather than parallel).

digital cordless telephone. Mobile telephone that uses digital radio transmission technology. CT2 is a standard for these devices.

digital design verification. A software application that includes logic simulation, timing analysis, hardware accelerators, hardware modelers, electrical rule checking, mixed signal simulation, transmission line simulators, and signal noise analysis.

digital panel meter. 1: An electrical switchboard or instrument board using continuously variable electrical signals known as analog signals. 2: Digital signals versus analog signals.

digital radiography. Equipment used for electronically detecting the arrival of X-ray photons transmitted through or emitted from an object on various media and converting the sensed analog signals to digital signals.

digital signal processor (DSP). High-speed general-purpose arithmetic unit used for performing complex mathematical operations such as Fourier transforms.

digitizer. A device used for the creation of digital information from alphanumeric or line artwork. More sophisticated digitizers are able to reproduce halftone images and usually are termed scanners.

diode. 1: A semiconductor device used to permit current flow in one direction in a circuit and to inhibit current flow in the other direction.

direct channel. The sale of equipment directly to the end user by a vendor that contributes significant development or integration to the product. Can be either sales of complete systems by turnkey vendors or sales of components of systems sold by individual suppliers.

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direct memory access (DMA). A computer feature, set up by the central processing unit (CPU), that provides for high-speed direct data transfer from a peripheral device to the computer memory or to magnetic disk or tape storage units. This feature releases CPU time to perform other procedures. Most DMA devices employ a CPU-cycle-stealing approach.

direct sales force. A sales method that employs a sales force to move a product through the distribution channel by making face-to-face contact with the consumer. Also referred to as outside sales.

direct thermal printer. A printer that uses point-specific heat and heat-sensitive substrate that change color when exposed to heat.

direct write e-beam. Equipment used in semiconductor manufacturing where electron beams are used to create heat that will expose selected areas of a wafer's surface to create a specific design. (See also **lithography.**)

disaster recovery and contingency planning. The planning and implementation of data backup and recovery procedures for a customer's site, based on an analysis of the critical business functions.

discrete component testers. Equipment used to test, check, and monitor the functionality of devices that have a single functional capability per package. These devices include resistors, capacitors, diodes, transistors, and other devices not classified as integrated circuits.

discrete device, security energy management. A circuit complete in itself used in the security and energy industries.

discrete semiconductor. An individually packaged semiconductor component complete in itself, such as a diode or transistor.

disk. 1: A high-capacity random-access storage device. Data are written onto and read from the surfaces of a stack of revolving record-like disks coated with magnetic material. May be fixed or removable. Capacity ranges from 0 to more than 1,000 pages per disk. Referred to as a rigid disk. (See also **random access.**) 2: A random-access magnetic storage medium in the form of a platter or thin wafer. (See also **magnetic disk.**)

disk drive. The unit that controls the reading and writing of disks.

disk drive IC. An analog IC designed for the mass-storage peripheral market. These ICs include read/write amplifiers, data separators, data processors, servo controllers, and motor controllers.

diskette (floppy disk). A record-like disk of magnetically coated Mylar enclosed in a protective square envelope. Holds from 80 to 250 pages of text. Unlike cassettes or cartridges, which store text serially, diskettes are formatted in a random manner, which allows faster access.

disk, magnetic. A storage device containing information recorded on the magnetizable surface of a rotating disk; a magnetic disk storage system is an array of such devices, with associated reading and writing heads mounted on movable arms.

disk operating system (DOS). 1: A computer system based on the Intel 80XX or 80XXX architecture that use the MS/PC-DOS operating system software. 2: An operating system that uses magnetic disks as its primary on-line storage.

dispatching. A software application used to execute the route plans of multiple vehicles, taking real-world events into account.

display peripheral. A component used to address the man-to-machine interface, whereas communication peripherals are used to address the machine-to-machine interface.

distribution. 1: The act or process of distributing. 2: The path by which a product moves from the manufacturer to the ultimate end user. 3: To place or position so as to properly apportion over or throughout an area.

distribution channel. The route taken either by the title to a product or by the physical product itself as it moves from the producer to the ultimate end user. The channel for a product extends to the last consumer who buys it without requesting any significant change in its form. When form is altered and another product emerges, a new channel is started.

distribution frame. A unit for terminating telephone wiring. This unit is typically used for terminating and cross-connecting telephones to the switching system.

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distribution method. A method employed to move a product through the distribution channel. It is separate and distinct from the channel in that many channel members may employ the same distribution method.

distributor. A wholesaler that sells to other resellers or end users. The distributor's primary function is to stock the inventory of multiple manufacturers to provide volume buying power to its end users.

DMA. See direct memory access.

documentation/drafting. A software application that includes detail drafting, schematics, technical illustration, charts, specifications, bills of materials, training manuals, and other drawing- or drafting-related applications. International standards such as ISO, DIN, or ANSI can be used to define text and feature format.

document management. A documentation system, generally computerized, that links and tracks all documents (drawings, procedures, specifications) related to an assembly or process.

dopant. Atoms of materials such as phosphorus, boron, or arsenic that are diffused into silicon to create resistors, diodes, and transistors.

DOS. See disk operating system.

dot matrix printer. A printer that produces images through selective printing of dots chosen from a dot array matrix. Dot matrix printers are segmented by the number of wires in the printhead: 9, 18, or 24 and greater wires. Within these technology segments, additional segments are defined by speed of printing, expressed in characters per second (cps).

DP. See data processing.

DRAM. See dynamic random-access memory.

DRAM controller. A device that governs DRAMs in some predetermined manner. Holds a process or condition at a desired level or status as determined by comparison of the actual value with the desired value.

drilling programmable machine tool. A machine tool fitted with an end-cutting tool that is rotated with sufficient power to create a hole or enlarge an existing hole in solid material.

drive. See tape drive.

drive, disk cartridge. A disk drive using a removable one- or two-platter cartridge; may incorporate a fixed-media capability.

drive, fixed Winchester. A disk drive that includes all fixed-media Winchester drives.

driver information. An electronic device used to assist the driver by giving visual or audio signals for direction. Examples include digital gauges, service reminders, digital clocks, trip/navigation computers, heads-up display, audio annunciator, CRT display, miles-to-empty indicator, and shift indicator.

dry etch. A technique in semiconductor manufacturing used to produce more uniform pattern definition on wafers without immersing the wafer in a liquid bath. Techniques include plasma etching and reactive etching through which gases and energetic ions remove unwanted chemical material from a wafer.

dry silver. A photosensitive film or paper coated with silver compounds that is developed by the application of heat. Popularized by 3M.

dry strip. A process in semiconductor manufacturing for removing photoresist from the wafer after etching. Dry strip comprises barrel strippers and single-wafer strippers.

DSMPU. See DSP microprocessor.

DSP. See digital signal processing.

DSP microprocessor (DSMPU). A general-purpose, programmable integrated circuit similar to a conventional microprocessor. Its distinction is characterized by the efficiency with which it implements repetitive multiplications and additions required by DSP algorithms.

DSU/CSU. See data service unit (DSU) and channel service unit (CSU).

DTMF. See dual-tone multifrequency signaling.

dual-disk drive. A system that provides for the use of two disks at the same time.

dual-tone multifrequency signaling (DTMF). A standard signaling method for touch-tone telephones using a combination of two different tones for any button pushed.

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duplicator. 1: A small offset printing press that uses a planographic image carrier. These presses are usually capable of one or two colors and are smaller, easier to operate, but less sturdy than offset presses. 2: Machine that requires a special master to make copies but produces copies at a higher rate of speed than copying. It differs from printing in that a direct-image master is used that yields a limited number of copies. Offset, spirit, gelatin hecto, stencil, and sometimes xerography are considered duplicating processes. (See also **copier.**)

dynamic random-access memory (DRAM). A random-access memory device that must be electrically refreshed frequently (many times each second) to maintain information storage. DRAM densities can range from 16K, with approximately 16,000 bits, to 16Mb, with approximately 16 million bits.

E

8mm tape cartridge. A class of tape drives using 8mm cartridges; used in camcorders.

E-1 multiplexer. An electronic device that consolidates or pools multiple digital streams representing voice or data signals onto a single high-speed E-1 data line. An E-1 line operates at 2.048 Mbits/second, a standard within Europe. See **T-1 multiplexer** for U.S. standard.

earth resources application. Studying the earth resources by performing seismic analysis, mapping, and oil field services.

EATE (electronic automatic test equipment). See **automatic test equipment.**

e-beam. A sophisticated system used in semiconductor manufacturing that uses an electron beam for maskmaking or for projecting patterns onto wafers. E-beam equipment allows smaller geometries (typically less than 1 micron) than are possible under other production methods.

ECAE. See **electronic computer-aided engineering.**

ECL. See **emitter-coupled logic.**

EDA. See **electronic design automation.**

education. The process of providing schooling or training by formal instruction and supervised practice.

educational publishing. A system with the main purpose/use of printing materials used for the process of educating.

EEPROM. See **electrically erasable programmable read-only memory.**

elapsed time meter. An electronic measuring instrument that counts the actual time taken to observe a recurring event.

electrically erasable programmable read-only memory (EEPROM). A nonvolatile memory device that can be erased and programmed electrically.

electrocardiograph. An instrument used to graphically record electrical manifestations of heart activity obtained from the body's surface.

electroencephalograph. An instrument used to graphically record electrical discharges of the cerebral cortex by electrodes attached to the surface of the scalp.

electronic calculator. A product with components that perform calculations and digitally display results. (See also **calculator.**)

electronic computer-aided engineering (ECAE). Computer-aided tools used in the engineering or design phase of electronic products (as opposed to the physical layout phase of the product). Examples of ECAE applications are schematic capture, simulation, and test pattern creation. ECAE systems are used most often by electrical engineers.

electronic design automation (EDA). Computer-based tools that are used to automate the process of designing an electronic product, including boards, ICs, and systems. Formerly referred to as ECAD.

electronic forms generation. The process of automatically producing documents requesting information.

electronic game. Home electronic games that typically are attached to television receivers.

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electronic keyboard. A keyboard on which characters are generated or encoded by electronic means, usually by contact closure, as opposed to mechanical linkages. Electronic keyboards have a different feel, and some have a built-in artificial bottoming feel and/or audible click to assure the operator a key actually has been depressed.

electronic mail (e-mail). An application that supports the movement of information between users connected to a networked computer system.

electronic musical instrument. An instrument that allows the transmission of musical sound by the use of transistors.

electronic publishing. Fully integrated automation of the printing procedure.

electronic warfare (EW). Electronic operations between enemies. Includes warning receivers, jammers, assorted electronic countermeasure systems, and associated test equipment.

electrostatic plotter. A plotter using the corona from high voltages applied to needles or nibs to produce shaped electrostatic charges on paper; toner is attracted to the charged area, and heat and pressure are used to fuse the toner to the paper.

elementary/secondary school. A regular school, defined as schools that are part of state and local school systems and most nonprofit private elementary/secondary schools, both religiously affiliated and nonsectarian.

e-mail. See **electronic mail.**

emerging technology. A technology that is not in widespread use and that appears to have potential for widespread acceptance.

emitter-coupled logic (ECL). 1: A form of integrated circuit used to implement very high speed logic functions. 2: The emitters of the input logic transistors are coupled to the emitter of a reference transistor.

employees. All civilians, who, during a reference time period, did any work for pay or profit (minimum of an hour's work) or worked 15 hours or more as unpaid workers in a family enterprise.

encryption. Process of encoding data, voice, or video transmissions for security purposes.

encryption unit. A device that encodes/decodes data, voice, or video transmissions for security purposes.

end user. The final purchaser of a finished product.

end-user average selling price. The average price that a user pays for a product inclusive of channel markups and discounts.

end-user revenue. End-user average selling price multiplied by shipment quantity.

enhanced service. Equipment and service charges associated with enhanced data communication networks, which may include protocol, electronic mail, or facsimile.

enrollment. In education, the total number of students registered in a given school unit at a given time, generally in the fall of a year.

entertainment system. 1: Electronic equipment used for amusement or pastime and not intended to, but may, increase productivity or skill. Examples include: radio, seek/scan, graphic equalizer, power amplifiers, noise reduction, cellular telephone, optical disk, CB radio, and digital audiotape. 2: A computer application to keep or hold the mind, something directing or engaging.

entry-level workstation. A low-cost computer workstation, priced less than $15,000. It is targeted at the end user who is sensitive to price. This segment tends to be dominated by occasional users who are not paid for producing documents on their system. Entry-level workstations mainly run 2-dimensional graphics and have a rating of less than 12 mips and a rating of 0.5 to 1.5 mflops.

environment. Where a product is used ultimately.

epitaxial wafer. Single-crystal silicon grown on a crystalline silicon substrate.

EPROM. See **erasable programmable read-only memory.**

equipment/maintenance management. A software application that assists in the management of equipment and the respective maintenance requirements and contracts. May also calculate depreciation.

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erasable programmable read-only memory (EPROM). A nonvolative memory device that can be erased by ultraviolet (UV) light and reprogrammed by the user.

ET. See **typewriter.**

etch-and-clean equipment. Equipment used in semiconductor manufacturing to remove and clean material from wafers.

EW. See **electronic warfare.**

expenditure. Charges incurred, whether paid or unpaid, which are presumed to benefit the current fiscal year. These include all charges for current outlays plus capital outlays and interest.

export. The delivery of products to a foreign country for the purpose of trade or sale.

F

fab. Abbreviation for wafer fabrication. See **fabrication.**

fabrication. A manufacturing operation that makes components rather than assemblies.

fabric ribbon. Fabric ribbons are struck repeatedly by the print mechanism until all the ink is depleted. Such ribbons are used commonly for general-purpose printing and are the most economical and durable ribbon substrate. Most fabric ribbons are made of nylon and are available in several forms, e.g., cartridge or web ribbon.

facilities design/management. A software application used to lay out, inventory, and manage assets (such as personnel, space, equipment, and utilities) within a building or geographic service area.

facilities management service. The responsibility of providing ongoing administration of a data processing or communications facility by a vendor.

facility planning and simulation. A facility system model is exercised and refined through a series of simulation steps until a detailed, optimum configuration is reached.

facsimile (fax). 1: An electronic device that uses telephone lines to transmit documents to and receive documents from a second facsimile machine. 2: An exact copy or the process of transmitting printed matter or still pictures by a system of either telephones, telegraph, or radio for reproduction.

factory automation equipment. Equipment that includes various types of capital equipment that are automated and used throughout a manufacturing facility.

factory average selling price. The average price per unit that is paid for a product. This figure takes into account discounts given to the distribution channel and multiple-purchase discounts.

factory revenue. The amount of money received by a manufacturer for its goods.

fast packet switch. A packet-switching technique in which small packets are switched at high-speed using hardware for the transport of voice, data, and video.

fast SRAM. A static RAM device that runs at speeds less than 70 nanoseconds. (See also **static random-access memory.**)

fatigue. In electronics, the degradation of the performance of materials, parts, or circuits with time.

fault detection, fault management, and adaptive control. A software application that determines if a manufacturing system or a process is functioning or performing within control limits. Fault management and adaptive control is a control method in which control parameters are continuously and automatically adjusted in response to measured process variables to achieve near-optimum performance.

fax. See **facsimile.**

FDDI. See **fiber distributed data interface.**

federal government. A form of government in which power is distributed between a central authority and a number of constituent territorial units.

FERRAM. See **ferroelectric random-access memory.**

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ferroelectric random-access memory (FERRAM). A nonvolatile, radiation-hard, fast read/write memory that can store data over long periods of time without power.

fiber distributed data interface (FDDI). A standard for high-speed packet switched data.

fiber optic. 1: The technique of transmitting light through long, thin, flexible fibers of glass, plastic, or other transparent material. Bundles of fiber can transmit complete images. 2: A technique used in electromagnetic wave propagation in which infrared and visible light frequencies are transmitted by a light-emitting diode (LED) or a laser through a low-loss glass fiber. This method is used in very high frequency (VHF) radiation transmission.

field-programmable gate array (FPGA). An integrated circuit incorporating an array of programmable logic elements that are not preconnected. Interconnections between the various elements are user programmable and consist of predetermined levels of interconnect that can be connected to, or disconnected from, other interconnect lines as defined by the user. Can be of either bipolar or MOS technology.

field-programmable logic array (FPLA). A logic array in which programming is accomplished by blowing fuse links or shorting base-emitter junctions.

film ribbon. See **single-strike ribbon** or **multistrike ribbon.**

finance. An application to support the management of money or other liquid resources and their respective management within an organization.

fixed asset. An application that supports the management of an organization's fixed assets, which are a capital asset that cannot be readily liquidated, such as plant, land, equipment, and long-term investments. Management of expected costs based on a specific level of production or other activity.

fixed disk. A memory disk that cannot be removed from the read/write device, as opposed to a removable hard disk, diskette, or magnetic tape.

fixed media rigid disk drive. A fixed media rigid disk drive has the platter enclosed in a housing that is not designed to be accessible to the user.

fixture design. The design of a variety of structural aids that hold the component or assembly during the manufacturing process.

flexible disk. See **flexible disk computer storage media.**

flexible disk computer storage media. A flexible disk made of a 3-mil polyester substrate coated with gamma ferric iron oxide particles dispersed in an epoxy binder and encased in a vinyl jacket. These are commonly supplied in 3.5- or 5.25-inch diameters.

flexible manufacturing system programmable machine tool. A manufacturing system that typically consists of a computer-integrated group of numerical control (NC) machines or workstations linked with material transfer devices for complete automatic processing of differing product parts or the assembly of these parts into different units.

floating-point coprocessor. A separate microprocessor used in the efficient handling of floating-point operations.

floppy (flexible) disk. A small, thin, electromagnetic media used for storing digital information.

floppy disk controller. A device controlling the storage and retrieval of data from a floppy disk.

font generation. Process whereby typeface and size is selected.

font management. The understanding, use, and control of fonts or typefaces that are displayed on a terminal or monitor, or printed out on a device such as a printer, plotter, or typesetter. Font management requires the understanding of the physical location of where the fonts reside—whether in diskette, hard disk, ROM, RAM, card, or cartridge. It also requires the knowledge of the type of font—whether bit map or outline, scalable or fixed point and pitch—and the applications and print system capability to address and place the fonts accurately on the screen or printing media.

forecasting. To estimate in advance or anticipate; to predict future events, trends, business conditions, etc.

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form. 1: Any material that has been printed for the primary purpose of facilitating the entry of written information by hand or machine. A form has repetitive information printed in fixed positions. Blank paper may be included, especially if it is continuous and has undergone some alteration such as punching or perforating to facilitate manual or machine entries. 2: Allows the user to graphically design a form for publication—may include data entry and database capabilities.

four-year institution. An institution legally authorized to offer and that does offer at least a four-year program of college-level studies wholly or principally creditable toward a baccalaureate degree.

FPGA. See **field-programmable gate array.**

FPLA. See **field-programmable logic array.**

front-end processor. A computer-based product expressly designed to relieve host computers of certain communications processing tasks. Included are remote concentrators that are not attached directly to a host computer. This segment does not include general-purpose computer systems functioning as front-end processors.

full-color copier. A reproductive device that can recognize the full range of colors on an original and reproduce them using the three subtractive primary colors and produce a full-color copy.

fully formed printer. A printer that prints fully formed characters by applying pressure on or to the paper and obtaining the characters from a wheel, band, type train, or drum. Such devices can be serial, fully formed printers and line, fully formed printers.

functional design. An application that supports component design, assembly verification, linkage and mechanism design, and other detail or functional design activities.

functional PCB tester. An equipment tester that accesses the normal input/output interface of the unit under test (UUT). Generally, this consists of the edge-connector pins, plus any special interface that may have been provided for testing. Provides stimulus patterns and measurement verification that the UUT actually operates correctly.

funds transfer terminal. A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **automated teller machine.**)

G

GaAs. See **gallium arsenide semiconductor.**

GaAs analog IC. There are two overlapping subsets in this segment; analog products and monolithic microwave integrated circuits (MMICs). Analog products have output that are linearly proportional to their inputs and function at a varying range of frequencies across the spectrum, depending on particular device design. MMICs operate in the microwave frequency spectrum (above 3 GHz).

gallium arsenide semiconductor (GaAs). A compound of gallium and arsenic used as a semiconductor material. GaAs devices are relatively expensive devices exhibiting very low internal noise and very high speed.

game. A software application or activity engaged in for diversion or amusement.

gas. A consumable material used throughout the fabrication of semiconductor devices. Includes both bulk and specialty gases.

gate array. 1: 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 RAM.) May be of either bipolar or MOS process technology.

gateway. Equipment or conceptual point that connects two otherwise incompatible systems. (See also **protocol converter.**)

general analysis. A software application designed to solve various technical problems and to further research subjects. The analysis is usually mathematical in nature and performed by scientists, physicists, chemists, biologists, and engineers.

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general ledger. A software application that supports the business function of entering accounting transactions and their subsequent transferring and reporting.

general operating system. An operating system with use not restricted to a particular type of computer or a specialized application.

general productivity. A software application that is used to enhance productivity within general disciplines.

general-purpose computer system. A computer system that is not configured for a specific purpose but rather for a general application. This category includes supercomputers, minisupercomputers, parallel processor computers, mainframes, workstations, and the like.

general-purpose input/output (I/O) circuit. A circuit that permits a system to communicate via a wide variety of input/output (I/O) devices with the outside world, which can include printers, modems, and monitors.

general test equipment. Test equipment not included under the definition of automatic test equipment (ATE).

geographic information system (GIS). A mapping software application that contains the functions of cartographic software and also allows data analysis through Boolean operations on multiple data layers.

geophysical instrument. An instrument used to observe and measure the physics of the earth and its environment.

GIS. See **geographic information system.**

global positioning system. Equipment that calculates location based on one of several technologies such as radio or internal navigation.

golf ball. A type of print element invented by IBM for use in the IBM Selectric typewriter. It is a round, metal element with raised characters.

government. The organization, machinery, or agency through which a political unit exercises authority and performs functions and which is usually classified according to the power within it. Includes the executive, legislative, judicial, administrative, and regulatory functions.

graphic design art. A method of applied art used to form a visual end product that conveys information. Methods include drawing, painting, photography, printing, and bookmaking.

graphics. Software that permits the pictorial representation of information at a screen or printer. Early graphics packages showed bar charts or line graphs on a character-based terminal by placing characters such as + or * on grids created by repetitions of characters such as | and or _ . The term has come to apply usually to bit-mapped graphics, which are capable of processing images, freehand input, and icons on a pixel-by-pixel basis. Examples of graphics software include MacDraw and MacPaint.

graphics/animation/imaging. A software graphics application used by scientists and engineers to process and display complex technical data. It also includes applications that use computers to generate or manipulate graphics images that are the end product, i.e., cartoons.

graphics board. An add-on board connected to the bus that provides video capabilities for a personal computer.

graphics controller. A device that governs information flow used to create visual images of data.

graphics draw/paint. A software application that creates, retrieves, modifies, and prints graphic images.

graphics supercomputer. The performance of mips, mflops, transforms per second, and shaded polygons per second distinguishes graphics supercomputers from superworkstations. Performance ratings range from 20 to 40 mips and 16 to 40 mflops. The best distinction between graphics supercomputers and superworkstations is the graphics performance ratings, 100K to 600K 3-D vector transforms/second and 25K to 150K Gouraud-shaded polygons/second. The average price ranges from $75,000 to $150,000.

graphics terminal. A display terminal that provides graphical presentation of information to the operator. 1: Data conversion graphics terminals support the use of graphics to summarize or

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otherwise relate discrete data that were not originally graphics data. 2: Concept design graphics terminals support graphics displays that help realize accurate images of ideas conceived in the human mind. 3: Imaging graphics terminals display a real image, visible or nonvisible, that was digitized to allow enhancements or data extraction.

grinding programmable machine tool. A standalone machine with expanding use of computer numerical control (CNC) and with advance efforts to incorporate grinders into flexible, automated systems. Creep-feed is a type of grinding technology.

gross lease additions. The total volume of new equipment leases.

H

hand-held personal computer. The hand-held personal computer is a less-than-2-pound, fully functional personal computer. To be considered a hand-held personal computer, units must operate using a fully implemented version of MS-DOS and be able to run some of the shrink-wrapped MS-DOS-based applications. These units are expected to have a subsize keyboard and utilize nonstandard mass storage devices. The criterion for inclusion in this classification is that the device may be held in one hand using the other hand for data entry via the included keyboard. They are fully battery powered units.

hard disk. See **rigid disk.**

hard disk controller. A device that controls the storage and retrieval of data from a user's hard disk drive.

hardware. Electronic equipment, systems, or peripheral devices.

hardware maintenance service. Remedial repair services for equipment, systems, and peripherals. Hardware maintenance can include on-site support, telephone/remote support, preventive maintenance, and other activities necessary to maintain hardware operation.

HDTV. See **high-definition television.**

head; manganese-zinc, landable. A type of head used in sealed fixed-media drives where heads land on the lubricated media surface and use hot-pressed manganese-zinc pole pieces.

health care. An environment or industry that includes establishments primarily engaged in providing medical, surgical, and other health services.

helical scan tape drive. A storage tape drive that records data on an angle rather than parallel. Tape dimensions can be 4mm, 8mm, 13mm, or 19mm. Segments of this category are VHS, DAT, 8mm, and other. (See also **VHS, DAT.**)

high-definition television (HDTV). A television standard with high-resolution, digitized images; wide, theater-like screen; and digital stereo sound. Requires a broader video bandwidth to accommodate increased picture transmission.

higher education. Study beyond secondary school at an institution that offers programs terminating in an associate, baccalaureate, or higher degree.

high school. A secondary school offering the final years of high school work necessary for graduation, usually including grades 10, 11, and 12 or grades 9, 10, 11, and 12.

home. The usual place of residence. A home-based business is an enterprise producing goods or services that is operated in or from the home.

horizontal-turning programmable machine tool. The tool of a machine that holds a piece along the horizontal axis for a certain function to be performed such as cutting, boring, or drilling.

host/vendor independent terminal. A host-independent display terminal produced by an independent manufacturer. It may operate in either character or block mode. The independent manufacturer does not supply mainframes or minicomputers to which its display terminals may attach. Not included is any terminal that is from an independent manufacturer and that is protocol-specific to either a minicomputer-based or a non-IBM, protocol-specific terminal.

hotels and lodging. An environment or industry that includes commercial and noncommercial establishments engaged in furnishing lodging, or lodging and meals, and camping space and camping facilities.

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household. The set of persons occupying a housing unit. Thus, counts or estimates of households, householders, and occupied housing units are always defined the same.

hybrid. 1: Made up of several different components. 2: A hybrid integrated circuit is made by putting several integrated circuit die and/or passive components on a ceramic substrate with a metal pattern. 3: A substrate containing more than one component. The substrate consists of multiple ceramic layers and also can contain multiple packages. 4: A device in a speech transmission system consisting of transformers that convert a two-wire channel into a four-wire channel, thus creating a separate wire pair for each direction of transmission.

hybrid analog IC. An analog IC that combines one or more semiconductor chips with other technologies, such as chip capacitors and film resistors, on a single substrate.

hydrogen. A chemical element used for hydrofining for sulfuration of petroleum products or to reduce metallic oxide ores.

I

IBM 3270 protocol terminal. A terminal that is protocol-specific to IBM's 3270 Information Display System. Included is any IBM 3270-type terminal or 3270-compatible terminal produced by another manufacturer. A terminal that can provide the appearance of a 3270 device when used with a protocol converter is **not** included.

IBM/VM/MVS. An IBM standard multiuser operating system.

IC. See **integrated circuit.**

IC layout and verification. A software application tool that is used to create and validate physical implementations of an integrated circuit (IC). IC layout tools include polygon editors for creating geometric data, symbolic editors, placement and routing (gate array, cell, and block), and DRC/ERC verification tools.

IDVT. See **integrated voice/data workstation.**

if-sold revenue. The amount of money paid for products based on list price. List price does not take into account discounts or markups.

if-sold value. A measure that reflects unit shipments multiplied by list price.

IGBT. See **insulated gate bipolar transistor.**

illustration software. An object-oriented software program that allows the user to create original artwork consisting of lines, arcs, and other mathematically generated geometric objects. (Line art is a term sometimes used to describe the results of illustration software.) Some illustration software can perform raster-to-vector conversion by allowing users to trace over scanned raster art. This trace can occur on screen or on a graphics tablet. Illustration software usually offers raster-fill patterns that extend to cover an area in an illustration bounded by geometric objects.

image communication. Equipment used in a business or residence to transmit image and text. Facsimile equipment, video teleconferencing, telex, and videotex are included in this classification.

image-editing software. A software program that allows a user to modify existing artwork existing in raster format. This art may have been scanned or captured as analog signal data and converted to digital data. Image-editing software can handle binary data, in which case it is called print software; or it can handle grey-scale and/or color data, in which case it is called image-retouching software.

image generation. Synonymous with image synthesis and equivalent to the historical use of graphics.

image management. The process of directing, controlling, or handling something that closely resembles another.

image processing. A series of actions, changes, or functions that bring about a particular result for something that resembles another.

imaging. See **graphics/animation/imaging.**

imaging subsystem. A peripheral device that does not possess video display terminal (VDT) functionality, but acts as output devices for the display of graphics and/or image data.

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impact printer. A family of printers that use direct impression impact of a type bar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

import. The supply of products from a foreign country for the purpose of trade or sale.

in-circuit PCB tester. An equipment tester that incorporates pin electronics (drivers and receivers) that verify the functionality of each part on an assembled circuit board. Verifies each component's parameter and limited functionality.

indirect channel. A variety of distribution channels in which product is brought to the end user. It includes value-added resellers (VARs) and original equipment manufacturers (OEMs).

inductor. A passive component that stores energy in the form of a magnetic field (flux) around a core body.

industrial design. A process that integrates the design tools defining the style and functional aspects of the total design.

industrial electronic equipment. Electronic equipment used in a manufacturing environment or industry.

industrial marking. A specified format on media that is recognized by electronic or visual means. Examples are the printing and use of forms, bar codes, ticket printing (lottery and airline, for example), and labels.

industry. A collective term for many of the productive activities of a nation or other large group. A collective term in which a number of firms produce the same kind of commodity or service or are engaged in the same kind of operation.

INEWS. See **integrated electronic warfare system.**

information center. A center designed specifically for storing, processing, and removing information for dissemination at regular intervals, on demand or selectively, according to the user's needs.

information resource management. A program that works with definitions, uses, values, and distribution of information that is processed by a user and handled by a computer system.

infrared. Those radiations, such as are emitted by a hot body, with wavelengths just beyond the red end of the visible spectrum. Wavelengths longer than those of visible light and shorter than those of radio waves.

ink jet. An image-producing process currently used in electronic printers, plotters, and full-color copiers that uses piezoelectric technology to expel a very small droplet of liquid ink through nozzles onto the output paper.

ink jet printer. A nonimpact printing method that uses ink droplets to form a printed image. This technology usually is classified by the nature of the drop stream; two major categories are continuous flow and drop-on-demand.

input/output (I/O) device. 1: Equipment used to communicate with a computer. 2: A general term applied to equipment used in communicating with a computer and the data involved in the computer. 3: The transmission of information from an external source to a computer or vice versa.

input/output (I/O) ratio. 1: A ratio of the value of a resource input to the value of the final product output, typically expressed as a percentage. 2: A measure of throughput for a computer system.

inspection. The process of testing or measuring an object or process by remote sensing in imaging technology.

installed base. The total number of product in active, day-to-day use.

institutional support. In higher education, the expenditures that include day-to-day operational support for colleges, excluding expenditures for physical plant operations. Examples of institutional support include general administrative services; executive direction; planning, legal and fiscal operations; and community relations.

instruction. In higher education, expenditures of the colleges, schools, departments, and other instructional divisions of higher education institutions and expenditures for departmental research and public service that are not separately budgeted. Includes expenditures for both credit and noncredit activities. Excludes expenditures for academic administration where the primary function is administration.

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instructional. Products used to increase the understanding (either problem-solving or self-improvement) of a specific subject matter. The primary focus of these products is the imparting of knowledge or skills to the user.

instructional staff. In education, the number of full-time equivalent positions, not the number of different individuals occupying the positions during the school year.

instrumentation. Designing, manufacturing, and using instruments for detection, observation, measurement, automatic control, automatic computation, communication, or data processing.

insulated gate. A gate that is separated from other conducting surfaces through a nonconducting material.

insulated gate bipolar transistor (IGBT). A power transistor that has the insulated gate properties of a MOS transistor with the low saturation ON voltage of a bipolar transistor.

insurance. An environment or industry that covers carriers of all types of insurance and insurance agents and brokers.

integrated application. A software application that combines several functions into one software package, which may include word processing, database management, and spreadsheet capabilities but is not exclusive to these functions. Data must be able to be shared among these functions.

integrated circuit (IC). A combination of interconnected semiconductor elements inseparably associated on or within a continuous substrate. Complete module of components manufactured as single, solid units made by either a film deposition or a diffusion process.

integrated electronic warfare system (INEWS). A combination of interconnected circuit elements associated on or within a continuous substrate to produce integrated systems used specifically in military operations.

Integrated Services Digital Network (ISDN). A digital network having the capabilities of simultaneous signaling, switching, and transporting over a single facility. A new worldwide telephone standard that will make it easier to communicate information such as voice, data, and video over phone lines.

integrating and totalizing meter for gas and liquid. A meter that registers consumption and positive displacement, including meters, fuel dispenser meters, and gas meters.

integrated voice/data workstation (IDVT). Terminal that possesses both telecommunications and computational capability.

integration. Integration of data types can be achieved using page composition and pagination applications.

intelligent terminal. An interactive terminal in which part of the processing is accomplished by a small computer or processor contained in the terminal itself. This type of terminal is sometimes referred to as a smart interactive terminal. Such a terminal has the following characteristics: (1) self-contained storage; (2) user interaction—with the terminal or the central computer; (3) stored program; (4) part of processing accomplished in the terminal; (5) on-line via communications line with large central computer and database; (6) human-oriented input—such as keyboard and light pen; and (7) human-oriented output—such as serial printer and CRT.

interactive language. Within a system, a human user or device serviced by the computer can communicate directly with the operating program or language.

intercom systems. A system that provides internal communication, allowing calling to be confined to inside the system. In most cases, key systems provide the intercom lines that allow quick communication between stations on the key system.

interconnect and bare-board tester. Equipment designed to check, monitor, and identify printed circuit boards for electrical connectivity and detect manufacturing defects.

interface IC. An analog IC that is dedicated to interfacing digital information (in bits) with external nonsemiconductor devices such as displays, lines, solenoids, and other peripheral devices.

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internal transfer. The process of conveying or moving goods and services from the producer within a company.

international telephone service. Telecommunication services between offices or stations in different states or between mobile stations that are not in the same state or are subject to different states.

interrupt controller. 1: An internal controller chip that can break into the normal flow process of a routine such that the flow can be resumed from that point at a later specified time. 2: A condition or event that temporarily suspends normal processing operations. 3: A temporary disruption of the normal operation of a routine by a special signal from the computer. 4: Copying technology: A feature that allows a job to be stopped to allow another job to be run without the loss of programming for the first job.

intrusion-detection alarm system. A warning system used to detect when someone or something has intruded in a specified area. (See also **alarm system.**)

inventory. Items used in the process of manufacturing a product and distributing it to the end user. Inventory can be stored at a stock point or at a work-in-process location. Inventory may consist of finished goods, parts of intermediate items, work-in-process, or raw materials.

inventory and distribution management. An application that monitors the status of materials at all levels of production, including receipts, issues, and inventory balances. It identifies both unit quantities and dollar values and provides essential input to both the general ledger for cost accounting and the production planning modules.

I/O device. See **input/output device.**

ion implantation. The use of an ion beam to bombard a silicon wafer, altering the concentrations of p-type and n-type material. This method of doping allows for very precise control of the device parameters. This process introduces dopant atoms into the surface of silicon wafers and accelerates them so that they bombard the wafer, causing them to penetrate the exposed portions of the wafer.

ion milling. A technique in semiconductor manufacturing in which a beam of charged particles is used to remove material from a wafer.

I/O ratio. See **input/output ratio.**

IR. See **infrared.**

ISDN. See **Integrated Services Digital Network.**

IVR. See **interactive voice response system.**

J

joint venture. Two or more companies providing capital or other resources to invest or make available for investment in the ownership of a new enterprise.

K

keyboard. An input device that allows an operator to enter alphanumeric characters through a typewriter-style key arrangement augmented with special function keys—manual operation of keys will generate electrical signals or cause tape to be punched, or both.

keyboard controller. A device that governs the functions of a keyboard transmitting a command to do something within a system.

key entry equipment. Data entry equipment such as key disk, key tape, or keypunch equipment.

key telephone system. A customer premises telephone switching system that allows telephones to interface to the public telephone central exchange or office without using an access code. This category includes the electromechanical 1A2 and electronic segments.

L

label. 1: A set of symbols used to identify or describe an item, record, message, or file. May be the same as the address in storage. 2: Matter attached to a document to identify or provide information. 3: To assign a symbol, acronym, or word as a means of identification to create a specialized record or filing handle. 4: A

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descriptive or identifying word or phrase. 5: To address, using self-adhesive addressing labels.

laboratory. 1: A software application that involves the use of computers inside analytical instruments and in linking these instruments together (instrumentation automation). Mass spectrometers and blood/gas analyzers are examples. 2: A place equipped for experimental study in a science or for testing and analysis.

laboratory and scientific apparatus. Any instrument, material, or equipment designed for a specific operation or particular use in the laboratory.

LAN. See **local area network.**

LAN-based e-mail. A software application that enables users of a local area network (LAN) to send and receive textual data. Some LAN-based e-mail software can send and receive computer files and graphic images.

language. In software, a set of commands that permits the programmer to perform arithmetic functions on data and/or give commands to specific hardware components of the computer system, such as the printer, terminals, disk, or memory. Statements in languages are generally required to be performed in a fixed order, although the order may be affected by loops and branches in the program and the values of parameters that control the looping and branching. Examples of low-level languages are C and assembler; high-level, or third-generation, languages include FORTRAN, COBOL, BASIC, and PL/1.

language editor. A set of computer commands forming code to edit files. May involve deleting undesired information, selecting desired information, inserting invariant symbols, and applying standard processes.

laptop A/C. The laptop A/C units reflect the standard laptop design, i.e., clamshell-style case with the display mounted in the top portion of the shell and covering the keyboard until the unit is opened for use. These units, like transportables, are designed to be easily moved from place to place but operate only on A/C power and do not contain batteries of any kind.

laptop D/C. The laptop D/C units are identical in style to the laptop A/C units except that they are powered by batteries and can be operated without direct connection to A/C power lines. Some of these laptop D/C units have a combination of battery- and A/C-power capability.

laptop personal computer. The laptop-case style is conducive to operation on the user's lap and is designed to be used in areas where space is restricted. This case style is referred to as the clamshell-type of system, with the display screen mounted in the top of the unit in such a way as to cover the keyboard when closed and be at the proper viewing angle in relationship to the keyboard when opened and ready for operation. This unit is completely self-contained and can be carried as a single unit that includes the keyboard, display, mass storage, and main system unit.

large-format plotter. This plotter uses media engineering size C (17 x 22 inches) or larger and corresponding metric sizes. (See also **plotter.**)

laser (light amplification by stimulated emission of radiation). 1: A device that transmits an extremely narrow and coherent beam of electromagnetic energy in the visible light spectrum. 2: A laser that operates at optical frequencies. In communications, lasers may be amplitude-modulated and used to carry speech information that is received by a light beam detector.

laser diode. A laser diode is a laser that is constructed with a semiconductor material. Many III-V semiconducting materials can be made to emit coherent light, creating a laser.

laser plotter. A device that produces an inscribed visual display of the variation of dependent variable as a function of one or more variables by the use of intense coherent beams of light.

laser printer. A type of nonimpact printer that combines laser beams and electrophotographic technology to form images on paper.

laser system. Any electronic device or system that is actuated by beams of coherent visible and infrared light to accomplish a task.

LCD. See **liquid crystal display.**

learning. An application that assists the user in learning. The subject can range from classic school subjects to games, art, and languages.

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lease. A contract by which one conveys equipment, facilities, or property for terms specified.

lease accounting. An application that supports the management of leases.

leased circuit. A service offering that provides a customer with permanent (rather than dialed) connections to all points on the circuit for the duration of a contract.

lease/rental conversion. The volume of contractual conversions between rental and lease options.

LED. See **light-emitting diode.**

library management. A software application that supports the administration of a library, including cataloging.

LIDM. See **line, impact, dot matrix.**

LIFF. See **line, impact, fully formed.**

light communication system. Electromagnetic radiation of a wavelength originating at one place and reproduced at a distant point.

light-emitting diode (LED). A pinhead-size device with a pn junction formed from combinations of gallium, arsenic, and phosphorus. Light emission is the result of hole-electron recombinations that take place near the junction of the p-doped and n-doped regions. As the electrons in the n region of the diode travel through the area near the junction, they recombine with a hole. As a result of this recombination between an electron and atom, light in the form of photons is produced. The wavelength of color of the light is determined by the energy level.

light-emitting display. Light-emitting diodes grouped together in a matrix of dots to form characters.

linear array/ASIC. An ASIC that is purely analog.

linear IC. An IC that is purely analog; both inputs and outputs are analog signals. Sometimes, linear and analog ICs are used interchangeably. Dataquest uses linear as an analog-only segment of the analog market (mixed signal analog/digital is the other segment).

line conditioner. Equipment that changes/enhances the transmission characteristics of a circuit.

line, impact, dot matrix (LIDM). A printer that prints one line of dots at a time using an array of elements in a printhead.

line, impact, fully formed (LIFF). A printer that creates one line of characters at a time by placing characters—from a band, type train, or drum—on the paper by the pressure of an impact mechanism (hammer).

line, nonimpact, thermal transfer (LNTT). A printer that prints a line at a time, using an electrically heated element to produce images.

line printer. A printer that usually prints one line at a time at a higher speed than a character printer. Typical line printers use a drum, chain, or train of print elements and have a hammer for each print position in the line. They usually have a buffer to hold one print line. Line printers are segmented by technology (dot matrix, fully formed, thermal) and by speed, expressed in lines per minute (lpm).

linkage mechanism. An assembly of components, with two or more movable parts usually providing some means of power, control, or fastening application.

liquid crystal display (LCD). A high-contrast, black-on-white display screen that uses closely spaced crystal segments on a square dot matrix. The crystal segments butt together to form solid characters. A liquid crystal hermetically sealed between two glass plates.

list price. The price of a product as indicated in the seller's price book. This figure is usually quantity one and is synonymous with manufacturer's suggested retail price.

lithography. 1: A printing process that prints from a planographic image on a printing plate. Lithographic presses are configured as sheetfed and web presses, depending on the format of the paper used. 2: A technique used in semiconductor manufacturing in which a silicon wafer is coated uniformly with a radiation-sensitive film (the resist) and an exposing source illuminates selected areas of the wafer's surface through a mask or template for a particular design.

LNTT. See **line, nonimpact, thermal transfer.**

local area network (LAN). The hardware, software, and peripherals that enable connection of a device to a cable-based network system that

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serves a building or a campus environment. Excluded are connections that are point-to-point, or go through PBXs or data PBXs. Ethernet and Token-Ring are popular LAN technologies.

local government. The political unit or organization governing counties, municipalities, townships, school districts, and numerous kinds of special districts.

local loop. The portion of the telecommunications system that connects the customer's equipment with the local telephone company's network.

local telephone service. A service that includes message telecommunications services, private line services, wide-area telecommunications services (WATS), and centrex services.

logic circuit. 1: A circuit (usually electronic) that provides an input-output relationship corresponding to a Boolean-algebra logic function. 2: An electronic device or devices used to govern a particular sequence of operations in a given system. 3: Circuits that perform basic logic decisions *and/or/not,* used widely for arithmetic and computing functions. Circuits can be of either bipolar or MOS technology.

long distance telephone service. The revenue generated by all long distance carriers for interstate and intrastate long distance telephone services.

M

machining-center programmable machining tool. A machine that is designed to fabricate a complete or near complete part of a single machine, with machining centers that perform a number of different operations in a single setup.

machining robot system. A robot that can pick up parts and place them in a new location. Parts are usually moved in and out of machinery or transferred from station to station.

mag card/mag tape. A tape or card that is coated or impregnated with magnetic material, on which information may be stored in the form of coded polarized spots.

magnetic. The effects of magnetism/flux on the system.

magnetic disk. 1: A random-access storage device consisting of magnetically coated disks accessible to a reading and writing arm, similar to an automatic record player. Data are stored on the surface of each disk as small, magnetized spots arranged in circular tracks around the disk. The arm is moved mechanically to the desired disk and then to the desired track on that disk. 2: A flat, circular plate with a magnetic surface on which data can be stored by selective magnetization of portions of the flat surface.

magnetic ink recognition. Property of automatic devices that can detect or read ink-containing particles of magnetic substance, i.e., the ink used for printing on some bank checks for magnetic ink character recognition (MICR).

magnetic media. Any of a wide variety of belts, cards, disks, or tapes (as contrasted with paper tape) coated or impregnated with magnetic material for use with the appropriate equipment and on which dictation or keystrokes can be recorded and stored.

magnetic recording head. A magnetic head that transforms electric variations into magnetic variations for storage on a magnetic medium such as tape or disk.

magnetic resonance imaging. Equipment used on an object placed in a spatially varying magnetic field that is subjected to pulses of radiation; the resulting nuclear magnetic resonance spectra are combined to give cross-sectional images.

magnetic tape. A serial-access magnetic storage medium. Typically, a flat ribbon of metal, plastic, or paper that is coated on one side with material that can be magnetized; information is stored on the tape by a combination of magnetized spots in certain patterns. (See also **magnetic media.**)

mailing/letter-handling/addressing equipment. Mailing systems and equipment that have been automated with components to increase capabilities and to streamline efficiencies.

mail order. A sales method by which a consumer may order products through a catalog.

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main distribution frame (MDF). A unit used in telephone wiring for terminating and cross-connecting telephone wiring to the telephone-switching system. The MDF is the primary (or first) distribution point. (See also **distribution frame.**)

mainframe computer. A general-purpose information system with price range of $350,000 and up. CPU bit width ranges from 32 to 64 bits. Physical environment can be either with or without special environmental controls and requires full-time support by professional computer systems support staff with 10 or more members. Number of concurrent users is 250 or more.

maintenance management. The upkeep of property, equipment, or tooling through planning, analysis, and documentation of maintenance functions.

management. An application that supports the management of data that can be achieved using document image management software and systems.

manufacturer. A producer or assembler of goods.

manufacturer's representative/agent. An independent contractor who represents multiple manufacturers. She or he does not take title to the product.

manufacturer's suggested retail price. See **list price.**

manufacturing automation. The use of a computer to aid and improve a manufacturing process.

manufacturing EATE N.E.C. Equipment that tests electronic systems that are composed of a number of subsystems. The testing equipment must verify operability and be capable of locating a faulty subsystem or component in event of failure.

manufacturing engineering tools. The small segment of manufacturing engineering that is concerned with tool and fixture design and the development of manufacturing processes.

manufacturing system. A system used to process raw material into a finished product.

mapping. Computer-aided tools that allow geographically related data to be captured, edited, analyzed, and managed. Typical users are civil and utility engineers, geophysicists, and geologists.

market. The demand for a product or service.

market share. A comparison of a company's performance with the total market so that its relative position and the amount of the market it captured is derived.

markup. 1: The amount added to the cost to determine the selling price for a specific product. 2: The amount added to the cost to determine the selling price for a specific product.

maskmaking e-beam. Semiconductor production equipment utilizing a method that allows submicron pattern generation for producing semiconductor mask plates or maskless lithography. (See also **lithography.**)

mask ROM. A semiconductor read-only memory programmed to the customer's specified pattern during the manufacturing process. (See **read-only memory.**)

mass merchandiser. A segment of the distribution channel with storefront locations. It differs from a dealer in that its primary business is the sale of a broad range of consumer goods.

mass property. The analysis of the physical characteristics of a part, assembly, or system. The evaluation of multiple properties—measures volume, weight, and surface area and locates center of gravity.

mass storage peripheral. A device that interfaces with the system or machine to external memory storage.

material. The designation of a number of basic metals, compounds, and gases to make up thermoelectric materials.

material-handling equipment and systems. Equipment such as 1: Movement—Automated guided vehicle systems, conveyors, and monorails;

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cranes and lift trucks are included only when they are computer-controlled; material-handling robots are included in Robotics in Manufacturing. 2: Storage—Automated storage and retrieval systems; miniload, microload, and carousels. 3: Identification—Bar codes, radio frequency, machine vision, and other sensors used for identification are covered in Sensors in Manufacturing. 4: Controls—Computers, programmable controllers, and software used in material handling are included in Computers in Manufacturing and Software in Manufacturing.

material-handling/loading robot systems. Robotics used in the loading, moving, storage, and unloading of materials.

material requirement planning (MRP). A planning method that uses bills of material, inventory data, and a master production schedule to calculate material requirements. This method makes recommendations to restock materials inventory. Further, because material requirements planning is time-phased, this method makes recommendations to reschedule open orders when due dates and need dates are not in phase. Originally seen only as a better way to order inventory, material requirements planning is thought of today primarily as a scheduling technique, i.e., a method to establish and maintain valid due dates on orders.

matrix printer. An impact printer that uses wire, hammer-like bristles, or needles to create characters formed by small dots. Matrix printers produce either serial or line output. The serial printer employs a moving printhead with a matrix block (i.e., 5 x 7 or 7 x 9) of needles. The printhead sweeps across the page to print full characters one at a time. The line printer uses a horizontal band with raised dots that moves from left to right across the paper. The individual needles strike programmed character dots to form one row of dots per sweep across the page. Successive passes of the line printer form complete characters and complete rows of textual data. High-resolution text, comparable to daisywheel output, may be produced by overlapping matrix printers that print characters via a highly concentrated matrix or successive, staggered passes of the printhead. Fonts for matrix printers are stored in ROM or PROM memory.

MBE. See **molecular beam epitaxy deposition.**

MCAE. See **mechanical computer-aided engineering.**

MCU. See **microcontroller.**

MDF. See **main distribution frame.**

mechanical. Mechanical CAD/CAM is the software application of computer-aided tools to design, analyze, document, and manufacture discrete parts, components, and assemblies.

mechanical assembly equipment. 1: Machinery or equipment that assembles mechanical parts into subassemblies or final products. 2: Dial or rotary assembly machines; in-line transfer machines; flexible assembly equipment (except robots).

mechanical computer-aided engineering (MCAE). The application of CAD/CAM tools for mechanical design and analysis. MCAE applications range from conceptual product design through detailed product design and analysis to supporting production design. Commonly used MCAE products are solid modeling and finite element analysis technology.

mechanical computer-aided manufacturing. See **mechanical.**

media-to-media data conversion equipment. Computer output-to-microfilm recording units, tape print units, card-to-tape conversion units, as well as document entry devices.

medical. An environment or industry that uses computers to control and/or collect and analyze data from patients, medical equipment, and/or instruments.

memory. 1: A device into which data can be entered and stored for later retrieval. 2: An integrated current (IC) designed for the storage and retrieval of information in binary form; can be either bipolar or MOS technology and includes dynamic random-access memory (DRAM), static random-access memory (SRAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), and electrically erasable programmable read-only memory (EEPROM).

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memory management unit (MMU). 1: An integrated circuit that manages the storage and retrieval of data found by cell location or address. 2: A component (or set of components) that implements the memory management function in a processor-based system.

merchant production. The sale of a good to a company other than the manufacturing company.

merger and acquisition. In financial terms, it means to absorb or acquire one company by another.

metalorganic CVD (MOCVD). A technique used to deposit material onto a wafer.

metal oxide silicon (MOS). 1: A circuit in which the active region is a metal oxide semiconductor sandwich. The oxide acts as the dielectric insulator between the metal and the semiconductor. 2: A process that results in a structure of metal over silicon oxide over silicon. 3: Technology that employs field effect transistors having a metal or conductive electrode that is insulated from the semiconductor material by an oxide layer of the substrate material.

meteorological instrument. An instrument used to monitor and observe the weather.

metropolitan statistical area. A large population nucleus, together with adjacent communities, that has a high degree of economic and social integration with that nucleus. Each metropolitan statistical area (MSA) must include at least: (a) one city with 50,000 or more inhabitants, or (b) a census bureau-defined urbanized area of at least 50,000 inhabitants and a total MSA population of at least 100,000 (75,000 in New England).

microcomponent. 1: An integrated circuit (IC) with high-speed, low-power density considered as a single part. 2: An IC that contains a processing unit or acts as an interface chip to such a device. Types of microdevices include microprocessor (MPU), microcontroller (MCU), microperipheral (MPR), and digital signal processor (DSP).

microcomputer. An information system with price ranging up to $100,000, with the majority priced at less than $50,000. CPU bit width is normally 32 bits, but can be as low as 8 bits. Traditionally used as a desk-side or desktop system configuration. Normally a multiuser system used in a common work area. Usually has a merchant (nonproprietary) microprocessor.

microcontroller (MCU). An integrated circuit, containing a CPU, memory, and I/O capability, that can perform the basic functions of a computer.

microperipheral (MPR). A support device or circuit for a microprocessor or microcontroller that either interfaces with external equipment or provides system support.

microprocessor (MPU). A single-chip component, or a collection of architecturally interdependent components, functioning as the central processing unit (CPU) in a system. A microprocessor may contain some input/output circuits, but it usually does not operate in a standalone environment.

microprogrammable digital signal processor (MPDSP). An integrated circuit that allows high-performance, modular DSP architectures to be designed using standard off-the-shelf components. Products include bit-slice and building block components.

microwave. 1: Any radio wave with a frequency higher than 890 MHz or a wavelength of between 1ml and 1m. 2: A form of electromagnetic radiation that has frequencies of 1 GHz. These high-frequency bands of energy are used extensively for radar and wideband communications.

microwave antenna. A device used for receiving and transmitting microwave signal beams. (See also **antenna.**)

microwave monolithic integrated circuit (MMIC). An electronic circuit employing monolithic integrated circuit technology fabricated by microelectronic techniques and capable of operating at frequencies above 1 GHz.

microwave oven. An oven that uses electron waves to produce heat for faster cooking of foods.

microwave radio equipment. Equipment that includes transmitter/receiver systems, power supplies, repeaters, and other equipment used in microwave radio systems. It also includes analog and digital equipment used both in common carrier and in private industrial systems.

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midrange. The combination of microcomputer, minicomputer, and superminicomputer.

military/aerospace electronic equipment. Electronic equipment used in the military and civilian aerospace industries.

military communication equipment. Voice, data, and cryptographic equipment used for communication in the military.

military computer system. A computer system used for military purposes; a set of hardware components that form a system intended solely for military applications. This category includes general-purpose CPUs, storage, input/output, and terminals and includes both commercial, ruggedized, and mil'spec versions for integration into military systems and for government-sponsored programs.

military electronic equipment. Electronic equipment used exclusively by the military. Usually, this equipment must meet government specifications and regulations.

military simulation and training. The performance of military maneuvers/exercises as training for real-life military situations. This category includes flight and battle simulators and equipment operation and maintenance systems.

milling programmable machine tool. A machine tool for the removal of metal by feeding a workpiece through the periphery to remove the material through the motion of workpiece and cutter.

minicomputer. An information system with prices ranging from $10,000 to $300,000 but mainly falling between $25,000 and $150,000. CPU bit width ranges from 8 to 16. Minicomputers are situated usually in a common work area and occupy more floor space than most tower configurations. Number of concurrent users ranges from 15 to 100. System usually incorporates proprietary processor, with notable exceptions, and is often packaged with third-party application software and/or peripherals and then resold into specialized applications or vertical markets. Examples of models are the HP 1000, HP 3000/70, PDP-11/84, and IBM Series/1.

minicomputer-based terminal. A display terminal provided by a minicomputer manufacturer or a display terminal that is protocol-specific to an IBM System/34, /36, or /38 computer. This terminal may operate in either character or block mode. Excluded from this category is any minicomputer-compatible terminal supplied by an independent manufacturer.

miscellaneous military equipment. Equipment that includes classified systems, test equipment (N.E.C.), vehicle control, medical equipment, assorted development and office equipment, and research and development equipment; all used in the military.

mixed signal ASIC. An ASIC that has one analog input or output and one digital input or output.

mixed signal IC. An integrated circuit that has one analog input or output and one digital input or output.

MMIC. See **microwave monolithic integrated circuit.**

MMU. See **memory management unit.**

mobile communications equipment. Equipment (base stations, mobile units, and antenna) used primarily for portable public or private communications.

mobile infrastructure. The central base station and other central equipment that provide mobile communication services.

mobile radio base station equipment. The base/centralized station equipment associated with cellular radio systems. This category includes both switching equipment and radio transmitter/receiver equipment.

mobile radio service. Service or network revenue associated with cellular radio systems. (See also **mobile service.**)

mobile radio system equipment. Electronic equipment used in the transmission and receiving of radio signals. Equipment includes main central control, base control mobile stations, and handheld car units. Used primarily with cellular and other mobile communication technologies.

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mobile service. Radio service between a fixed location and one or more mobile radio stations, or between mobile stations.

mobile telephone service (MTS). Radio communication between a mobile (portable) unit and the public switched network including cellular service.

modeling. An application that supports the representation of a process or system by using equations that simulate and represent behavior under varying conditions.

modem. 1: An electronic device that provides modulation and demodulation functions of transmitted data signals over telephone lines. They convert digital data signals to analog for transmission over leased lines or the analog public switched telephone network. 2: The integrated circuits used in a modem.

molecular beam epitaxy deposition (MBE). A technique used in semiconductor manufacturing to deposit a single crystal layer on a substrate by use of a molecular beam.

molecular engineering. See **computational chemistry/molecular engineering.**

money management. An application that identifies and controls the source, flow, location, and earning potential of an organization's cash and investments.

monitor. 1: To check the operation and performance of a system or circuit by examining parts of transmissions. 2: The physical CRT unit, associated electronics, and housing used in display systems. 3: A station or equipment arranged to supervise system operation. 4: To supervise and verify the correct operation of a system, device, or program. 5: The screen of a video display terminal. 6: An analog monitor can display an almost infinite number of colors, while a digital monitor can display a more limited range of colors.

monolithic analog integrated circuit. An analog IC constructed from a single piece of material. All circuit components are manufactured in or on top of a single crystal of semiconductor material.

MOS. See **metal oxide silicon.**

MOS application-specific IC. See **application-specific integrated circuit.**

MOS cell-based IC. See **cell-based integrated circuit.**

MOS custom IC. See **custom integrated circuit.**

MOS digital. A semiconductor technology in which the active devices are n-channel, p-channel, or complementary MOS transistors that operate in a digital or binary mode. (See also **digital.**)

MOS FPGA. See **field-programmable gate array.**

MOS gate array. See **gate array.**

MOS logic. See **logic circuit.**

MOS memory. See **memory.**

MOS microcomponent. See **microcomponent.**

MOS microcontroller. See **microcontroller.**

MOS microperipheral. See **microperipheral.**

MOS microprocessor. See **microprocessor.**

MOS nonvolatile memory. See **nonvolatile memory.**

MOS PLA. See **programmable logic array.**

MOS PLD. See **programmable logic device.**

MOS PMD. See **programmable multilevel logic device.**

MOS standard logic. See **standard logic.**

MOS transistor. A field-effect transistor (FET) with a gate that is insulated from the semiconductor substrate by a thin layer of silicon dioxide. Being field-effect transistors, MOS-FET provide a voltage-input-to-current-output relationship called transconductance. MOS-FET are excellent switches because voltage at the gate turns the output current on or off.

mouse. A hand-held device that is moved on a surface to provide coordinate input to a graphics system. It is used most often to position a pointer or cursor.

MPDSP. See **microprogrammable digital signal processing.**

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MPR. See **microperipheral.**

MPU. See **microprocessor.**

MPU load programmer. A device that allows engineers and IC designers to program a variety of programmable devices (ICs), thereby speeding up the design process. The device to be programmed is loaded directly on the device programmer.

MTS. See **mobile telephone service.**

multilingual publishing. A system with the purpose/use of printing in a variety of languages.

multimedia. A process that uses more than one form of communication.

multiplexer equipment. Public telecommunication equipment used to combine a number of channels for transmission over a common medium, such as satellite, microwave radio, cable carrier, or fiber-optic cable. Excluded from this are data-only customer premises multiplex equipment and multiplex equipment that is integral to carrier or microwave radio systems.

multistrike ribbon. A ribbon that advances only part of a character width; characters slightly overlay one another on the ribbon, but no character hits the exact same spot on the ribbon.

multiuser system. A computer system inherently designed for environments with multiple users.

N

natural resources and construction. An environment or industry that includes establishments primarily engaged in agricultural production, forestry, commercial fishing, hunting and trapping, and related services; and mining or quarrying, developing mines, or exploring for nonmetallic minerals except fuel. Also, certain well and brine operations and primary preparation plants, such as those engaged in crushing, grinding, washing, or other methods of concentration.

navigation, military. A process for directing ships, aircraft, spacecraft, and other crafts to a specific destination. Equipment determines position, distance, and course of vessel or craft.

n-channel metal oxide semiconductor (NMOS). Pertaining to MOS devices made on p-type silicon substrates in which the active carriers are electrons that flow between n-type source and drain contacts. The opposite of PMOS. NMOS is two to three times faster than PMOS. (See also **MOS.**)

net additions. 1: The change in stock, such as installed base or inventory. 2: The relative increase or decrease in the total installed base of a product.

NETVIEW. IBM network management product.

network management. A software application that controls the logical connections and information flow among computers on a network. This software may have additional functions such as performance measurement and diagnostic and accounting functions.

network support services. All services that help customers better utilize their networking facilities. The services include site planning, installation, and ongoing on-site and remote maintenance support, as well as professional services such as network design/planning, integration, administration, and operations management.

network terminating devices. Equipment that connects a data network to the data terminal.

new placement demand. The total end-user demand for new products (as compared with replacement products).

newspaper publishing. A system with the main purpose/use of printing newspapers; typically daily or weekly publication containing such elements as news, feature articles, and advertising.

nitrogen. A chemical element.

NMOS. See **n-channel metal oxide semiconductor.**

non-IBM, protocol-specific terminal. A terminal that is protocol-specific to a Burroughs, Honeywell, or Sperry mainframe computer. Included is any terminal of this type that connects to another computer by means of protocol emulation.

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nonimpact printer. A hard-copy computer output device that forms images through electrostatic or other nonimpact methods. These printers include ink jet, laser, and thermal printers. (See also **ink jet printer.**)

nonvolatile memory. An integrated circuit using two-junction transistor technology where memory retains information when the power is off. Also known as core or permanent memory. Can be either bipolar or MOS technology process.

nonvolatile random-access memory (NVRAM). A read/write semiconductor memory device that does not lose information when the power is turned off.

notebook personal computer. The notebook personal computer is a system that resembles a laptop personal computer in general form factor and appearance. This personal computer is smaller and lighter in weight than a laptop D/C unit. The "standard" notebook size is 8.5 inches by 11 inches by 2 inches or less, and the weight of these units is in the 5- to 7-pound range. Notebook computers also, presently, make use of industry-storage mass storage media including 3.5-inch floppy disk.

nuclear radiation detection and monitoring instrument. An instrument used to detect, inspect, monitor, and control alpha particles (neutrons, protons, and electrons) that emanate from the atomic nucleus as a result of radioactivity and nuclear actions.

numerical control. 1: Computer instructions that automate machining and drafting tools. 2: A technique of simulating the operation of a machine tool. 3: Descriptive of systems in which digital computers are used for the control of operations, particularly of automatic machines. A technique of controlling a machine or process through the use of command instructions in coded numerical form.

numerical-control (NC) part programming. The programming of a numerical-control machine tool or automated processing system. Graphics and language-based programming tools are available.

NVRAM. See **nonvolatile random-access memory.**

O

OCR. See **optical character reader.**

OEM. See **original equipment manufacturer.**

office equipment. Equipment used in a business or office environment. Equipment may include copiers and duplicators, electronic calculators, dictating machines, electronic typewriters, word processors, banking systems, cash registers, and mail- and letter-handling equipment.

off-line robotics programming. A special-purpose process simulation that graphically represents the sequence of steps to program a robot for a particular operation. The resulting data can be downloaded to a robot to update its control program.

oil field services. A software application that uses small computers in the oil rigs or the wellhead areas to log and analyze data from sensors in the well.

OLTP. See **on-line transaction processing.**

one-time programmable read-only memory (OTP ROM). An EPROM packaged in plastic without a quartz window for erasure. Such a device is therefore programmable only once.

on-line transaction processing (OLTP). The input, tracking, and output of a well-defined record of information, processed in real time rather than batch. Examples include ATMs and airline reservations systems. OLTP systems are usually large and complicated enough that each one is customized, so there are few generic OLTP products. The RAMP-C and Debit-Credit benchmarks are examples of OLTP standards.

op amp. See **operational amplifier.**

open systems interconnection (OSI). A communication standard for network architecture that allows communication between various equipment.

operating environment. A set of conventions for screen appearance, keyboard, mouse and screen operations, and program functions. Operating environments function within an operating system.

operating system. 1: The software program in a computer that maps logical constructs to physical locations in the computer. The operating system is the program that lets a user access data by a file

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name without knowing where the file is physically located on the disk. 2: The operating system controls the computer's operations by managing disk, screen, file maintenance, and printer activity, while loading and running application programs.

operating utilities. A program or routine of general usefulness and applicable to many jobs or purposes.

operational amplifier (op amp). A type of integrated circuit (IC) that generates an amplified output that is exactly proportional to its input.

operator support system. Special equipment and/or software that facilitates the operation of a switchboard or comparable equipment.

optical CD/wafer inspection. Critical dimension (CD) refers to the line, element, or feature that must be manufactured and controlled to stringent specifications. Wafer inspection refers to the inspection of a patterned wafer for process defects by visual image process techniques.

optical character reader (OCR). 1: A device or scanner that can read printed or typed characters and convert them into a digital signal for input into a data or word processor. 2: The machine identification of printed characters through the use of light-sensitive devices; computer-input-only hardware.

optical disk controller. A device that controls the storage and retrieval of data from a video disk that is sensed through a laser beam.

optical disk drive. A data storage device utilizing laser technology. Types include CD-ROM, WORM, and erasable optical disk drives.

optical jukebox. A library system that holds multiple disk drives and optical disks to create a large storage environment on optical media.

optical media. The substance on which data are stored electronically and read by laser technology.

optical-scanning equipment. See **optical character reader.**

opto. See **optoelectronic.**

optocoupler. 1: A device that transmits electrical signals, without electrical connection, between a light source and a receiver. Also called an optoisolator. 2: A device that consists of an LED separated from a photo detector by a transparent, insulating, dielectric layer, all mounted in an opaque package. A current pulse in the LED causes a radiation pulse to flow across the dielectric layers to a photo detector, which produces a current pulse at the output. The input and output circuits are coupled with high-standoff voltage isolation.

optoelectronic (opto). A semiconductor device in which photons cause electron flow or vice versa. Optoelectronic chips contain transducers used between photonic circuit media and electronic media; they also may contain amplifiers, logic functions, and/or other photonic or electronic functions.

order entry and sales support. An application to support the process of accepting and translating what a customer wants into terms used by the manufacturer. This can be as simple as creating shipping documents for a finished goods product line to a more complicated series of activities including engineering effort for make-to-order products.

order entry/processing. Acceptance and translation of customer requirements into terms used by a manufacturer.

organization operation. A software application that supports the day-to-day running of an organization.

original equipment manufacturer (OEM). 1: An OEM may manufacture a product for assembly into another system or larger configuration by another manufacturer or vendor. 2: A purchaser of materials, components, or equipment to be incorporated into its product line. 3: A product reseller that integrates hardware, software, and/or services. The reseller may or may not own the hardware or software. An OEM differs from a VAR in that it adds its own label to the product and backs up its warranties.

OSI. See **open systems interconnection.**

OS/2. Computer systems based on the Intel 80XXX architecture and using OS/2 operating system software.

other. A subject or segment that is not distinctly defined within the Dataquest High-Technology Segmentation scheme.

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OTP ROM. See **one-time programmable read-only memory.**

P

PABX. See **private automatic branch exchange.**

pacemaker. An electronically pulsed oscillator implanted in the body to deliver electric pulses to the heart at a fixed rate in response to a sensor that detects when a person's heart rate slows.

packet assembler/disassembler (PADS). A system element that buffers data sent to and from character-mode devices and assembles and disassembles the packets needed for X.25 operation.

packet data switching. Data network switches that connect terminals and packet assemblers/disassemblers to a pre-edit node using a high-speed link (56,000 bps). Can be public or private.

PADS. See **packet assembler/disassembler.**

page composition. Refers to the page composition software used to produce finished draft or camera-ready pages whereby text and graphics have been aesthetically laid out using an editable WYSIWYG display environment.

page, nonimpact, plain paper (PNPP). A printer with the ability to buffer, in part or in whole, a page of images received from an electronic source and then to transfer these images to a receiving substrate.

page printer. A printer that prints characters one at a time to full-page format. Page printers are rated by speed categories, expressed in pages per minute (ppm).

paging equipment. Communication equipment that produces an audio signal in a radio receiver carried by an individual to tell him that he is needed at the telephone. Communication system for summoning individuals or making public announcements.

paging system. The equipment necessary to selectively alert individuals by tone or voice paging, either by pocket radio receivers or speakers within a building.

painting robot system. A system consisting of a number of robots programmed to paint by carrying spray guns and applying a coating of material. Also known as finishing robot.

PAL. See **programmable array logic.**

panel-type instrument. 1: Switches, dials, and buttons that are mounted on an electronic unit that controls and monitors a system. 2: Electronic instrumentation devices mounted on a panel for a variety of equipment purposes.

paper. Sheets of fiber formed on a fine screen from a water suspension. There are hundreds of different types of paper based on weight, brightness, color, opacity, and coating.

particle accelerator. A device that accelerates electrically charged particles (protons, electrons) to high energies.

part process design. The design of the actual manufacturing process and sequence.

parts service. Spare hardware modules or components used in the repair and/or replacement of failed hardware units.

passive device. 1: An inert component that may control, but does not create or amplify, energy. 2: A device that exhibits no transistance. A component that does not provide rectification, amplification, or switching but reacts to voltage and current. 3: Pertaining to a general class of device that operates as signal power alone.

patient monitoring. Equipment used to monitor, control, and record data on activity concerning or affecting a patient's health.

pay phones. A telephone instrument located in a public location that accepts coins for operation.

payroll. A software application that supports an organization making payment to its employees for work performed.

PBX-private branch exchange. See **PBX telephone system.**

PBX telephone system. A telephone switching system on the customer premises that, by dialing an access code, permits a telephone to interface to the public telephone central exchange or office.

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PC. See **personal computer system.**

PCB layout. Products that are used to create the layout of the traces and components to be placed on a printed circuit board.

p-channel metal oxide semiconductor (PMOS). An MOS device made on an n-type silicon substrate in which the active carriers are holes (p) flowing between p-type source and drain controls.

PC logic chipset. A semiconductor device (or set of devices) that integrates standard logic and controller functions onto a very large scale integration (VLSI) chip, resulting in a reduced component count on the PC motherboard.

PCN. See **personal communications network.**

pen-based personal computer. This is a new classification of portable computers for 1991. The general identifier for this class of machines is that they utilize a pen or stylus for data input and do not normally require a keyboard to operate. (Keyboard options are included in some of these models, but the system can be fully utilized without the inclusion of a keyboard.) Pen-based computers do not have to be able to run MS-DOS or applications that run under DOS. It is expected that there will be three or more operating systems utilized in this product: PenPoint by GO Corporation, Pen Windows by Microsoft, and others that have not been made public at the time of publication.

percent retirement. See **retirement.**

periodical publishing. A system with the main purpose/use of printing publications issued at intervals.

peripheral device. 1: Any instrument, device, or machine that enables a computer to communicate with the outside world, or areas in the operation of the computer. 2: Equipment that is connected to a computer but is not part of the computer. Examples include printers, terminals, and disk drives.

peripheral I/O management. 1: A program that interacts with the central processing unit (CPU) of a computer to communicate with devices beyond the CPU. The program interprets and responds to instructions from the CPU. 2: Information flows between the CPU and a unit of peripheral equipment.

personal communications network (PCN). A class of communications technology that allows communication with a mobile entity. Sample technologies include mobile radio, cellular, and paging services.

personal computer operating system. A personal computer operating system is a program that supervises and controls the operation of a personal computer.

personal computer system. A personal computer intended for use on the user's desk or work surface and not designed to be readily moved from place to place. Personal computers are those systems that include, as part of the basic system, a BIOS- or ROM-based software code that is designed to permit the use of the system with any of the existing personal computer operating systems.

personal electronics. Electronic equipment for personal use.

personal finance. A software application that records, processes, and reports on personal financial data, including personal banking, credit card management, and budgeting. These applications are suitable for small businesses as well as home use.

personnel management. A software application that supports an organization in managing its employees; may include many subapplications.

photoblank. A blank glass plate that is processed to become a photomask for use in semiconductor manufacturing.

photomask. A glass plate covered with an array of patterns, used to form circuit patterns on semiconductor wafers. Photomasks may be made of emulsion, chrome, iron oxide, silicon, or a number of other materials.

photoreceptor. The photoreceptor is the central element in an electrophotographic copier or nonimpact printer. The photoreceptor consists of two parts; a support or substrate, usually in the form of a drum or flexible belt, and a photoconductive coating consisting of one or more layers.

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photoresist. The light-sensitive film spun onto semiconductor wafers and exposed using high-intensity light through a photomask.

photosensitive. Capable of emitting electrons when struck by light rays.

photosensitive plotter. A plotter that uses photosensitive properties to create an image.

photosensor. An optoelectronic semiconductor that responds to radiant energy. Examples are photodiodes and phototransistors.

physical property test, inspection, and measurement. An instrument designed to inspect and measure physical property.

physical vapor deposition (PVD). A process through which specific materials are physically layered on a wafer. Includes sputtering and evaporation.

pin diode. A diode made by diffusing the semiconductor with p-dopant from one side and n-dopant from the opposite side with the process so controlled that a thin or intrinsic region separates the n and p regions. (See also **power diode.**)

PLA. See **programmable logic array.**

placement. End-user consumption of a product that is either purchased, leased, or rented.

planning. An application that facilitates the quantitative aspects of business planning, such as modeling, budgeting, analysis, and forecasting.

plasma etchant. A highly ionized gas (plasma) in the manufacture of high-density semiconductors.

plastic-processing machinery. Numerically controlled machinery used for injection, structural foam, extrusion, blow molding, thermoforming, and reaction injection.

plastics. 1: A polymetric material of large molecular height that can be shaped by flow; usually refers to the final product. Examples include polyvinyl chloride, polyethylene, and urea formaldehyde. 2: Displaying or associated with plasticity.

PLC. See **programmable logic controller.**

PLD. See **programmable logic device.**

plotter. 1: A recorder that charts, in graph form, a dependent variable as a function of one or more variables with an automatically controlled pen or pencil. 2: Any (vector or raster) computer hardcopy devices that perform mainly graphics functions. These devices include pen plotters, electrostatic plotters, photographic and laser plotters, and ink jet plotters.

PMD. See **programmable multilevel logic device.**

PMOS. See **p-channel metal oxide semiconductor.**

PMR. See **private mobile radio.**

PMR. See **projection microradiography.**

PNPP. See **page, nonimpact, plain paper.**

point-of-sale terminal. A terminal device that operates as a cash register in addition to transmitting information.

polysilicon. A silicon layer grown on a wafer in a furnace.

population. The total of individuals occupying an area or making up a whole. A *de facto* population should include all persons physically present in a country (state, province, region, city, or town) or designated area at a reference date. A *de jure* population, by contrast, should include all usual residents of a given country or designated area, whether or not they are physically present at the reference date. By definition, therefore, a *de facto* total and a *de jure* total are not entirely comparable.

portable electronic measuring instrument. An electronic measuring instrument that can be carried or transported with ease.

portable radio receiver transmitter. A device for converting radio waves into perceptible signals.

portfolio management. A software application that allows investors to clarify, estimate, and control the sources of risk and return in their portfolio.

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postsecondary education. The provision of formal instructional programs with a curriculum designed primarily for students who have completed the requirements for a high school diploma or equivalent.

potentiometer. A device for the measurement of an electromotive force by comparison with a known potential difference.

power diode rectifier. A diode is a two-terminal device that permits current flow in only one direction. This property is used in diodes and rectifiers to convert AC current to DC.

power grid control. See **power management.**

power IC. An analog integrated circuit that can control one or more amps of current, dissipate one or more watts of power, or is capable of operating with voltages exceeding 100 volts.

power management. A real-time application that monitors and controls power generation equipment and power line grids.

power supply. 1: A unit that supplies electrical power to another unit. 2: Energy source that provides power for operating electronic apparatus.

power train. The mechanism by which power is transmitted from the engine to other part of the vehicle that it drives. Examples include ignition, spark timing, fuel control, turbo control, emissions systems, voltage regulator, alternator, engine control, and diagnostics.

power transistor. 1: A transistor that dissipates power of one or more watts. 2: A transistor designed for high-current, high-voltage applications.

premises switching equipment. Voice equipment that provides switching or call-routing functions. Includes equipment such as PBX telephone system and key telephone system.

presentation graphics. 1: A software application with a principal function of formatting text or numeric data into specified formats for the presentation of ideas. This may include graphs, charts, and/or lists suitable for professional presentations. 2: An image written, printed, drawn, or engraved; an image outlined or set forth for commercial, professional, or industrial purposes.

print element. The mechanisms used in fully formed character printers and typewriters by which marks are made on the paper. The three types of print elements are printwheels, also known as daisywheels, golf balls, and thimbles.

printer. The unit that produces copy on paper—a typewriter or a line printer. Often connected to a CPU that transforms electronic data into hard-copy form. (See also **ink jet printer** and **line printer.**)

printer controller. 1: Within a printer, the device used to regulate, accelerate, decelerate, start, stop, reverse, or protect devices connected to an electric controller. 2: A device or instrument that holds a process or cartridge at a desired level. 3: Hardware and/or software, usually either printed circuit board- or diskette-based, that takes data streams from software and converts it to printer-specific commands. The controller may reside in a CPU; may be connected to the print engine by an interface cable, a diskette or chip set in the CPU or printer; or, as in most cases, may be a physical attachment to or integrated component of the printer itself.

printer controller board. See **printer controller.** (Except all devices are loaded onto a board.)

printer, impact. Family of printers that use direct impression impact of a typebar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

printer, nonimpact. A printer capable of imaging on a substrate without physically striking it; these include ink jet, laser, and thermal printers.

print system network. Hardware and software that is integrated to manage the information sent to one or a number of printers, usually shared by more than one user. The system may be as simple as a switch box connected to two CPUs and one printer, or as complex as a full local area network that controls print streams to many printers from multiple CPU systems and controls job-queuing management, printing error conditions, spooling, and rerouting.

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printwheel. A print element for certain character printers. The characters are engraved at the end of spokes, the entire printwheel resembling a daisy. Also known as daisywheel.

private automatic branch exchange (PABX). One type of telephone switching system that is typically used in larger businesses. The PABX allows computer-like programming of incoming and outgoing calls to optimize network configurations and provide additional call management features.

private line. A telecommunications network connection for the exclusive use of one organization. (See also **leased circuit.**)

private mobile radio (PMR). See **cellular service.**

private packet data switching. A private packet data network switch connects terminals and packet assemblers/disassemblers to a packet node using a high-speed link (56,000 bps). (See also **packet data switching.**)

private school or institution. A school or institution that is controlled by an individual or agency other than a state, a subdivision of a state, or the federal government; usually supported primarily by funds other than public funds; and is operated by other than publicly elected or appointed officials.

process control, nonunified system. System-type instruments and related equipment for process control activated from standardized electrical transmission signals, in which control and signal conditioning are separated from the display and operator interface.

process control system. 1: Monitoring and maintaining the operation of plants that manufacture homogeneous materials such as oil, chemicals, and paper. Process control systems are capable of detecting errors in input variables and environment and taking corrective action. Closed-loop systems are self-correcting, and open-loop systems alert an operator. 2: A computer-based system that controls physical transformation and/or the mixing of products in a fluid state.

process control system, auxiliary station. Peripheral equipment of a process control system not in direct communication with the central processing unit or system.

process control system, controller. The controller describes that portion of a process control system that continuously measures the value of a variable quantity or condition and then automatically acts on the controlled equipment to correct any deviation from a desired present value.

process control system, indicator. A portion of the process control system that produces a diagram measuring the pressure volume changes in a running system.

process control system, industrial process computer. A computer that monitors the manipulations and changes of numerous conditions within a process control system automatically.

process control system, recorder. A portion of a process control system that makes a graphic or acoustic record of one or more variable quantities.

processing terminal. A display terminal that has local processing capability but is dependent on communication with a host, controller, or server to provide files and application programs. Such a terminal does not have a mass data storage device.

process manufacturing. 1: *Continuous process* produces a continuous stream of products, the units of which are not differentiated from one another (i.e., gasoline). 2: *Batch processing* produces product by reference to a recipe (i.e., bread).

processor. A device for handling information in a sequence of reasonable operations. Any device that can perform operations on data.

process planning and control. See **process control system.**

process simulation. The computerized simulation of the sequence and interdependencies of manufacturing processes. Also involves process modeling and includes NC part programming as a subset.

product. A good or service.

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product category. A grouping of similar products.

production. The manufacture of goods.

production planning and control. Software used to plan for factory resources of a manufacturing company.

professional publishing. Systems dedicated exclusively to the job of publishing; typically, PC-based professional publishing systems focus on a single task or stage in the document production cycle, rather than managing the entire document production process.

professional services. A range of services including consulting on information technology, contract/custom programming, systems integration, facilities management, education, and ongoing maintenance.

programmable array logic (PAL). PAL is a trademark of Monolithic Memories, Inc. (now part of Advanced Micro Devices), referring to a family of logic devices that are customer programmable.

programmable logic array (PLA). 1: A form of programmable logic device containing a structured, partially interconnected set of gates and inverters that are fuse programmed by the user. Can be manufactured in bipolar or MOS technology.

programmable logic controller (PLC). A device or transmission control unit in which hardwired functions have been replaced with software or microcode. A programmable controller enables a user to add, change, or tailor computer capacities to the user's needs; programmable solid-state devices that replace mechanical relays for controlling sequential operations, timing, counting, and similar simple control actions. Where the capabilities exist as a function of the PLC, this definition includes more sophisticated tasks such as mathematical computations, data acquisitions, reporting, and process equipment control.

programmable logic device (PLD). A type of application-specific integrated circuit (ASIC) that is user programmable (after assembly) rather than mask programmable. The function of a PLD is determined by blowing fuse links or programming memory devices to create the desired interconnections between the fixed logic elements on the device. Can be either a bipolar or MOS technology. (See also **programmable logic array.**)

programmable machine tool. Numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and flexible machining centers used for metal cutting and metal forming.

programmable multilevel logic device (PMD). A semiconductor that can be manufactured by a bipolar or MOS technology process. The device, evolved from the basic programmable logic array (PLA), incorporates architectures to implement complex logic functions efficiently. PMDs can implement multiple levels of logic without sacrificing input/output or I/O cells or pins.

programmable read-only memory (PROM). A nonvolatile fuse-programmable solid-state memory circuit that is programmable only once, with special equipment. It is a programmed ROM that may be programmed after manufacture by blowing fuse links or shorting base-emitter junctions. PROMs provide high-speed access to frequently needed data and instructions. They allow a vendor company to customize a system before delivery to the user.

projection/aligner. Wafer fabrication lithography equipment that uses mirrors instead of lenses. The wafer and mask are separated by distance, not allowing the entire wafer to be exposed. This process lines up two or more layers of a wafer so that the components of one layer are compatible with the components of the other layer. (See also **lithography.**)

projection microradiography (PMR). An electron beam is focused onto an extremely fine pencil, generating a point source of x-rays; enlargement is achieved by placing the sample very near this source and several centimeters from the recording material.

project management. A software application that supports the ordering of activities across time. This application assists in planning and implementing projects by providing tools for forecasting requirements, projecting costs, and providing other charting and analysis features.

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PROM. See **programmable read-only memory.**

prosthetic medical equipment. Equipment used in the surgical and dental specialties concerned with the artificial replacement of missing body parts.

protocol. A set of rules (not a program) for software programs to conform with in data communications. A program that reacts properly to data sent to it in a form that does not conflict with these rules and that sends data in conformance with these rules is said to support, or be in compliance with, the particular protocol. An example of a protocol is the one used by humans over two-way radio: the protocol is that one person finishes speaking by saying "over"; the other party then speaks, until finished and says "over"; the end of transmission is signalled by saying "over and out." Examples of protocols in data communications are BSC (IBM) and T201 (Tymnet).

protocol converter. Equipment that converts data from one format (protocol) to another. (See also **gateway.**)

proximity/contact aligner. Equipment that places a mask in direct contact with the wafer after the mask is aligned. With proximity, the mask does not come into direct contact with the wafer. (See also **lithography.**)

PTT. Postal, telegraph, and telephone organization. An organization that provides basic telecommunications services. For U.S., see regional bell operating companies.

public data network service. A packet-switched or circuit-switched network service available for public use. It includes the equipment and service charges associated with data communications networks that are offered to the general public. These networks connect user terminals and computers to the network and may offer enhanced or value-added services, such as conversion of speeds, codes, protocols, electronic mail, or facsimile.

public packet data switching. See **packet data switching.**

public school or institution. A school or institution controlled and operated by publicly elected or appointed officials and deriving its primary support from public funds.

public switching equipment. Equipment used in public telecommunications to switch or route voice and data calls. This segment includes equipment such as digital central office switching equipment and digital access cross-connect systems.

public telecommunications equipment. Equipment that includes public network services and equipment. It includes the various voice and data communications services provided by common carriers and the transmission and switching equipment used to implement these networks.

public telecommunications service. A service provided by public telecommunications carriers. It includes services such as local telephone, long distance telephone, international telephone, leased circuit, public data network, enhanced network, and mobile communications.

public transmission equipment. The equipment used in public telecommunications to transmit voice and data signals. It includes equipment such as multiplex equipment, carrier equipment, microwave radio equipment, and satellite earth state equipment.

publishing. 1: The business or profession of the commercial production and issuance of literature and information. 2: Computer-aided systems to automate the creation and printing of documents.

punch/shear/bend programmable machine tool. Describes the action that occurs to a composite or material, generally metal, on a machine. Punching literally punches a hole in the material, shearing cuts the material, and bending forms the material to a specified predetermined shape. These three activities are performed on three separate machines.

purchasing. A software application that has computer-assisted generation or procurement documents specifying materials, quantities, and delivery times.

purchasing and vendor management. Contains statements as to the quantity, description, and price of the goods; agreed terms as to payments, discounts, date of performance, and transportation.

PVD. See **physical vapor deposition.**

PW—private wire leased circuits. See **private line.**

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Q

QC. See **quality control.**

QC analysis. Quality control analysis is generally performed throughout the manufacturing process, comparing the actual part shape or feature size to the design specification.

quality. The measure of how well a product or service meets customer expectations. Alternately, the ability to produce consistently a product or service within control limits or well-defined specifications.

quality assurance. The establishment and execution of procedures to measure product quality and adherence to acceptance criteria.

quality control. Process by which product is measured to ensure conformance to specification and standards.

query language. A generalized computer language that is used to interrogate a database.

R

R&D. See **research and development.**

radar. A radio device used to locate objects by frequency waves reflected off the object and received by the sender, allowing the sender to determine characteristics of an object. Includes airborne, shipboard, and ground search, flight control acquisition, detection, tracking, and associated test systems.

radio. 1: The use of electronic waves/signals to produce sound. 2: Home radio receivers including AM, AM-FM, and FM radios that are classified as table models, clock models, and portable radios. This category does not include high-fidelity receivers, radio-phonograph combinations, and television receivers, nor does it include automobile radios, stereos, or tape players.

railroad control. An application that monitors and controls railroad and urban rapid transit traffic.

RAM. See **random-access memory.**

random-access memory (RAM). An integrated circuit permitting read-and-write access to any memory cell or address in a completely random sequence. Can be of either bipolar or MOS technology process. A memory device with the qualities of allowing arbitrary reading or writing of a desired data location. The system accesses the addressed material without reading through intervening data. Information may be retrieved more speedily from RAM than from serial media, such as tape. Also called read-and-write and scratch-pad memory.

rapid thermal processing (RTP). Process that uses machines of low temperature for contact alloying and systems for the deposition of thin gate oxides. Similar to the diffusion furnace.

RBOC. See **regional bell operating company.**

reactant gas. Molecules that act upon one another to produce a new set of molecules.

read-only memory (ROM). 1: Computer memory that can be read from but not written to. Permanent memory on chips wherein information can be retrieved but not stored. Memory is not lost when the power to the computer system is turned off. 2: A memory device the contents of which can be read but not altered. (See also **mask ROM.**)

real estate. An environment or industry that includes owners, lessors, lessees, buyers, sellers, agents, and developers of real estate.

real-time clock. A clock that indicates actual time, such as elapsed time, as opposed to a fictitious time established by a program.

real-time data acquisition and control. 1: The process by which events in the real world are translated to machine-readable signals. 2: Automated systems in which sensors of one type or another are attached to machinery. 3: Data processing is performed so that the results are available in time to influence the controlled or monitored system.

reconnaissance. Equipment used to secure data/information about activity and resources concerning an enemy or potential enemy's territory.

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reduced-instruction-set computing microprocessor (RISC MPU). The number of instructions a microprocessor runs for a specific application are reduced from a general-purpose complex-instruction-set computing (CISC) microprocessor to create a more efficient computing engine.

reel-to-reel tape drive. A tape format in which the running tape is wound onto a separate take-up reel. Also known as open reel.

regional bell operating company (RBOC). Seven holding companies formed by the divestiture of AT&T to provide regulated and nonregulated telecommunications services in the United States.

relational database management system. A software application for the storage, retrieval, update, and analysis of multiple databases. These databases are linked (related) through one or more identical fields, called keys.

relay. 1: An electronic or electromechanical device for transferring a signal from one electrical circuit to another. 2: To forward a message through an intermediate station. (See also **passive device.**)

remote batch. A method of entering jobs into the computer from a remote terminal.

remote control. Any system of control performed from a distance. The control signal may be conveyed by intervening wires, sounds, light, or radio signals.

remote processing. A procedure in which the operating system can be used to process messages received from remote locations via telephone lines and telephone equipment. In effect, it is an extension of the data processing and programming facilities of the computer to remote locations.

remote sensing. The acquisition of information (usually in the form of an image) about an object or area by recording electromagnetic radiation emanating from or reflected from the target. The electromagnetic energy is received and processed by a detector system that is not in physical contact with the target under study. Common platforms for detector systems are aircraft and satellites, but the definition is not restricted to these two.

removable media disk drive. Removable media rigid disk drive has the platter enclosed in a housing that is designed to be user-accessible.

replacement demand. The subsequent demand by end users for new equipment.

research and development (R&D). Basic and applied research directed toward the discovery, invention, design, or development of new products and processes.

research supercomputer. An information system defined by a minimum of 32 low-performance computing nodes. Optimized to run highly parallel applications. Price ranges between $300,000 and $2 million.

residual value. The value of a product at the end of its useful life. Typically used with depreciation and leasing calculations.

resistor. A passive device that measurably opposes the passage of an electric current (e.g., doped silicon). (See also **passive device.**)

respiratory analysis. Equipment used to examine, detect, and analyze the respiratory system.

retail trade. An environment or industry that includes establishments engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of the goods. In general, retail establishments are classified by kind of business according to the principal lines of commodities sold.

retirement. The number of products that are removed from use. A product is considered retired from the installed base if it is scrapped, returned to the manufacturer, or placed in storage.

return. The number of units previously sold outright that have been returned or retired by the customer. (See also **retirement.**)

revenue. The amount of money that a company receives from its customers for goods and services.

rewritable optical disk drive. An optical disk drive that uses removable media that can be erased and reused many times (also called erasable optical disk drive).

ribbon. A strip of inked material or fabric, which when struck with a print element forms a character on paper. (See also **single-strike ribbon, web ribbon, film ribbon, multistrike ribbon.**)

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rigid disk. See **rigid disk computer storage media.**

rigid disk computer storage media. A rigid disk has a nonflexible substrate and can be made of aluminum, plastic, glass, or other rigid material.

RISC MPU. See **reduced-instruction-set computing microprocessor.**

robot. A reprogrammable multifunctional manipulator designed to move objects through variable motions for the performance of a variety of tasks. Intelligent robots commonly rely on vision systems to control their behavior through their ability to recognize objects.

robotic electronic assembly. Electronic manipulative machines that can perform functions ordinarily ascribed to humans in the assembly of material.

robotic nonelectric assembly. Same as robotic electronic assembly except that robots are mechanically maneuvered rather than through the methods and principles of electronics.

robot programming and simulation. The use of computer-controlled manipulators or arms to automate a variety of manufacturing processes such as welding, material handling, painting, and assembly.

robot system. Programmable manipulative machines that can perform functions ordinarily ascribed to humans. Included are robotic mechanisms, control hardware and software, and all associated peripheral equipment. These peripherals include end effectors and grippers that are used for the processing of parts, tools, and assemblies within the factory.

ROM. See **read-only memory.**

routing. An application that supports route planning. It is used to schedule the sequence of stops a transport vehicle makes.

RTP. See **rapid thermal processing.**

S

safety and convenience. Equipment related to the automobile and truck industry including devices that prevent loss, hurt, or injury, or that lend ease and comfort to passengers. Examples include: climate control, light reminder, keyless entry, heated windshield, sensing wipers, automatic door lock, automatic headlights, dimming, rear window defogger, antiskid braking, window control, and airbags/restraint control.

satellite. 1: A specialized radio transmitter/receiver placed in orbit around the earth to provide transmission channels for information to be transmitted over great distances. 2: A celestial body orbiting another of larger size.

satellite communication equipment. Equipment used for communication by use of an active or passive satellite to extend the range of a radio, or other transmitter, by returning signals to earth from an orbiting satellite.

satellite earth station equipment. The total earth-based equipment used in connection with orbiting, geostationary satellites. This category includes the Very Small Aperture Terminals (VSAT), as well as the antennae and electronic transmitting/receiving terminals.

scanner. Input devices used for the optical sensing of images and text and/or graphics for conversion to dot patterns for incorporation into a document. This category includes both ICR and OCR scanners with a resolution of less than 400 dpi.

scheduling. An application that supports the scheduling of events.

schematic. This is a detailed diagram. In a mechanical application, schematics are used to describe hydraulic and pneumatic systems. A set of symbols are available for both applications representing standard components.

scholarships and fellowships. College expenditures applying only to money given in the form of outright grants and trainee stipends to individuals enrolled in formal coursework, either for credit or not. Aid to students in the form of tuition or fee remissions is included. College work-study funds are excluded from this category and are reported under the program in which the student is working.

Schottky TTL (STTL). A form of transistor-transistor logic using Schottky diodes as transistor clamps to increase the speed of circuit operation. A high-speed form of bipolar logic.

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scientific application. A diverse group of software applications covering varied subject matter and research on the natural sciences when these are concerned with the physical world and its phenomena. Applications are divided into two subcategories: general analysis and scientific research. General analysis is the use of computers to solve various technical problems and to further research on subjects; this use is generally mathematical in nature. Scientific research applications are used specifically in the following fields: thermonuclear chemistry, nuclear physics, general physics, mechanical sciences, electronics research, geophysics, fluid dynamics, thermodynamics, materials research, and genetic engineering.

scientific research. A software application that pertains to research and development, not to applied science.

scientific visualization. An image computer is used for scientific modeling, technical data analysis, medical imaging, or similar large-volume data analysis.

security. 1: The existence and enforcement of techniques that restrict access to data and the conditions under which data can be obtained. 2: A measure taken by a command to protect a system from espionage, observation, sabotage, annoyance, or surprise. 3: Protection of a system by use of commands and codes.

security/energy management. Safety and power management within industrial equipment and manufacturing.

seismic analysis. 1: Seismic analysis helps support exploration activities by indicating favorable conditions for finding oil or coal reservoirs. 2: Analysis relating to an earth vibration caused by earthquakes, or other natural phenomena.

semiconductor. 1: A group of materials that are electrical nonconductors in a pure state that can be altered by the selective introduction of impurities into its crystalline structure. Its resistivity can sometimes be changed by light, an electric field, or a magnetic field. 2: An electronic device made using semiconductor material.

semiconductor tester. Equipment designed to test, check, and monitor the functionality of electronic circuit packages of varying complexity and functionality.

serial, impact, dot matrix (SIDM). A printer that creates a character image by selectively placing individual dots on the substrate using mechanical force.

serial, impact, fully formed (SIFF). A printer that prints one character at a time using type elements to create fully formed character impressions.

serial input/output (SIO). 1: A device that permits data to be transmitted into and out of a computer over a single conductor one bit at a time. 2: Pertaining to time sequential transmission of, storage of, or logical operations on parts of data words. 3: A technique for handling binary data words (which have more than one bit). 4: A device or technique where data are transferred to or from an I/O port in a serial or in-line manner.

serial, nonimpact, direct thermal (SNDT). A printer that creates the desired image a dot at a time using point-specific heat and a heat-sensitive substrate that changes color when exposed to heat.

serial, nonimpact, ink jet (SNIJ). A printer that creates the desired image a character at a time by emitting ink from an array of orifices or nozzles.

serial nonimpact, thermal transfer (SNTT). A printer that creates the desired image a dot at a time using point-specific heat to transfer ink from a ribbon to a receiving substrate.

server. A processor that provides a specific service to a network, such as connecting nodes of different networks.

services. Intangible items of trade, such as education, transportation, banking, and legal and medical care.

SFDSP. See special-function DSP products.

sheet feeder. A sheet feeder is mounted on top of a printer and automatically inserts cut sheets into the printer and receives the ejected paper in a hopper. Sheet feeders may be single or dual tray

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for the feeding of letterhead and second sheets, or they may incorporate an envelope-feed tray for the printing of letters and envelopes simultaneously.

shipment. The number of products delivered.

shop floor and cell control. A system for utilizing data from the shop floor as well as data-processing files to maintain and communicate status information on shop orders and work centers. Provides actual output data for capacity control purposes.

shop floor planning and control. See **shop floor and cell control.**

SIDM. See **serial, impact, dot matrix.**

SIFF. See **serial, impact, fully formed.**

silicon epitaxy deposition. A process through which vaporized silicon is deposited on a wafer. (See also **deposition.**)

silicon precursor gas. A specialty gas used in semiconductor manufacturing. Gases such as silane, dichlorosilane, trichlorosilane, and silicon tetrachloride are used in epitaxial and chemical vapor deposition (CVD) processes to deposit layers of silicon or silicon components onto silicon substrates.

silicon wafer. A nonmetallic element that is the most widely used semiconductor material today. Silicon is used in its crystalline form as the substrate of semiconductor devices.

simulation. An application or system that uses representative or artificial data to reproduce various conditions in a model that are likely to occur in the actual performance of a system. Simulation frequently is used to test the behavior of a system under different operating policies.

simulation and training equipment. Equipment used to augment the acting out of real-life maneuvers/exercises as training in preparation for real-life situations. Equipment includes aircraft, flight and situation simulators, equipment operation, and maintenance systems.

single-strike ribbon. A film ribbon. Each time a character strikes the ribbon, the ribbon advances far enough so that the next character has a completely new ribbon area to strike. The ink formulation is such that the ink on the ribbon is depleted from the area where the print element strikes the ribbon. These ribbons produce the highest print quality, but ribbon life is low compared with that of fabric and multistrike ribbons.

single-user enhanced system. See **workstation computer.**

SIO. See **serial input/output.**

slow SRAM. A random-access memory (RAM) integrated circuit (IC) that runs at speeds greater than 70 nanoseconds. (See also **static random-access memory.**)

small-format pen plotter. A computer plotter that uses engineering-size A (8.5 x 11 inches) or B (11 x 17 inches), architectural-size 1 (9 x 12 inches) or 2 (12 x 18 inches), or metric-size A4 (21 x 29.7 centimeters) or A3 (29.7 x 42 centimeters) media. (See also **plotter.**)

small-signal diode. A diode with a forward current of less than 100 milliamperes (0.1 amperes). The sides of the silicon chip are metallized and encapsulated in a tubular glass package.

small-signal transistor. A transistor that dissipates power of less than 1 watt.

smart card. A credit card or credit-card-size device that contains one or more integrated circuits. These devices usually are carried by an individual. Common applications include financial transactions, record keeping, and user identification.

smart interactive terminal. See **intelligent terminal.**

smart power. An integrated circuit (IC) that contains both control logic circuits and power control elements.

smoke alarm. A detector that is activated automatically when exposed to smoke.

SNA. See **system network architecture.**

SNDT. See **serial, nonimpact, direct thermal.**

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SNIJ. See **serial, nonimpact, ink jet.**

SNTT. See **serial, nonimpact, thermal transfer.**

socket. An opening that supports and electrically connects to vacuum tubes, bulbs, or other devices or components when they are inserted into it.

software. 1: Any set of explicit procedures constituting a computer program. 2: Programs, procedures, rules, and any associated documentation pertaining to computer operations.

software support service. Activities that assist the end user in use and implementation of software products. Software support includes bug fixing, updates, and documentation, as well as support of ongoing operating problems including product-specific consulting, programming services, and training.

solar cell. A pn junction device that converts the radiant energy of sunlight directly and efficiently into electrical energy.

solid modeling. An application that represents the external and internal part geometries, allowing the solid nature of an object to be represented in a computer. Solid models are constructed in two ways: using primitive building blocks (constructive solid geometry) and/or using boundary definitions (boundary representation).

solid state. Pertaining to circuits and components using semiconductors. (See also **semiconductor.**)

solid-state subsystem. Computer memory products that comprise a block of semiconductor memory, a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

sonar. A device used to detect submerged objects by sonar waves reflected off the object. Also can be used to measure depth or distance. Includes search, detection, tracking, guidance, navigation, communication, sonabuoys, and associated test systems.

SONET. See **synchronous optical network.**

space military equipment. Military equipment used beyond the earth's atmosphere. Includes satellites with accompanying communication and reconnaissance equipment, various other space platforms, launch vehicles, and ground control.

special automotive IC. An analog IC designed for a specific automotive application.

special consumer IC. An analog IC designed for use solely in consumer home entertainment and appliance products.

special-function analog IC. An analog integrated circuit function used in specialized applications. Examples are sensors, timers, and oscillators. These devices differ from application-specific standard products (ASSPs) in being functional blocks rather than complex configurations of functions for specific applications.

special-function DSP products (SFDSP). Products built using DSP techniques and architectures but designed for specific functions. Examples include: modems, codecs, speech processors, digital television circuits, digital filters, and fast Fourier transform (FFT) chips. Generally, these devices cannot be programmed by users to perform operations other than their defined function.

special-function IC. A linear IC that does not fall into the standard product categories. This product has a specific function such as timer, oscillator, signal generator, or sensor but is not limited to a single application or market.

special-purpose computer system. A computer system designed for a specific purpose. For example: a banking computer system, word processor, or cash register.

specialty gas. A gas used in manufacturing semiconductors that is supplied in gas cylinders rather than in bulk because smaller volumes are used.

splice. A joint used to connect two lengths of conductor with good mechanical strength and good conductivity. (See also **passive device.**)

spot-welding robot system. A robot carries a resistance welding gun to produce welds.

spreadsheet. An application with the principal function of organizing data into columns and rows to allow the user to perform numerical analysis.

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SRAM. See **static random-access memory.**

standard cell. An integrated circuit designed to a customer's specifications using precharacterized cells as building blocks.

standard logic. Off-the-shelf integrated circuits belonging to "families." Bipolar digital families include AS, FAST, LS, and ALS. MOS digital families include HC, HCT, and FACT. Standard logic is available from a number of suppliers and may be used in many different applications. Sometimes referred to as glue logic. Normally has less than 150 logic gates.

start-stop tape drive. A tape drive that starts and stops on reading or writing a data record.

state government. One of the constituent units of a nation having a federal government.

static random-access memory (SRAM). A RAM that maintains memory as long as power is applied and does not require refreshing. SRAM densities can range from 1K, with approximately 1,000 bits, to 4Mb, with approximately 4 million bits.

statistical multiplexer. An electronic device that consolidates several data streams onto a single high-speed bit stream for transmission over a telephone line.

stepper. A semiconductor manufacturing device that uses a step-and-repeat process to transform the pattern image of a reticle or mask onto the surface of the semiconductor wafer.

stereo headphone. A device worn on the head that permits the transmission of sound through two earphones connected by a band.

stereo (hi-fi) component. Equipment that produces high-fidelity reproduction of sound.

storage controller board. 1: A board containing input data or parameters for an application of a general routine. 2: Those parts mounted on a board that carry out the instructions in proper sequence, interpret each instruction, and apply the proper signal.

storage management. Functions that manage the storage of information in which information can later be retrieved. Includes storage protection, storage temperature, storage print, and storage allocation.

storage subsystem. Computer memory product that comprises a storage device(s), a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

streamer tape drive. A tape drive that uses a continuously moving tape; one that does not start and stop on each data record.

streaming tape drive. Tape drives (1/4-inch and 1/2-inch width) where the data stream over the head without stopping (continuous flow).

structural. The dynamics of the physical system; usually refers to the static stability/integrity of a part, assembly, or system.

structural modeling/analysis. A software application for modeling and analysis of the integrity of a structure.

STTL. See **Schottky TTL.**

studio transmitter link. Equipment used to generate and amplify a radio signal.

styling. A detailed design process where aesthetic considerations are foremost. Systems supporting this application have special refinements for rendering, modeling, and editing functions.

subsidiary. A company partially or wholly owned by another company.

supercomputer. A high-performance computer designed for numerically intensive applications. The current price ranges from approximately $100,000 to $20 million.

superminicomputer. An information system with price ranging typically from $100,000 to $1 million, with a minority below $100,000. CPU bit width ranges from 32 to 48 bits, with emphasis on 32. Environment is almost exclusively an ordinary office with no special environmental controls. Equipment typically is supported full-time by a professional computer systems support staff of fewer than 10 members. It usually is built around proprietary processor and typically supports from 32 to 350 concurrent users. Examples of models are the HP 3000/930 and 950, DEC VAX 8700 and Micro VAX 3500, and IBM 9370.

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superworkstation. A superworkstation has higher graphics performance than a traditional workstation. It also has a higher processing performance rating to support graphic computations. The average price is $40,000 to $80,000 with performance ratings of 8 to 20 mips and 2 to 16 mflops.

surgical support. Equipment relating to, or having connection with, surgery.

surveying and drafting instrument. An instrument used to detect, access, and measure radiation. The instrument is used in the drawing of objects, structures, or systems by engineers and scientists.

switch. 1: A mechanical or electrical device that competes with or breaks the pattern of a current or sends it over a different path. 2: A device that connects, disconnects, or transfers one or more circuits and is not designated as a controller, relay, or control valve. (See also **passive device.**)

switch/multiplexer IC. Analog switches gate analog signals under the control of logic. Multiplexers are specialized analog switches that select only one of many inputs.

synchronous optical network (SONET). An emerging standard for optical networks.

system management. The administration and operation of a computer system including staffing, scheduling, equipment, and service contract administration, equipment utilization practices, and time-sharing.

system network architecture (SNA). An IBM standard for data communication.

systems integration service. The implementation phase of tying together dissimilar devices. Services are coordinated by a single contractor who manages the procurement, installation, integration, and support of all software, hardware, and communications devices.

systems integrator. See **value-added reseller.**

system software. Software that provides support structure in which applications may operate. This includes operating systems, operating environments, and utilities.

systems planning and design. "Front-end" consulting services that are required to determine the nature of a customer's needs and the actions necessary to meet those requirements.

system subroutine library. An organized collection of computer programs that is maintained online with a computer system by being held on a secondary storage device and is managed by the operating system.

system support peripheral. An integrated circuit (IC) considered a traditional peripheral, where each processor has a set of six to eight dedicated peripherals that provide rudimentary functions necessary to construct a microprocessor (MPU)-based system. (See also **traditional peripheral.**)

system utilities. Products that aid in the maintenance and/or repair of computer hardware, operating systems, or data recovery.

T

2-D modeling. The representation of a part in two dimensions (has an x and y coordinate). This format requires three or more views (top, front, side) to depict all aspects of the part. This is the most common geometric modeling format and is used extensively with a drafting function.

3-D modeling. The representation of a part in three dimensions, usually in a wire-frame format (has an x, y, and z coordinate). This format is used commonly in high-level CAD systems to determine the placement and fit of components in an assembly. This format is not generally used for final drafting, although some systems have the capability to translate the 3-D image to a 2-D standard drafting format.

T-1. A high-speed, time-division, digital network link operating at 1.544 Mbps and above.

T-1 multiplexer. A unit that allows multiplexing, or combining, several voice and/or data channels onto one communications link, in this case, a high-speed T-1 channel.

tape drive. A class of computer backup device that uses reel-to-reel, cartridge, or cassette tapes as media.

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tape recorder. A device that records and plays sound from magnetic tape.

tax accounting. An application concerned with keeping records for tax purposes, setting up accounts for paying taxes, making tax computations, and preparing tax returns.

TDM. See **time-division multiplexer.**

teaching machine and aid. Equipment designed to assist in the training, educating, and instructing of persons to acquire knowledge or skill in a particular field(s) of interest.

technical data analysis. An application that analyzes technical or experimental data. The data may have been generated from instruments, captured from other electronic measuring devices (such as thermocouples or strain gauges), or generated by other analysis programs.

technical illustration. A drawing of a component or assembly that generally is intended for publication. This drawing will omit unnecessary dimensions and other detailed drating items and will be drawn so as to depict the part realistically.

technical productivity. An application that enhances the productivity of technical disciplines and is specialized for the engineering, scientific, or manufacturing fields.

technical publishing. The printing of user manuals or guides.

telecommunication integrated circuit (IC). An analog IC designed for the voice and data communication market.

telecommunications. Products and services that provide or manage the flow of information from person to person, person to machine, machine to person, or machine to machine. The telecommunications market is segmented into a combination of the premises and public telecommunications market segments.

telecom services. Includes that portion of telecommunications charges related to access and use of the public network. These charges typically are seen as a monthly usage charge for local, long distance, and private line access/utilization.

teleconferencing. Equipment and services related to one-way and two-way video communications that use specialized video equipment and/or transmission networks. These communications enable conferencing between locations.

telemarketing. A sales method that employs a sales force to move a product through the distribution channel by contacting the consumer via the telephone. Also referred to as inside sales.

telemetering system. See **telemetry.**

telemetry. Transmission of data from remote measuring instruments by electrical or, usually, radio means.

telephone. A terminal or handset used for voice and data transmission and communications. It functions as an interface between a user and a telephone switching system.

TELeprinter EXchange (TELEX). A worldwide dial-up telegraph service enabling users to communicate directly and temporarily among themselves by means of start-stop apparatus and circuits of the public telegraph network.

teletex. An interactive communications network designed for transmission of text and graphics to televisions or other low-cost terminals.

TELEX. See **TELeprinter EXchange.**

tension arm tape drive. A 1/2-inch reel-to-reel tape drive that uses mechanical tension arms to provide tape tension and buffing.

terminal equipment. 1: A device at a node of a network through which information can be entered, extracted, or monitored. 2: Any device capable of sending and/or receiving information over a communications channel. Includes a keyboard and display that cannot stand alone because it lacks processing capability. Terminals are usually simple ASCII text-entry devices.

terms and conditions. The provisions of a contract that are stated or offered for acceptance that determine the nature and scope of the agreement.

test and measurement. The process of determining the magnitude of the response of an object to a given stimulus. Also the degree to which an object may be characterized along a dimension

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(quantification of an entity). Computer-based inspection and test systems used for quality and/or process control data analysis; data may be collected by manual input or sensory devices.

test equipment. Equipment designed to test, check, monitor, and identify varying degrees of device functionality and complexity that may include quality, speed, and performance. Automated test systems and equipment such as IC testers and PC-board testers, as well as general test equipment (such as oscilloscopes, spectrum analyzers, and digital multimeters).

text capture. Process whereby words or groups of words are controlled.

therapeutic. Medical applications involved in treating specific medical conditions.

thermal. The effects of temperature on the system.

thermal plotter. 1: A process that produces a visible image by heat-induced chemical reactions or chemically reactive media. 2: A thermally induced phase change process of a pigment-binder mixture, which is transferred from a donor sheet to the media.

thermal transfer printer. An imaging process using heated printing elements to produce prints or copies; can be either dye diffusion (coated paper) or wax based (plain paper). This process currently is used in electronic printing, facsimile machines, and full-color copiers.

thimble. A thimble-shaped print element that floats freely across the platen of a character printer, working in a similar fashion to a daisy-print element. It is shaped like a cup, with the spokes extending around the rim of the cup, with characters positioned at the end of the spokes.

thyristor. A type of diode that consists of a four-layer slice of silicon. The device is characterized by continuous switching. Once a thyristor has been triggered into conducting current, it will continue to conduct current until the main current falls to zero.

ticketing. A software application that supports the sale and management of tickets. The application may be as simple as ticketing a single event or as complex as ticketing airline reservations.

tie ratio. A ratio that describes the relationship between two or more product units, usually used when one product is part of or connected to another product. For example, a disk drive tie ratio to PCs of 0.8 indicates that 80 percent of the PCs contain a disk drive.

time and materials service. Remedial repair services on a per-call basis. Pricing is based on the actual length of time-to-repair, travel charges, and specific parts or materials required to complete repairs.

time-division multiplexer (TDM). One of several technologies used to multiplex, or combine, several voice and/or data channels onto one communications link. TDM uses "time slicing" to allocate blocks of time to each channel. See also **statistical multiplexer.**

TLX. See **TELeprinter EXchange.**

toner. The substance used that develops a latent xerographic image from a photoreceptor onto a substrate, usually paper. Monocomponent toner contains both the imaging material and the carrier (usually called developer) needed to transport the toner to the latent image. In dual-component toner, the imaging material and developer are held separately until they are mixed by the copier or printer itself. Liquid toner has the imaging material suspended in a solvent.

tool design. The design of custom-made tooling to facilitate an effective manufacturing process.

tools. A software program that is used by application developers or users to create applications. Examples are spreadsheets, word processors, editors, macro languages, screen painters, and report generators. Tools are higher-level products than languages; a tool is written in a language. Unlike languages, most tools are nonprocedural, i.e., they do not require users to create code that is sequentially executed. A good example of this is a spreadsheet, where the developer/user navigates up, down, and sideways with the arrow keys or mouse and can add or delete rows and columns at any time. Examples of tools include Lotus 1-2-3 (spreadsheet); Multimate (word processor); EDLIN (line editor); and Ojectworks (graphical editing and object manipulation environment).

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trading turret/dealer board. A specialized type of telephone system that allows simultaneous access to multiple telephone lines. This system is used in any business that requires frequent conversations between two or more parties (i.e., stock brokers).

traditional peripheral. An integrated circuit that has an intermediary control device, which links a peripheral unit to the control processors.

traditional workstation. A midrange workstation priced between $15,000 to $50,000. Its performance ratings are 4 to 15 mips and 0.5 to 2 mflops.

traffic control. A real-time software application, mechanism, and system used to monitor and control, exert control over, and/or enforce the movement of vehicles.

transducer. Any device or element that converts an input signal into an output signal of a different form. (See also **passive device.**)

transistor. A transistor is as a current-amplifying device or switch, as follows: 1: Current amplifying—a small change in a small current flows between the collector and the emitter. 2: Switch—a sufficiently large voltage applied to the base causes the maximum amount of collective current to flow. It can be manufactured in bipolar or MOS technology process. A bipolar transistor consists of a sandwich of doped silicon layers. The transistor has three electrical connections: base, emitter, and collector. Each of these areas provides access to one of the doped regions.

transistor-transistor logic (TTL). A logic circuit design with the diode inputs replaced by a multiple-emitter transistor.

translator. The process performed by an assembler, compiler, or other routine that accepts statements in one language and converts them to another language. 2: A device that transforms signals from one form to another form. 3: A system that has a number of inputs and outputs and is connected so that input signals representing information expressed in a certain code result in output signals that represent the input information in a different code.

transmitter. 1: A device for transmitting a coded signal. 2: The carbon device in the telephone handset used to convert speech to electrical energy.

transparency. 1: The property of being insensitive to the meaning of a code being manipulated. An example is a paper-tape transmitter capable of transmitting any code submitted to it. If a device interprets and reacts to coded information that it is handling, it is said to be code sensitive (not transparent). 2: Clear substrates upon which images can be written, copied, or printed for projection onto a screen by an overhead projector.

transportable personal computer. The transportable personal computer is a self-contained system that can be moved from place to place as a single unit. These systems include, in a single unit, the keyboard, display, mass storage, and main system unit. Such a personal computer operates on A/C power only (no battery power).

transportation. An environment or industry that includes establishments providing, to the general public or the other business enterprises, passenger and freight transportation.

transportation electronic equipment. Electronic equipment used in the automotive railway and airline industry.

transportation management. The planning, analysis, and control of activities for transporting or being transported.

TTL. See **transistor-transistor logic.**

two-year college. A postsecondary school that offers general or liberal arts education usually leading to an associate degree or courses that are creditable toward a baccalaureate degree.

two-year institution. An institution legally authorized to offer and offering at least a two-year program of college-level studies that terminates in an associate degree or is principally creditable toward a baccalaureate degree.

typewriter. A machine for writing in characters by means of a keyboard operated by striking through an inked ribbon. Usually refers to the standard office typewriter (mechanical, electrical, or electronic).

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U

UART/USART. See **universal asynchronous receiver/transmitter/universal synchronous asynchronous receiver/transmitter.**

ultrasonic cleaners, drills. 1: An instrument used to clean debris and swarf from surfaces by immersion in a solvent in which ultrasonic vibrations are excited. 2: A drill in which ultrasonic vibrations are generated by the compression and extension of a core electrostrictive or magnetostrictive material.

ultrasonic generator. A generator consisting of an oscillator driving an electracoustic transducer used to produce acoustic waves.

ultrasonic scanner, medical. A device that produces a picture display of ultrasonic frequency waves sent through the sample to be inspected or examined.

ultraviolet electrically programmable ROM. An EPROM that is erasable with an ultraviolet light source.

unit. A single quantity.

universal asynchronous receiver/transmitter/universal synchronous asynchronous receiver/transmitter (UART/USART). An electronic circuit that converts data between the parallel format and the serial format transmitted sequentially over a communication line.

UNIX. An operating system designed to be used with microprocessors and with the C programming language.

useful life. The economic life of a product. Typically used to determine depreciation and leasing schedules.

user interface. 1: The point at which a user interacts with a computer. 2: An interactive computer program that sends messages to and receives instructions from a terminal user.

users per system. The typical number of simultaneous users that a computer system will support.

utilities. An environment or industry that includes establishments providing electricity, gas, steam, water, or sanitary services to the general public or to other business enterprises.

UV EPROM. See **ultraviolet electrically programmable ROM.**

V

vacuum column tape drive. A 1/2-inch reel-to-reel tape drive with start-stop capability that uses vacuum columns to provide tape tension and buffing.

value-added network (VAN). A data communication network that provides enhanced services such as protocol conversion.

value-added reseller (VAR) systems integrator. A product reseller that integrates hardware, software, and/or services; it does not apply its label to the product. Systems integrators are a type of VAR and may or may not own the hardware or software.

VAN. See **value-added network.**

VAR. See **value-added reseller systems integrator.**

VAX/VMS. A Digital Equipment Corporation standard multiuser operating system.

VCR. See **videocassette recorder and player.**

vertical-turning programmable machine tool. The tool of a machine that holds a workpiece along the vertical axis for a certain function to be performed such as boring, drilling, and cutting.

vibrational. The effects of vibration and shock on the system.

video. 1: Relates to the bandwidth (megahertz) and spectrum position of the signal arising from television scanning. 2: The reception or recording of electronic signals that create images on a screen or display.

video camera. A camera that records visual images and sounds on magnetic tape.

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videocassette recorder and player (VCRs or VTRs). A complete system that has a tape format such as beta, VHS, or 8mm.

videodisc player. A complete video system that has a disc format.

video equipment. Equipment includes amplifiers, television cameras, and other equipment such as synchronization equipment, live cameras, and control consoles.

video home system (VHS) helical scan tape drive. A 13mm helical scan tape drive commonly used for recording television broadcasts.

videotex. An information delivery system that uses information from a database that allows the user to interact with the service, selecting information to be displayed on the user's CRT providing financial services, electronic mail, and teleshopping.

virtual private network (VPN). Similar in function to a leased circuit with the exception that the circuit is not dedicated to one customer.

VLSI. Very large scale integration.

VMS. See **voice-messaging system.**

voice-messaging system (VMS). A computer-based system that enables flexible, nonsimultaneous voice communications. This definition does not include personal-computer-board-level products.

voice-recognition computer device. The capability of a computer to recognize spoken commands. Each user must first "train" the computer by speaking a series of words that the computer can analyze and match with stored information.

voice response unit (VRU). A computer-connected device that selectively links sentences of stored words, creating a spoken word.

voice synthesizer. A device that simulates speech by assembling a language's elements under digital control.

voice terminal. See **telephone.**

voltage regulator and reference IC. 1: A device that provides power to other circuits at a specified DC voltage. 2: A device that provides a specified constant DC voltage to a load over a wide range of variations in input voltage and output current.

VPN. See **virtual private network.**

VRU. See **voice response unit.**

VTR. See **videocassette recorder and player.**

W

wafer. A thin (10 to 20 mils) disk of semiconductor material from which semiconductors are fabricated.

wafer fab. The integrated circuit production process—from raw wafers through a series of diffusion, etching, photolithographic, and other steps to finished wafers.

wafer fabrication equipment. Machinery used to produce wafers in the semiconductor industry. (See also **e-beam, etch-and-clean equipment, stepper.**)

wafer inspection. Inspection of patterned wafers for process defects by visual and image-processing techniques.

water quality and sewage control. A real-time software application that monitors and controls water quality and sewage.

WATS. See **wide area telephone service.**

web ribbon. Web or towel ribbons are wide ribbons used on line, dot matrix, and line, fully formed printers. They are as wide as the print line is long—usually approximately 15 inches.

wet chemical. A chemical used in semiconductor wafer fabrication. Examples are acids and solvents.

wet etch. Immersing method for wafers in an etching solution. Chemical removal of a material by bathing the wafer in acid.

white-collar worker. A person working in an occupation classified by the Bureau of Labor Statistics under the following category headings: managerial and professional specialty and technical, sales, and administrative support.

wholesale trade. An environment or industry that includes establishments or places of business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, construction contractors, or professional business users; or to other wholesalers; or acting as agents or brokers in buying merchandise for or selling merchandise to such persons or companies.

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wide area telephone service. An enhanced telephone company service allowing reduced costs of certain telephone call arrangements. This service can be in-wats or 800-number service (calls can be placed to a location from anywhere at no cost to the calling party) or out-wats (calls can be placed out from a central location).

word processing. A software application with the principal function of editing, entering, and formatting text.

word processor (WP). A standalone word processor capable of functioning independently from a central controller or storage device, although they may communicate with each other. These products generally have removable magnetic media. Products that have evolved from electronic typewriters generally are not included in this category. The ability to share a printer among workstations does not disqualify a product from being a standalone word processor; shared-system word processors are connected to an external file server or controller; word-processor file servers are centralized data storage devices that are accessible and dedicated to shared word processing units.

work force. All persons of either sex who furnish the supply of labor for the production of economic goods and services during a specified time period.

workstation computer. A single-user computer that is distinguished from a personal computer by its features and by the user's potential migration path within the platform. A technical workstation is a system designed with integrated networking; high-performance graphics; floating point; coprocessor; and a virtual, multiuser/multitasking operating system (DOMAIN, UNIX, VMS).

WORM. See **write-once/read-many.**

WP. See **word processor.**

write-once/read-many (WORM). 1: The WORM optical disk market includes drives that can read and write data using various optical diskette media. 2: A data storage device using laser technology that uses a removable disk ranging in size from 3.5 to 14 inches.

X

X-ray (lithography). A machine that uses an X ray for generating a mask plate of direct image transfer to a semiconductor wafer.

X-ray, medical. Equipment used to detect, examine, treat, or analyze body systems through photographic X-rays.

X.25. A CCITT standard that defines the interface between a public data network and a pocket-mode user device; also defines the services that these user devices can expect from the X.25 public data network.

Y

year-average population. The installed base of a product computed at the midyear between the beginning installed base and the ending installed base of the same year.

Z

zener diode. 1: A diode that has a controlled, reverse-voltage/current relationship. 2: A two-layer device that has a sudden rise in current above a certain reverse voltage.

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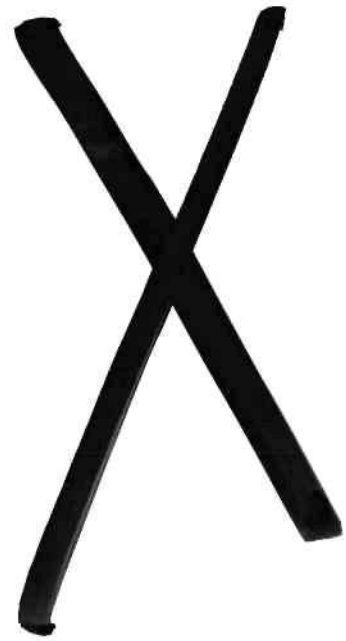

Dataquest

Dataquest Inquiry Summary

Semiconductors *Worldwide*

December 21, 1992

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This month's questions

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1. Intel makes two claims for its recently introduced i486SL: that it provides twice the performance of its predecessor, the i386SL, while using one-half the power and 60 percent of the board space that the i386SL does. How is this possible? 2
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10. I heard that the Electronics Industry Association of Japan (EIAJ) recently opened an office in the San Francisco Bay Area. What is the purpose of this opening and how can EIAJ be reached? 9
11. Have you heard of the company Semitherm Inc.? I'd like some basic information. 11
12. Our corporate management has started a new program to benchmark the performance of company functions including IC purchasing. We are a vertically integrated electronics manufacturer with facilities in most world regions including Europe, North America, and Asia. Can you give me some background? 12
13. What can you tell me about the company named Euphonics? 12

For more information on the semiconductors worldwide industry, please call Rick Spence at (408) 437-8642

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14. What is the 1993 semiconductor capital spending outlook in Japan? 13
15. It is my understanding that the antidumping law, under which Micron Technology has filed against the Korean DRAM makers, requires an 8 percent pretax profit margin by the seller to avoid being guilty of sales below fair market value, as defined by the law. However, very often semiconductor makers seem to be unable to make profits that high, especially in tough times. How often has Micron been able to achieve such a pretax profit rate? 14
16. Please provide an assessment of semiconductor distribution in Taiwan, South Korea, and Singapore. 15

Products

Q1 Intel makes two claims for its recently introduced i486SL: that it provides twice the performance of its predecessor, the i386SL, while using one-half the power and 60 percent of the board space that the i386SL does. How is this possible?

A The comparisons Intel is making refer to fully configured systems. For example, for purposes of this comparison, Intel assumes the use of the i387SL coprocessor as well as 8KB of external primary cache in the i387SL calculation. The i486SL integrates all of these functions on-chip.

Additionally, the i486SL uses a 3.3V power supply. The combination of the four-chip i386SL solution into one i486SL chip provides the 60 percent power savings. The integration also contributes to the power savings; however, the prime contributor is the reduction in the processor's power supply from 5V to 3V. Based on this power savings, Intel believes that the full-on power consumption of a typical PC motherboard will be reduced from 4W to 2W. This 50 percent power savings on the motherboard translates into a 25 percent savings for the whole system.

Jerry Banks

Q2 Why are analog ICs found in digital mass storage devices such as rigid disk drives?

A Analog and mixed-signal ICs, with 1991 revenue of U.S.$488 million, represent close to 30 percent of the IC value in the disk drive market. Analog ICs are used for the fundamental reason that signals, not numbers, are stored on the magnetic medium of the disk. The disk drive mechanism has a read-write amplifier in close proximity to the read-write head. Further analog signal processing is provided by analog signal processing that precedes the digital data extraction.

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A further use of analog or mixed-signal ICs is to control the two motor assemblies, the head positioning motor and the spindle driver motor. Digital ICs provide the controller logic and the digital data processing beyond the basic rigid disk mechanism. As drives get smaller, the limited space available has pressed integration substantially. The result is a few mixed analog/digital ICs to provide the complete read-write and motor control electronics.

Gary Grandbois

Q3 What prices do you expect to see for 64-bit microprocessors through 1996?

A Table 1 shows Dataquest's price range estimates for the emerging market of 64-bit MPUs. These data are based on current average prices and historical high-end 32-bit microprocessor price curves.

Table 1
64-Bit MPU Price Range Forecast: 1992 to 1996 (U.S.$)

	1992	1993	1994	1995	1996
Price Range	700-1,300	500-800	350-600	300-500	250-450
Average Selling Price	900	600	450	400	375

Source: Dataquest (December 1992)

Mark Giudici

Q4 What's the biggest static RAM (SRAM) cache that can practically be put on a hard disk drive?

A Probably the single most important use of slow SRAMs in North America is in caches for hard disk drives. These caches serve the following two purposes:

- To reduce the average access time of a hard disk (for example, from 17ms to 11ms)
- To cut power consumption

The first purpose is equally important in both battery-operated and desktop computers; the second is mostly for battery-operated devices.

The theory behind hard disk caches is driven by the assumption that software reads data from a disk in sequence. If a given sector is accessed, it is likely that the next sector is the next thing that will require access from the disk. When a disk sector is accessed by a program, the disk controller will automatically read one or more succeeding sectors into the cache in anticipation of these sectors'

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future use. If the next access can be serviced by the cache, the cycle is called a "hit"; but if the cache does not contain the appropriate word, the cycle is a "miss," and the hard disk will need to be accessed directly (with correspondingly different succeeding sectors read into the cache). A standard 20MB hard disk will often feature a 32KB cache. This size of cache typically affords a 30 percent hit rate—that is, the cache can be accessed instead of the disk for approximately one-third of all would-be disk accesses. This hit rate can be used either simply to speed up the apparent access time of the drive or to allow the disk motor to be powered down until a cache miss occurs.

It follows that the largest possible cache is a RAM equally as big as the disk drive. Similarly, if the entire disk is read into this RAM during the first cache miss cycle, all succeeding cycles will be hits; and the disk will never again need to be read into the cache. In this event, the cache hit rate will be 100 percent.

Dataquest asked hard disk drive designers about this, and they reported that they would use the largest possible device that meets the following three important criteria:

- The entire cache must be as small as possible (a single chip).
- Power dissipation must be as low as possible (again, a single chip).
- Cost must be as low as possible.

The last criterion is the one that seems to motivate disk drive manufacturers' current widespread use of 256K bit devices. Dataquest believes that, as the price of SRAMs of higher densities continues to decay, ever-larger devices will find their way into this important application. With hard disk drives' densities continuing to escalate, there appears to be no end to the size of cache that will be used in tomorrow's systems.

Jim Handy

Markets and Applications

Q5 What are the worldwide growth opportunities for video compression ICs and video codes?

A The main growth opportunities for video compression ICs are video telephony and multimedia—which includes videophones, PC videophones, and videoconferencing. This can be split into equipment supporting full-motion video (FMV) and still-frame display. Table 2 presents the Dataquest forecast for this area.

David Moorhouse

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Table 2
Worldwide Video Compression IC and Video Code Market Forecast in Units and Revenue (Thousands of Units)

	1991	1992	1993	1994	1995	1996
Videoconferencing						
Telephone	6	85	138	218	366	628
Telephone (U.S.$M)	13.6	36.9	50.7	68.4	89.3	115.2
FMV Semiconductors	3	139	933	3,873	8,817	14,045

Source: Dataquest (December 1992)

Q6 What are the major worldwide electronic data processing (EDP) applications that use microcontrollers?

A Table 3 shows the key EDP applications that use microcontrollers and our forecast for 1996. (The word length of the controller and what this is forecast to be in five years is also included in this table.)

Table 3
Worldwide Unit Forecast for Key EDP Applications (Millions of Units)

	Production		Word Length (Bits)	
	1991	1996	Current	Future
Keyboards	32.0	54.0	8	8
Disk Drives	32.0	70.0	8	16
Printers	16.0	19.0	8	8
Terminals	5.6	6.1	8	8
Tape	2.3	3.6	8	16
Copiers	2.5	3.0	8/16	16

Source: Dataquest (December 1992)

Mike Glennon

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Q7

What percent of the 1992 North American gate array design starts are being captured below 1 micron?

A According to Dataquest's latest ASIC supplier survey, 32 percent of the designs are being captured below 1 micron. The following shows the percent of designs being captured by each drawn line width in North America:

Less than 2 micron—1 percent of design starts

1.6 to 2 micron—2.5 percent of design starts

1.1 to 1.5 micron—20.2 percent of design starts

0.9 to 1 micron—44.3 percent of design starts

0.7 to 0.8 micron—28.1 percent of design starts

Less than 0.7 micron—3.9 percent of design starts

Bryan Lewis

Technology

Q8

How are microprocessors acting as process technology drivers?

A Microprocessors may not be driving new processes in terms of minimum feature size as DRAMs do, but they are serving as a vehicle for the development of multilevel metallization process flows. Table 4 shows the process technology and selected parameters for several current and future microprocessors.

The different processors shown in Table 4 can be characterized as being highly integrated: they tend to incorporate the CPU, FPU, data and instruction cache memory, cache control logic, memory management unit (MMU), bus control logic, and other functions integrated on the chip. Many new microprocessors are also shifting to 64-bit internal bus architecture. Clearly, the incorporation of memory, control, and test logic onto the same chip as the integer and floating-point execution units creates a large demand for additional interconnect layers to route the increased number of signals and to maintain a manageable die size. This trend is expected to continue as future processors become even more highly integrated, with multiple processors integrated onto a single chip as well as associated complex logic, higher levels of test support, error detection and correction, and other functions.

Because complex microprocessors and application-specific standard products (ASSP) derived from the processor cores comprise an increasing portion of total semiconductor production, advanced

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Table 4
Process Technologies for Current Microprocessor Products

Manufacturer	Microprocessor Architecture	Minimum Line Geometry (microns)	Number of Metal Interconnect Layers	Die Size (sq. mm)	Number of Transistors (millions)
Intel	486	0.8	3	82	1.2
AMD	486	0.7	3	NA	1.2
Intel	Pentium	0.8	3	264	3.1
IBM/Motorola	Power PC 601	0.65	4*	103	2.8
Motorola	68060	0.5	3	149	2.8
TI	SuperSPARC	0.8	3	255	3.1
Digital	Alpha	0.75	3	233	1.7

NA = Not available
*Uses a metal local interconnect layer in addition to four full interconnect layers
Source: Dataquest (December 1992)

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multilevel metal processes will constitute a larger fraction of the worldwide production capacity. This carries some strong implications for the wafer fab equipment industry. For a three-layer metal process, the number of process steps from the beginning of the process to the point at which the first metal layer is deposited is approximately equal to the number of process steps from that point to the end of the process flow. In other words, the three-layer metal process is the point at which the multilayer metallization process steps become equal to all of the front-end process steps.

The mix of wafer fabrication equipment will, therefore, tend to be more heavily weighted toward process tools that are used in the multilevel metal process module—sputter deposition systems, metal chemical vapor deposition (CVD) systems for contact and via plugs, dielectric CVD and PECVD systems for the intermetal dielectric (IMD) deposition, dry-etch systems for contact and via etching, and process tools for planarization of the IMD and the tungsten contact and via plugs.

Starting in about 1988, the purchases of CVD/physical vapor deposition (PVD) equipment and dry-etch/dry-strip equipment have risen as a percentage of total spending, while the purchases of lithography/track equipment have fallen. This shift in equipment spending has been caused by greater use of multilevel metallization processes and by the evolution from batch to single wafer-processing equipment, particularly for intermetal dielectric processes. Dataquest expects this trend to continue as multilevel metal processes find greater use in production and the number of interconnect layers continues to grow.

Charles Boucher

Company and Other Issues

Q9 What is the latest update on Japanese semiconductor capital spending?

A Table 5 shows historical capital spending trends and the latest update for six major Japanese semiconductor companies.

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Table 5
Japanese Semiconductor Capital Spending Trend
(U.S.$M)

	1989	1990	1991	1992
Fujitsu	595	622	703	519
Hitachi	643	738	650	516
Matsushita	486	547	462	355
Mitsubishi	475	583	665	476
NEC	616	703	752	615
Toshiba	679	816	789	496
Others	2,247	2,141	2,166	1,754
Total	5,740	6,150	6,186	4,732

Note: Columns do not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Kazunori Hayashi

Q10 I heard that the Electronics Industry Association of Japan (EIAJ) recently opened an office in the San Francisco Bay Area. What is the purpose of this opening and how can EIAJ be reached?

A EIAJ and an affiliate organization established by EIAJ members, known as the Users' Committee of Foreign Semiconductors (UCOM), have jointly opened a new office in Foster City, California. The general charter of this office is to promote commerce between U.S. and Japanese electronics industries.

UCOM, which currently includes a membership of 62 Japanese semiconductor users, will specifically serve as an information clearinghouse with the intention of providing knowledge that will facilitate access to the Japanese semiconductor markets by foreign chip suppliers. Facts concerning such things as Japanese end users' activities, needs, and chip requirements—as well as sales protocol and distributor information—will be disseminated by UCOM California. In addition, data regarding U.S. technical trends, requests, and product updates will be forwarded to the Japanese members of UCOM.

In joint efforts with the Semiconductor Industry Association of the United States, UCOM California has and will continue to conduct trade mission seminars and symposia designed to expedite the communication of both engineering requirements and marketing information from U.S. semiconductor suppliers to potential Japanese chip consumers. In particular, the office in Foster City intends to give special attention to U.S. vendors that are either neophytes in the

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Japanese market or do not have marketing representation in Japan. UCOM California can be reached at the following location:

- Address
  - UCOM California
  - Metro Center Tower
  - 950 Tower Lane, Suite 825
  - Foster City, CA 94404
- Telephone—(415) 570-5018
- Facsimile—(415) 570-5270

The new semiconductor trade agreement, which was renewed in August 1991, mandates that 20 percent of Japanese chip consumption should be supplied by foreign-based companies by the end of 1992. The governments of the United States and Japan have also agreed to the methods and formulas used to measure the progress toward the targeted goals specified by the trade agreement.

Previously, the often conflicting numbers calculated by the Ministry of International Trade and Industry and World Semiconductor Trade Statistics have only aggravated the disputes over market share trends and the achievement of a specified degree of foreign supplier presence in the Japanese semiconductor markets. Currently, 17.9 and 16 percent are two estimates of foreign supplier market share—computed using two of the standardized formulas approved by both governments—of the second-quarter 1992 Japanese semiconductor market.

Although many Japanese semiconductor companies have made conspicuous efforts toward increasing their levels of foreign chip procurement, many people in the Japanese chip industry remain skeptical that the 20 percent goal will be accomplished by the end of this year. It is hoped that the Japanese government and semiconductor industry's collective effort to establish a liaison office in Silicon Valley will provide a vehicle for more U.S. suppliers to successfully compete in the Japanese market, as well as demonstrate Japan's willingness to buy products from any supplier.

The historical market share numbers for the foreign-made chips in the Japanese semiconductor market are shown in Figure 1.

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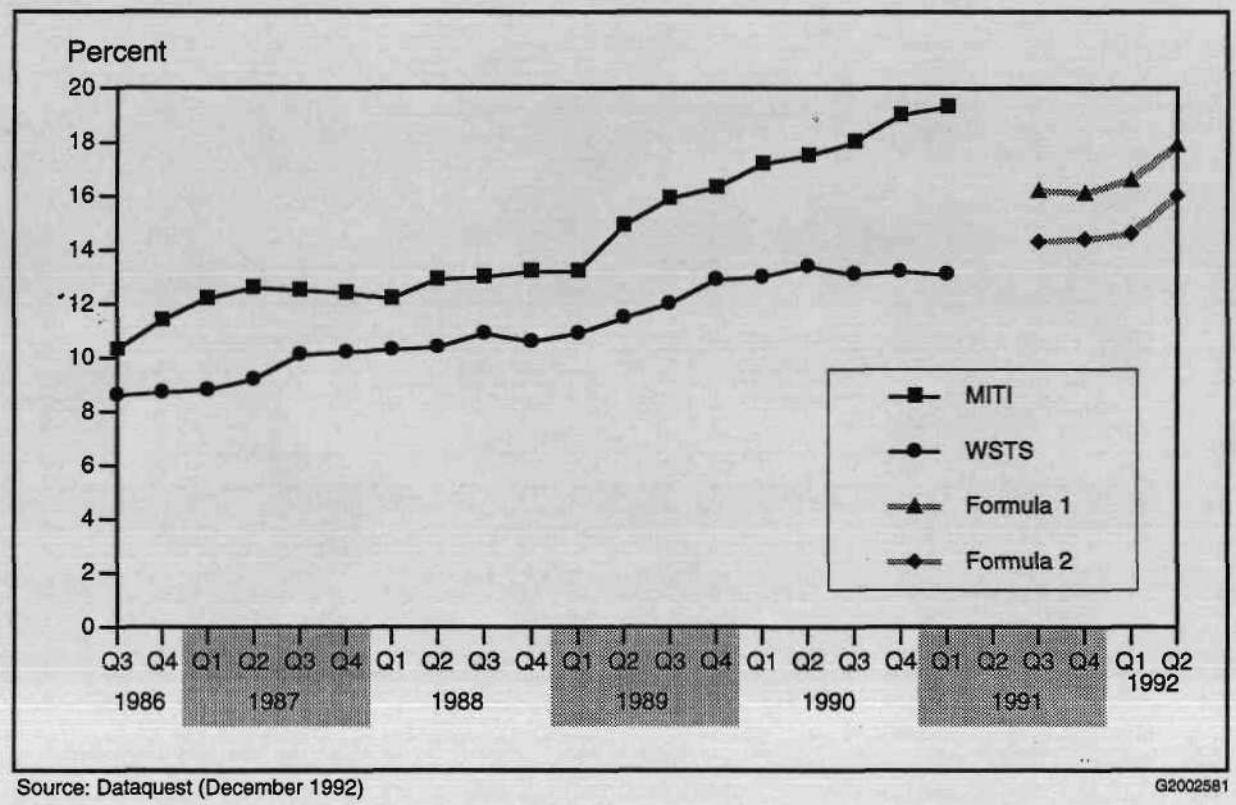
Figure 1
Foreign Semiconductor Market Share in Japan (Percent)



Source: Dataquest (December 1992)

G2002581

Junko Matsubara

Q11 Have you heard of the company Semitherm Inc.? I'd like some basic information.

A Semitherm Inc. is an R&D and manufacturing house for computerized wafer-processing equipment. Founded in 1987, it employs 15 people and has estimated 1992 projected sales of U.S.$3 million. Semitool Inc., of Kalispell, Montana—which was started in 1977—is allied with Semitherm Inc. through common ownership and/or financial interest. Semitool of California and Semitool LTD, of Cambridge, United Kingdom, operate as distribution points for the Semithern/Semitool equipment. Raymon F. Thompson is the President.

You can reach the company at the following location:

- Address
  - Semitherm Inc.
  - Box 2136
  - 4051 Highway 93 S
  - Kalispell, MT 59901

Mary A. Olsson

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Q12 Our corporate management has started a new program to benchmark the performance of company functions including IC purchasing. We are a vertically integrated electronics manufacturer with facilities in most world regions including Europe, North America, and Asia. Can you give me some background?

A This has been a hot subject for many of our Procurement clients. For some Semiconductor Procurement Service (SPS) clients, benchmarking is a relatively new concept, while others have been benchmarking their operations and processes for the last 5 to 10 years.

Xerox Corporation has been a leading proponent and beneficiary of benchmarking since the early 1980s. At Japan-based manufacturers, benchmarking is generally an ingrained aspect of the strategic planning/market intelligence function, although the word benchmarking is not used.

To date, benchmarking has been applied more by electronics manufacturers than other manufacturers or service firms and more by U.S.-based companies than Europe-based companies. For example, Digital Equipment, Hewlett-Packard, IBM, and Motorola have well-established benchmarking programs.

There are several similar, but slightly different, definitions of benchmarking. Xerox originally defined benchmarking as "...the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders."

In effect, there are three types of benchmarking—internal, competitive, and best practices—all of which can be illustrated by examples from Xerox. Internal benchmarking is exemplified by Xerox's benchmark comparison of manufacturing processes and efficiencies in North American, European (Rank Xerox), and Japanese (Fuji Xerox) plants. Competitive benchmarking is exemplified by the product tear-downs conducted by Xerox of competitors' systems regarding components and technology. Xerox's competitors also tore down Xerox's systems. And, best practices benchmarking is exemplified by Xerox's discovery through market research that L.L. Bean—a relatively small Maine (U.S.)-based company that is not involved in the electronics industry—operated a world-class warehousing function, against which Xerox benchmarked—and then modified—Xerox's warehousing practices.

Ronald Bohn

Q13 What can you tell me about the company named Euphonics?

A Euphonics, founded in 1987 by Dr. Jeffrey Barish, is an R&D consulting company that provides solutions throughout the development process to audio and electronic music products through the use of digital technology. Euphonics offers a range of services including product conceptualization, hardware design, programming,

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DSP coding, and signal processing and analysis. Clients of Euphonics include Analog Devices, Crystal Semiconductor, Yamaha, Ford Motor Company, E-mu Systems, Jensen, Kawai, Sanyo, Digidesign, and other companies.

For more information Euphonics can be reached at the following location:

- Address
  - Euphonics
  - 61 Pine Tree Lane
  - Boulder, CO 80304
- Telephone—(303) 938-8448
- Facsimile—(303) 938-8885

Rick Spence

Q14 What is the 1993 semiconductor capital spending outlook in Japan?

A One only has to look at the flurry of poor quarterly reports coming out of Japan to understand why semiconductor capital spending in Japan will continue to decline in 1993. By our estimates, spending will fall 12.7 percent in 1993 following a precipitous drop of 28.7 percent in 1992.

Across the board, Japanese device makers are reporting miserable earnings, and they are scrambling to shore up their balance sheets by cutting spending. A downturn in all the major semiconductor end-user markets in Japan is causing companies to be more cautious. Data processing, consumer electronic, automobile, and communications applications are all suffering.

Mainframe demand, which is the largest data processing segment using ICs, was negative in 1992, and it is unclear when financial and manufacturing companies will begin buying these systems again. A fierce price war in overseas markets is exposing the vulnerability of Japanese PC makers. Already, U.S. and Taiwanese companies are targeting Japan with their lower-priced machines, which is widely expected to enable them to gain market share at the expense of the established domestic vendors.

Japanese consumer electronics sales are weak, causing companies to cut production of semiconductors going into this application. Pressure on household incomes continues to erode consumer confidence, which is being translated into reduced consumption expenditure.

Vehicle sales have fallen on a year-over-year basis for the last 18 months, with the exception of June 1992. Reflecting difficulties in the automobile sector, Nissan Motor—Japan's second-largest car manufacturer—reported its first pretax loss since World War II and suspended its dividend for the first time.

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The communications sector is also weak as NTT—Japan's domestic telephone company—cut its capital spending budget dramatically. As a result, telecommunications systems are also recording weak sales.

Structural Change for Japanese Industry

The current downturn in Japan is driven by domestic asset deflation and the reversal of the credit cycle of the late 1980s. Stock prices are more than 50 percent below their peak, and urban land prices have fallen approximately 20 percent. Negative money supply growth demonstrates the severity of the financial system's capital shortage.

We believe that 1993 is likely to be marked by a softening in the labor market through further reductions in compensation growth and cutbacks in regular employment growth. It is very likely that the slower growth in wages is the endgame of an adjustment process that began in the fall of 1990 with a tightening of monetary policy by the Bank of Japan.

Consequently, we expect to see an improved environment for semiconductor capital spending in 1994 and beyond. But, the unbridled spending spree by Japanese companies is not likely to be repeated. Slower domestic gross national product growth, mounting competitive pressures, and lopsided trade imbalances suggest that the scramble for semiconductor market share will no longer be the main strategy for Japanese device makers.

Mark FitzGerald

Q15

It is my understanding that the antidumping law, under which Micron Technology has filed against the Korean DRAM makers, requires an 8 percent pretax profit margin by the seller to avoid being guilty of sales below fair market value, as defined by the law. However, very often semiconductor makers seem to be unable to make profits that high, especially in tough times. How often has Micron been able to achieve such a pretax profit rate?

A

Since 1983—its first fiscal year—Micron's pretax profits have fallen below 8 percent in 24 of the 40 quarters. These 24 quarters include 10 in a row during the first dumping debacle and 10 of the last 12 since the company's 1990 fiscal year began in September 1989. The company lost money in 14 of these 40 quarters; it made pretax profits greater than 35 percent in 9 quarters.

One could argue, of course, that one company is forced to sell below cost to meet the price of other dumpers, as was certainly the case in 1985 to 1987. Then, any company that did not meet the market price was forced to stop shipping altogether, which would mean going out of business for Micron.

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A reconstructed cost comparison is only one of the criteria of this law; another important one is the assessment by the International Trade Commission that the domestic industry has been damaged by the sales below fair market value.

Lane Mason

Q16 Please provide an assessment of semiconductor distribution in Taiwan, South Korea, and Singapore.

A Distribution profiles for these countries are given below.

Semiconductor Distribution Profile: Taiwan

The following are highlights of Taiwan's semiconductor distribution:

- The primary means of distribution in Taiwan's dynamic and competitive semiconductor market is through distributors and direct branch office sales. The means and mix of distribution depends on the origin of the company, the product lines sold, and the size of the accounts being served.
- All semiconductor companies utilize distributors in addition to their direct house accounts. As far as determining a percentage of semiconductors sold through distributors versus through branch offices, this varies so widely from company to company that it is very difficult to assess the total market. The means of sales to a customer can change at times when the quantity and/or product purchases change.
- Distribution segments in terms of niche products versus broad-line products can determine whether a distributor is used. In most cases, companies will use distributors to sell standard products to nonmajor account clients. However, in the case of custom products, a company will service the account directly, even though the sales quantity is minor.
- Gross margins of distributors again depends on the products being offered. The market norm in Taiwan is a 5 percent margin for distributors. For DRAMs, the margin might be slightly lower than the norm, or closer to 4 percent. At the lowest end of the market, for example in mask ROMs, distributors' gross margins might be as low as 3 to 4 percent.
- Distributors in Taiwan play an active role in the marketplace. If creating demand means aggressively pushing sales of all old and new products, then distributors play a very important part in influencing consumption.
- The degree of technical expertise among the distribution companies in Taiwan depends on the size of the distributor. Small distributors with 5 to 15 employees will likely employ one field application engineer (FAE). Middle- and large-scale distributors will have as many as 5 to 10 FAEs. In situations where technical support is an important part of

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the distributor's business, there will be a larger proportion of engineers relative to standard product distributors.

- The customer base of distributors, as previously mentioned, is determined by the criteria of the supplier. The most basic and important criterion is the size of the account; the second most important criterion is the technology being sold. In cases where there is a gray area as to the size or technology being purchased by a new client, the branch office is likely to allocate the account to the person or distributor that closed the first sale.
- Customer needs are adequately satisfied by local distributors that have an intimate understanding of the market and the ability to foster long-term relationships.
- No significantly new distribution trend is developing in Taiwan. U.S. and European companies that want to make rapid inroads to the Taiwanese market will be best serviced by utilizing a variety of distributors that usually speak English and understand the business culture.
- The factors that determine the success of distributors in Taiwan are, simply stated, everything: Pre-, during-, aftersales service; delivery; engineering services; product reliability; and pricing.
- More than 10 "major" distributors are in Taiwan. This figure excludes the distributors of Japan-made semiconductors because Japanese companies will utilize distributors that only sell their own products. Furthermore, distributors of Japanese semiconductors in Taiwan are Japanese companies, not Taiwanese companies. U.S. and European companies, for the most part, will choose their distributor regardless of whether other U.S. companies are being represented (again, this depends on products and companies).
- The first distributor that comes to mind is World Peace, which represents Texas Instruments, Chips & Technologies, IDT, and Rockwell. This company generates about U.S.$80 million in monthly sales revenue. Other major distributors include Acer, Mitac, and Mercuref & Associates Ltd. (representing Motorola and Kyocera, about U.S.$40 million per month).
- As previously mentioned, distributors offer expertise, relationships, and market inroads that branch offices must spend years to develop.

Semiconductor Distribution Profile: South Korea

The following are highlights of South Korea's semiconductor distribution:

- The three basic semiconductor sales channels in South Korea are stock sales, representative sales, and direct branch office sales (major accounts). In cases such as SPARC product,

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which require a high degree of technical competence, branch offices or major agents will distribute rather than stock sell, which affords no technical support.

- The percentage of semiconductor components sold through distributors depends on the size of the account and the nature of the product being sold. Because of the predominant consumer electronics equipment demand, about 60 percent or more of commodity-related semiconductors are sold through distributors.
- Gross sales margins generally are 25 percent for stock-based transactions and 5 percent for representative offices.
- Distributors in South Korea do not significantly impact or create the market demand, but aggressive agents and competitive pricing will impact sales quantity.
- Technical expertise among distributors in South Korea generally is weak, in part because the nature of the semiconductor market—which is predominantly consumer applications of commodity products—requires little technical expertise.
- The customer base of distributors' versus vendors' branch office or headquarters varies according to account size. While minor accounts rely on distributor support, the major accounts will work directly with an agent of a branch office or headquarters.
- Customer needs in South Korea do not differ from anywhere else in the world and rank according to quality, delivery, and price.
- Distributors in South Korea generally are small-scale operations. Vendors are able to provide volume and technical support better than small distributors, which have difficulty expanding their business volume because of inferior service.
- We do not have a list of these small distributors in South Korea, but there are many.
- The primary benefits of using a distributor in South Korea are the minimal risk involved and the absence of the need for a newcomer to fully understand the local market.

Semiconductor Distribution Profile: Singapore

The following are highlights of Singapore's semiconductor distribution:

- Distribution channels in Singapore are much more straightforward than those in Taiwan because semiconductor sales accounts are serviced predominantly by multinational branch offices and there is little use for using distributors except in the case of small accounts of standard products.

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- Based on the percentage of electronics equipment production done by large multinationals, it is fair to say that more than 90 percent of semiconductors used are sold directly, while less than 10 percent are sold through distributors.
- Most semiconductor suppliers with niche products prefer to sell directly if they are customized in Singapore. For example, Texas Instruments offers a variety of bipolar products sold directly because of their custom nature.
- Distributors' gross margins will vary according to their products as in other parts of the world, but margins remain comparable with Taiwan at about 5 percent.
- The degree of technical expertise is relatively weak among Singapore's distributors, in part because of the nature of the market and the availability of FAEs willing to work as distributors in Singapore.
- Customer base of distributors is, again, small-scale manufacturers or niche users of relatively standard technology products.
- Customer needs in Singapore are based on a major account mentality emphasizing quality and reliability, service, product migration, technical competence, and on-time delivery.
- The current trend of direct account sales will continue in Singapore. However, there is a growing need for distributors in neighboring Malaysia because a large number of small- and medium-scale Taiwanese, Korean, and Hong Kong electronics equipment companies are establishing manufacturing facilities in the region.
- The success of distributors in Singapore depends on the factors of service, price, on-time delivery, and quality/reliability mentioned previously.
- The benefit of using a distributor in Singapore is less cultural than in Taiwan because the market is almost totally controlled by multinational manufacturers. Therefore, the major benefit to using a distributor is to service small accounts that otherwise would be ignored by the branch office.

Daniel A. Heyler
J.H. Son

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Dataquest Inquiry Summary

Semiconductors *Worldwide*

November 9, 1992

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For more information on the Semiconductors *Worldwide* industry, call Rick Spence at (408) 437-8624

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Products

Q1 Please provide details on the PowerPC 601 chip recently announced by IBM and Motorola.

A The 601 chip is the first chip to come out of the Motorola/IBM/Apple agreement and was announced on October 1. The starting point for the 601 chip was IBM's RS/6000 Model 220 microprocessor. The features and specifications are as follows:

- Single-chip implementation
- 2.8 million transistors (about 56 percent for cache)
- 32Kb instruction/data cache; the cache is dynamically allocated between instruction and data
- 32-bit data and instruction but can access 64 bits at a time
- Added functionality beyond the 220 includes the following:
  - Single precision floating point
  - SMP
  - Motorola 88110 bus technology
- Manufactured using a CMOS process, as follows:
  - Drawn dimension = 0.6 micron
  - Effective channel length = 0.45 micron
- Five layers of interconnect, as follows:
  - Four global metal layers
  - One local metal layer (Yes, metal)
- Die size about 160K mils square
- 304 pin QFP; the 601 will be bus-compatible but not pin-compatible with the 603 or 604
- Power supply requirement is 3.6V (but with TTL I/O levels); follow-on products (such as 603 and 604) will require a 3.3V power supply
- Performance estimates as follows:
  - 50 MHz as follows:
- SPECint89: 40
- SPECfp89: 60
  - 66 MHz as follows:
- SPECint89: 50
- SPECfp89: 80

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According to the companies, the design and fabrication was completed in 12 months. It will be manufactured by IBM in Burlington, Vermont. Motorola has the option to manufacture but initially IBM will manufacture the chip. Both Motorola and, we assume, IBM will sell it.

The publicly announced companies that will announce 601-based systems in the next 12 to 18 months are IBM, Apple, Groupe Bull, and SGS-Thomson. We expect the first of these to be announced in the fourth quarter of 1993.

Jerry Banks

Q2 What is the current and future status of wide-word/video-RAM capacity relating to lead times and prices? How does this compare with standard x1 DRAM capacity?

A The combination of electronics demand is running at a steady positive growth rate of 7-plus percent for this year, and a similar forecast for 1993, with flat to negative capital expenditure for semiconductor capacity, increases the potential for dislocation of semiconductor supplies as the current level of semiconductor capacity fills up. Based on survey results of key semiconductor procurement managers and input from some major semiconductor suppliers, the current ample supply of aggregate semiconductor capacity may come into balance with demand in the second to third quarters of 1993 time frame. This shift from a buyer to a seller market would first impact areas with fewer suppliers (such as specialty memories and VRAMs) and then filter down to the commodity memory suppliers. The lack of a uniform robust worldwide demand scenario is inhibiting many suppliers (U.S., Japanese, and Korean) from adding to their capital stock that would supply the 1993 to 1994 slow growth trend that began 12 to 18 months ago. Maximizing returns on existing capacity is a major focus, especially because the next-generation fabs will require expenditure upward of $500 million. Users of semiconductors need to fully inform their key suppliers as far in advance as possible of changes to forecasts and should hedge their first-half 1992 supplies of semiconductors (in particular specialty memories, DRAM, and selected MPUs) with increased percentages of contractual buys along with current spot market bargains.

Lane Mason

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Markets and Applications

Q3 Dataquest was recently quoted in the trade press regarding the market for 3V DRAMs. What is the breakout by density behind this forecast?

A Table 1 shows the basic data. We expect wide-word architectures, because of their greater use in BBU equipment, to pick up the 3V DRAMs more quickly. Although the price premium in the 4Mb density is up to 100 percent and more for early production, we expect it to drop rapidly as volume increases, to about 10 to 20 percent by the middle of 1993. It will almost be a moot point by 1996, as the high-volume 16Mb parts will all be 3V inside, driving most 5V devices from the market.

Table 1
3V DRAM Forecast, 1992-1995

		1992	1993	1994	1995
1Mb	Revenue ($M)	4.5	8.0	9.5	11.1
	Units (M)	1	2	2.5	3
	ASP ($)	4.50	4.00	3.80	3.70
	Percentage of Units	0.13	0.44	1.00	2.61
4Mb	Revenue ($M)	31.5	150.0	320.0	288.0
	Units (M)	1.8	15	40	45
	ASP ($)	17.50	10.00	8.00	6.40
	Percentage of Units	0.41	1.84	4.32	6.72
16Mb	Revenue ($M)	0	8.0	262.5	1,196.0
	Units (M)	0	0.1	7.5	52.0
	ASP ($)		80.00	35.00	23.00
	Percentage of Units		0.29	4.05	15.76
Total ($M)		36.0	166.0	592.0	1,495.1

Source: Dataquest (November 1992)

Lane Mason

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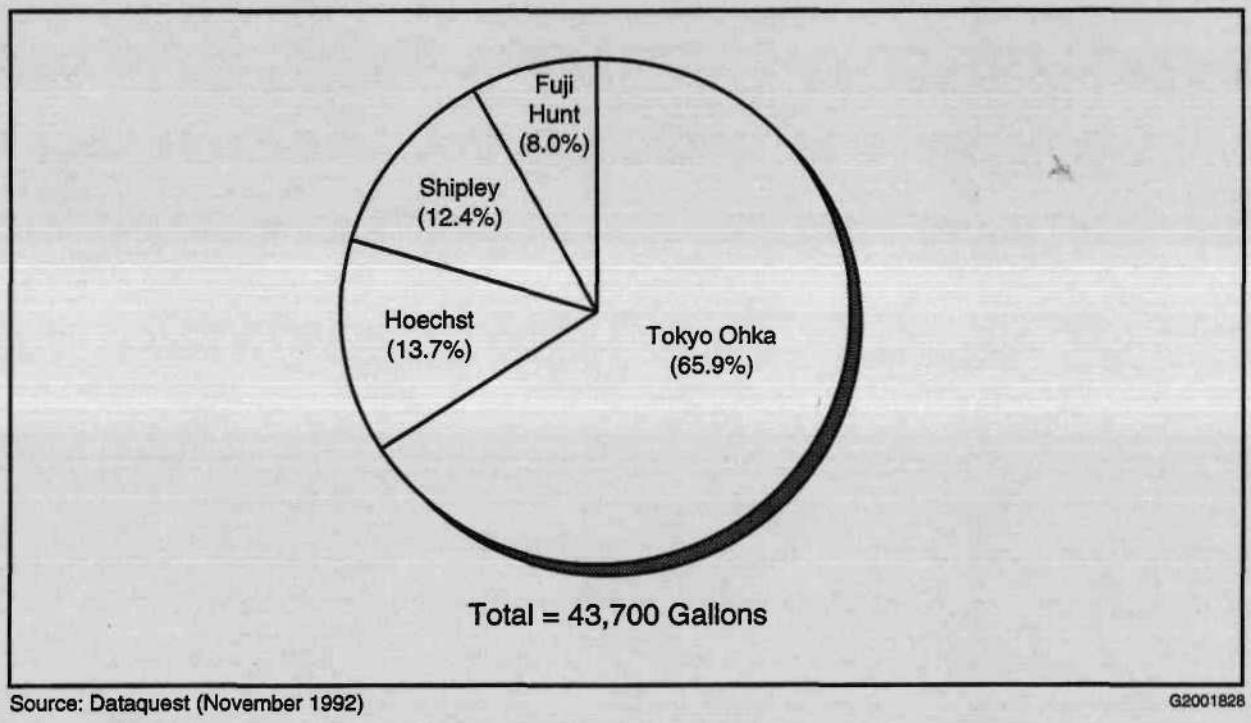
Q4 What is the Japanese photoresist shipment for TFT-LCD applications, and what is the supplier market share?

A The consumption for photoresist in TFT-LCD application totaled 43,700 gallons in 1991. This amount is equivalent to only 8 percent of photoresist for semiconductor applications, but is expected to grow rapidly over the next five years. Figure 1 shows 1991 Japanese photoresist market share.

Kunio Achiwa

Figure 1
1991 Japanese Photoresist Shipment for TFT-LCD Applications



Source: Dataquest (November 1992) G2001828

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Q5

What are the major film applications for the various categories of CVD equipment?

A

See Table 2.

Table 2
Film Applications for Various CVD Equipment Categories

Application	Tube HLPCVD	Tube VLPCVD	Nontube LPCVD	Tube PECVD	Nontube HPECVD	Nontube APCVD	ECR CVD
Thermal Nitride	X	X					
Polysilicon	X	X					
Plasma Nitride				X	X		X
Undoped Oxide	X	X	X	X	X	X	X
Doped Oxide (PSG, BPSG)	X	X	X		X	X	
Tungsten Silicide			X				
Tungsten			X				
Aluminum			X				

Source: Dataquest (November 1992)

Peggy Marie Wood

Q6

Which semiconductor vendors are offering or developing chips for the asynchronous transfer mode (ATM) market, and what is the forecast market size from 1995 to 1997 in Europe?

A

The following companies are involved in semiconductor development to support ATM:

- National Semiconductor (which has an alliance with Adaptive Corporation, a subsidiary of National Equipment Technology, and plans to have product to market by next year)
- PMC-Sierra (a new company owned by Sierra Semiconductors, formed by acquisition of the majority stake in Pacific Microelectronics Centre)
- Texas Instruments (via a cross-sourcing arrangement with TranSwitch Corporation)
- Base2 Systems Inc.

The European ATM chip set market forecast estimates include the three possible types of equipment that would use this technology. The equipment types are ATM ports/connections, ATM switches, and cell assemblers/disassemblers.

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The forecast market size for ATM products is as follows:

- 1995: 22,000 units
- 1996: 45,000 units
- 1997: 100,000 units

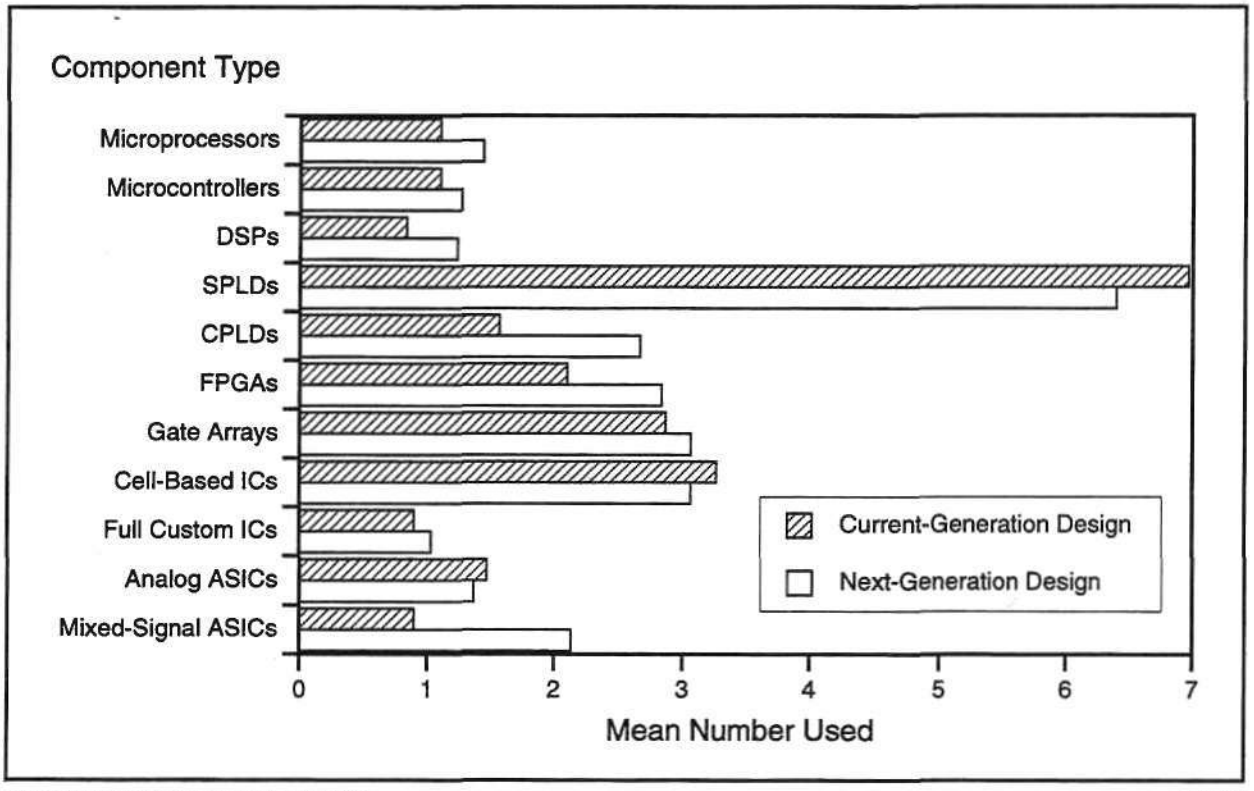
David Moorhouse

Technology

Q7 What types of devices are designers using to create their electronic systems today? In particular, what areas will see an increase in new design activity over the next one to three years?

A Dataquest recently finished collating data on a worldwide end-user research project delving into the perceptions of electronic designers. More than 600 designers worldwide were asked the types of components they were using in their current design, and what they anticipated using in their next-generation design. Figure 2 shows

Figure 2
Worldwide Mean Component Usage in Electronic Systems



Source: Dataquest (November 1992)

G2001829

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the mean number of each type of component. It is important to use these data not as a quantitative measure of IC consumption, but as a signpost to recognize trends in the overall industry. For example, it is clear that usage of programmable technologies, particularly high-density CPLDs and FPGAs, will increase in the coming years, as will mixed-signal ASICs. However, expect a slight decline in the number of SPLDs and cell-based ICs being used. Please note that this is a gauge of user perceptions, and many other factors, including technology availability, pricing trends, economic stability, and vendor supply issues, also play an important role in forecasting overall IC revenue.

Robert K. Beachler

Q8 What percentage of the North American MOS gate array design starts are now using three-layer metal interconnect?

A Dataquest has just finished collecting North American ASIC supplier data for both MOS gate arrays and MOS cell-based ICs. There has been a rapid increase in three-layer metal MOS gate array design starts in 1992. During 1990, only 9 percent of the MOS gate array design starts used three-layer metal interconnect. Preliminary survey results for 1992 show that about 25 percent of the North American MOS gate array design starts now use three-layer metal interconnect. This rapid increase is due to the major cost savings associated with three-layer metal versus two-layer metal in high-density designs. Gate utilization for a sea-of-gates gate array architecture using two-layer metal is about 40 to 45 percent; with three-layer metal interconnect, gate utilization jumps to 70 to 75 percent. Increased gate utilization means that the die required for a given application can be shrunk, which translates to higher yields and a significant cost savings for both ASIC suppliers and ASIC users.

Bryan Lewis

Company and Other Issues

Q9 DRAM makers' profits have been thin for more than 18 months, but our own analysis suggests that a good DRAM manufacturer could make plenty of money with $12.00 4Mb DRAMs, and $3.50 1Mb DRAMs. Why are DRAM profits so low, and where do they lie in relation to the historical experience curve?

A By most analyses, prices today lie below the experience curve, meaning that profits are subnormal (or, losses). But the amount under the curve depends exactly on how one poses the questions, whether PPB is yen- or dollar-denominated, or is some hybrid currency that reflects "world price" or "world cost." The learning curve, as well, is an empirically observed relationship between

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cumulative volumes and costs, for which the internal mechanism relating one to the other is not well understood in most cases.

For certain, though, profits have been depressed, as the leading Japanese vendors' year-end financial results have attested, as well as those of Micron Technology and Texas Instruments. This poor performance also has been because of underutilization of capacity, highly competitive markets, and, we believe, some overreaching of the R&D effort, which has failed to realize sufficient present-time cost-reduction results.

As a result of a tough and useful client inquiry, we became convinced that our mid-1990s DRAM pricing is somewhat lower than is likely to occur. Therefore, we will be giving increased consideration to the experience curve in the DRAM forecast revision later this year.

Mark Giudici

Q10 What is the newest quarterly Japanese electronic equipment production forecast for 1993?

A See Table 3.

Naotoshi Yasuhara

Table 3
Quarterly Japanese Electronic Equipment Production Forecast 1993 (Billions of Yen)

	1992 Estimates	Forecasts			1993 Forecasts			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Data Processing	1,696	1,496	1,660	1,761	1,696	1,547	1,729	1,833
Communication	832	651	747	704	848	682	787	748
Industrial	932	767	857	808	904	822	898	862
Consumer	1,751	1,859	1,795	2,011	1,766	1,927	1,893	2,091
Military/Aerospace	53	53	53	53	54	54	54	54
Transportation	335	328	333	344	336	338	342	357
Total	5,599	5,153	5,446	5,681	5,604	5,371	5,703	5,944

Source: Dataquest (November 1992)

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Q11 What is the link between Epson Portland and Seiko Epson Corporation?

A Epson Portland Inc. (EPI), is the first manufacturing plant for Seiko Epson Corporation in the United States. Epson Portland division locations are as follows:

Corporate Headquarters and Printer Division
3950 NW Aloclek Place
Hillsboro, Oregon 97124
(Main plant is 176,110 square feet.)

Computer Products Division
1880 SW Merlo Drive
Beaverton, Oregon 97006
(Facility has 64,000 square feet.)

Epson Research Center
2250 Agnew Road
Santa Clara, California 95054
(Facility has 43,000 square feet.)

Current production in the United States includes computers, printers, circuit boards, dot heads, and precision injection molded plastic parts. EPI has more than 800 employees. Seiko Epson Corporation has invested more than $24 million for land, facilities, and equipment for the EPI divisions. EPI was incorporated in 1985. Printer assembly began in 1986. Computer assembly began in 1987. Nine-pin-dot head assembly began in 1987. Plastic injection began in 1988. The Research and Design Center was acquired in 1990.

Mary A. Olsson

Q12 What is the total 1991 sales revenue, semiconductor sales revenue, and net profit for the following semiconductor suppliers?

A Table 4 lists each manufacturer's total sales and semiconductor portion, for comparison.

Table 4
Financial Data for Selected Semiconductor Suppliers

Company	Total Sales ($M)	Semiconductor Sales ($M)	Net Profit ($M)
Siemens	44,184	1,263	1,084
Intel	4,778	4,019	818
Philips	30,613	2,022	645
Motorola	11,341	3,802	454
Harris	3,040	623	19
National Semiconductor	1,701	1,602	(154)
Texas Instruments	6,784	2,738	(443)
NEC	27,482	4,774	(404)
AMD	1,230	1,226	145

Source: Dataquest (November 1992)

Sarah Jacob

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Q13 What is the relationship between Telefunken Electronics Group and the Daimler Benz Group, and what is their role in antilock braking systems (ABS)?

A Telefunken was part of a bigger AEG-Telefunken group until 1982. It was dissolved and its computer systems division was sold to Siemens, its TV production facility was sold to Thomson, and its Telenorma and ANT telecommunications subsidiaries were sold to the Robert Bosch group. The remainder of the company, the components division, at the time had no captive semiconductor sales. The U.S. company, United Technologies Corporation, owned 49 percent of Telefunken; the remainder was owned by Daimler-Benz at the time. United Technologies later sold its holding to AEG (which also became a part of the Daimler-Benz conglomerate circa the mid-1980s) Through a number of alliances and joint ventures, Telefunken owns 98 percent of Eurosil. The entire TEG is now fully owned by the Daimler-Benz group.

About 20 percent of Telefunken's business is in the Far East (supplying PAL-TV chip sets to companies such as Goldstar); 12 percent of the business is in the United States (mainly FM radio chip sets sold to Chrysler and Ford); and the remainder is in Europe (mainly Germany).

In the automotive area, Telefunken designs and builds automotive control components and hybrid modules for Daimler-Benz (Mercedes-Benz) and the Volkswagen-Audi Group. Applications include remote door locking systems, ABS modules, ignition control ICs, and wipe and wash IC controllers. The company also has a license for multiplex ICs (through its relationship with Siliconix and AEG). The automotive business represents about 20 percent of its IC business worldwide.

In a more recent development, Telefunken announced in 1991 that it was developing (with Intel) an ABS module at its Heilbronn plant in Germany for the Volkswagen-Audi Group. The R&D for automotive applications is in Ingolstadt, Germany. The company spends an estimated 30 percent of its turnover on R&D annually. This policy on R&D expenditure levels is expected to be maintained, but with more of this amount being allocated to automotive research and development.

Telefunken does not make any complete ABS anywhere in the world, but it designs and fabricates the IC modules integrated into ABS control units by companies such as Alfred-Teves, a subcontractor to the Volkswagen-Audi Group.

With the newly formed semiconductor group and soon to be announced merger of all the Daimler-Benz semiconductor and electronic companies, the bigger Telefunken Electronic Group will comprise Eurosil Electronic, Telefunken Electronic, Siliconix Electronic, and MHS Electronic. This consolidation and the force behind the group will likely result in a stronger automotive electronic component supplier and player on the global market.

Mike Williams

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Q14 What is the current impact of weak computer system sales on semiconductor production in Japan?

A The four largest system manufacturers in Japan—Fujitsu, Hitachi, NEC, and Toshiba—are also the four largest device makers. August 1992 data from MITI indicate that mainframe production dropped 23 percent and personal computer production is off 1 percent. Dataquest believes that the current downturn in system sales is severely impacting these companies' semiconductor operations because of their large captive semiconductor demand and their dominant position in the DRAM market. Table 5 shows 1991 semiconductor sales for the four largest system manufacturers in Japan.

Table 5
1991 Semiconductor Sales for the Four Largest System Manufacturers

	Worldwide Revenue ($M)	Percentage Captive	Percentage DRAM	Percentage Japan
Fujitsu	2,705	29.0	18.6	73.0
Hitachi	3,765	20.0	17.6	68.2
NEC	4,774	26.0	15.6	72.9
Toshiba	4,202	15.0	22.8	58.0

Source: Dataquest (November 1992)

Mark FitzGerald

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Dataquest Inquiry Summary

Semiconductors *Worldwide*

October 12, 1992

INFORMATION RESOURCE CENTER
DATAQUEST INCORPORATED
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This month's questions

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1. Dataquest's Semiconductor Procurement service (SPS) during 1992 has used historic life cycle pricing analysis to estimate the forward-stage price of Intel's next-generation 32-bit X86 MPU, referred to as the "P5" or "586." Is there any update to this information? 2
2. What is the BiCMOS forecast for ASIC and memory specifically? 2

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13. I keep hearing about Texas Instruments aggressively protecting its intellectual property. Is this a significant source of revenue for TI or is it TI's attempt to focus the attention on something other than its poor financial performance? 14
14. What is the ranking for the top 10 Japanese semiconductor distributors and their product lines? 14

Products

Q1 Dataquest's Semiconductor Procurement service (SPS) during 1992 has used historic life cycle pricing analysis to estimate the forward-stage price of Intel's next-generation 32-bit X86 MPU, referred to as the "P5" or "586." Is there any update to this information?

A Yes, several factors have changed. Intel publicly announced that the device will be introduced during the first half of 1993 and not the second half of 1992.

Several SPS clients recently provided SPS analysts with additional information on likely product specifications. We have learned recently that the device will likely operate at a speed of 66 MHz versus the original SPS operating assumption of 50 MHz. Also, the product likely will include cache memory, for which SPS originally made no direct assumption.

The upshot is that, under these assumed specifications, our client sources indicate an introductory pricing somewhat higher: an estimated $1,500, versus our original estimate of $1,268 (50-MHz, no cache assumed) for a volume of 100 to 1,000 units.

Ronald Bohn

Q2 What is the BiCMOS forecast for ASIC and memory specifically?

A See Table 1.

Gene Norrett

Table 1
BiCMOS Revenue Estimates (Millions of Dollars)

	Analog/Mixed-Signal	ASIC	Memory	Total
1991	325	232	350	907
1992	405	344	463	1,212
1993	527	533	511	1,571
1994	760	842	568	2,170
1995	980	1,289	602	2,871
1996	1,200	1,902	721	3,823
2000	2,500	3,327	1,271	7,098

Source: Dataquest (October 1992)

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Markets and Applications

Q3 Who were the top 10 semiconductor vendors to the data processing market in 1991?

A See Table 2.

Table 2
Worldwide Semiconductor Shipments to Data Processing Applications (Millions of Dollars)

Intel	3,135
NEC	2,387
Hitachi	1,920
Fujitsu	1,650
Toshiba	1,603
Texas Instruments	1,470
Motorola	1,087
Mitsubishi	1,082
Samsung	956
AMD	846
Top 10 Total	16,137

Note: Column may not add to total shown because of rounding.
Source: Dataquest (October 1992)

Nick Samaras

Q4 What is Dataquest's latest Japanese semiconductor consumption forecast, by application?

A See Table 3.

Table 3
Japanese Semiconductor Consumption Forecast, by Application (Billions of Yen)

	1991	1992	1996	CAGR (%) 1991-1996
Data Processing	1,291	1,149	1,743	6.2
Communication	412	383	520	4.8
Industrial	301	274	423	7.0
Consumer	882	800	1,109	4.7
Military	37	39	45	4.1
Transportation	135	124	191	7.1
Total	3,059	2,771	4,032	5.7

Source: Dataquest (October 1992)

Kun Soo Lee

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Q5 Who are the leading providers of specialized sound chips for computer applications?

A Suppliers of specialized IC and chip sets are as follows: The leader is Yamaha, with its OPL 3 and Magic offerings; Cirrus Logic/Media Vision, Sierra Semiconductor, AOM, E-mu Systems, Roland, Zoran, and Integrated Circuit Systems round out the list. Providers of general-purpose DSP products used in sound applications include Texas Instruments, with its MWave technology, and Analog Devices, with its Business Audio offering.

Gregory Sheppard

Q6 We recently received the DRAM forecast, and you show a market contraction in 1995. Why do you believe that will happen?

A We believe that the DRAM market is cyclical, and that what has begun will be a not atypical expansion that will build through about late 1994 and subside with weakening bit growth and excess capacity. Although the DRAM market is vastly different from earlier periods in many ways, we believe that the fundamentals that create a cyclical market will be relatively unchanged.

Over the past 20 years, we have seen four cycles that exhibited much common behavior, as follows:

- Stage 1: Competitive market, growing but with small profits, or worse. With thin margins, capacity expands slowly because suppliers have better things to do with their money, and capacity is already in excess. This period may run five to nine quarters, but cannot go on forever, because at current profit rates there is not enough money to fund the next round.
- Stage 2: End-demand begins to respond to the steadily lower prices and new generations of DRAM-using equipment come out. The tough times have gone on for such a time that DRAM suppliers are suspicious of the reality of the strength of demand (sometimes it is false!). It takes a while to absorb available capacity, and margins stay poor until it is. This period takes two to five quarters (Dataquest believes that this is where we are now). We have yet to be convinced that the recession is over.
- Stage 3: Good times. Demand growth continues, placing pressure on supplies to keep up. Rate of price-per-bit (ppb) decline slows, profits improve. Texas Instruments and Micron Technology stock prices rise. Self-disequilibrating behavior of market takes place, in the form of false double orders, ordering further in advance of need, increasing inventory buffers, and delusions of grandeur among end-equipment vendors (20 companies with 20 percent each of

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the market!). To a degree, fab efficiency decreases as suppliers force fabs to the max. Capacity expansion belatedly rushes to catch up, and catch profits. For a period, we enjoy the profits.

- Stage 4: Production catches up, even as demand still grows (although maybe at a slower rate). Self-disequilibrating forces work in reverse: inventories sold back into market, lead times collapse, and orders canceled in anticipation of lower prices later. Serious price competition takes place. Rate of ppb decline increases. Revenue contracts. This phase takes three to five quarters before a new revenue base is established.
- Stage 5: Revenue growth resumes, but it is a competitive, excess-supply, small-profit market. Suppliers adjust their strategies to their own new realities. This period may take six to nine quarters, with demand still growing, ppb still declining steadily (cost equals price, almost), and profits nil. This is where we came in (Stage 1).

Table 4 provides a tabular comparison of the quarterly revenue and DRAM ppb behavior over the past four cycles. These cycles are not atypical of any high-fixed cost industry that produces a "consumable" product, which DRAMs are.

The "silicon (DRAM) cycle" is not immutable, by any means. But what we have seen since summer 1989, when 1Mb DRAM prices started their major decline, has been quite similar to earlier cycles. Capacity, though in excess now, faces strong demand, even as Japan searches for the bottom. Japanese capital spending cutbacks for FY1992 are expected to be nearly 30 percent below FY1991 levels, which will accelerate the time of market balance if demand strength

Table 4
Quarterly Revenue and DRAM Price-per-Bit Behavior, Past Four Cycles

		Revenue/Quarter		
Point in Cycle	Date	Length/Amount of Decline (%)	Length/Amount of Expansion	Price per Bit Decline (%)
Peak	Q4/74		12Q	
Trough	Q2/75	2Q, -18		-27
Peak	Q2/80		20Q, 1,096	-88
Trough	Q3/81	5Q, -47		-63
Peak	Q4/84		16Q, 700	-54
Trough	Q3/85	3Q, -75		-81
Peak	Q2/89		18Q, 887	~Flat
Trough	Q1/90	3Q, -34		-50
Peak	Late 1994 (est.)		9Q, 25*	-50

*To date
Source: Dataquest (October 1992)

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continues. Already, we are seeing the demand respond to DRAM ppb that are 75 percent below those in the summer of 1989, when the last cycle peaked.

Given the length of cycle's past variability, and the demand uncertainty now existing, the precise timing of any ultimate market contraction cannot be foreseen with any degree of accuracy, but a "typical" cycle would place it beginning in late 1994.

Lane Mason

Technology

Q7 When will true 0.5-micron technology be used in volume manufacturing, and for what application?

A It is first necessary to define what is meant by 0.5-micron process technology before this question can be answered. Table 5 indicates the minimum feature sizes for each critical layer in a typical 0.5-micron process flow. Table 5 clearly shows that the minimum feature size is defined by the N channel MOSFET drawn gate length, and this dimension is adopted to describe the overall process technology.

New process technology generations usually are developed using DRAM or SRAM products as technology drivers, and these products will first utilize the process technology in a production environment. For a given generation of process technology, the DRAM technology driver will be four times the density of an SRAM product built with the same technology level, because the SRAM memory cell contains four (or even six) transistors, whereas

Table 5
Minimum Feature Sizes for Typical 0.5-Micron Processes

Layer	Line Dimension (micron)	Space Dimension (micron)
Active	0.5	0.6
Poly	0.5	0.6
N Gate	0.5	-
P Gate	0.6	-
Contact	0.6	-
Metal 1	0.6	0.7
Via	0.6	-
Metal 2	0.6	0.7

Source: Dataquest (October 1992)

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the DRAM cell only contains one. It should be noted, however, that although either vehicle can be used to develop the basic facets of a technology generation, such as lithography capability, etch techniques, thin film deposition methods, and overall defect reduction, DRAM process flow and SRAM process flow in the end are different entities. Many DRAM process enhancements have in fact focused on reducing the size of the storage capacitor to minimize memory cell size. Conversely, SRAM process enhancements have been largely concerned with improving the memory cell stability, and typically utilize three or even four layers of poly at the 4Mb level, involving a host of unique process integration problems.

Process technologies are also becoming increasingly differentiated for different product segments. DRAM processes typically used a single metal layer through the 4Mb generation, expanded to two metal layers at the 16Mb level, while ASIC products and highly integrated microprocessors currently are using three layers of metal and are migrating to four-level metal processes. Many specific process issues need to be solved in a multilevel metal process, which are distinct from the generic problems associated with patterning and etching smaller features.

The current SRAM and DRAM families in volume production are 1Mb SRAM and 4Mb DRAM devices. These products are built using 0.7- to 0.8-micron process technology. Currently in development and early pilot production are 4Mb SRAMs and 16Mb DRAMs. These devices are being developed using 0.55- to 0.6-micron process technology, and Dataquest predicts that both will begin low-volume production in late 1993, ramping strongly during 1994 and 1995. We expect design rules to continue to be pushed as improved process capability is established, and 0.5-micron processes to be in volume production in 1994 as shipments of 4Mb SRAMs and 16Mb DRAMs begin to grow rapidly.

Charles Boucher

Company and Other Issues

Q8 What are design engineers saying about the two most popular hardware description languages (HDLs), verilog HDL and VHSIC hardware description language (VHDL)?

A Dataquest believes that end users will ultimately vote with their checkbooks. To understand how engineers like the HDL they are using, Dataquest examined what existing users of HDLs will use for their next-generation design. Figures 1 through 4 show the perception of current users of a specific HDL, and what HDL they will try next. North American verilog users exhibit more brand loyalty than do their Japanese counterparts, yet a full 56 percent of North American verilog users will try VHDL. Few North American

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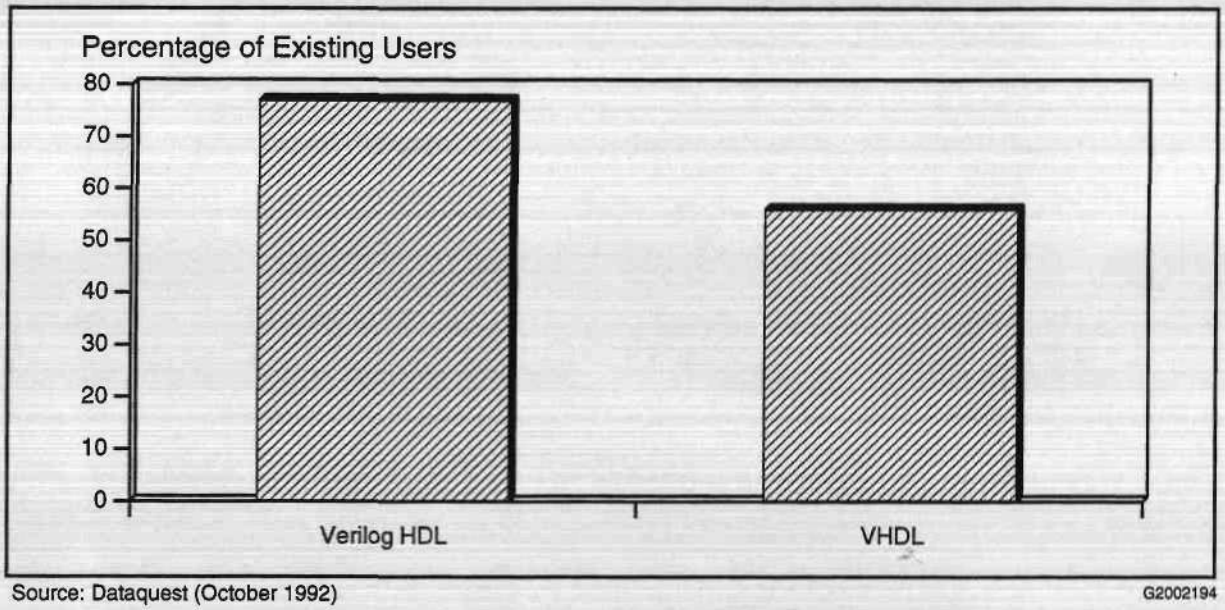
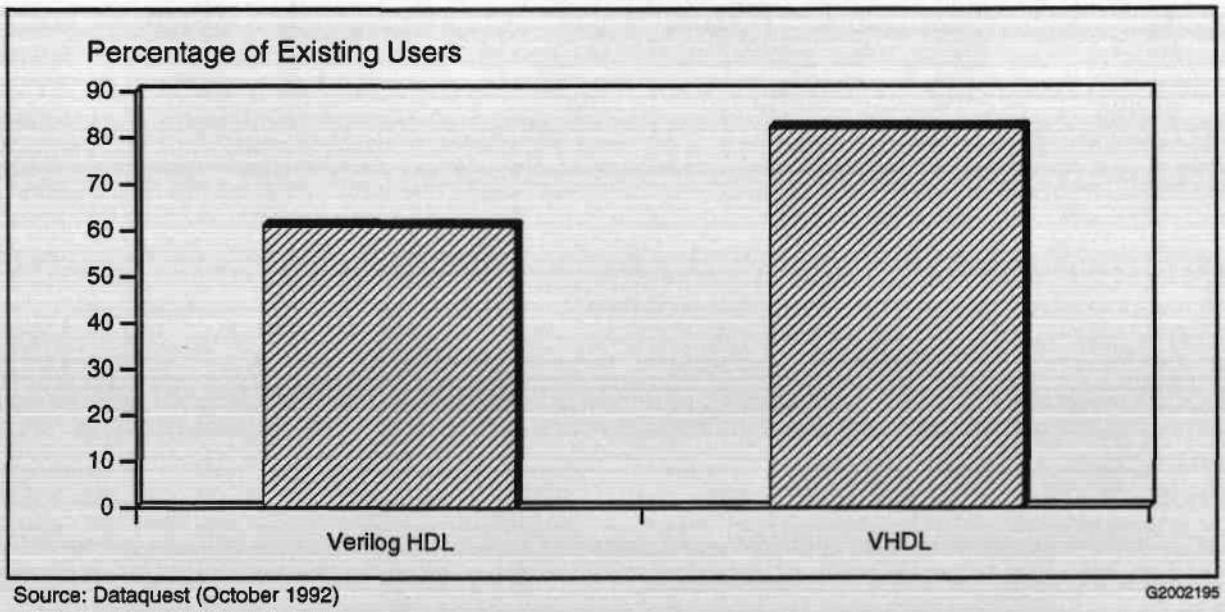
Figure 1
HDL Language to Be Used in Next-Generation Design by North American Verilog Users



Source: Dataquest (October 1992) G2002194

Figure 2
HDL Language to Be Used in Next-Generation Design by Japanese Verilog Users



Source: Dataquest (October 1992) G2002195

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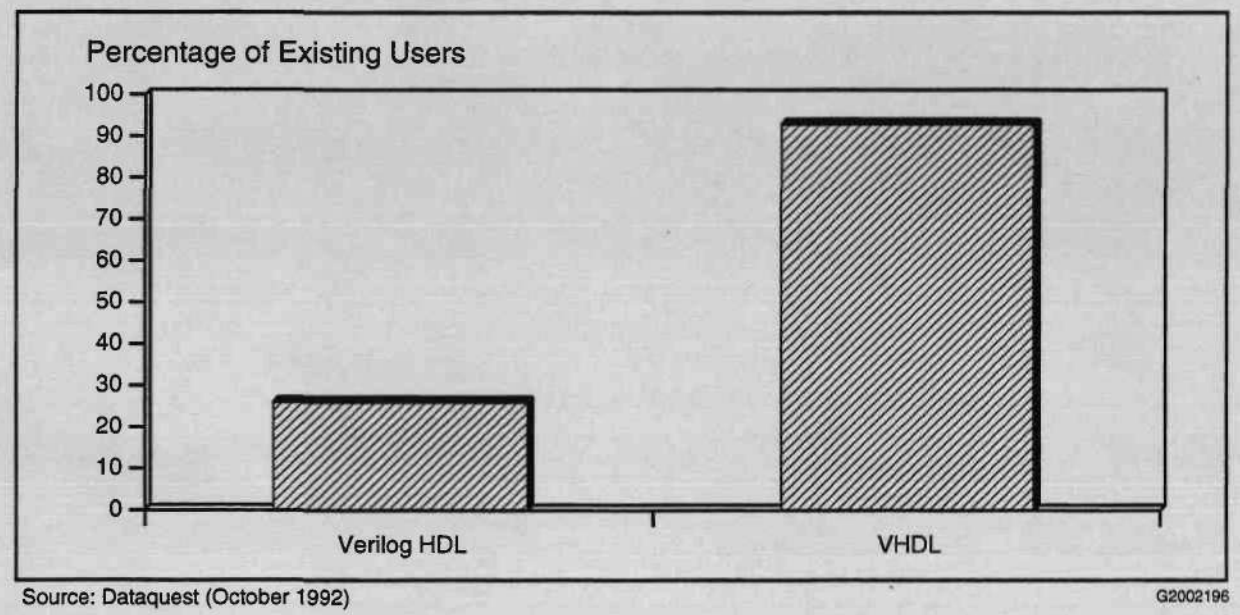
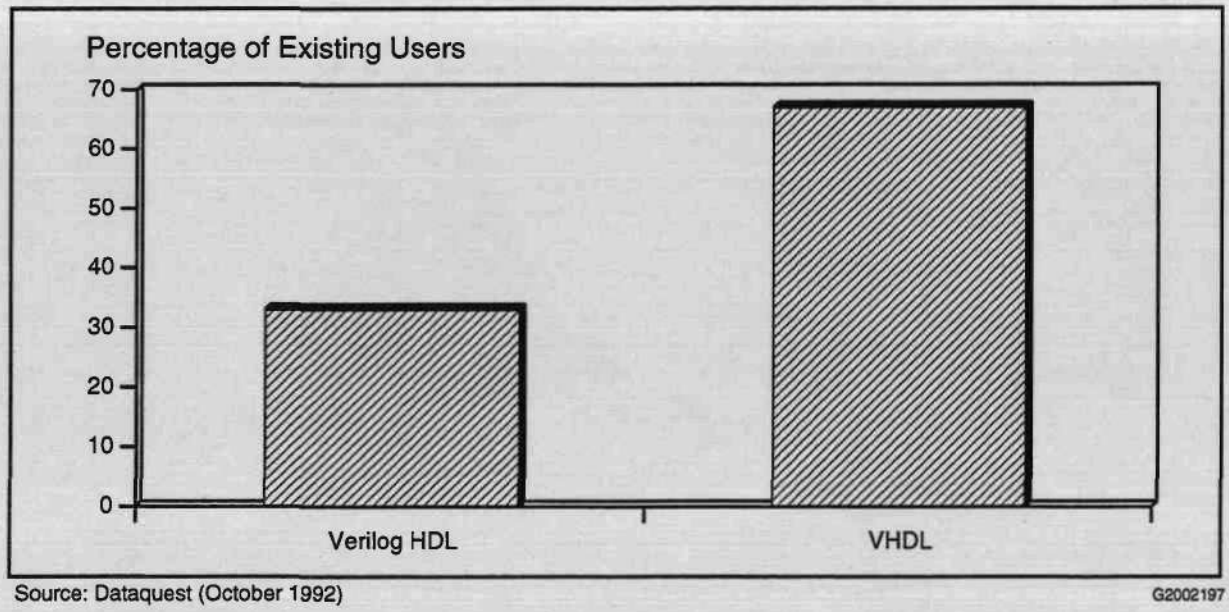
Figure 3
HDL Language to Be Used in Next-Generation Design by North American VHDL Users



Source: Dataquest (October 1992) G2002196

Figure 4
HDL Language to Be Used in Next-Generation Design by Japanese VHDL Users



Source: Dataquest (October 1992) G2002197

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VHDL users will try verilog for their next designs, perhaps signaling satisfaction with their existing VHDL tools, but more likely because they believe that more EDA vendors are working on VHDL-based solutions than verilog-based solutions.

Bob Beachler

Q9 Who are the largest suppliers of pick and place equipment to the assembly market?

A Dataquest does not rank the suppliers of pick and place equipment. See Table 6 for a list of the known suppliers of pick and place equipment and their total company revenue for 1991.

Mary Olsson

Table 6
Pick and Place Equipment Suppliers

Company	Location	1991 Total Revenue ($M)
ATS Inc.	Canada	+25
Automated Production Concepts Inc.	United States	NA
Automation Unlimited	United States	NA
AXYZact Inc.	United States	NA
B & B Electronics Inc.	United States	NA
Calx Inc.	United States	1
Clauss Cutlery Co.	United States	+50
Conceptronic Inc.	United States	NA
Contact Systems Inc.	United States	+5
Delta Design Inc.	United States	NA
Daedal Division, Parker Hannifin Corp.	United States	+10
Dynapert	United States	+50
EFD Inc.	United States	+10
ELVO-Zumbach Electronics Corp.	United States	NA
Excellon Automation	United States	+50
Fisnar, I&J Inc.	United States	+1
Fuji	Japan	NA
Gelzer Systems Co.	United States	+10
GMFanuc Robotics Corp.	United States	+250
Intrade Inc.	United States	+5
Ismeca	United States	+5
Kahnetics Dispensing Systems	United States	+1
Micro Robotics Systems	United States	+1
Mitchell-Bate Co.	United States	+1
Q Corp.	United States	+1

(Continued)

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Table 6 (Continued)
Pick and Place Equipment Suppliers

Company	Location	1991 Total Revenue ($M)
Quad Systems Corp.	United States	NA
Seiko Instruments	Japan	NA
Siemens Energy & Automation Inc.	United States	NA
Semiconductor Equipment Corp.	United States	+5
Sony Factory Automation Division	Japan	NA
Spirol International Corp.	United States	+5
Start International	United States	NA
Taumel Assembly Systems	United States	+5
TDK	Japan	NA
Teledyne TAC	United States	+250
Terra Universal Inc.	United States	NA
United Silicone Inc.	United States	+5
Wyle, Charles, Engineering Corp.	United States	NA

NA = Not available
Source: Dataquest (October 1992)

Q10 What have been the historical overall lead-time averages for semiconductors over the past three years?

A See Table 7.

Mark Giudici

Table 7
Semiconductor Historical Lead Times, September 1989 to September 1992 (Weeks)

	1989	1990	1991	1992
January		9.7	9.0	9.2
February		9.6	8.6	9.0
March		9.4	8.4	9.1
April		10.2	8.9	9.6
May		9.6	8.8	10.1
June		9.9	9.4	11.1
July		9.0	10.1	9.8
August		9.3	9.0	10.4
September	10.3	9.0	10.3	9.9
October	10.9	9.3	9.5	
November	11.0	9.8	9.1	
December	10.6	8.9	9.2	

Source: Dataquest (October 1992)

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Q11

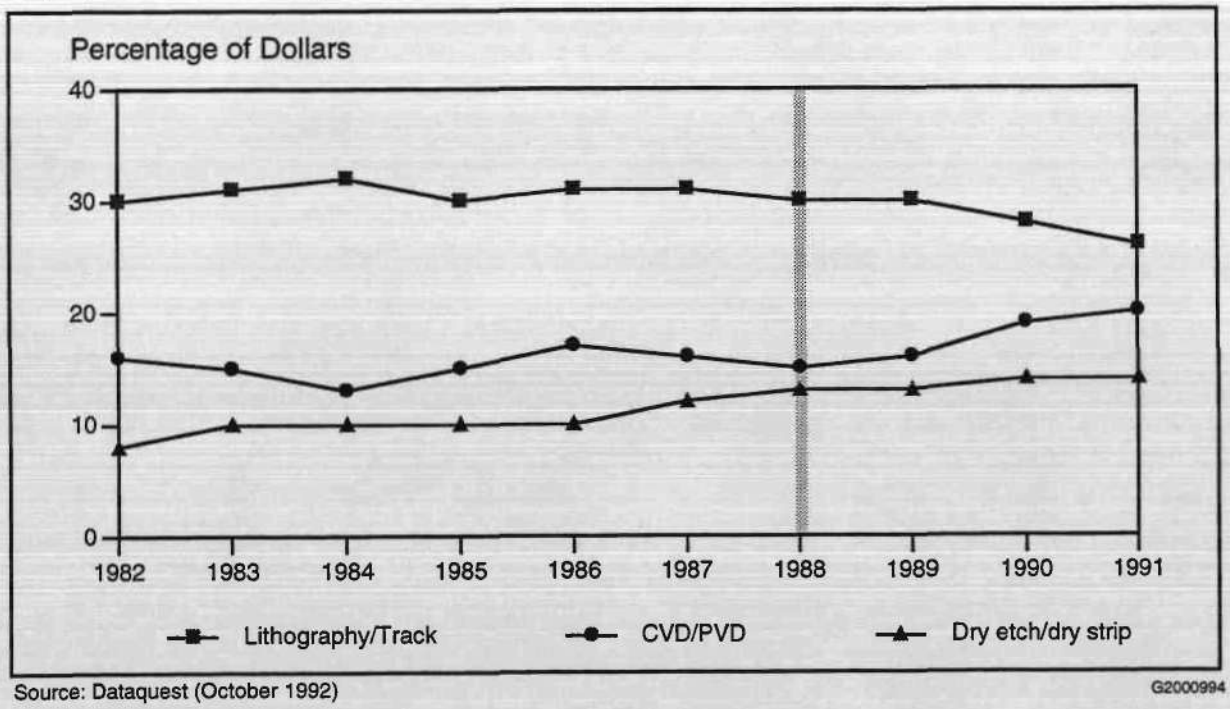
What has been the historical trend in the percentage share of total wafer fab equipment spending for the major wafer fab equipment segments?

A

Figure 5 shows the historical market trends for three major segments of equipment as a percentage of total wafer fab equipment spending. A line at the year 1988 distinguishes what we believe are two different periods of market behavior. Throughout much of the early and mid-1980s, lithography and track equipment maintained essentially a constant 30 percent slice of the total equipment spending pie. The combined categories of CVD and PVD during this same period have varied somewhat on the order of 1 to 2 percentage points per year. The etch/strip categories of equipment essentially have maintained a constant level with some modest increases noted beginning in the mid-1980s.

Clearly, though, in the last three to four years, lithography/track equipment spending has declined as a percentage of the total while CVD/PVD equipment has garnered a larger and larger portion of total wafer fab equipment spending. Part of the explanation for this can be directly correlated with the move to multilevel metallization schemes for ASICs and advanced logic, and now to DRAMs for the 4Mb shrink and the 16Mb products.

Figure 5
Major Equipment Segments as a Percentage of Total Wafer Fab Equipment Spending



Source: Dataquest (October 1992)

G2000994

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A second component of our explanation for this market trend is the consideration of system throughput. Stepper manufacturers have aggressively worked to increase wafer throughput and to improve overall equipment productivity. At the same time, there has been a significant emphasis in the CVD arena to move from batch to single-wafer systems, which has had a net effect of reduced throughput for a given unit of CVD equipment. We believe that these two factors are the major reasons behind the increase in CVD/PVD spending over the last several years.

Peggy Marie Wood

Q12

I have been reading a lot about multimedia, and MIDI is often referred to. What is MIDI?

A

In the early 1980s, a group of electronic keyboard/synthesizer manufacturers got together and developed a standard that would allow keyboards, sound modules, and signal processing gear to "talk" to computers and each other. This resulted in the protocol known as MIDI, which stands for musical instrument digital interface. MIDI has evolved into one of the most important standards in the area of electronic music and will continue to proliferate as audio, particularly music in multimedia applications, is incorporated on the desktop. MIDI protocol is unidirectional and transmits 31,250 bits of performance data per second. Carried in these digital signals is a representation of the musical performance (what took place). In other words, MIDI does not transmit the sound produced by the sound modules but the events that took place to trigger the sound modules. Though much more complex, MIDI-compatible keyboards and sound modules can be thought of as modern digital versions of the old player pianos that used scrolls of paper (performance data) to trigger the piano (sound module).

MIDI data offers several advantages over digitally recorded audio. It takes up a lot less disk space. The "compression rate" for digital audio to MIDI is about 400:1. One minute of 16-bit stereo audio uses about 10MB of memory. MIDI editing tools known as sequencing software allow a composition to be edited in endless ways unthinkable in the digitally recorded domain. The composition also can be synchronized to external devices including video, lighting, and special effects.

MIDI is an exciting and essential building block in the world of multimedia. We will explore the who, what, where, and why of MIDI in an upcoming Semiconductors Worldwide *Dataquest Perspective.*

Rick Spence

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Q13 I keep hearing about Texas Instruments aggressively protecting its intellectual property. Is this a significant source of revenue for TI or is it TI's attempt to focus the attention on something other than its poor financial performance?

A We will answer this question in two parts. First, we will address TI's revenue potential through licensing and royalties.

As Table 8 shows, TI's royalty income, which started in 1987, accumulated nearly $1 billion through 1991. Early indications in 1992 suggest that this run rate may increase. Although the royalty income of 1991 was only 3.8 percent of TI's revenue, it is nearly dropped straight through to the bottom line. Royalty income in 1989 represented more than half of TI's net income. Without this income stream, 1990 and 1991 would have been much more negative. Therefore, we would rather state that TI's royalty is a significant portion of its profit rather than its revenue.

Table 8
Texas Instruments' Royalty Income
(Millions of Dollars)

Year	Royalty Income ($M)
1987	191
1988	152
1989	165
1990	172
1991	256

Source: Texas Instruments' annual reports

The second part of the question related to TI's recent financial performance. We would say that TI's recent financial performance has been relatively good and is indicative of a company at the beginning of a turnaround.

Jerry Banks

Q14 What is the ranking for the top 10 Japanese semiconductor distributors and their product lines?

A See Table 9.

Satoshi Oyama

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Table 9
Top 10 Japanese Semiconductor Distributors and Their Product Lines

	Distributor	Major Product Lines
1	Ryosan	NEC
2	Ryoyo Electro	Mitsubishi, Intel, Hewlett-Packard
3	Sanshin Electric	NEC
4	Fujitsu Device	Fujitsu, Cypress
5	Toshiba Device	Toshiba
6	Tokyo Electron	Advanced Micro Devices, Motorola, Fujitsu
7	Hitachi Micro Device	Hitachi
8	Satori Electric	NEC
9	Marubun	Texas Instruments, Motorola, Catalyst
10	Ryoden Trading	Mitsubishi, National Semiconductor, Hewlett-Packard

Source: Dataquest (October 1992)

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Dataquest Inquiry Summary

Semiconductors *Worldwide*

September 14, 1992

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This month's questions

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10. What is the status of and justification for the legislation before the United States Congress to adjust the depreciation schedule of semiconductor equipment from five to three years? 9
11. Where in the product development flow do you expect the ANSI IEEE 1149.1 boundary scan test bus to have the greatest impact? 10
12. What are the key electronic equipment companies in the five Asia-Pacific regions of China, Hong Kong, Singapore, South Korea, and Taiwan? 10

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Products

Q1 What is the latest quarterly single in-line memory module pricing in Japan?

A See Table 1, which is based on volume mean prices in Japan.

Table 1
SIMM Volume Mean Price in Japan (Yen)

Configuration	Q1/92	Q2/92	Q3/92	Q4/92
1Mbx9	5,250	4,400	3,940	3,640
512Kbx36	-	10,270	8,710	7,800
1Mbx36	-	14,950	13,650	12,480
2Mbx36	-	31,200	28,080	25,480

Note: 4Mbx16 price is about ¥2,000 less expensive than the x36 version. The price for parity check version has about a 10 percent premium.
Source: Dataquest (September 1992)

Akira Minamikawa

Q2 What is Dataquest's definition of MCM-L?

A In its market coverage of the multichip module (MCM) market, Dataquest adheres to the IPC definitions of the MCM market. MCM-L modules use PWB technology of reinforced laminates. The MCM-L category of the total MCM market represents a very low cost module with moderate performance improvements over single-chip designs. The laminate designs will serve 50-MHz to 60-MHz systems. Design applications for the MCM-L category are expected to be newer miniature-designed PCs such as pocket computers, as well as memory modules such as stackable memory designs, and multiple COB design applications with low I/O and lower speed demands. A comparison of individually packaged chips with MCM-L designs indicates that costs should be comparative if the module yields are good.

Mary Ann Olsson

Q3 What are the estimated 4Mb DRAM shipments for the first half of 1992?

A See Table 2.

Lane Mason

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Table 2
Estimated 4Mb DRAM Production Rates, 1991-1992 (Millions of Units)

	1991	Q1/92	Q2/92
Fujitsu	12.8	5.4	5.8
GoldStar	2.6	4.0	5.0
Hitachi	26.0	11.1	12.7
Hyundai	3.8	2.6	4.0
Intel	0	0	0
Matsushita	1.6	1.0	1.1
Micron Tech	1.8	1.5	3.1
Mitsubishi	13.2	7.4	9.5
Motorola	2.6	1.6	1.9
NEC	16.6	7.8	9.5
NMB	0.2	0.1	0.1
Oki	8.3	4.1	5.0
Samsung	21.0	12.5	16.5
Sanyo	0	0	0.1
Sharp	0.4	0.3	0.3
Siemens	3.9	3.1	3.8
Texas Instruments	7.8	5.4	7.6
Toshiba	22.0	9.8	11.7
Vitelic	0	0	0
Total	144.6	77.7	97.7
ASP ($)	17.62	13.00	11.70
Revenue ($M)	2,548	1,010	1,143

Source: Dataquest (September 1992)

Markets and Applications

Q4 What is the size of Japanese semiconductor gas market?

A See Table 3.

Kunio Achiwa

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Table 3
1990 Japanese Semiconductor Gas Market
(Millions of Dollars)

Bulk Gas	
Nitrogen	189.8
Hydrogen	32.5
Oxygen	10.0
Argon	18.7
Bulk Gas Total	251.0
Specialty Gas	
Silicon Precursor	30.3
Dopant	13.4
Etching	20.7
Reactant	6.2
Others	1.1
Specialty Gas Total	71.7
Total Japanese Gas Market	322.7

Source: Dataquest (September 1992)

Q5 Who were the top 10 semiconductor suppliers to the communications market for 1991?

A See Table 4.

Gregory Sheppard

Table 4
Worldwide Semiconductor Shipments to Communications Applications
(Millions of Dollars)

	1990	1991	Growth (%) 1990-1991
Motorola	896	1,027	14.6
NEC	783	859	9.7
Toshiba	624	687	10.1
Fujitsu	624	649	4.0
AT&T	539	520	-3.4
Hitachi	457	452	-1.1
Texas Instruments	397	411	3.5
SGS-Thomson	352	359	2.0
National Semiconductor	364	352	-3.2
Philips	297	303	2.1
Top 10 Total	5,333	5,620	5.4

Source: Dataquest (September 1992)

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Q6

Can you provide some insight on the cache-tag RAM market?

A

Few markets are as shrouded in obscurity as the cache-tag RAM market. This comes from a lack of deep study by market research companies because of the market's low sales and small number of contributors.

Dataquest estimates the worldwide cache-tag market to be between U.S.$10 million and U.S.$20 million. This is in sharp disparity, we are told, with the figure from our competitor, In-Stat, which estimates the market to be about $110 million. Why the difference? Because Dataquest reports only those specialty SRAM devices designed to be cache-tags, whereas we hear that the In-Stat number includes standard SRAMs used in cache-tag applications. This is not necessarily a bad approach, because it is an indication of the available market. However, the Dataquest figure is meant only to state the actual market for the specialty devices themselves, rather than to include alternatives.

The market for cache-tag SRAMs has not thrived, even though devices have been available from the cache-tag pioneer, Texas Instruments, since about 1984. One good reason is that these devices are rarely multiply sourced. Thus system designers are inclined to use alternative routes when designing caches, in order to keep costs down (sole-sourced devices are not subject to competitive pressures as fiercely as are widely sourced devices). These alternatives come in several forms, driven quite simply by the vast number of ways that exist to partition cache designs. A cache-tag RAM is a somewhat standard SRAM with a high-speed comparator incorporated. Some designs use a standard SRAM with an external comparator as an alternative, and others put the comparator into an ASIC, along with the other logic required to implement the cache. Finally, some designers absorb both the comparator and the SRAM into a cache controller chip.

Dataquest does not expect any big changes in this scenario. Companies that now offer cache-tag SRAMs will continue to offer them, but some may choose not to add new offerings. Few new manufacturers are expected to join the fray, and we do not expect this market to ever reach the $100 million mark.

Jim Handy

Q7

What is Dataquest's analysis of the semiconductor market in Latin America?

A

The Latin American semiconductor market is increasingly interesting, with the coming of more open, market-oriented economies. Last year, Brazil made significant reductions in its long-standing trade barriers, opening the market for sales of foreign computers, telecom equipment, and components, and for foreign investment. Argentina, Mexico (especially with the coming North American Free

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Trade Agreement, or NAFTA), and Chile are also increasingly attractive for investment and sales opportunities.

Many are prone to dismiss Latin America because of its government policies and relatively lower per-capita incomes. But with a combined population of 450 million, a substantial middle class of final consumers is spread through Latin America. Liberalized investment policies will certainly act to increase the domestic electronics production and semiconductor consumption.

Brazil, with a population of 165 million, is by far the largest semiconductor market. According to a recent report by the American Consulate in Rio de Janeiro, the Brazilian IC market for 1991 was estimated to be about $460 million (up to 50 percent larger if illegal imports were included). The reduction of stiff import restrictions will undoubtedly move "contraband" into legitimate channels.

According to U.S. Department of Commerce export-import data, U.S. net exports of semiconductors to Mexico in 1991 were about $85 million, and the overall consumption may be 1.5 to 2.5 times that amount, if all net sales into Mexico from other countries are included. The Argentine market is about $80 million to $100 million, and the markets of other countries are smaller still. Argentina and Brazil also have some domestic semiconductor production capabilities, which are largely confined to older bipolar technologies.

For Mexico, NAFTA should be a significant stimulus to investment and consumption for semiconductors throughout the decade.

Lane Mason

Q8 What is collimated sputtering and what effect will it have on the CVD metal market?

A Collimated sputtering is a technique in which a collimator, which is a type of filter, is placed between the sputtering source and the wafer in a conventional sputtering system. The collimator only permits metal atoms to pass that are nearly perpendicular to the wafer, and blocks divergent atoms. The result is that metal deposition can be realized in small, high-aspect-ratio contacts and vias with excellent step coverage. Experimental studies have successfully deposited metal into contacts with aspect ratios as high as 7:1. However, for practical applications, the technique will probably not be economical beyond the 0.35-micron technology generation, which will utilize via aspect ratios of between 2:1 and 3:1.

Dataquest believes that the dominant applications for collimated sputtering will be the deposition of diffusion barrier materials and adhesion layers for CVD tungsten deposition. The most widely used materials are Ti/TiN or TiW for diffusion barriers, and TiN for the tungsten adhesion layer. Collimated sputtering has several inherent advantages over CVD for these materials. The film is deposited at

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low temperature, possesses known properties, and utilizes a mature equipment technology with a relatively inexpensive modification. The only major drawback is that the net deposition rate is reduced by the collimator, thereby reducing throughput. The collimator also presents a potential source of particles, but existing techniques for particle control should prevent that from becoming a serious problem.

The net result is that the Ti and TiN sputter applications market will grow at a healthy rate, at least through 1996. Table 5 shows the forecast revenue growth in the sputter market segmented by film application. The market for Ti and TiN sputtered films is expected to grow at 16.7 percent and 19.1 percent CAGR, respectively. This growth will be driven by the increased use of Ti/TiN barriers and tungsten for contact/via plugs and interconnect in process flows as a greater fraction of the fab capacity shifts to 0.35- to 0.5-micron technology levels. Dataquest therefore believes that the market for CVD TiN will not begin to develop until the 1995-1996 time frame.

Charles Boucher

Table 5
Worldwide Sputtering Equipment Market Forecast, by Film Application (Millions of Dollars)

Sputtered Film	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Aluminum Alloys	281	265	290	339	394	452	10.0
TiW	24	20	21	20	20	22	-1.8
TiN	42	45	53	69	85	102	19.6
Titanium	55	57	67	85	102	120	17.1
MoSix	15	12	10	10	11	12	-4.0
WSix	8	8	9	10	11	12	8.2
Other Films	13	11	11	11	12	13	0.1
Total Worldwide	438	416	460	546	637	734	10.9

Source: Dataquest (September 1992)

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Company and Other Issues

Q9 In reviewing Dataquest's recent capital spending forecast and semiconductor production forecast, we noticed that the ratio of capital spending to production in the United States has dropped. Please explain your reasoning behind this trend.

A The reasoning is as follows:

- In the short run, the worldwide overcapacity situation means that revenue can grow without additional capacity.
- Over the longer term, Dataquest expects device makers to focus on raising their fab utilization rates. National is a good example. It has gone from 55 percent utilization to more than 70 percent by closing older fabs. Further evidence of this trend is the increased level of fab closures in the United States (19 in the last two years).
- Dataquest believes that the number of "green-field" sites in the United States will decline dramatically from historical levels. Consequently, land purchases and building infrastructures will decline as companies focus more on upgrading or retrofitting existing facilities.
- Military capital spending is expected to decline. Though small, these cuts will pull down the ratio because military capital spending is high relative to the IC revenue generated.
- Though equipment ASPs are increasing quickly, we expect productivity gains to keep ahead of the ASP curve. The sharp decline in the annual unit shipment of steppers is a prime example.
- The growing trend toward alliances as evidenced by the recent spate of announcements will spread the capital investment over several companies, thereby slowing capital spending.

Table 6 provides the historical ratio of U.S. capital spending to U.S. production. Table 7 provides the forecast ratio of U.S. capital spending to U.S. production.

Mark FitzGerald

Table 6
Historical Ratio of U.S. Capital Spending to U.S. Production, Merchant and Captive Semiconductor Company Data (Millions of Dollars)

	1985	1986	1987	1988	1989	1990	1991
Device Production	12,654	14,456	16,712	20,171	21,324	22,789	25,103
Capital Spending	2,629	2,082	2,594	3,434	3,875	4,088	3851
Capital Production (%)	20.8	14.4	15.5	17.0	18.2	17.9	15.3

Source: Dataquest (September 1992)

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Table 7
Forecast Ratio of U.S. Capital Spending to U.S. Production, Merchant and Captive Semiconductor Company Data (Millions of Dollars)

	1992	1993	1994	1995	1996
Device Production	27,695	31,136	34,542	36,063	38,592
Capital Spending	3,559	3,754	4,344	4,883	5,688
Capital Production (%)	12.8	12.1	12.6	13.5	14.7

Source: Dataquest (September 1992)

Q10 What is the status of and justification for the legislation before the United States Congress to adjust the depreciation schedule of semiconductor equipment from five to three years?

A In October 1991, legislation was introduced in Congress to address the gap in capital spending between the United States and Japan by adjusting the depreciation schedule of semiconductor equipment from its present level of five to three years. Dataquest understands that there are 80 sponsors of the bill in the House of Representatives and 30 sponsors in the Senate. The bill has been submitted to the appropriate committees of Congress, including the powerful House Ways and Means Committee. Dataquest understands that as yet, there has been no action on the bill because the committees have not been allowing any new issues for review. Because the November general election looms, Dataquest believes that it is unlikely that any action on this bill will be taken until the end of the year or in early 1993.

The main justification for going to a three-year depreciation schedule is that the technological life of a majority of semiconductor equipment is less than five years. The pace of technological change is the main driver behind this rapid rate of obsolescence. Thus, the window in which semiconductor manufacturers can hope to recover their investment is very narrow. Another justification for a three-year depreciation schedule is to offset the tax advantages of the United States' competitors. For example, if a Japanese semiconductor manufacturer operates its equipment more than eight hours per day, it can write off up to 50 percent of the equipment cost in the first year, compared with 32 percent written off in the United States. This difference represents a significant advantage because most Japanese manufacturers have 24-hour-per-day operations. Also, Japanese manufacturers can recover 100 percent of the equipment cost in one year if the equipment is utilized for a joint R&D venture. Tax policy is clearly a key competitive issue for the semiconductor industry because of the high capital costs associated with device manufacturing.

Peggy Marie Wood
Julie Ruiz

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Q11

Where in the product development flow do you expect the ANSI IEEE 1149.1 boundary scan test bus to have the greatest impact?

A Boundary scan's impact will be in the debug of system-level products. Research by Dataquest shows that electronic designers would like to shrink their board-level design cycle by 30 percent over the next three years. Indeed, after board prototypes are received, more than 50 percent of electronic designers in North America find that functional violations consume more debug time than timing errors, and boundary scan will be a key element in reaching the designers' time-to-market reduction goal. Semiconductor manufacturers will need to continue to broaden their offerings of JTAG-compliant devices to help shorten the electronic designers' product development cycle.

Bob Beachler

Q12

What are the key electronic equipment companies in the five Asia-Pacific regions of China, Hong Kong, Singapore, South Korea, and Taiwan?

A See Table 8.

Table 8
Key Asia-Pacific Electronic Equipment Companies, by Application

Country Field	Application
China	
AEG China Ltd.	Industrial
Apple Computers	Computers
AT&T of Shanghai Ltd.	Telecommunication
Beijing IC Design Center	SC
China Huajing Electronics Group	SC
Chinatron Corporation	LCD
Dazix	EDA
General Electric	Telephones
Hewlett-Packard	Data processing
Hewlett-Packard	Industrial
IBM	PCs/motherboards
Magtron (Taiwan)	Data processing
Mitsubishi	Consumer
Philips	Consumer
Philips	Data processing

(Continued)

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Table 8 (Continued)
Key Asia-Pacific Electronic Equipment Companies, by Application

Country Field	Application
China (Continued)	
Philips Semiconductor Corporation	Semiconductors
Shangai Belling Microelectronics Manufacturing Ltd.	Semiconductors
Shanghai Bell	Communication
Sharp	Consumer
Siemens A.G.	Communication
Stone Group	Data processing
Toshiba	Consumer
Varitronnix International	Consumer
Hong Kong	
AST Research	Computers
General Electric	Communication
Informtech	Motherboards
Informtech Ltd.	Data processing
Porro Technologies	Motherboards
Porro Technologies Ltd.	Data processing
Renful International	Data processing
Semi-Tech	Motherboards
Universal Code Ltd.	Data processing
Video Tech	PCs/games
Singapore	
AIWA	Audio
Apple Computers	Computers
Compaq	Invest PCB
Conner Peripherals	Data processing
Fujitsu	Data processing
General Motors	Automotive/radios
Giant Fujitsu	Telecommunication
Hitachi Electronic Devices	Invest capacitors
Integrated Peripherals (Colorado)	Data processing
International Applications Solutions (IBM/Hong Kong Leong)	Data processing
Matsushita Refrigeration	Invest refrigerator
Maxtor	Data processing
Miniscribe	Data processing
Ministor Peripherals	Data processing
Motorola	Pagers
Murata	Components

(Continued)

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Table 8 (Continued)
Key Asia-Pacific Electronic Equipment Companies, by Application

Country Field	Application
Singapore (Continued)	
Seagate	Data processing
Seiko	Clocks
Sony Precisions Engineering	Video
Toshiba Data Dynamics	Data processing
Western Digital	Data processing
South Korea	
Daewoo	Consumer
Daewoo Telecom	Telecommunication
Datacommunications Corporation	Telecom
Electronic and Telecommunications Research Institute (ETRI)	Government
ETRI	Communication
Europe	VCRs
Goldstar Electron	Consumer
Goldstar Information Communications Co. Ltd.	Telecommunication
Hyundai	Consumer
Korea Telecom	Telecommunication
Korean Telecommunications Authority (KTA)	Telecommunication
Korean Aerospace Research Institute (KARI)	Aerospace
Koryo Systems	Computers
Oriental Telecommunication Co.	Telecommunication
Samsung	Consumer
Samsung Aerospace (with General Dynamics)	Aerospace
Samsung Electronics Company	Telecommunication
Taiwan	
Accys Technology Corporation	Telecommunication
Acer Inc.	Computers
Action Electronics Company Ltd.	Aerospace
Aquarius Systems Inc.	Computers
ARC	Computers
Arche	Computers
AST	Computers
Atari	Computers
Auto Computer Corporation	Computers
Autocomputer	Computers
Capital Spending	R&D
CCL	Computers

(Continued)

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Table 8 (Continued)
Key Asia-Pacific Electronic Equipment Companies, by Application

Country Field	Application
Taiwan (Continued)	
Centron Electronics Co. Ltd.	ISDN
Chen Tech Taiwan Industries Corporation	Military/aerospace
Chicony Electronics Corporation	Computers
Commodore	Computers
Compall Electronics Inc.	Computers
Copam Electronics Corporation	Computers
Datatech Corporation	Computers
Elite (Computer) Group	Motherboards
Elitegroup	Computers
EMMT Systems Corporation	Aerospace
Far East Machinery Company Ltd.	Industrial
First International Computer Corporation	Computers
Great Electronics Corporation	ISDN
Industrial Technology Research Institute (ITRI)	Aerospace
Kingtel Telecommunications Ltd.	ISDN
LEO	Computers
Masbe Corporation Ltd.	Aerospace
Microelectronics Technology Inc.	Aerospace
Microsoft	Software
Microtek	Premise
Mitac	Computers
Nantan Computer Corporation	Computers
NEC	Computers
Northman Company	Aerospace
Sampo	Computers
Sharp Flat Panel Display Manufacturing Co.	LCD
Sun Moon Star Co. Ltd.	ISDN
Synopsis Inc. (US)	Components
Systex	Computers
Taichung Machinery Works Company Ltd.	Industrial
Taicom	ISDN
Taiwan Aerospace	Aerospace
Taiwan Telecommunications Industry Co.	ISDN
Tatung	Aerospace/computers
Thunder Tiger Model Company	Aerospace
Twinhead International Corporation	Computers

(Continued)

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Table 8 (Continued)
Key Asia-Pacific Electronic Equipment Companies, by Application

Country Field	Application
Taiwan (Continued)	
Vita Technology	Motherboards
Wyse	Computers
Zenith	Computers

Source: Dataquest Taiwan (September 1992)

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Conference Announcement

Dataquest's 18th Annual Semiconductor Industry Conference

Each October, Dataquest brings together the top executives in the electronics industry for a forum on the latest issues facing this industry. This year's conference will focus on today's semiconductor marketing and technology issues, and preview tomorrow's major semiconductor applications that are *Fueling the Engines for Growth.*

Highlights of the conference are as follows:

- Special guest speaker: David Packard, Cofounder and Chairman of the Board of Hewlett-Packard.
- Eleven top industry executives sharing their insightful perspectives, real-world experiences, lessons, and bottom-line analyses.
- Two interactive panel discussions covering ASICs and strategic processor directions. Panels will be moderated by Dataquest and feature key industry leaders.
- Four breakout sessions presented by Dataquest senior analysts. The sessions will focus on manufacturing trends, semiconductor procurement issues, and two emerging applications areas: personal information and communications devices (PICDs), and multimedia.

In addition to the presentations and panel discussions, this year's agenda has been designed to allow social time for conferring with your peers on the critical issues and challenges facing the industry. You'll find the two days interesting, very informative, and, we hope, thoroughly enjoyable.

Seats are limited for this premier semiconductor event. To register for this conference, or to request a complete conference agenda, please call our toll free number, 1 (800) 457-8233, today!

Semiconductor Industry Conference

Monterey Conference Center
Monterey, California
October 5 and 6, 1992
Dataquest Client Rate: $1,095
Nonclient Rate: $1,295

Conference Registration Desk

Telephone (Toll Free): 1 (800) 457-8233
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Dataquest Inquiry Summary

Semiconductors

August 24, 1992

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For more information, call your Dataquest Analyst.

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Products

Q1 What is happening with 1MB slow static RAMs?

A The year 1991 was peculiar in the static RAM (SRAM) business. In most years there is a relatively predictable progression from one SRAM density to the next. In 1991 things came almost to a halt. Although 1MB SRAMs were widely available, system manufacturers were not changing their designs over to the new density. This really surprised SRAM vendors, who lowered the price of the 1MB device to below per-bit price parity with the 256K device—without the expected result.

Suddenly, in the first quarter of 1992, the megabit market heated up and took off. Dataquest believes that this was an adjustment to make up for the lack of acceptance in 1991. Current shipment levels of 1MB SRAMs as a percentage of overall SRAM shipments are where they would have been expected to be in 1992, given historical life cycles, despite the lack of acceptance in 1991. It appears that system manufacturers were postponing the manufacturing phase-in of new designs as a cost-reduction measure in 1991, and in 1992 have finally cut loose. This even appears to be the case in Japan, despite that nation's economic woes. The conversion is back on track.

This phenomenon did not occur in the tiny existing market for 1MB fast SRAMs, mostly because of the small size of the market (less than $200 million worldwide in 1991). 1MB fast SRAMs are almost never used in the major fast SRAM market, which is cache memories on PCs. This somewhat removed the sales dependency of the device on consumer spending patterns, and being less of a commodity, the device tends to sell into the less volatile capital equipment market.

By Jim Handy

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Q2 What impact will the industry capacity-demand balance have on DRAM price trends for the next several quarters?

A DRAM prices came down fast in the first half of 1992, despite strong unit demand, because of the uncharacteristically weak Japanese market in fourth quarter of 1992 and the first quarter of 1992, and the rapid rise of Goldstar and Hyundai. Following Micron's antidumping petition, prices resumed their downward trend, albeit at a slower pace.

Demand continues to be rather strong, despite the fact that Japan is still underconsuming, by recent historical standards. Most analysis points to increased DRAM use in newer PCs, with Windows 3.1. The migration to 486 and memory-intensive software have demonstrated the ability to increase DRAM demand with only modest growth in PC units. Workstations and telecom are also indicated as strong markets for DRAMs.

Uncertainty pervades the thinking of buyers and sellers alike. Distribution is getting a disproportionate share of the overall DRAM business, and most suppliers are loath to add further capacity, though all are increasing production in existing facilities. Japanese capital spending for 1992 is expected to be off sharply (down 30 percent compared to 1991). After more than six months of relatively good business, there is still cause for concern as to whether this upturn is real. So let's wait.

On the supply side, Texas Instruments is now bringing into play some vast capacity it built from 1989, including in Avezzano, Italy (more than 1.2 million 4Mb DRAMs per month now), about 500K 4Mb DRAMs per month from Acer (with more than 1.2 million by year-end), and 16Mb DRAMs from Kobe and Dallas 4.2. Add to this more than 2 million 4Mb DRAMs from Miho, and another 9,000 200mm starts from TECH early in 1993, and TI could be a major player, again, in the DRAM market.

IBM is a big unknown, but is expected to somehow be a DRAM player in the not-too-distant future. Korea is running at near capacity and adding additional fabs. Micron is at its maximum and can increase output only by die shrinks and masking level simplification, which is going quite well.

Japan is consistently reported as running at about 50 percent of 4Mb DRAM capacity. Capital spending in Japan has been rather flat for two years, and barely approached the levels (yen base) of the 1984 to 1985 peak period. Additionally, fab yields are already high (75 to 90 percent probe and 70 percent line yields), leaving little headroom for increases in unit shipments without running more silicon. Finally, all DRAM makers are now running advanced 4Mb products on the trailing edge of their 16Mb processes, for smaller die and better performance.

All things considered, there appears to be clear sailing for the remainder of the year, with continued moderate price erosion.

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However, a steadily growing market for 1993 and 1994 will certainly need more facilities in place to keep a balance in the market. If not, look for slower price declines, and improving profits at DRAM makers.

By Lane Mason

Markets and Applications

Q3 What are the sizes, in units, of the key U.S. household appliance markets, and who are the manufacturers (not brand names)?

A Table 1 lists the breakout according to *Appliance Magazine*, the source we use.

Table 1
Key Household Appliance Markets

Company	Market Share (%)
Air Conditioners (4.4 million units)	
Fedders	23
Electrolux	19
Whirlpool	19
Matsushita	8
Others	31
Coffee Makers (17 million units)	
Mr. Coffee	28
Black & Decker	20
Wear Ever	16
Braun	9
Others	27
Dishwashers (3.6 million units)	
General Electric	40
Whirlpool	32
Electrolux	20
Others	8
Dryers (Electric) (3.3 million units)	
Whirlpool	51
General Electric	17
Maytag	15
Others	17
Washers (6.2 million units)	
Whirlpool	51
Maytag	18
General Electric	16
Others	15

(Continued)

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Table 1 (Continued)
Key Household Appliance Markets

Company	Market Share (%)
Refrigerators (7.1 million units)	
General Electric	34
Whirlpool	23
Electrolux	20
Maytag	12
Others	11

Source: Appliance Magazine

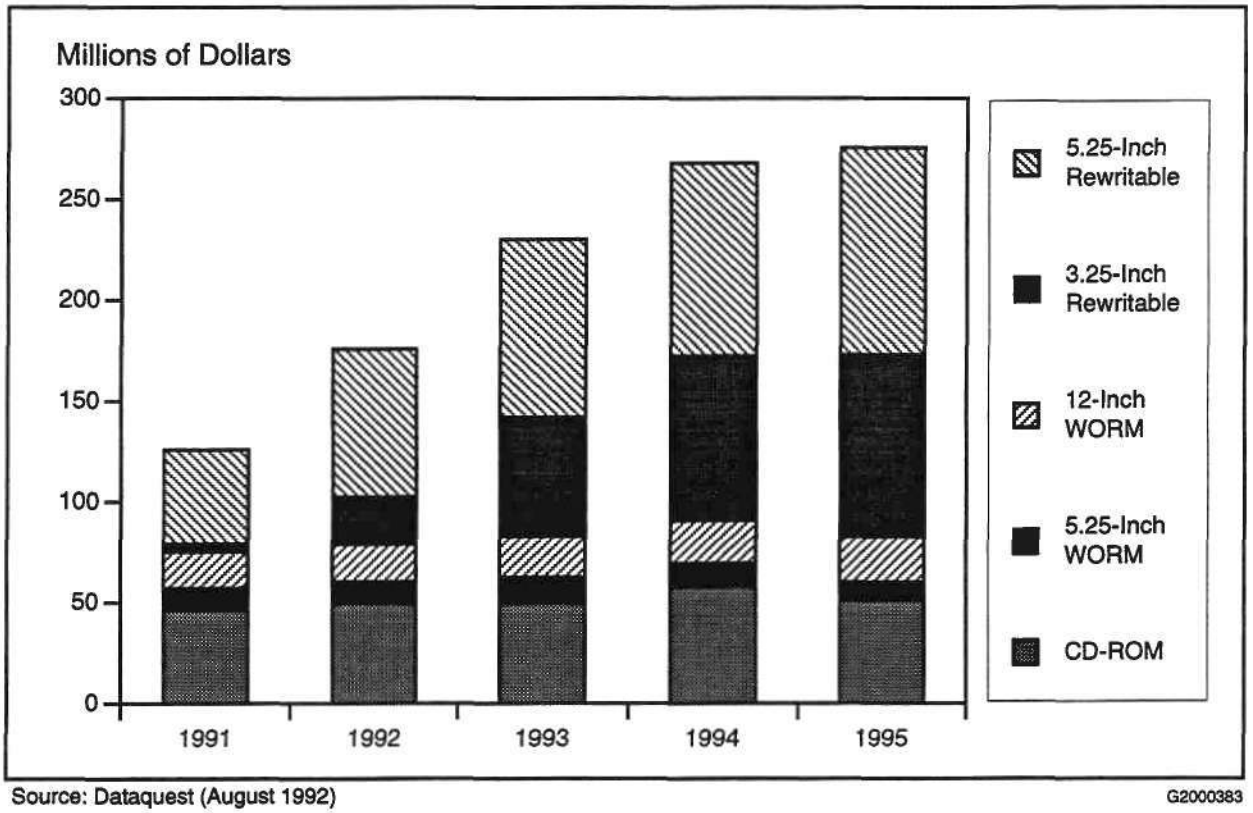
By Gregory Sheppard

Q4 What are the semiconductor opportunities in the optical disk drive market?

A Figure 1 shows the worldwide total available market (TAM) for semiconductor vendors by drive type. The CD-ROM and 3.5-inch rewritable drives present the most promising opportunities.

By Nicolas Samaras

Figure 1
Worldwide Semiconductor TAM, Optical Disk Drives



Source: Dataquest (August 1992)

G2000383

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Table 2
Use of BiCMOS ASICs

	% Using BiCMOS ASICs	
	Today	Next Generation
Military	18	44
Total Computer	10	42
RISC Designers	29	50

Source: Dataquest (August 1992)

Table 3
Estimated Gate Array Consumption, by Technology (Millions of Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total	1,339	1,405	1,527	1,738	1,990	2,277	2,600	13.1
MOS	873	947	1,051	1,240	1,451	1,669	1,902	15.0
Bipolar	431	410	406	390	366	341	310	-5.4
BiCMOS	35	48	70	108	173	267	388	51.9

Source: Dataquest (August 1992)

Q5 Who is using BiCMOS gate arrays and what is Dataquest's latest forecast for BiCMOS gate arrays in North America?

A According to Dataquest's end-user survey of more than 260 system designers in North America, military and RISC computer designers are the largest users to date. When asked their plans for next-generation system design, we noted that a large number of designers plan to use some BiCMOS ASIC in their next-generation system (see Table 2).

Table 3 shows Dataquest's new gate array forecast, which was released in July 1992.

By Bryan Lewis

Q6 What are the main applications of slow SRAM and fast SRAM?

A Figure 2 shows that about 40 percent of slow SRAM is used for storage applications in disk drives, printers, VCRs, copiers, and transportation, and that 25 percent of slow SRAM is consumed for buffering products in printers, plotters, monitors, and computers. Another 20 percent goes into battery-supported laptop PCs, data scanners, POS systems, and portable instruments. The remaining 15 percent is used for main memory in games, memory cards, and computers.

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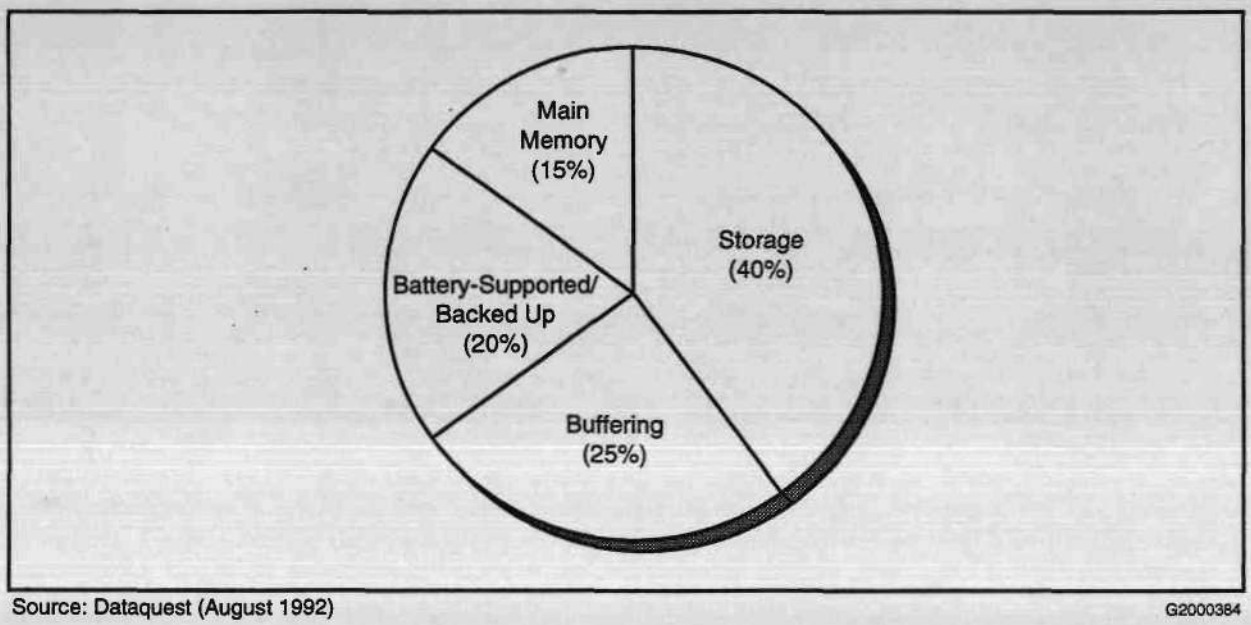
Figure 3 shows fast SRAM applications. Half of the total fast SRAM is used as a cache for workstations and high-end PCs, and 20 percent of fast SRAM is used for buffering in mass storage, disk drives, and laser printers. Supercomputers and mainframes consume about 15 percent of fast SRAM for main memory.

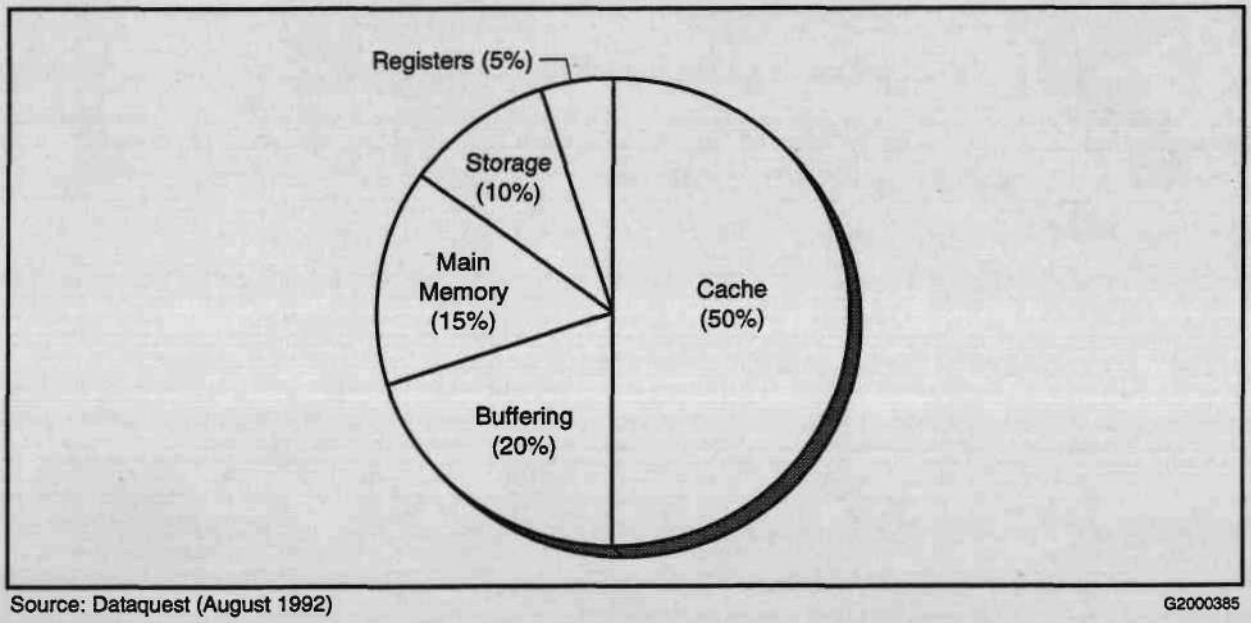
By Akira Minamikara

Figure 2
Worldwide Slow SRAM Applications



Source: Dataquest (August 1992) G2000384

Figure 3
Worldwide Fast SRAM Applications



Source: Dataquest (August 1992) G2000385

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Technologies

Q7 What is driving the move to low-voltage power supplies?

A The current drive for low-voltage standards is being driven by the power and weight requirements of notebook and subnotebook PCs. The industry is currently struggling to work out the problems associated with moving to the first low-voltage standard of 3.3V. Standards are beginning to firm up and product availability is beginning to improve, but most of this product is simply a recharacterization of 5V products. We have yet to see optimized 3.3V products based upon optimized 3.3V processes. As a result, today's 3.3V products are much slower than their 5V counterparts (as much as 50 percent slower for logic). We do not expect to see general availability of 3.3V products until late 1992. As a result, we do not expect to see significant shipments of systems based upon a 3.3V standard until 1993.

The new category of hand-helds, or personal information/communications devices (PICDs) will initially start out in the 3V range because many of the components for this market are being designed for the 3.3V standard. This arena will be a battle among performance, power consumption, and price. PICDs that are pen-based will require powerful processors to perform script recognition. Operating such devices below the 3.3V standard seems unlikely in the short term, because of the degraded performance such a move would bring. PICDs that use keyboard entry of some sort can probably get away with the lower performance of a sub-3.3V power supply. It is also very likely that these sub-3V devices will be designed to operate using standard alkaline batteries (for example, Hewlett-Packard's 95 series) with a small backup cell. As a consequence, these electronic components must be able to work over an unregulated voltage range of 2.0 to 3.3V, rather than the regulated specification of 3.3V ±10 percent. It is highly unlikely that these very low voltage devices can afford the inefficiencies, cost, size, and weight of a voltage regulator.

By Jerry Banks

Company and Other Issues

Q8 Concerning systems houses purchasing IC layout tools, what percentage of ICCAD revenue has come from nonsemiconductor houses?

A "IC Layout Market Continues to Stumble" in Vol. 1, No. 3 of the EDA Applications *Dataquest Perspective* described end use of IC layout tools. Table 4 shows the percentages for 1990. Dataquest does not expect this mix to shift dramatically over the next three to five years.

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Table 4
1990 Worldwide IC Layout Software End-User Market Segmentation

	Percentage
Semiconductor	55.8
Computer	12.1
Consumer	10.6
Telecom	7.1
Mil/Aero	4.4
Automotive	3.0
Industrial Control	1.8
Other	5.2

Source: Dataquest (August 1992)

By Bob Beachler

Q9 What are the main impediments to systems houses internalizing IC design?

A The main impediments are tool price and emergence of floorplanning tools.

As for tool price, the high cost of IC layout tools will continue to hinder their acceptance by systems houses. The systems house must have a burning need to bring IC layout in-house. Additionally, as silicon area becomes less expensive and systems houses begin to use software as more of a market differentiator and value added, there is less need for squeezing out the last square micron of space. Yet, even if the price were to come down, Dataquest believes that there is limited elasticity in the IC layout market because of the investment that would need to be made by systems houses in training and support of IC design.

The emergence of floorplanning tools will relieve some of the pressure to bring IC layout tools in-house, as floorplanners will be increasingly used as a "bridge" to convey information between front-end design and back-end layout, especially timing information, as timing-driven design becomes more accepted. Yet one may classify floorplanners as an ICCAD design tool, in which case the purchase of IC tools by systems houses would increase.

By Bob Beachler

Q10 Who were the top semiconductor-specific capital spenders in 1991 and 1992?

A Table 5 lists the top capital spenders.

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Table 5
1991 and 1992 Calendar Year Semiconductor Capital Spending Estimates (Merchant) (in Millions of U.S. Dollars), Top 10 Rankings

	1991 Rank	1991	1992 Rank	1992
Intel	2	948.0	1	1,000.0
Fujitsu	1	1,147.2	2	769.6
Samsung	8	530.0	3	730.0
NEC	4	752.2	4	654.2
Toshiba	3	789.3	5	654.2
Motorola	5	673.0	6	550.0
Hitachi	7	646.0	7	500.3
Mitsubishi	6	664.5	8	461.8
Goldstar	11	410.0	9	380.0
Sony	9	519.8	10	365.6
Matsushita	10	462.6	11	344.8

Source: Dataquest (August 1992)

By Mark FitzGerald

Q11 For the third quarter of 1992, Dataquest's SPS forecast of North America bookings pricing estimates a price of $11.05 for 4Mbx1 DRAM 80ns SOJ in contract volume of 100,000 to 200,000 units. What is the methodology behind this price forecast?

A The Semiconductor Procurement Service (SPS) quarterly price survey provides information and forecasts for the North American bookings prices of more than 200 semiconductor devices. For the price forecast, SPS provides detailed specifications regarding each device's speed, configuration, package, and volume. We base the forecast on North American bookings price information collected on a quarterly basis from North American suppliers and major buyers of these products. The methodology described as follows pertains in general to all products covered in the survey. However, some product-specific differences do exist.

The survey begins with Dataquest sending the prior SPS quarterly price forecast for updating purposes to survey participants. For example, regarding DRAM, the survey pool includes a combined total of 16 to 18 users and suppliers. All user-participants are SPS clients located in North America, mainly computer manufacturers but also telecom and industrial houses. Regardless of country of origin, the suppliers that participate in the survey are located and book orders in North America. For DRAM, typically the supplier-participants included first-tier, Japan-, North America-, and Korea-based suppliers.

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Dataquest seeks the price of orders that were or will be booked in the current quarter. For example, during the most recent May to June 1992 survey, Dataquest sought the North American bookings price for ICs booked during April to May 1992. In addition, we seek user-supplier forecasts of the bookings price for strategically important quarters such as the third and fourth quarters of 1992 or the fourth quarter of 1993. From the recent survey on 4Mb DRAMs as specified earlier, we received nine survey responses on the third quarter 1992 price—which ranged from just under $11 to $11.50. The survey average was $11.08.

When all survey prices have been collected, SPS inputs the quarterly bookings prices into its database in several forms: total raw average and, for selected products such DRAMs, user raw average and/or supplier raw average. For devices in the SPS quarterly price survey that are also included in Dataquest's Online DQ Monday service (that is, world regional prices), SPS analysts Mark Giudici and Ronald Bohn compare the current quarterly price forecast against the survey raw averages and the twice-monthly North American bookings prices as published in the Online DQ Monday report. The SPS analysts also establish assumptions regarding market supply-demand trends, supplier strategies, government action, and related factors. The preliminary SPS price forecast is formulated and then presented to Dataquest's Semiconductor Product analysts—Lane Mason for DRAMs. Dataquest analysts then meet to exchange information and reconcile forecast assumptions. The SPS pricing forecast is then finalized. Shortly thereafter, the completed forecast is delivered to SPS clients via the SPS online service and in a Source: Dataquest document (entitled *North American Semiconductor Price Outlook: Third Quarter 1993* regarding the most recent forecast).

By Ronald Bohn

Q12

What is the estimated share of subcontract assembled telecom ICs in North America?

A

After surveying other subcontract assemblers as well as telecom IC manufacturers in North America, it was discovered that interest in this subject was of a worldwide scale. A quick survey of telecom ICs manufacturers worldwide revealed the information in Table 6.

Table 6
Share of Subcontract Assembled Telecom ICs

	United States % Telecom ICs	Japan % Telecom ICs	Europe % Telecom ICs
Captive Assembly	90	93	97
Subcontract Assembly	10	7	3

Source: Dataquest (August 1992)

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Although telecommunications companies in both Europe and the United States subcontract 100 percent of their telecom ICs to assembly houses, their share of the regional market is very small in comparison to the captives that assemble all of their ICs in-house. One of the largest suppliers of telecom ICs, Northern Telecommunications (NT), maintains 100 percent captive assembly. NT supports 60,000 employees worldwide and announced revenue of more than $6.8 billion in 1990. NT and Bell Canada maintain eight R&D facilities in Canada, Japan, the United Kingdom, and the United States under the name of Bell Northern.

By Mary Olsson

Q13

What is the HDTV production forecast in Japan?

A Table 7 provides Dataquest's forecast of HDTV production in unit and average selling price (ASP).

By Naotoshi Yasuhara

Q14

What is the status of the semiconductor industry in China and key joint ventures?

A Dataquest estimates that China manufactured about U.S.$313.8 million in semiconductors during 1991. We expect this figure to reach U.S.$524.8 million by 1995, largely because of joint ventures expected to come to fruition before that time.

The government's past policy supporting state-owned industries was very expensive and not profitable. To make up for policy mistakes of the past, the government started promoting the idea of joint ventures with U.S., European, and Japanese companies to acquire technology know-how. This strategy has proved more successful than the previous approach, but there are still major obstacles for the industry. One fact is that China can only provide half of the revenue-based semiconductors that it consumes. Dataquest expects the situation to worsen before it improves as the data processing segments continue to grow.

Table 7
Japanese HDTV Production Forecast

	1991	1992	1993	1994	1995	1996	2000	CAGR (%) 1992-1996	CAGR (%) 1996-2000
HDTV (Thousands of Units)	2	14	54	138	289	507	4,164	145.3	69.3
ASP (Thousands of Yen)	2,900	1,150	950	760	610	510	360	-18.4	-8.3

Source: Dataquest (August 1992)

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Dataquest is aware of more than 100 semiconductor fab and assembly facilities in mainland China. The majority of these factories are state-owned and state-run operations, but numerous joint ventures in China warrant particular attention.

Philips Semiconductor Corporation of Shanghai (PSCS) is a joint venture between Philips (Holland) and a consortium of Shanghai-owned operations. The venture was coordinated on the Chinese side by the Shanghai municipal government and was supported by the central government's ministry of Machinery and Electronics Industries. The new company of PSCS employs about 480 employees and is growing. Its technical/engineering staff numbers about 100, or 20 percent of the work force. Production was scheduled to begin in 1992 and there is reason to believe that Philips will meet its goals. Its initial main products will be consumer-related so as to supply Philips' growing number of consumer equipment factories in China. In particular, color television semiconductor components will be shipped to the numerous Philips television plants in China as well as to other interested factories. The core technology reportedly is bipolar logic circuitry. Dataquest estimates that 1992 production will reach 15 million and double to 30 million in 1993.

PSCS has had partnership agreements with Shanghai No. 19 Radio Factory, which assembles and tests consumer-related devices including bipolar TTL, HTL IC, digital interface circuitry, amplifier, small-signal transistors, and television IC assembly. We estimate its 1990 revenue to be U.S.$300,000 and its 1991 sales at U.S.$400,000. Its primary role with Philips has been in the assembly and test of Philips' devices to be sold in China. Some technology was reported to have come from Hitachi and Motorola earlier in the factory's history.

Shanghai Belling Microelectronics Manufacturing Company is a semiconductor manufacturing and assembly/test joint venture between BTM of Belgium and the municipal government of Shanghai. The majority of the 390-person work force was trained and transferred from Shanghai No. 14, which is also a fab and assembly/test facility that employs nearly 1,000 people. Dataquest estimates that 15 percent of its work force is technically trained or of an engineering background. This plant began production in 1990 with estimated sales revenue of U.S.$6 million. Its main products include communications switching devices for the 1240 digital switching system. This technology was transferred from BTM of Belgium.

An equity agreement between NEC and Beijing Steel is financed 60 percent by the Chinese government and 40 percent by NEC. The estimated cost of the 2-micron, 4-inch 64K DRAM facility is U.S.$200 million, which will be spent over the course of two years. The facility, which will comprise one building for fabrication and one for assembly and test, is scheduled to begin production in 1993. Depending on the quality cost of the products manufactured at the new facility, between 30 and 50 percent of output could be

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exported. The planned capacity of the facility is 30,000 wafers per month. It is possible that the plant might allocate as much as 10 percent of its production to television ICs.

Motorola's semiconductor involvement in the mainland until now has been at the Shanghai No. 19 Radio Factory. The joint venture announcement to construct a large wafer facility was delayed because of the Tiananmen crisis in 1989. Motorola will proceed with the venture and continues to rapidly expand its mainland position. We expect to see exact products, size, and investment amount finalized later this year.

By Daniel A. Heyler

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Dataquest Inquiry Summary

Semiconductors *Worldwide*

July 13, 1992

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Markets and Applications

5. In a May 18, 1992 *Dataquest Perspective* article published by the Semiconductor Equipment, Manufacturing, and Materials Service, you described how Japanese wafer fab equipment companies have continued to gain market share in the worldwide wafer fab equipment market. Has this market share gain been observed in all major segments of equipment? 4
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For more information, call your Dataquest analyst.

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13. How many FPD fab lines of Japanese manufacturers are scheduled to start production in 1992? 11
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Products

Q1 Which ASIC suppliers have announced sub-0.8-micron ASIC products to date?

A There have been three announcements to date, as follows:

- On April 6, 1992, LSI Logic announced a 0.6-micron (drawn) gate array line with up to 600,000 usable gates.
- On April 14, 1992, Toshiba announced a 0.5-micron (drawn) gate array line with up to 560,000 usable gates.
- On June 8, 1992, AT&T announced a 0.6-micron (L-effective) CBIC line with both 3V and 5V libraries.

By Bryan Lewis

Q2 What is the component cost of a typical 386SX personal computer today?

A The typical component cost of a basic 386SX PC selling for $1,500 is $935. The remaining $565 cost includes labor, overhead, sales and general administration, and markup. Table 1, which is based on Semiconductor Applications Market Service I/O analysis, shows the estimated cost breakout.

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Table 1
Cost Breakout for a Basic $1,500 386SX

Component	Cost ($)	% of Total Cost
VGA Monitor	200	13
Motherboard	180	12 (assuming some I/O)
Keyboard	75	5
Disk Drive	240	17
Memory Modules	140	9
Graphics	100	6
Total	935	62

Source: Dataquest (July 1992)

By Greg Sheppard

Q3 What are the monthly 1Mb DRAM and 4Mb DRAM North American price trends from April 1992 through mid-June 1992?

A Table 2 shows the price trends for both products.

Table 2
Price Trends for 1Mb and 4Mb DRAMs

Date	1Mb DRAM	4Mb DRAM
4/1/92	$3.15-$3.50	$12.25-$12.85
5/1/92	$3.10-$3.30	$11.85-$12.35
6/1/92	$3.15-$3.35	$11.65-$12.00
6/15/92	$3.15-$3.25	$11.45-$12.00

Source: Dataquest (July 1992)

By Mark Guidici

Q4 What have you been seeing in volume discount pricing on the 1Mb DRAM from the first quarter of 1991 to the second quarter of 1992?

A Table 3 shows typical pricing for lots of 100k to 200k pieces. The discount can range anywhere from 2 to 10 percent with a purchase of 1 million units or more.

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Table 3
1MB DRAM Pricing in Lots of 100K to 200K

Quarter	Price ($)
Q1/91	4.55
Q2/91	4.50
Q3/91	4.33
Q4/91	4.00
Q1/92	3.80
Q2/92	3.50

Source: Dataquest (July 1992)

By Ronald Bohn

Markets and Applications

Q5 In a May 18, 1992 *Dataquest Perspective* article published by the Semiconductor Equipment, Manufacturing, and Materials Service, you described how Japanese wafer fab equipment companies have continued to gain market share in the worldwide wafer fab equipment market. Has this market share gain been observed in all major segments of equipment?

A In the past five years, Japanese equipment companies increased their share of the worldwide wafer fab equipment market from 38 percent share in 1987 to 53 percent share last year. As Table 4 shows, the Japanese equipment companies have achieved market share gains in all major categories of front-end wafer fab equipment. Japanese companies accounted for 50 percent or more of worldwide sales in 7 of the 11 categories of equipment identified in Table 4, In 1991. U.S. companies still hold a strong position in the CVD and implant equipment markets.

Japanese companies have established dominant share in these equipment categories through a combination of domestic technology development and acquisition of overseas companies and their technology. In the cases of diffusion and critical dimension (CD) measurement equipment, Japanese companies led the way in establishing vertical diffusion and CD SEM systems as next-generation replacement technologies for the more traditional segments of horizontal diffusion furnaces and optical CD measurement. The Japanese companies hold a strong position in the stepper market because powerhouse optics companies Nikon and Canon chose to manufacture full stepper systems rather than just supply sophisticated lens optics to other stepper vendors. Tokyo Electron's buyout of the TEL/Lam and TEL/Thermco joint ventures added dry etch and tube LPCVD technology, originally developed at U.S. companies, to an already flourishing technology base in Japan. In 1990, dominant share of the PVD market shifted from U.S. companies to

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the Japanese, in large part because Sony acquired sputter equipment manufacturer Materials Research Corporation.

Table 4
Japanese Company Share of the Worldwide Market for Key Segments of Wafer Fab Equipment (Percentage of Dollars)

Equipment Category	1987	1991	Gain in Share
Steppers	68	82	14
Wet Process	40	67	26
Track	46	62	16
Diffusion	23	61	38
Critical Dimension	54	61	7
PVD	41	57	16
Dry Strip	47	50	2
Dry Etch	24	45	21
Wafer Inspection	27	42	15
CVD	14	26	13
Implant	14	18	4

Source: Dataquest (July 1992)

By Peggy Wood

Q6 Is the static RAM market about to be taken over by alternative technologies?

A Static RAMs are now, always have been, and will probably always be in what appears to be a precarious position. All of today's SRAM applications will eventually be displaced by either increased integration, where the SRAM will be pulled into the device that currently accesses it, better alternatives such as fast DRAM, or inexpensive flash memories, or simple obsolescence, where the need for the end system disappears. On the other hand, the majority of today's SRAM applications were unheard of 10 years ago, and the applications that will consume the majority of SRAMs 10 years from now have yet to be explored.

As an example, back in 1982, microcontrollers had no more than 256 bytes of internal SRAM, there were no DSP chips or ASICs, all modems were straight linear designs, mainframes tended to use SRAMs for main memory, fax machines were rare, and cache memories were only used in the most esoteric mainframe computers and certain superminicomputers. Hot consumer products included phone recorders, movie cameras, and personal stereos. Twelve-inch laser disks were being touted as a means of showing movies in the home. The PC was just catching on, usually with a

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300K 5-inch floppy disk as the only mass storage device. The state-of-the-art production SRAM was a 70ns 2Kx8, and the worldwide SRAM market was about $540 million.

Today, microcontrollers have anywhere up to 16KB of internal SRAM displacing the SRAM previously used in small systems, DSPs and ASICs with internal SRAM abound, and most 32-bit microprocessors have internal caches of up to 8KB. Mainframes have all but stopped using SRAM as main memory, in favor of DRAMs augmented by fast SRAM caches. Faxes are everywhere, about half of all desktop computers offer external SRAM caches, and the preferred modem implementation is based on DSP. Hot consumer products include hand-held camcorders and musical 5-inch laser disk (CD) players. Burgeoning SRAM applications are taking root in hand-held computing and hard disk caches, things unthought-of 10 years earlier. The state-of-the-art production SRAM is a 15ns 1Mb, and the worldwide SRAM market is expected to be closing in on $3 billion.

In 2002, DSP will find itself in consumer applications ranging from HDTV to digital cellular telephones, as well as in compressing faxes. Typical DSPs, microcontrollers, and ASICs are likely to contain up to 1MB of SRAM, and microprocessor chips will offer cache sizes of up to 512KB, probably in support of multiple CPUs. The popularity of external SRAM caches in personal computing systems will probably have died, and extremely fast DRAMs likely will find prevalence in large computer caches. New applications for caches, which may be serviced by a combination of SRAM and DRAM, should arrive in data communication within personal systems. Flash memory will have replaced SRAM in many battery-operated computing applications. The state-of-the-art SRAM should be a 6ns 128Mb device. The SRAM market will have continued to grow to about the $15 billion level.

SRAM has been threatened at each of these stages. At each stage the major applications of SRAMs have been radically different than for either the preceding or following decade. Dataquest expects SRAM to continue to grow, with increases in density, speed, and economy driving the invention of new applications.

By Jim Handy

Q7 What is Dataquest's latest Japanese electronic equipment production forecast?

A See Table 5.

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Table 5
Dataquest's Japanese Electronic Equipment Production Forecast (Billions of Yen)

	1991	1992	1996	CAGR (%) 1991-1996
Data Processing	6,977	7,191	8,786	4.7
Communication	3,118	3,250	4,800	9.0
Industrial	3,888	3,960	5,533	7.3
Consumer	8,389	8,707	11,014	5.6
Transportation	2,261	2,269	2,795	4.3
Total	24,633	25,377	32,928	6.0

Source: Dataquest (July 1992)

By Kun Soo Lee

Q8 What is the mil/aero market for analog ICs?

A See Table 6.

Table 6
Estimated 1991 Mil/Aero Market for Analog ICs

	1991 Mil/Aero Revenue ($M)
Analog Monolithic	660
Linear	293
Mixed-Signal	313
Analog Hybrids (from Semiconductor Vendors Only)	85

Source: Dataquest (July 1992)

By Greg Sheppard

Q9 What is the size of the market and market share for charge-coupled device (CCD) image sensors?

A Optical CCDs have shown strong growth in recent years because of their use for image sensing in camcorders and fax machines. Because of the strong consumer market for these devices, the leading consumers and manufacturers are in Japan. Dataquest's 1991 market share estimates are in Table 7.

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Table 7
1991 Market Share Estimates for CCDs

Rank	Company	Market Share (%)	Revenue ($M)
1	Sony Corp.	34.5	194.0
2	Matsushita Electronics Co.	32.9	185.0
3	Texas Instruments	7.5	42.0
4	Toshiba Corp.	7.1	40.0
5	NEC Corp.	5.9	33.0
6	Sharp	3.9	22.0
7	Sanyo	1.8	10.0
8	Hamamatsu Photonics K.K.	1.8	10.0
9	Fujitsu	1.2	7.0
10	Tektronix Inc.	0.9	5.0
	Others	2.5	14.0
Total		100.0	562.0

Source: Dataquest (July 1992)

By Gary Grandbois

Technologies

Q10 What technologies are designers using for their standard ICs?

A Dataquest investigated technology usage by North American designers and asked them what types of technologies they were using for standard ICs (see Figure 1). As expected, CMOS and TTL were the most widespread technologies. However, North American designers will begin to experiment with more GaAs and BiCMOS devices for speed-critical and high-drive applications. This information should be used for technology acceptance purposes only, as Dataquest believes that the majority of volume opportunities will be dominated by CMOS technologies for the next three to five years.

By Robert K. Beachler

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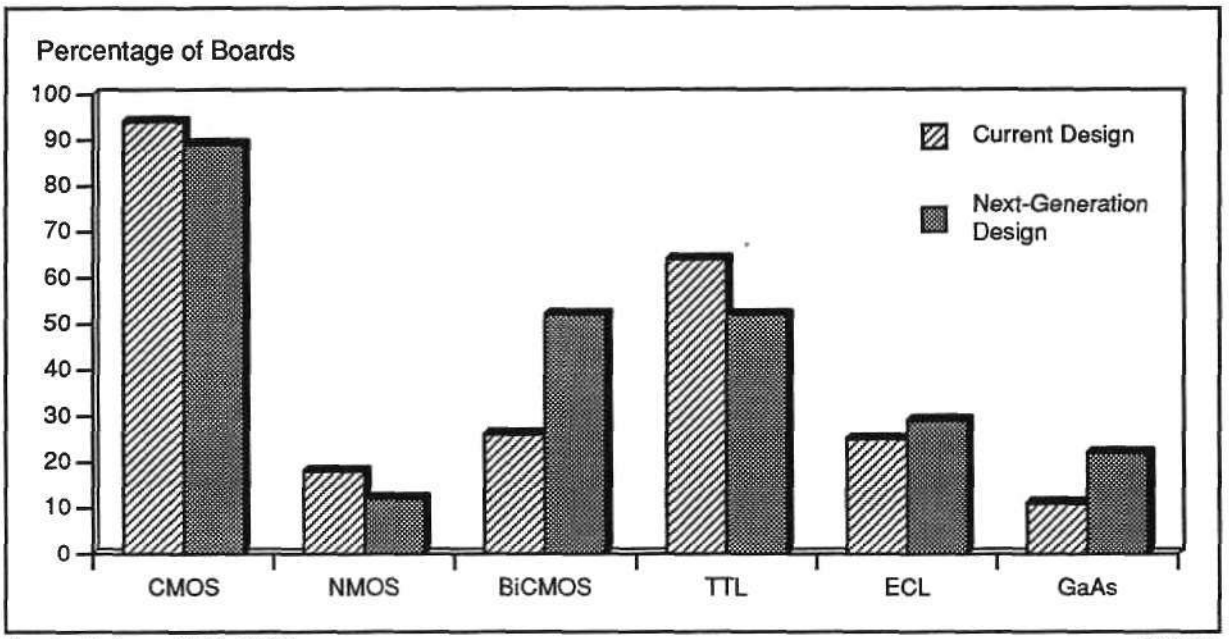
Figure 1
North American Standard IC Technology Use



Source: Dataquest (July 1992)

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Company and Other Issues

Q11 Who are the largest mass merchandisers of electronics in the United States?

A See Table 8 for the top 10 in terms of 1991 electronic sales, according to *TWICE,* an industry trade journal.

Table 8
Top 10 Mass Merchandisers

Company	Sales ($)
Radio Shack	2.75 billion
K Mart	2.74 billion
Sears	2.6 billion
Circuit City	2.3 billion
Service Merchandise	1.5 billion
Wal-Mart	1.1 billion
Target	900 million
Silo	816 million
Sam's Wholesale Club	780 million
Montgomery Ward	763 million

Source: TWICE

By Greg Sheppard

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Q12 We depend heavily on DRAMs from Siemens for our European operations. Recent articles in various trade journals, and Siemens' pullback from the 64Mb program with IBM, both indicate a reduced commitment by Siemens to being a first-tier player in the DRAM business. What should we do?

A Perhaps no company has agonized more, for longer, than Siemens about its DRAM future. Still, it has managed to maintain a solid competitive position as the sole native European DRAM supplier–price competitive and with state-of-the-art product. It has achieved this through licenses with Toshiba for its successful 1Mb program, through government and Siemens Corporate funding for the 4Mb program, and through 64Mb and 16Mb technology in the past 18 months from its joint ventures with IBM. On June 19, Siemens announced a pullback from its 64Mb program, but vowed to continue to participate through the 16Mb generation. It has decided against building an additional advanced 64Mb facility.

The forward economics of DRAM process development and facilities are forbidding, especially for a company never recognized as a low-cost manufacturing powerhouse. Even in 1989, the second of the most recent DRAM glory years, Siemens lost money. From a profitability standpoint, 1990 and 1991 must have looked horrendous, with Siemens having a smaller presence in the 4Mb than it had in the 1Mb in 1988 to 1990, plus advanced development costs to support the IBM DRAM ventures.

But Siemens is hanging in there, and we believe that IBM has little intention of letting the last thread of "domestic European sourcing" pass through its hands. Already, though, Siemens' own commitment to a second fab was withdrawn. It also has already announced availability of 16Mb DRAMs from the IBM joint venture. With the 16Mb DRAM already coming on, and IBM as a partner, that takes one close to the end of the decade.

For its own part, IBM has made immense efforts to shore up the non-Japanese competitive semiconductor market over the past 5 to 6 years, with some success, through joint venture, technology licensing, and other alliances. Siemens may very well appear as IBM's surrogate entry into the merchant semiconductor business, or merely the European marketing arm for IBM's announced entry into the merchant DRAM market. As it stands now, Siemens is now, in many ways, already a seller of IBM rebranded DRAM products with whom one can be assured of technical leadership (via IBM).

But clearly, with the changes that have happened in the industry in the past four to five years--technology disassociated from manufacturing from marketing, plus the political constraints in which the industry must operate--the procurement questions are far more complex. At the same time, RAM users have a far wider range of supplier relationships to choose from. Users that feel a weakening commitment to domestic European DRAM supplies would do well to

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evaluate their procurement options in light of where the industry has been the past four to five years, and look at equity relations with European suppliers, binding purchase commitments, or relations with reliable Japanese, U.S., or Korean sources now being established in Europe.

By Lane Mason

Q13 How many FPD fab lines of Japanese manufacturers are scheduled to start production in 1992?

A A total of nine lines of flat panel display (FPD) are planned to start production in 1992. See Table 9.

By Junko Matsubara

Table 9
Flat Panel Display Fab Lines (Production Starts in 1992)

Company	City	Fab Name	Production Starts	Product
Citizen	Hachinohe	NA	4/92	STN
Hoshi	Kobe	Nishijin	1992	a-SiTFT
Matsushita	Ishikawa	Ishikawa	3/92	10-inch TFT
Mitsubishi	Kumamoto	Advanced Display	Q1/92	10-, 15-inch TFT
Optrex	Amagasaki	Amagasaki 2	1992/1993	TN, STN
Seiko Epson	Malaysia	Penun	1992	TN
Sharp Electronics	Taiwan	SET	2/92	STN assembly
Sony	Nagasaki	Nagasaki	Q1/92	10-inch TFT
Toshiba	Fukaya	Pilot Line	Q3/92	TFT

NA = Not available
Notes:
FPD: Flat Panel Display
LCD: Liquid Crystal Display
TFT: Thin Film Transistor
MIM: Metal Insulator Metal
TN: Twisted Nematic
STN: Super Twisted Nematic
Source: Dataquest (July 1992)

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Q14 Do you have a measure of the royalty flows throughout the semiconductor industry for the past several years, and who the biggest payers and beneficiaries are?

A Texas Instruments, of course, is by far the most visible, especially since it raised the ante in the 1987 round of licensing negotiations. In 1992, net royalty income for TI from its patent portfolio (mostly semiconductors) was $256 million. Although not nearly so public with its licensing program, or its income derived from royalties, perhaps SGS-Thomson Microelectronics is the second biggest winner, with press reports last year estimating its returns since 1987 at more than $350 million. Much of its portfolio was obtained through its purchase of Mostek Corp. in 1987 for $70 million, and with it Mostek's substantial DRAM and memory patent portfolio. In fall 1990, Motorola also announced a microcontroller licensing agreement with Mitsubishi expected to net $100 million over the life of the agreement. Intel and IBM, though far quieter about their efforts, are also big gainers. Standard Microsystems' broad licensing agreements from the 1970s and 1980s were substantial, but truly pale against those that have come later. Just this past quarter, NSC announced fiscal fourth-quarter gains of $11 million from licenses, substantially greater than it had ever gained.

The biggest payers are the DRAM makers. Micron Technology has paid out (or given debt) of about $50 million to both Intel and IBM since 1989, for technology licenses. Its payments have averaged more than 9 percent of sales for each of the past three years. The Korean DRAM makers each are paying an estimated 10 percent or more of revenue back to the key DRAM patent holders, including many leading Japanese DRAM makers. Of course, all the Japanese themselves are licensees of Texas Instruments and of STM, also.

Newcomers to the DRAM business obviously face a formidable barrier to entry in the IPR arena. But although such licenses are expensive, they can be overcome. And unlike in non-DRAM areas, the licenses are available and can be had for a price. While such sums are significant, one might ask at the same time whether a company such as AMD would rather pay a 10 percent per-unit fee to Intel for rights to the 3h86, or be excluded entirely.

These are only the most visible transactions, in which money changed hands. However, the vast majority of returns on IPR results from superior products that incorporate proprietary technologies. Also, often IPR is traded for other valuable compensation, such as foundry rights, cross licenses, or marketing rights. Each of these also contains an implicit "return on IPR" that is difficult to value precisely.

By Lane Mason

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Dataquest Inquiry Summary

Semiconductors

June 8, 1992

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In addition to current deliverables, clients will receive an *Inquiry Summary* every month. This issue is the Semiconductor Group's first *Inquiry Summary*. It is intended to keep readers abreast of hot topics and to provide a snapshot of the types of inquiries Dataquest has answered during the past month. Individual summaries are submitted from around the world by Dataquest's staff of Semiconductor Group analysts.

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Products

Q1 What are the current production lead times for gate arrays and CBICs, on average?

A The current production lead time for gate arrays is 8 to 10 weeks; for CBICs it is 10 to 12 weeks. The lead time average is lengthening because of lower learning curve yields related to newer designs in the 0.8-micron technologies that utilize additional wafer starts. As yields improve, lead times should stabilize and decline slightly.

By Bryan Lewis

Q2 What is happening in 3V static RAMs?

A Although there is a lot of activity, no real trends are arising. First, let us define what we mean when we say 3V, because there is some confusion.

There are two kinds of 3V SRAMs: those destined for use in battery-operated systems, and those that use reduced voltage swings to improve output speed.

In the first realm, several manufacturers have 3V designs in engineering to support a possible explosion of battery-operated applications, ranging from camcorders and video games up to handy terminals and portable PCs and workslates. Several are screening existing product to operate at reduced speeds at 3V. Micron has introduced a 3V, 20ns, 16Kx16-bit SRAM specifically targeted at battery-operated cache applications, in which it claims that a cache can produce substantial power savings over the same system without a cache. If this is true, expect an explosion in demand of high-speed 3V 8- and 16-bit-wide SRAMs. However, this trend appears more to exist in the minds of SRAM suppliers than in the minds of laptop designers at present. Most 3V applications are still slow SRAM applications.

The reduced voltage swing version of 3V appears to be a field that has only been exploited to date by Performance Semiconductor with some very fast 4Kb SRAMs. This market will emerge much more slowly and will suffer the chicken-and-egg syndrome because 3V very high speed SRAMs will be used in systems with similar logic and processors, whose availability promises to be weak for the near term.

These two different markets share some commonalities. First, EIA's JEDEC standards committee has been working to assure mutually

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agreed-upon specifications for the logic levels used in both sorts of systems. Second, both trends will be driven somewhat by semiconductor suppliers' desires to use 3V 0.4 micron (and smaller) processes.

Still, Dataquest expects it to be quite a while before either 3V standard becomes the dominant voltage level in the SRAM market.

By Jim Handy

Q3

I understand that analog gallium arsenide (GaAs) IC revenue grew dramatically in 1991. What is driving this growth?

A

In 1991, GaAs analog IC shipments grew to $308 million, an increase of 27.3 percent over 1990. Two primary factors helped boost the sales of these ICs. First, the successful insertion of GaAs ICs in major weapons systems in North America and Europe required production quantities of many types of GaAs ASICs. The second factor was the successful commercialization of GaAs microwave monolithic ICs (MMICs). These ICs found their way into satellite and fiber communications systems, cellular phones, TV receivers, navigation receivers (such as portable GPS types), traffic control, and security systems. The growth by category is shown in Table 1.

By Gary Grandbois

Q4

What are some of the recent developments in flash memory and SSDs?

A

AMD announced the first single-transistor cell 1Mb flash memory device that operates from a single 5V supply. The Am29F010 is by far the fastest flash memory chip with a 45ns read access time, a feature that may eliminate the need to download the flash data to SRAM in order to improve execution time. The Am29F010 is segmented into eight 16KB sectors that can be independently programmed/erased. Endurance is 100,000 cycles per sector.

Table 1
Estimated Merchant Revenue, GaAs Analog ICs (Millions of Dollars)

Product	Revenue 1991	Revenue 1990	Percentage Growth
NRE	47	48	-2.1
MMIC Amps	54	42	28.6
ASICs	164	114	48.9
Others	43	38	13.2
Total Analog GaAs	308	242	27.3

Source: Dataquest (June 1992)

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Intel announced an 8Mb flash memory device and the series-2 flash memory cards based on this new flash chip. The 28F008SA can store 1MB of data or code, and by virtue of its pricing ($29.90) comes close to DRAM cost per megabyte. The device uses a 5V power supply for read operations and a 12V supply for write/erase. A 3.3V (read) version is available for portable applications. This traditional single-transistor cell-based design offers 100,000 cycles for endurance rating and 85ns access time. The memory array is segmented into 16 64KB blocks that can be independently erased/programmed. The 28F008SA is the highest-density flash memory offering to date. The series-2 memory cards are based on this new 8Mb flash memory and come in 4MB, 10MB, and 20MB densities priced at $163.50, $331.50, and $611.50, respectively. These cards are clearly aimed at mass storage applications.

AT&T entered the memory card and solid-state disk market by second-sourcing Sun Disk's IDE interface SSD subsystem and card architectures.

Microsoft announced the Flash File System (software), which supports Intel's 8Mb devices. The FFS-2 is now in beta sites and should be available later this year. Microsoft's Flash File software is a key component and necessary for solid-state disk subsystems that (unlike the SunDisk solution) will use off-the-shelf flash memory ICs.

The Personal Computer Memory Card International Association (PCMCIA) has ratified the technical content of two new standards for mass storage on memory cards. The PCMCIA-ATA (AT Attachment) specification incorporates the ATA mass storage protocol as a PCMCIA standard for mass storage on a memory card. The Auto Indexing Mass Storage (AIMS) specification is for memory cards that will be used in electronic imaging and multimedia applications.

By Nick Samaras

Q5 Every day, it seems, I read about a new company entering into or a new product being offered to the memory card market. Are there any guidebooks available that provide a snapshot of all the choices available for memory cards for our printer application?

A Although printers are not the most lively area for using memory cards, there are some examples of printer companies beginning to use such cards to add different fonts.

A good source of information of suppliers of memory cards and connectors is a guide published by AP Research, 19672 Stevens Creek Boulevard, Suite 175, Cupertino, CA 95014-2465; telephone (408) 253-6567/Fax (408) 253-5794.

AP Research offers a directory entitled "IC Cards: A Definitive Reference Guide," which is a comprehensive source of information

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on memory cards and connectors. Containing over 300 pages, it describes the specifications for more than 800 memory cards and 150 connectors and lists the companies that supply the market. It catalogs a complete listing of PCMCIA/JEIDA cards, JEDEC cards, and other custom memory cards. Each entry describes the producing company, the memory technology employed in the card, pin count, bus width, memory size, and applicable industry standard.

Key suppliers listed in the reference guide include AMP, DDK Electronics (Canada), Datakey, Du Pont Electronics, Epson America, FDK America, FOXCONN International, Fujikura America, Fujitsu Microelectronics, Hirose Electric (USA), ITT Cannon, and dozens more. The guide costs $375 plus sales tax and shipping.

By Lane Mason

Q6 What impact will the Micron Technology dumping suit against Korean DRAM makers have on the market?

A We believe that the impact will be temporary and rather small. It certainly will have nowhere near the impact that the claims filed in 1985 had.

In our view, the aggressive pricing seen in March and April was the result of inventory sell-offs in Japan. The Japanese market has been weak since late 1991, and, with the fiscal year ending March 31, 1992, there was some very aggressive selling to reduce inventories before year-end. This depressed the Japanese market price to below those in the rest of the world. Some of this low pricing, down as low as $2.50 for 1Mb DRAMs and near $10.50 for 4Mb DRAMs, leaked out into the U.S. and Far East markets. The newer DRAM players (such as Hyundai and Goldstar) sometimes met these low prices. Of course, this hurt Micron Technology, which is still 80 percent DRAMs, and a rather late entrant into the 4Mb fray itself. Whether these pricing actions by Hyundai, Goldstar, and Samsung constituted "dumping" is still an open issue.

Nonetheless, we believe that the caution in the market and the firming we have seen in low-end pricing since the suit was filed in April will be temporary, and that prices will resume their steady downward march by midyear.

By Lane Mason

Markets and Applications

Q7 How large is the worldwide cordless telephone market in units? How fast is it growing and how is it distributed geographically?

A Table 2 provides an overview of the worldwide cordless telephone market.

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Table 2
Worldwide Cordless Telephone Market*

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Worldwide (Millions of Units)	18.5	22.6	27.5	33.6	38.6	41.5	44.4	14.5
North America Market (%)	65	61	56	49	45	42	40	
European Market (%)	18	20	23	26	28	30	32	
Japan/Asia/ROW Market (%)	17	19	21	24	26	27	28	

*Excludes PCN communicators
Source: Dataquest (June 1992)

Q8 What is the mix of analog and digital in today's systems designs?

A Based upon a recently completed survey of end users by Dataquest, we believe that today's typical board design in North America is 82 percent digital and 18 percent analog. In Japan, the typical board design has 1 percent more analog functionality, or an 81/19 digital/analog split. Users indicate a small trend to increase the amount of digital functionality, and Dataquest anticipates that in the next three years the typical board design will consist of 83 percent digital functionality and 17 percent analog functionality.

By Bob Beachler

Q9 In "Users Beware of a Truncated 1.5-Micron Gate Array Life Cycle," in the November 25, 1991 Semiconductor Procurement *Dataquest Perspective*, Dataquest warned of the potential impending departure of suppliers from the 1.5-micron CMOS gate array business. What has happened in this market since then?

A The article proved accurate. For example, during the first quarter of 1992, VLSI closed its 1.5-micron gate array lines. Although 1992 production volume is not negligible, there are few new 1.5 micron designs (for example, low-gate devices).

Based on some user input and related industry sources, Dataquest believes that LSI Logic and Motorola have in effect left the 1.5-micron CMOS gate array business. The financial difficulties of another supplier—IMP—signal the same reality. Fujitsu's view for 1992 is that the company will continue to support users but expects the life cycle to terminate during 1993. National Semiconductor and Toshiba remain committed to serving user demand over the medium term.

By Ronald Bohn

Q10 What has been the trend in regional company ownership of the wafer fabrication equipment market? Are North American companies gaining any market share?

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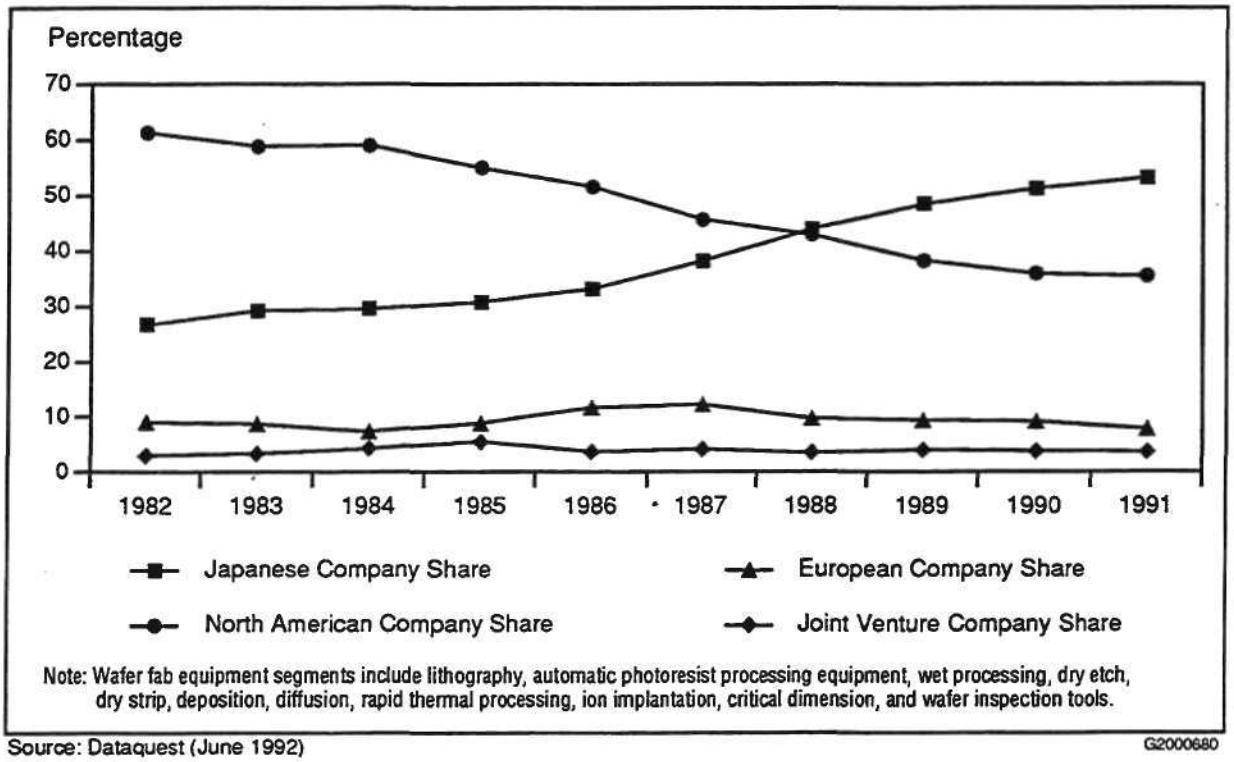
A Trends in regional company market share are a perennial topic of interest in the semiconductor industry, be it for devices, equipment, or materials. Figure 1 shows that the steady increase in market share by Japanese companies throughout the 1980s was mirrored by a similar loss in share by North American companies for key segments of wafer processing equipment. Although North American companies still lost market share last year, the pattern of market share erosion appears to have slowed somewhat. The worldwide market share of North American companies declined only a half of a percentage point in 1991, in contrast to the average 3 percentage point decline observed throughout the 1980s.

On a regional basis, North American companies gained market share position in Japan and Europe last year, and lost share in Asia/Pacific and their home market of the United States. The gain in wafer fab equipment market share in Japan should garner much interest in light of the market access disputes and trade friction that currently characterize U.S./Japanese relations. While the Japanese equipment market experienced only modest growth of 1 percent in 1991, North American wafer fab equipment companies increased their sales in Japan by 19 percent. This increased sales

Figure 1
Worldwide Market Share of Regional Companies for Key Equipment Segments, 1982-1991 (Percentage Revenue in Dollars)



Note: Wafer fab equipment segments include lithography, automatic photoresist processing equipment, wet processing, dry etch, dry strip, deposition, diffusion, rapid thermal processing, ion implantation, critical dimension, and wafer inspection tools.

Source: Dataquest (June 1992) G2000680

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activity resulted in a 2.8 percent market share gain for North American companies in Japan, and covered a broad number of equipment categories including lithography, CVD, PVD, silicon epitaxy, ion implantation, and rapid thermal processing equipment.

By Peggy Wood

Q11

Who were the top 10 1991 MOS gate array suppliers in North America?

A

The top 10 suppliers, according to Dataquest's preliminary 1991 market share survey, are listed in order as follows:

- LSI Logic
- Toshiba
- NEC
- VLSI
- Motorola
- Fujitsu
- Seiko
- Oki
- National
- NCR

By Bryan Lewis

Q12

What is the current status of new 16Mb DRAM fab lines in Japan?

A

For 16Mb DRAM production, 19 new fab lines (including planned lines) have been announced in Japan. In 1992, 5 fab lines for 16Mb DRAM are scheduled to start operation (see Table 3).

Table 3
16Mb DRAM Fab Line Plans in Japan

Company	Plant Name	Fab Name	Operating Year	Wafer Size (Inches)
Hitachi	Kofu	K-2	1992-1993	8
Matsushita	Uozu	NA	1992-1993	6
NEC	NEC Kyushu	No. 8	1992	8
Oki	Oki Miyazaki	M3	1992	6
Toshiba	Oita	Step 4	1992	6

NA = Not available
Source: Dataquest (June 1992)

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However, two are postponed to 1993 because of the sluggish Japanese semiconductor industry condition.

By Junko Matsubara

Technologies

Q13 What is the status of laser drilling in the PCB market?

A Laser drilling of PCBs became popular in about 1988. Mechanical drilling and punching are the most common forms of providing interconnect holes for components to boards. Most laser drilling is for high-frequency microwave devices that incorporate TAB bonds. The majority of the boards produced are currently 15 to 20 layers. Laser drilling works extremely well in a software-controlled automated environment.

Laser drilling is more cost-effective than mechanical punching in high-volume production and in areas requiring smaller vias. Mechanical drilling and punching becomes very difficult at 4 to 6 mils. Fifteen layers of tape average 300 vias per layer, with 50 circuits at a cost of 0.03 cents per via; 10,000 circuits cost 0.01 cent per via, and 200,000 circuits cost 0.07 cents per via. NRE charges vary by application, volume, and company from no charge to $100 per layer. Besides improved costs, laser-drilled via holes are round and their shape is always consistent.

By Mary Olsson

Company and Other Issues

Q14 Why is National Semiconductor expanding in Scotland?

A National announced a $90 million expansion of its manufacturing facility in Greenock, Scotland. The expansion will add facilities for handling 6-inch silicon wafers for the production of bipolar linear or analog circuits to the existing 6-inch line for bipolar logic circuits. First production at the new 6-inch facilities is expected to begin in May 1993.

National is currently running about 65 percent utilization on its fabs. The company has set a goal of raising that utilization rate, and it has announced plans to close three four-inch fabs in Santa Clara, California. Much of this production will be shifted to the Greenock fab running 6-inch wafers. Dataquest estimates that the net result will be 90 percent fab utilization rates, lower manufacturing costs, and improved productivity. In short, it should be a good move for the bottom line.

By Mark FitzGerald

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Q15 Please define the Japanese "keiretsu" system and describe how it relates to the Japanese electronics industry.

A Broadly speaking, a keiretsu is a network of corporations that may not have any explicit ownership bonds but, nevertheless, have synergistic relationships. There are two major types of keiretsu: bank-centered and independent keiretsu. Both types have been involved in the Japanese electronics industry.

Among the six major bank-centered keiretsu, Mitsui, Mitsubishi, and Sumitomo are direct descendants of the pre-World War II zaibatsu, or family-owned conglomerates. The remaining three are groups centered on the Fuyo (Fuji Bank), Dai-ichi Kangyo, and Sanwa institutions. The bank-centered groups are loosely affiliated and highly diversified. The members have business ties with each other and use the powerful bank in each group as their primary link.

The second type is the so-called independent (or supply) keiretsu. Though a wide variety of groups fall in this category, they are all centered on a large business, usually a manufacturer, and are more specialized than the bank-centered type. The independent groups can be further divided into five subtypes based on their growth mechanisms, as follows:

- Groups containing companies, each in a field different from the parent organization, that have grown into major, semi-autonomous corporations that have in turn spawned their own networks of diverse affiliates and subsidiaries. The group led by Hitachi is representative of this subtype.
- Groups formed by dividing a parent company into operating divisions that have set up separate companies and subsequently grown independent, frequently resulting in overlap, redundancy, or even direct competition. The Matsushita group is a typical example.
- Groups created when a dominant parent/customer company organizes its subcontractors, usually involving the parent's manufacturing processes, into a vertical, multilayered structure. The group formed by Toyota is good illustration of this subtype.
- Groups led by companies that have granted independence to their regional manufacturing subsidiaries and expanded into new fields by spinning off satellite companies and fostering a diversity of affiliates. The subsidiaries forming the NEC group belong to this category.
- Groups of related companies united through the strong leadership of the parent company's founder or owner. The real estate and leisure companies under Seibu Railway form one such group.

Figure 2 shows the relationships between Japan's six major bank-centered keiretsu groups and their relationships to electronic companies. The bank-centered groups are not actually as closely

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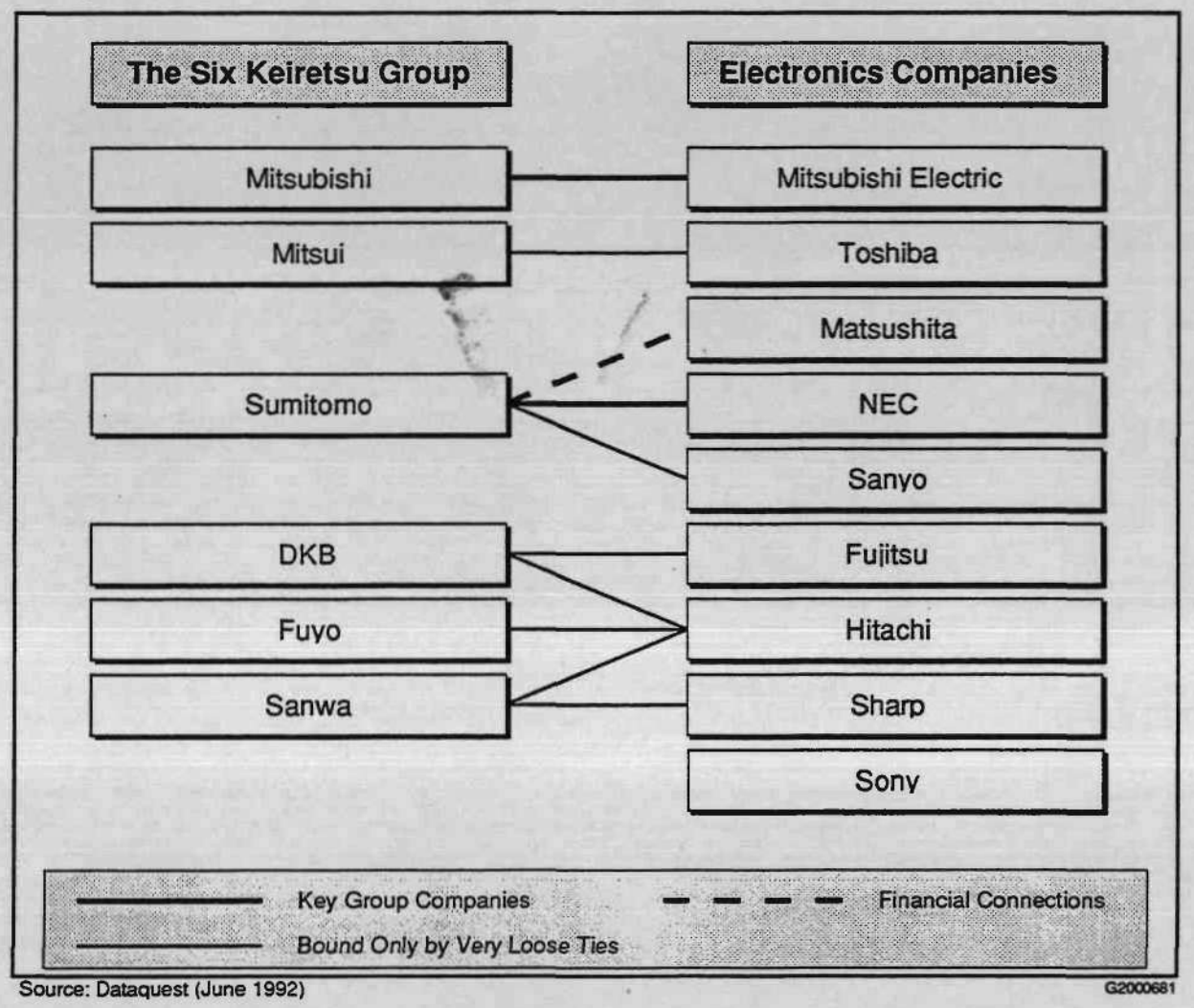
Figure 2
The Relationships between Six Japanese Keiretsu Groups and Electronics Companies



Source: Dataquest (June 1992) G2000681

bound as foreigners often assume. Cross-shareholding is a common practice among bank-centered keiretsu members and is frequently criticized by foreign investors. However, keiretsu members have found cross-shareholding to have many fringe benefits. It represented an effective means of deterring hostile takeovers and usually provided access to parent company information that could strengthen the financial position of a keiretsu member. For example, Sumitomo Bank was instrumental in providing NEC, a member of the Sumitomo group as well as head of its own subgroup, with timely information in connection with several of NEC's major investments in the semiconductor field. All members of the group benefited. Those that do not benefit from these relationships are

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those that do not belong to a large keiretsu group. Evidently this places pressure on smaller corporations to join a keiretsu, which in turn raises issues concerning antitrust principles.

In today's electronics industry, technology exchanges across company boundaries are a virtual necessity as no single company or keiretsu can compete as a totally independent or isolated entity. The resources, in terms of capital investment, R&D expense, and personnel required to successfully produce a single leading-edge product is simply too great, or rather the risk burden is too great, to bear. Witness the joint venture Display Technologies, formed by an alliance between Toshiba and IBM in an effort to supply thin film transistor-based LCD display panels.

Keiretsu will probably continue to flourish in one form or another in Japan. As far as the electronics industry is concerned, one could say that the traditional keiretsu is evolving. Replacing the interdependent family of companies of the old keiretsu is a more loosely grouped organization that participates in joint ventures and alliances with any number of nonkeiretsu companies.

By Junko Matsubara

Q16 What does Goldstar's R&D picture look like?

A Since the opening of Korea's first privately owned R&D center in 1975, the Goldstar Central Research Laboratory, Goldstar has placed great emphasis on developing its own technology. In 1990, there were 3,550 researchers at the Central Research Laboratory, Information Systems Laboratory, Production Engineering Research Laboratory, Quality Assurance Laboratory, and seven regional laboratories. Goldstar also has three overseas research laboratories, one each in California, Japan, and Ireland. In 1990, Goldstar spent 165 billion won on R&D, representing 5.5 of sales for that year. Goldstar plans to devote 7 percent of annual sales to R&D by the year 2000. The number of R&D personnel is expected to increase from 8 percent of the company's total employees in 1990 to about 15 percent by the year 2000.

The following are Goldstar's semiconductor R&D spending from 1986 to the present (U.S. dollars):

- 1986, $10 million
- 1987, $36 million
- 1988, $45 million
- 1989, $50 million
- 1990, $30 million
- 1991, $50 million
- 1992, $70 million (estimated)

By J.H. Son

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Dataquest Perspective

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In This Issue...

Market Analysis

Communications Market Spurs Semiconductor Growth

This article focuses on the communications market as a major driving force for future semiconductor growth. A communications market forecast is presented for the standard semiconductor categories. In addition, the forecast is viewed from the perspective of analog, digital, and mixed-signal ICs.

By Gary Grandbois *Page 1*

Market Analysis

Communications Market Spurs Semiconductor Growth

For the past century, the need for improved communication has been the major driving force in the development of electronics. The vacuum tube, the transistor, and the integrated circuit are some major electronic breakthroughs fostered by communications research. Although we live in an "information age" where information processing has taken center stage, improving communication still remains a primary need. Information processing depends on the free-flowing communication of information, in its multitude of forms. In the broad sense, communication encompasses most consumer entertainment products, as well as military electronics. Dataquest, however, defines communication more narrowly, confining it to the telecommunications and data communications markets and excluding communications aspects of the military, industrial, and consumer markets.

Figure 1 shows the semiconductor types used in the communications market. The $8.1 billion of semiconductor revenue represents only about 8 percent of the total communications equipment market, as shown by the contrasting end-equipment breakdown in Figure 2. Semiconductor devices are used in five basic communications groupings: premise telecommunications, public, mobile, broadcast, and others.

End-Market Segments Defined

Premise telecom equipment includes the broad range of customer-owned equipment that ultimately ties into public telephone switching and transmission equipment. Premise equipment includes telephone sets, PBXs, automatic call distributors, modems, and other computer-based data communications products such as local area networks. Public communications equipment

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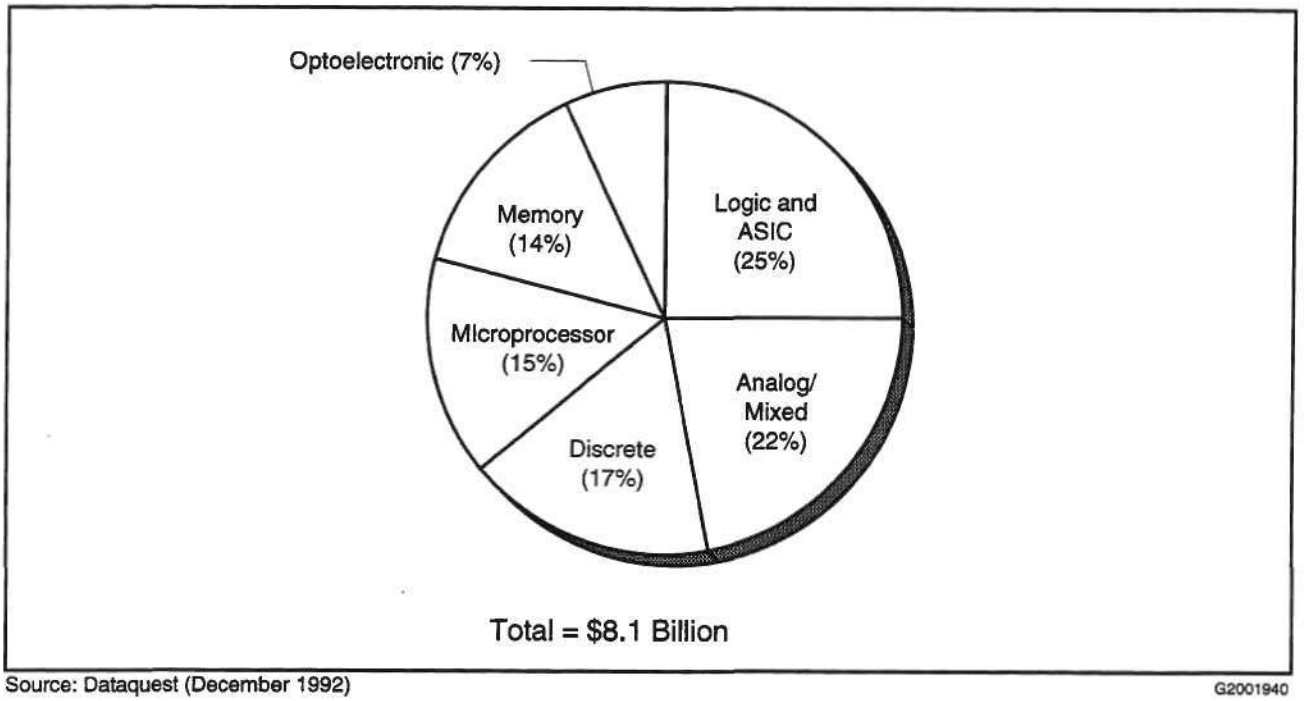
Figure 1
1991 Communications Market: Semiconductors



Source: Dataquest (December 1992)
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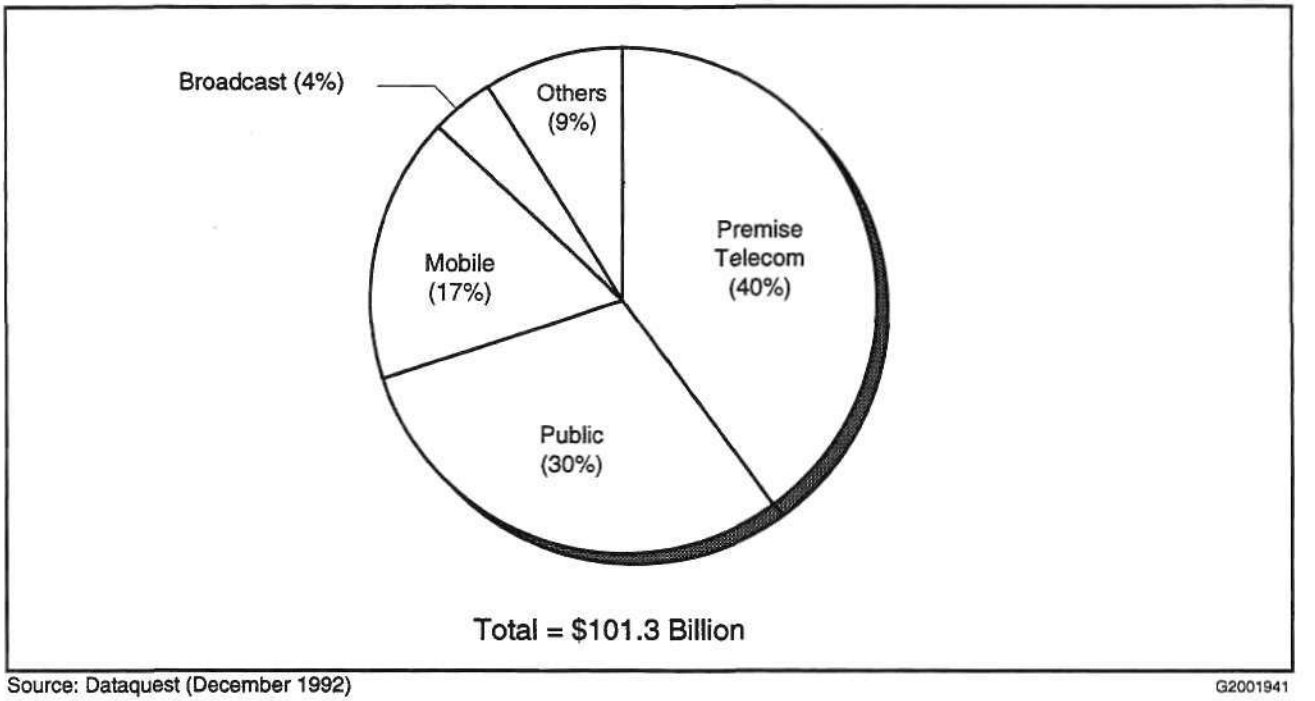
Figure 2
1991 Communications Market: End Equipment



Source: Dataquest (December 1992)
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includes the switching, multiplexing, and transmission equipment used in basic telephone services. Mobile communication includes cellular telephones and mobile radio systems. Broadcast and studio equipment includes the electronics used in the professional side of public radio and TV broadcasting, cable TV, recording studio, and theater equipment. Home reception equipment is not included.

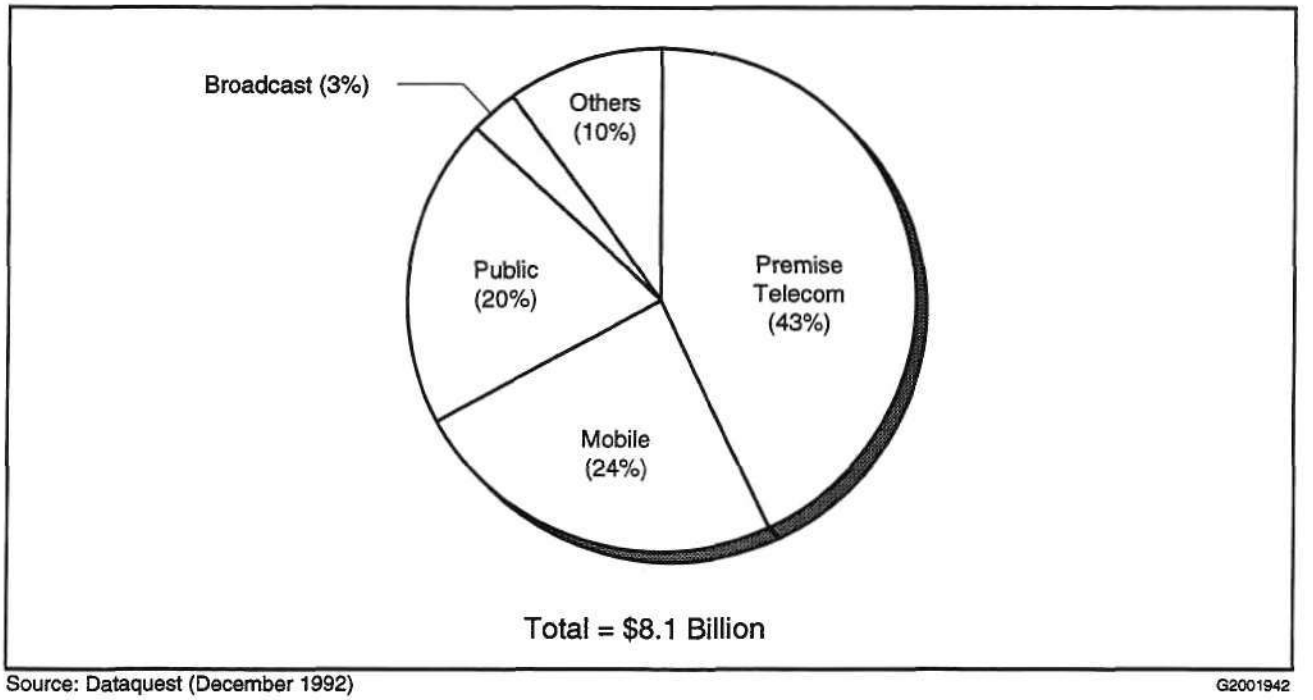
Grouping the semiconductors into these end-market categories gives the breakdown shown in Figure 3. The difference in the proportional representation of semiconductors to equipment points out variances in the semiconductor content of the end equipment. Public telephone equipment does not have as strong a semiconductor content as premise equipment does. A cellular handset, for example, represents a product much higher in relative semiconductor value than does the central exchange equipment.

Five-Year Forecast

Each of these communications equipment markets offer different driving forces for the growth of the semiconductor market. Dataquest expects faster growth in the consumption of semiconductors for the communications market than it sees for the consumption of communications end equipment. Table 1 shows the five-year forecasts for communications equipment and for the semiconductors used.

The forecast of Table 1 shows an increasing semiconductor content for telecommunications end products. Much of this increase will come from the growth of telecommunications in the personal computer and personal communications environments. An example is shown in Figure 4, where the growth in personal communications equipment is outstripped by the growth of the semiconductor content of the equipment. Note that the equipment value on Figure 4 is divided by 10 to put it in the same scale as the semiconductor value. In 1991, we see that semiconductors represent about 10 percent of the product value. The forecast shows semiconductor revenue and the proportion of semiconductor content to the end-product value increasing over this period. This increasing semiconductor content signals two important shifts in cellular communication. The first is that these products are moving into the realm of becoming a consumer product. The second is the transition from a lower-cost analog product to a more complex and costly digital cellular product.

Figure 3
1991 Semiconductors by End-Equipment Type



Source: Dataquest (December 1992) G2001942

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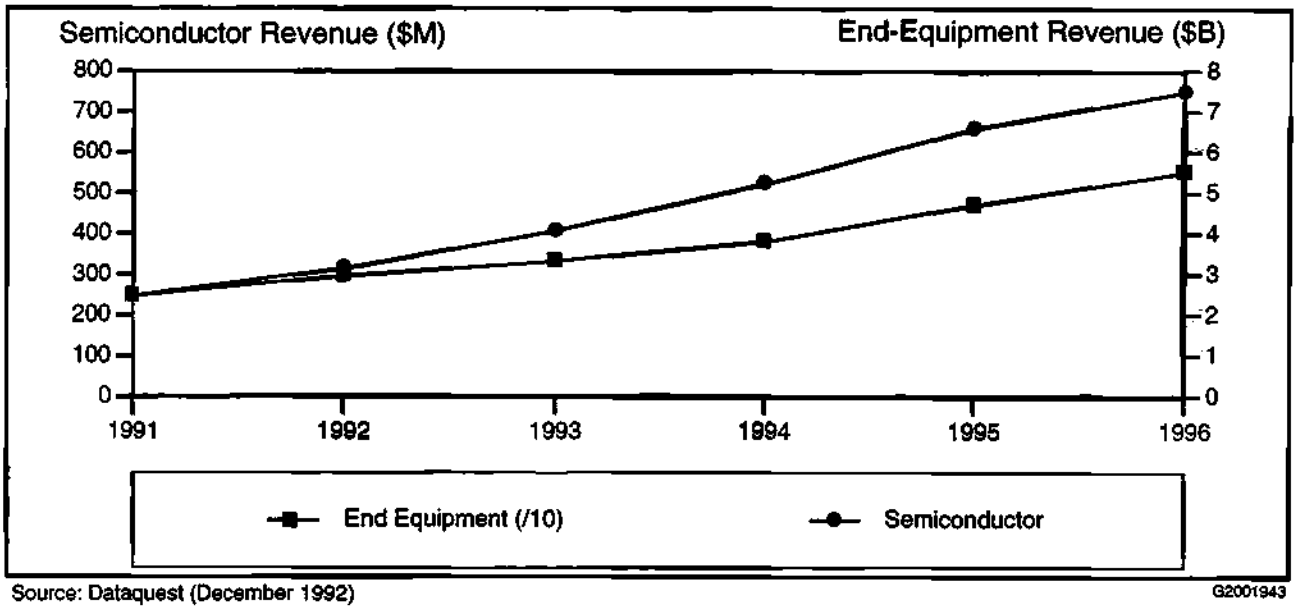
Table 1
Communications Market Five-Year Forecast (Revenue in Billions of Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Equipment	101.3	107.5	116.7	124.5	134.9	143.5	7.2
Semiconductors	8.1	8.5	9.8	11.0	11.9	12.9	9.6
Semiconductor Content (As a Percentage)	8.0	8.0	8.4	8.8	8.8	9.0	

Source: Dataquest (December 1992)

Figure 4
Cellular Communications Market



Source: Dataquest (December 1992) G2001943

Forecast Impact on Semiconductor Types

Table 2 breaks down the forecast by the major semiconductor product categories. Analog/mixed-signal ICs and microprocessor ICs represent the two major growth areas in this market. Optoelectronics show a slower-than-average growth because many fiber-optic markets are experiencing relatively low growth. The speed at which fiber optics replaces coaxial cable in the CATV market could have a major impact on this growth.

The forecast of Table 2 is plotted in Figure 5 to illustrate the relative size and growth expectations of each category of semiconductors used in the communications market.

Table 3 looks at the forecast in a different manner, by segmenting the ICs into linear, mixed-signal, or digital categories. The mixing of analog and digital, crucial for personal and portable communications products, creates an IC category that will be a major beneficiary of the growth in telecommunications. Integrating delta-sigma data converters with digital signal processors (DSPs) and logic provides the highly integrated, low-power solutions for the personal voice communications markets.

The growth of linear IC products is being severely hindered by the integration of linear functions into mixed-analog digital products. Figure 6, for example, shows low growth for linear and discrete device revenue in cellular

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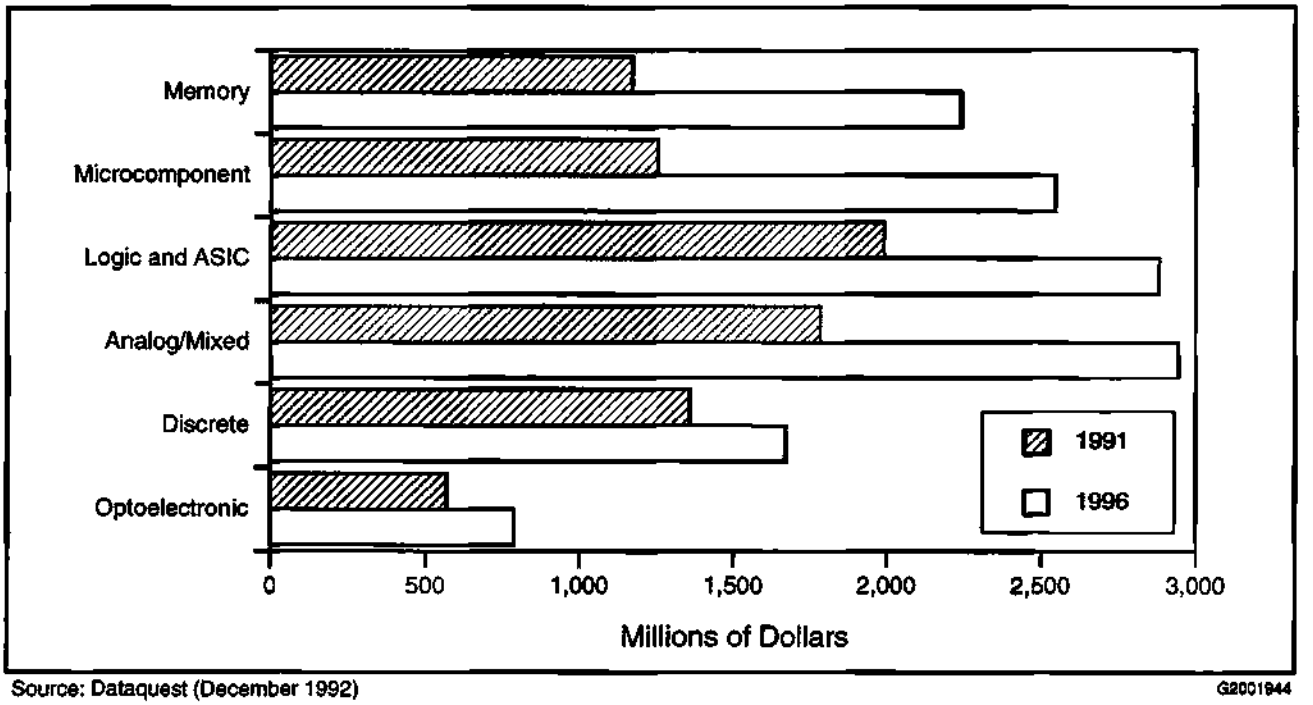
Table 2
Semiconductors in Communications Forecast, by Product Category: 1990 and 1991 Actuals (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Analog/Mixed	1,692	1,785	1,965	2,285	2,625	2,930	3,200	12.4
Microprocessor	1,030	1,256	1,404	1,641	1,940	2,199	2,489	14.7
Memory	1,137	1,174	1,270	1,529	1,758	1,759	1,830	9.3
Logic/ASIC	1,816	1,991	1,949	2,216	2,423	2,622	2,879	7.7
Discrete	1,323	1,359	1,374	1,460	1,533	1,589	1,671	4.2
Optoelectronic	469	568	583	635	694	741	785	6.7
Total Semiconductor	7,468	8,131	8,544	9,765	10,972	11,840	12,854	9.6

Source: Dataquest (December 1992)

Figure 5
Semiconductor Forecast, by Type: Communications Market



Source: Dataquest (December 1992)
G2001944

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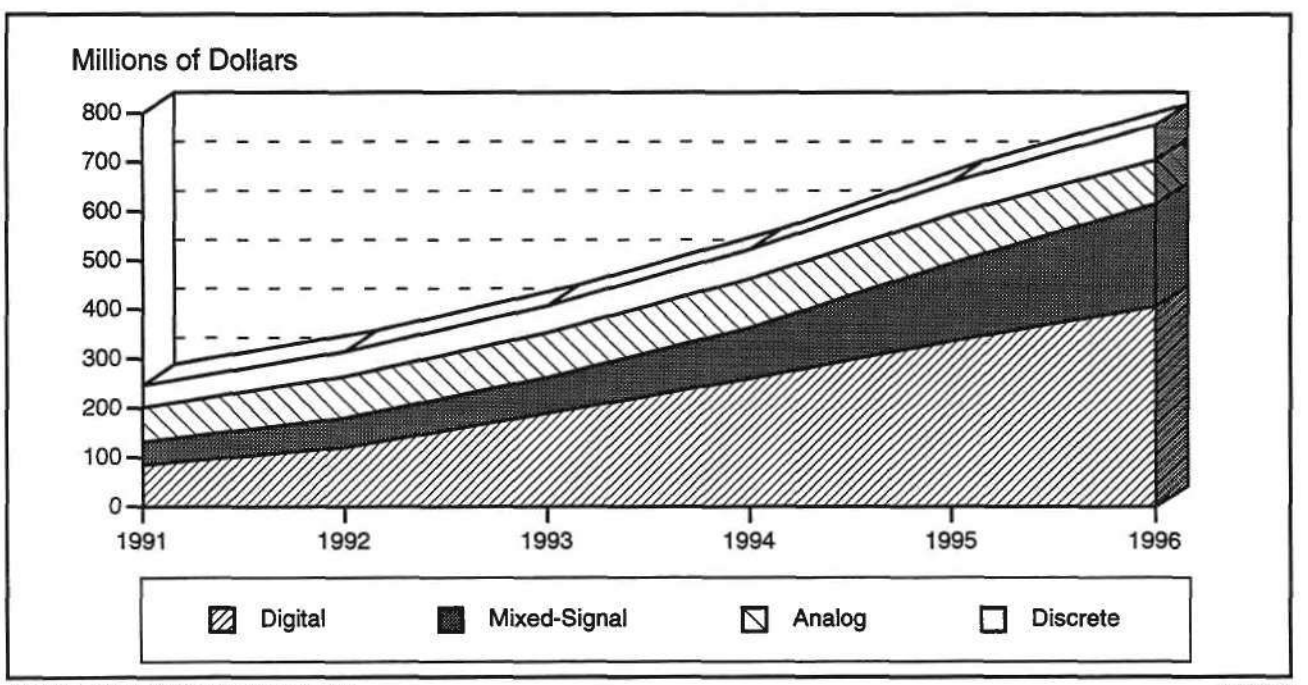
Table 3
Five-Year Forecast: Linear, Mixed-Signal, and Digital ICs (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Linear	737	737	735	795	825	849	800	1.7
Mixed-Signal	955	1,048	1,230	1,490	1,800	2,081	2,400	18.0
Digital	3,982	4,419	4,622	5,385	6,120	6,580	7,198	10.2
Discrete	1,323	1,359	1,374	1,460	1,533	1,589	1,671	4.2
Optoelectronic	469	568	583	635	694	741	785	6.7
Total Semiconductor	7,468	8,131	8,544	9,765	10,972	11,840	12,854	9.6

Source: Dataquest (December 1992)

Figure 6
Cellular Communications Market for ICs



Source: Dataquest (December 1992)

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communications products over the five-year forecast period. Like other growth markets in communication, growth in cellular communication translates into growth for the digital IC and mixed-signal IC categories within semiconductors.

Forecast by Technology

The division of the communications IC market into linear, mixed, and digital allows an easy mapping of the product forecast into a five-year forecast by process technology. Table 4 and Figure 7 show this five-year forecast by process for the ICs consumed in the communications market.

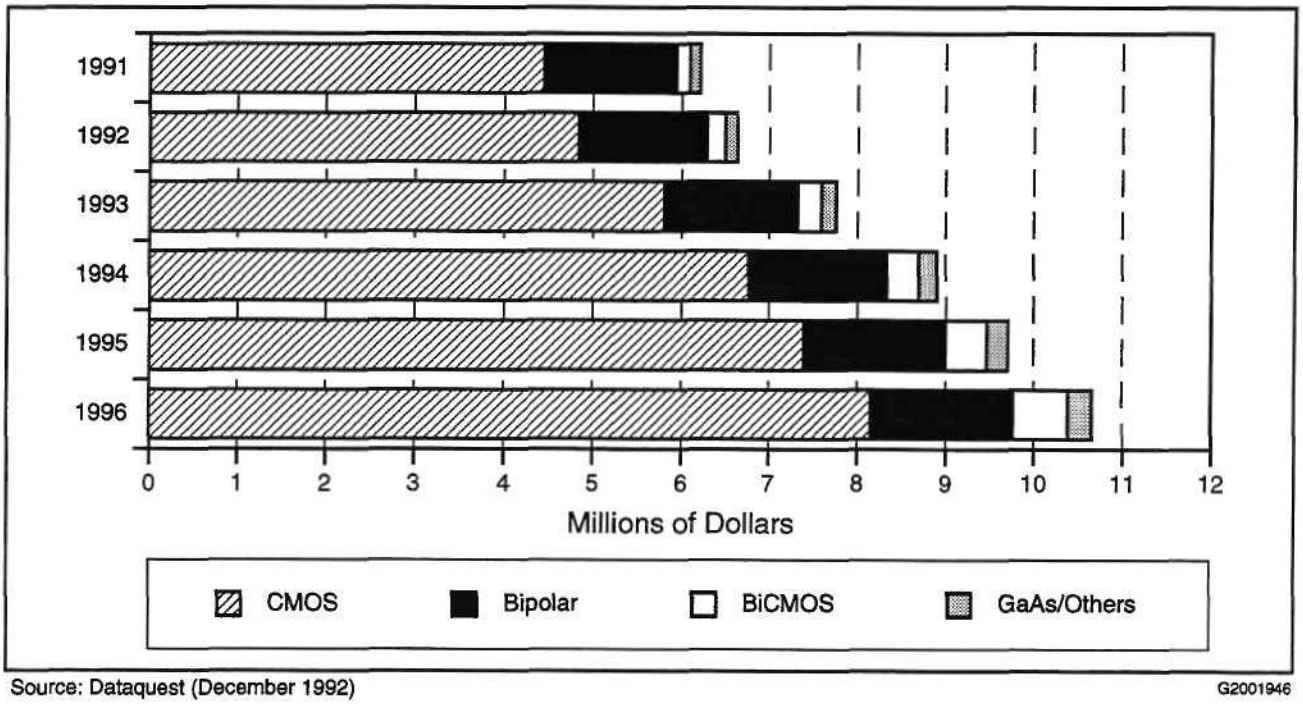
It is important to realize that the GaAs revenue shown are only for nonoptoelectronic ICs used in communications equipment for nonmilitary markets. GaAs has important applications and significant revenue within military communication, but this revenue is categorized as being within military equipment rather than

Table 4
Communications Market IC Forecast by Technology (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
CMOS	3,906	4,434	4,829	5,799	6,767	7,401	8,155	13.0
Bipolar	1,565	1,503	1,458	1,524	1,561	1,596	1,616	1.5
BiCMOS/BCD	129	154	206	268	360	472	614	31.9
GaAs/Other	75	114	137	165	205	240	270	18.8
Total IC	5,675	6,206	6,508	7,671	8,746	9,510	10,398	10.9

Source: Dataquest (December 1992)

Figure 7
Semiconductor Forecast, by Technology



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communications equipment markets. GaAs-based optoelectronic devices are classified as a separate category and not as part of the IC category.

Dataquest Perspective

The communications market has not yet relinquished its role as a major driver of the semiconductor industry. The universe of communications needs, whether they are within the commercial communications markets or are parts of the radio, television, and military/aerospace communications markets, provide a market pressure equal or greater than that of data processing. The division between computing and communication will continue to blur as digital computers become increasingly portable, with increasing needs for a communications tether to a central database.

Communication has always involved signals, signal processing, transmission, and reception. The market is changing, however, as these fundamental communications functions are modified by terms such as personal, wireless, digital, or optical. DSPs, mixed-signal ICs, and GaAs devices are three of the semiconductor sectors to be strongly affected by the changing nature of communication in the coming years.

By Gary Grandbois

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In This Issue...

Conferences and Exhibitions

Semiconductor Conference Highlights

A record number of attendees turned out for Dataquest's 18th Annual Semiconductor Conference October 5 and 6 in Monterey, California. It was an exciting event marked by insight, emotion, and debate. This article focuses on the highlights of the two-day conference.

By Rick Spence *Page 1*

Conferences and Exhibitions

Semiconductor Conference Highlights

For almost two decades now, Dataquest's 18th Annual Semiconductor Conference has brought together the electronics industry's top executives to share their thoughts, ideas, and vision on a variety of topics that will all affect the semiconductor industry. This year the conference, held October 5 and 6 in Monterey, California, was packed with informative speakers, panel discussions, and breakout sessions.

This article will provide an overview of conference events and present some themes and highlights that emerged from the numerous outstanding presentations and discussions throughout the two days. (Transcripts of the entire conference are also available. Call 1-800-457-8233 for more information.)

Semiconductor Outlook

The theme of this year's conference, "Fueling the Engines of Growth," focused on application markets including computers, communication, and the consumer, as well as the marriage of all three, multimedia. Applications of the future will be interdependent, and an understanding of how these hybrid semiconductor markets will emerge is absolutely essential.

In his opening remarks, Gene Norrett, vice president and director of Dataquest's semiconductor group, kicked off the conference by identifying hot and not-so-hot markets in North America and abroad for 1993. Mr. Norrett said that Dataquest's 1993 worldwide electronic equipment forecast shows data processing, consumer, and communication as the top three drivers for future growth—or, stated another way, the engines that will need fueling.

What will be the petrol in 1993? "Clearly 4Mbit is on top, but we're forecasting that the flash

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memories are going to grow substantially next year, up to almost $560 million, a growth of 103 percent," Mr. Norrett said (see Table 1). "Complex PLDs and FPGAs will rise to over $500 million, a growth of 31 percent. On the not-so-hot side, obviously the older devices, older technologies, are being replaced by the newer technologies, such as 1Mb and the lower-density EPROMs."

Where will the devices sell? Mr. Norrett identified Asia/Pacific as a particularly hot region. In fact, he said that total semiconductor sales in Asia/Pacific will equal all of Europe by the fourth quarter of this year, and that by next year they will remain equal to or surpass European consumption. That means the ranking of the regions, in terms of where the semiconductors go, will be Japan, North America, Asia/Pacific, and Europe.

Mr. Norrett also pointed out the following significant revelations and events of 1991:

- North American companies' sales in Asia/Pacific surpassed those of the Japanese companies.
- Asia/Pacific companies surpassed the European companies in Asia.
- Taiwan passed Korea as the largest consuming country in Asia.
- Intel became the No. 1 supplier to the U.S. market.
- Sematech: "Fabs will cost $2 billion by 2005."

Dataquest believes that the electronics industry (the engines) will grow 7.7 percent in 1993. Our forecast for the fuel or semiconductors for these products—which include data processing, communication, industrial, consumer, military/aerospace, and transportation—calls for 15.5 percent growth in the coming year. What about troubled world economies? We believe that the recession may soon be over for the United States, but we are concerned about Japan and Europe. The following sections discuss some of the opportunities.

Communications

Digital video communication is one application that, in many instances, brings two or more of the three engines together. Curtis Crawford, vice president of AT&T Microelectronics, shared his thoughts on the subject with his speech entitled "Advanced Video Communications and Computing." The following are some key areas where Mr. Crawford sees a merging of technologies:

- Information appliances: Appliances that integrate standalone consumer products of today, such as cordless telephones, radios, and TVs.
- Interactive TV, video, CD-ROM: Viewers can participate in live broadcasts. For instance, armchair quarterbacks watching a football game could call the plays as they happen and compete with other viewers on a play-by-play basis. NTN Communications of Carlsbad, California offers this capability to restaurants, bars, and hotels for $650 a month. NTN

Table 1
Hot and Not-So-Hot IC Devices in 1993

	Dollar Growth (%)	Market Size ($M)
Hot		
4Mb DRAM	38	6,500
32-Bit MPU	19	4,100
Flash Memories	103	558
CPLDs and FPGAs	31	508
Not so Hot		
1Mb DRAMs	-28	1,395
ST^2L Logic	-14	1,065
≤1Mb EPROMs	-17	810
Bipolar PLDs	-18	228

Source: Dataquest (November 1992)

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believes that there will be 20 million to 25 million "interactive-ready" homes within the next 10 years. Other possibilities for ITV range from real-time voting to participating in television programs such as game shows.

- Education and entertainment: Ordering a movie, doing research on a particular subject, or attending class at the local college from the comfort of your own living room.
- Home control/security
- Intelligent automobiles
- ISDN video phone

In comparing the fundamental ways in which people exchange information, Mr. Crawford stressed the point that visual communication is much more rewarding than audio. For example, the ability to see and talk to a faraway friend or relative is much more fulfilling than a disembodied voice. He pointed out how difficult it would be to verbalize such information as the Dow Jones average, schematic diagrams, and maps without the use of visual aids. Perhaps Mr. Crawford summed it up best by saying, "We see a hell of a lot more than we hear."

AT&T formed a partnership with EO INC, Matsushita, and Marubeni earlier this year that underscores its commitment to personal communicators. Its vision for advanced video communication begins with these products. AT&T believes that, by the turn of the century, personal communicators will be wireless, have cordless phone and voice recognition capability, and provide the functionality of full-featured video phones with high-quality resolution. Working with Matsushita and Marubeni to manufacture and distribute these respective products is a good example of a well-thought-out partnership that exploits each company's area of expertise, which industry executives agree is essential for competing in an ever burgeoning global economy. Being all things to all people will not be possible nor smart, for most companies. Those that go it alone will charter unfamiliar and unfriendly waters. Only the companies with varied talents and experience will make it safely to the promised land.

And it will be a journey worth making, as Dataquest analysts Jerry Banks (director and principal analyst in the Semiconductor Industry service) and Nick Samaras (principal analyst in the Semiconductor Applications Market service), pointed out during their breakout session, which focused on personal information and communications devices (PICDs). Worldwide shipments of PICDs are expected to grow to 40 million units by the year 2000 (see Figure 1). Key elements for this growth will include low-power semiconductor devices, flash memories (64Mb by 1995), pen-based operating systems, data compression, and increased connectivity.

DSP: The Enabler

What do digital answering machines, high-density TV (HDTV), 3-D graphics, video phones, and other "impossible" or breakthrough systems have in common? The answer is digital signal processing (DSP), a technology rightfully receiving much attention lately. DSP takes analog signals such as music, speech or video, converts them into the digital domain, and uses data-intensive complex algorithms to compress, enhance, or otherwise alter the original signal to suit a particular application. For example, sampling the waveform of the sound produced by a car's exhaust system and applying the same waveform 180 degrees out of phase to the original signal will result in considerable noise cancellation and quieter cars (see Figure 2). Video phones can be used over standard phone lines because they use DSP-enabled compression to eliminate redundant or unnecessary information that results in lower bandwidth requirements. One of the simplest and probably most useful applications of DSP is digital answering machines, which will save the world from endless loop, leaderless, mini and standard size, and analog cassette tapes. They work in much the same way as do today's voice mail systems, with instant access to digitally stored messages. Acoustical room simulation is an application soon to find its way into U.S. automobiles. DSP will be used to allow drivers to simulate different acoustical environments: for example, small nightclubs, dance bars, and Carnegie Hall. Tonal and reverberation qualities specific to a venue are appropriate for different styles of music and personal taste, and most can be artificially created through the use of DSP.

In his speech entitled "DSP: The Enabling Technology for Emerging Computer, Multimedia, and Consumer Applications," Dr. Wally Rhines, executive vice president of Texas Instruments, explored the myriad applications made possible

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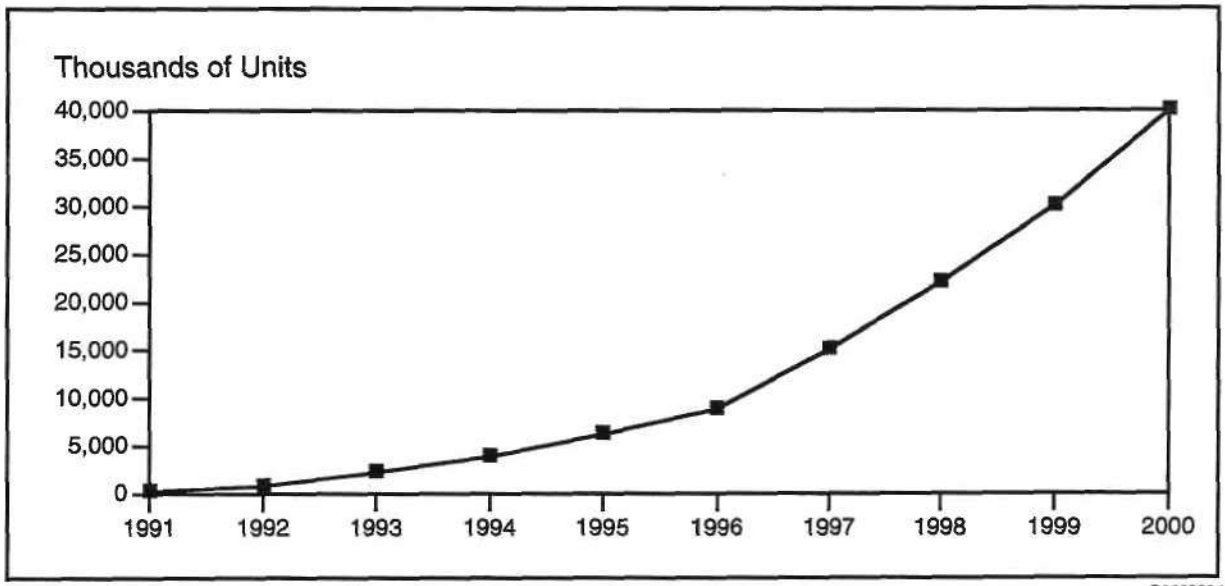
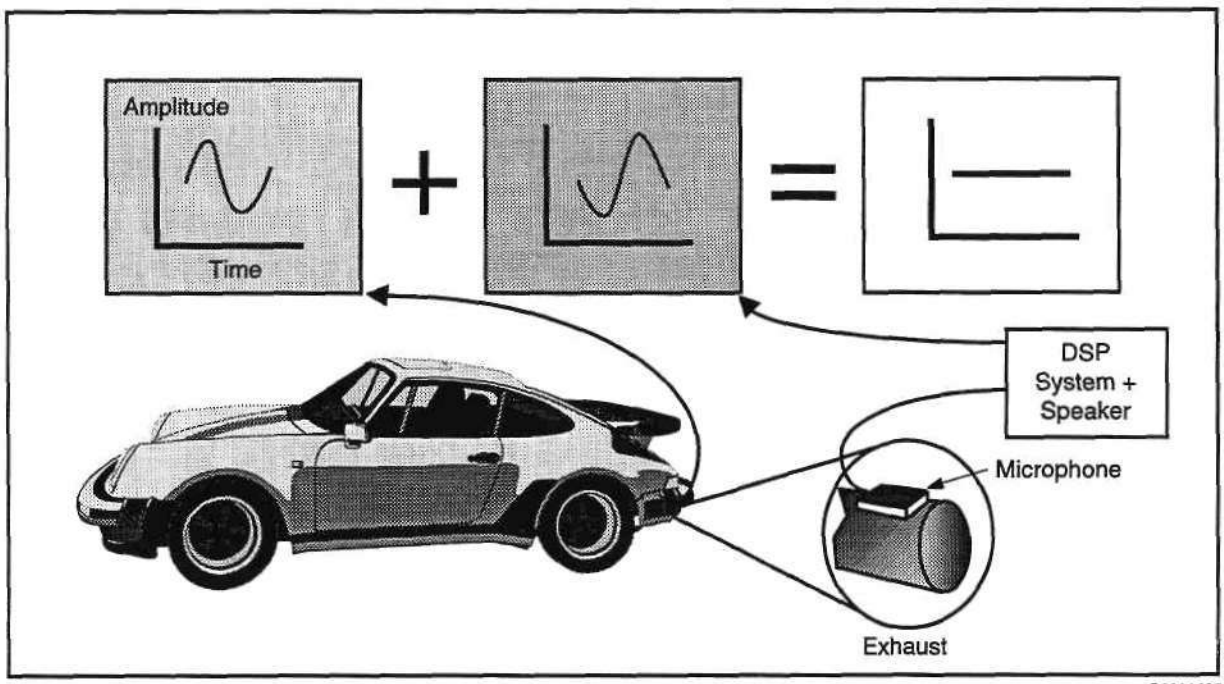
Figure 1
Personal Information and Communications Devices Worldwide Shipment Forecast



Source: Dataquest (November 1992) G2002384

Figure 2
Example of an Automotive Muffler



Source: Texas Instruments Inc. G2002385

by DSP. Dr. Rhines, who was responsible for TI's first speech synthesis chips (used in the well known Speak'N Spell learning tool), took the audience on an inspired journey into the future world of DSP. He sees a world with DSP-CORE-based ASIC products that allow the merger of standard ASIC, analog, memory, and DSP. Dr. Rhines also believes that video will be an important driver in the years ahead, a view echoed by other speakers.

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The Benefits of GPS

The challenge of navigating streets in an unfamiliar major metropolitan area may soon be avoided altogether because of advances in global positioning satellites (GPS) used in automotive electronics. This technology, which already appears in Japan, represents a driver as a dot on an electronic map inside the vehicle console display and ensures travel in the correct direction. In San Jose, California, Avis offers cars equipped with NavMate, a GPS system using technology developed by Zexel of Sunnyvale, California. Those who have tried NavMate have given it good reviews, although they say the range is limited. Navigation systems are just one application spoken of during a speech on the next frontiers in automotive electronics given by Dr. Ralph Wilheim, director of Delco Electronics Corporation's advanced development and systems integration group.

Dr. Wilheim pointed out that, as high-end stereo systems, steering wheel controls, heads-up displays (HUD) and data bus transmission were hallmarks for the 1980s, key frontiers in the 1990s will be complex power trains, vehicle communications, safety, and advanced high-content HUD, which provide better car/human interaction. Consumers will demand reliable high-quality electronics that will result in the need for ultrareliable components.

Entertainment and Multimedia

Entertainment and multimedia are markets that will be defined in this decade. The possibilities will depend on imagination: "anything is possible" is becoming a reasonable statement, as a look at hardware will attest. We are on the verge of high-end products for the home, including HDTV, digital compact cassette (DCC), recordable CDs, Nintendo and Sega videogames with near-arcade quality, and karaoke, which are samples of standalone gear. Inclusion of a personal computer with a CD-ROM drive, sound card, modem, and other multimedia-making goodies results in a whole new world. With the addition of cable and phone companies that would like to offer information and entertainment on demand, the possibilities are unlimited. For example, Time/Warner and IBM in May 1992 started exchanging ideas on how to deliver Time/Warner's entertainment holdings using IBM transmission technology and Time/Warner's cable networks. IBM's compression techniques could be used to store and electronically deliver on demand a library of movies; the network would also allow viewer interaction with television programs.

Greg Sheppard, director and principal analyst of Dataquest's Semiconductor Applications Market service, gave a multimedia presentation and shared findings in Dataquest's just released focus report on multimedia. Mr. Sheppard gave a view of the multimedia applications implementation over time (see Figure 3). The applications move from personal to collaborative as networking capabilities increase.

When will use of this technology become an integrated part of our lives? One of the strongest influences on a multimedia society will be advancement of the telecommunication infrastructure and deployment of high bandwidth to the curb. Dataquest estimates that almost 25 percent of central offices (where a phone line is connected) will be Integrated Services Digital Network (ISDN)-capable by 1994. ISDN, which has not caught on as fast as many people would like, is an important merger of key technologies that will provide the high bandwidth needed for thirsty mixed-media messages. In the telecommunication world, this means the seamless merger of voice, video, and data.

True multimedia occurs when all three functional media can interactively exchange information regardless of the location of the databases and the equipment being used. It will be perceived to be almost free of cost, much as local telephone service is today. "Even though the local calls are not free, the perception is they are," said Ken Landoline, group director of Dataquest's Telecommunications service. My daughter will stay on the phone for five hours at a time, and luckily it doesn't cost me any money. That's really when multimedia will take off. When you're database is in Europe and you're in San Jose working on your PC while you're tying in to a colleague in Japan and it all happens so seamlessly, that's when true multimedia comes to play."

The Future of Processors

Craig Barrett, executive vice president of Intel, addressed the business need and directions of advanced processors and the delivery

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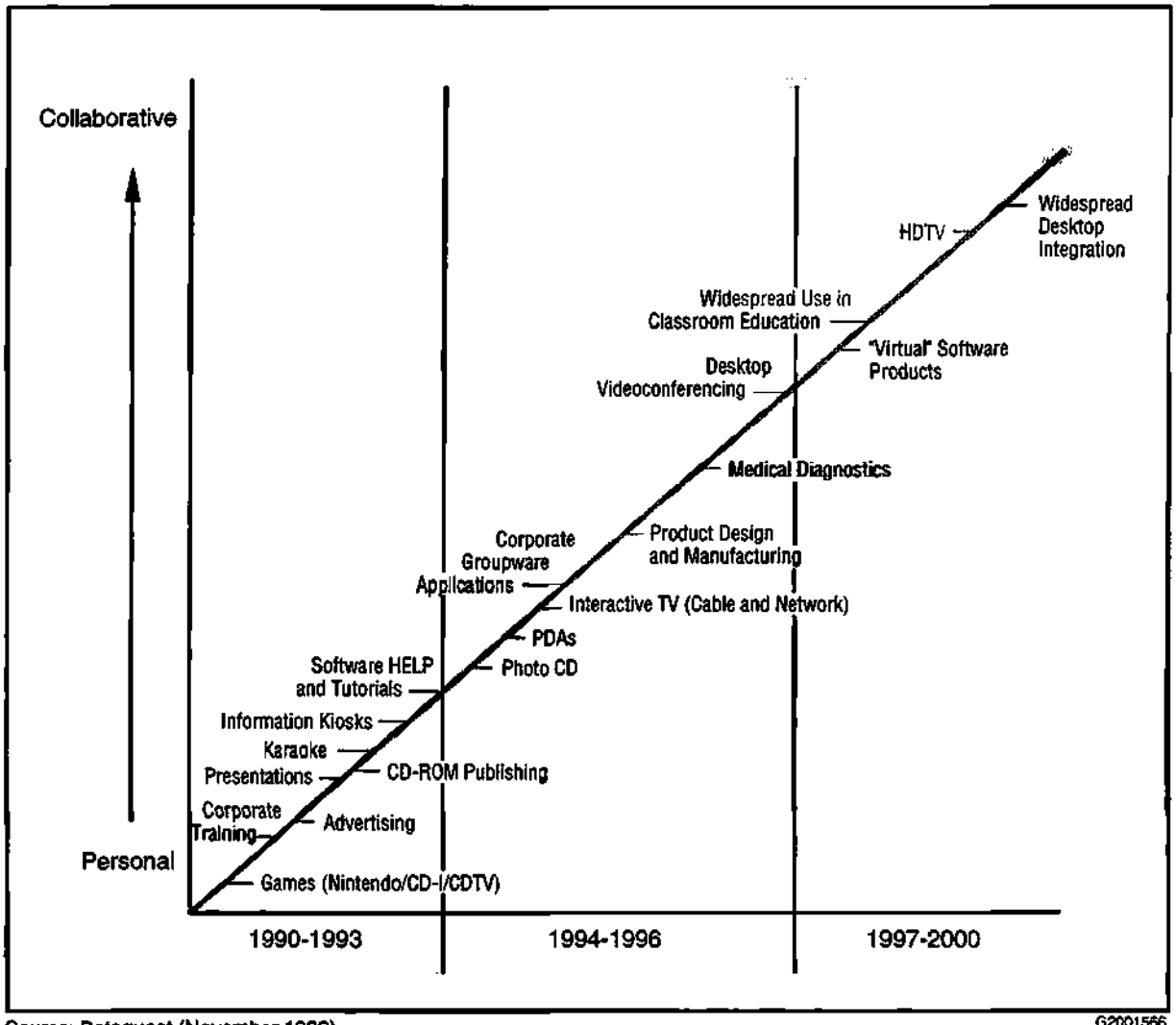
Figure 3
Multimedia Applications Implementation



Source: Dataquest (November 1992)
G2001566

of computer-supported collaboration. He touched on the importance of easy access, readily available information that will help the corporations of tomorrow make faster and more informed decisions. Mr. Barrett referred to this as just-in-time (JIT) business. This JIT business model will utilize natural data-type transactions such as voice and handwriting recognition. As a result, the complexity and amount of software needed to run these systems will increase, which Mr. Barrett referred to as the software spiral (see Figure 4), the ever widening amount of available applications. This will drive introduction of next-generation microprocessors. Intel believes that the microprocessor of the year 2000 will have 100 million transistors and perform 2 billion instructions per second (see Figure 5).

What about RISC-based architecture? Dataquest's Ken Lowe, senior industry analyst in the Semiconductor Industry service, hosted a panel discussion on microprocessors, which featured proponents of SPARC, MIPS, PA-RISC, Power, and Alpha designs. Panel members representing Sun Microsystems, MIPS Technology, Hewlett-Packard, IBM, and Digital Equipment Corporation were all asked whether RISC processors and open systems computing can end the 80x86 dominance of mainstream personal computers.

Each panel member presented an opening statement, and then Mr. Lowe and the audience were

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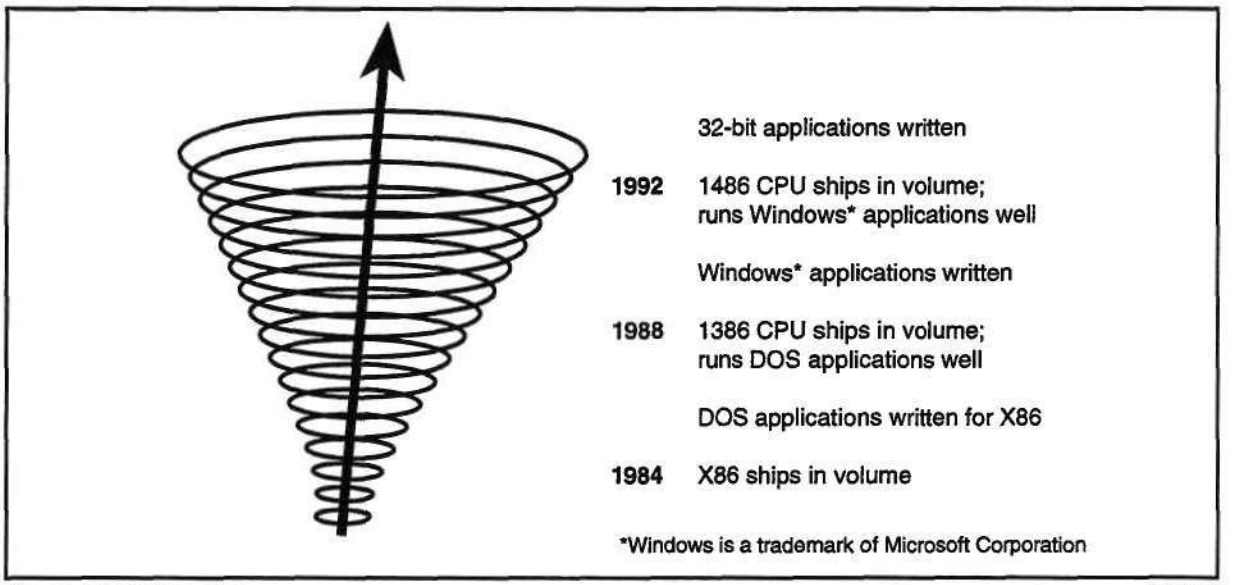
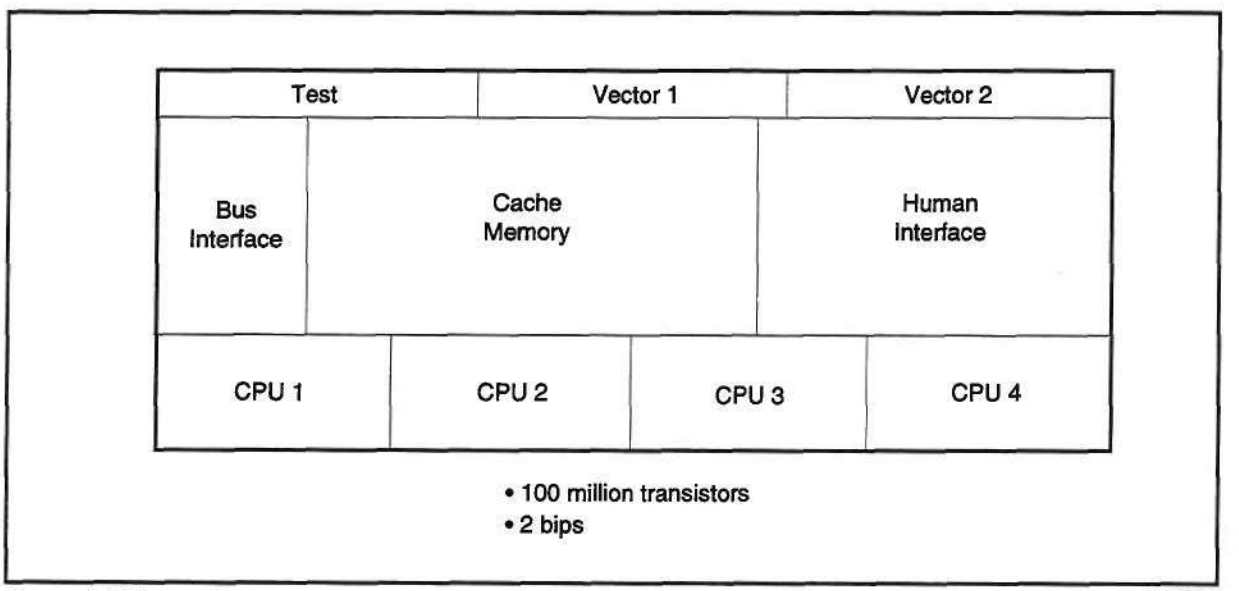
Figure 4
CPU Software Spiral



Source: Intel Corporation G2002387

Figure 5
Microprocessor of the Year 2000



Source: Intel Corporation G2002388

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free to ask questions. Key issues raised included the following:

- Does RISC offer any real cost advantages?
- How important are portables versus desktops versus data centers?
- Is the 80x86 architecture becoming an open standard?

Key positions taken by the five companies included the following:

- Sun strongly emphasized that UNIX is the future.
- MIPS stressed the abundance and variety of the MIPS application base.
- HP, alluding to the mainstream possibilities, stated that there are two types of vendors: those who admit they are porting to Windows NT and those who do not admit it.
- IBM emphasized that versions of Power PC will be available for notebooks, desktops, and technical workstations.
- Digital stated that RISC's success will belong to companies that offer both the system products and develop the processors.

While there were many different views, there was a general consensus that all five RISC families could not survive. Table 2 details the CISC challengers.

Make It Better

The Malcom Baldrige quality award is not something to be taken lightly, and companies that receive it usually already are or go on to be successful. Dr. Nishimura, president and co-CEO of Solectron Corporation, gave an animated and emotionally charged presentation on what it took to become the 1991 winner of the National Quality Award. Dr. Nishimura took the audience step by step through the Baldridge process, which includes surveying customers once a week to get grades on delivery, quality, serviceability, and communication. He touched on internal issues ranging from the financial process and accounting procedures to the importance of employee input and training.

Quality and building relationships were recurring themes throughout the conference. At the end of his speech and when asked by the audience about the subjects, Dr. Nishimura stated, "My philosophy is, if business exists, and we happen to be the best, we will get the business we want . . . a company will say how we reward you for doing a great job is we give you more business, and that's been happening. We do a lot of marketing studies. We can't take on everybody. The important thing is we select our customer. When we select that customer, we treat them like we would treat our biggest customer."

It's My Patent and I'll Sue if I Want To

Protecting intellectual property is becoming a priority among companies and is generating considerable revenue and profit for companies with large portfolios. Texas Instruments is an

Table 2
RISC Family Challengers

	SPARC	MIPS	PA-RISC	Power	Alpha
1991 Chip Volume	280,000	175,000	18,000	40,000	0
Major System Vendors	Sun	SGI	HP	Apple	Digital
	Fujitsu	NEC	Hitachi	IBM	Cray
Current Silicon Vendors	Cypress	Performance	HP	Motorola	Digital
	Fujitsu	IDT	Hitachi	IBM	
	LSI	LSI	Samsung		
	TI	NEC	Winbond		
	Weitek	Siemens			
		Toshiba			

Source: Dataquest (November 1992)

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example. TI took in $300 million in royalties and licensing fees in the first three quarters of this year. If previous collections back to 1987 are added, the total is almost $1 billion.

The main intellectual property components are as follows:

- Patents, which offer the legal protection of novel ideas that permit, in practice, the solution of specific technological problems.
- Copyrights, which protect individual works of authorship fixed in any tangible medium of expression.
- Trade secrets, which protect disclosure of and appropriation of industrial secrets gained by virtue of employment.
- Trademarks, which are marks that distinguish goods or services of an industrial or commercial enterprise or group of enterprises.

Lois Abraham, an expert in technology litigation at Brown and Bain, focused on patents in her presentation, "Intellectual Property Strategy: A Necessity, Not an Option." Her discussion stressed the importance of knowing how the system works and offered insight to those with and without strong patent portfolios. Ms. Abraham presented an actual disclosure history that showed the complexity and idiosyncrasies of patent law (see Figure 6). The application was filed in 1971, split into two divisionals, and revised to cover emerging technology, all perfectly legal. There are reforms on the table that would implement expiration dates on such filings, but those who understand the current system can keep something alive for a long time. Ms. Abraham referred to these as submarine patents: filings that go underwater for years and suddenly emerge in the middle of an industry that has been built up with no knowledge of the patent's pending grant.

Patent litigation has increased more than 50 percent in the last 10 years. The number of patents that have been issued is nearing that percentage. A patentee currently can sue whoever is in the chain of buy, sell, or use of property believed to be infringing on a patent, including third parties. The playing field is not even and it may not be anytime soon. Patents that used to be ignorable nuisances are now considered powerful weapons. And a company without weapons of its own had better start learning how to disarm or charm its competitors.

Turn Up the Carpet

What about the fun stuff, such as gadgets and things that talk? Before kicking off the second day of the conference, Joe Grenier, director of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service, had some fun sharing with the audience some of the more esoteric applications for chips. These applications include microprocessor-controlled paperless toilets with heated seats, talking garbage cans that indicate when they are full, medicine bottles preprogrammed by pharmacies to alert patients when it is time to take their medicine, talking dog collars, waiter-specific espresso machines from Italy, and electric carpets from Japan.

Voice of a Legend

The record number of attendees were also treated to a special keynote address after Monday night's dinner. David Packard of Hewlett-Packard was on hand to share his thoughts on politics, the future, and how to run a company that can last into the future. Mr. Packard's introduction was as impressive as anything heard the entire two days. The audience looked on in awe of Mr. Packard as Judith Hamilton, president of Dataquest, identified only the highlights of his illustrious career. His contributions not only helped to mold and forge the future of high technology, but to promote and enhance the quality of life for individuals everywhere.

Mr. Packard spoke of his early love for radio and relived some of his memories as a student at Stanford and as an engineer at General Electric in the 1930s. His speech was an autobiography filled with insights, opinions, and many lessons learned.

Mr. Packard also touched on the current state of America's corporate culture. He is concerned that many organizations have their priorities out of order. He identified what he believes are the top three priorities needed to run a successful company. "The first obligation is to your customers," he said; employees and suppliers are second and third. Mr. Packard also said that, although many company executives consider the responsibility to the shareholders as their No. 1 responsibility, it really should fall last on the list.

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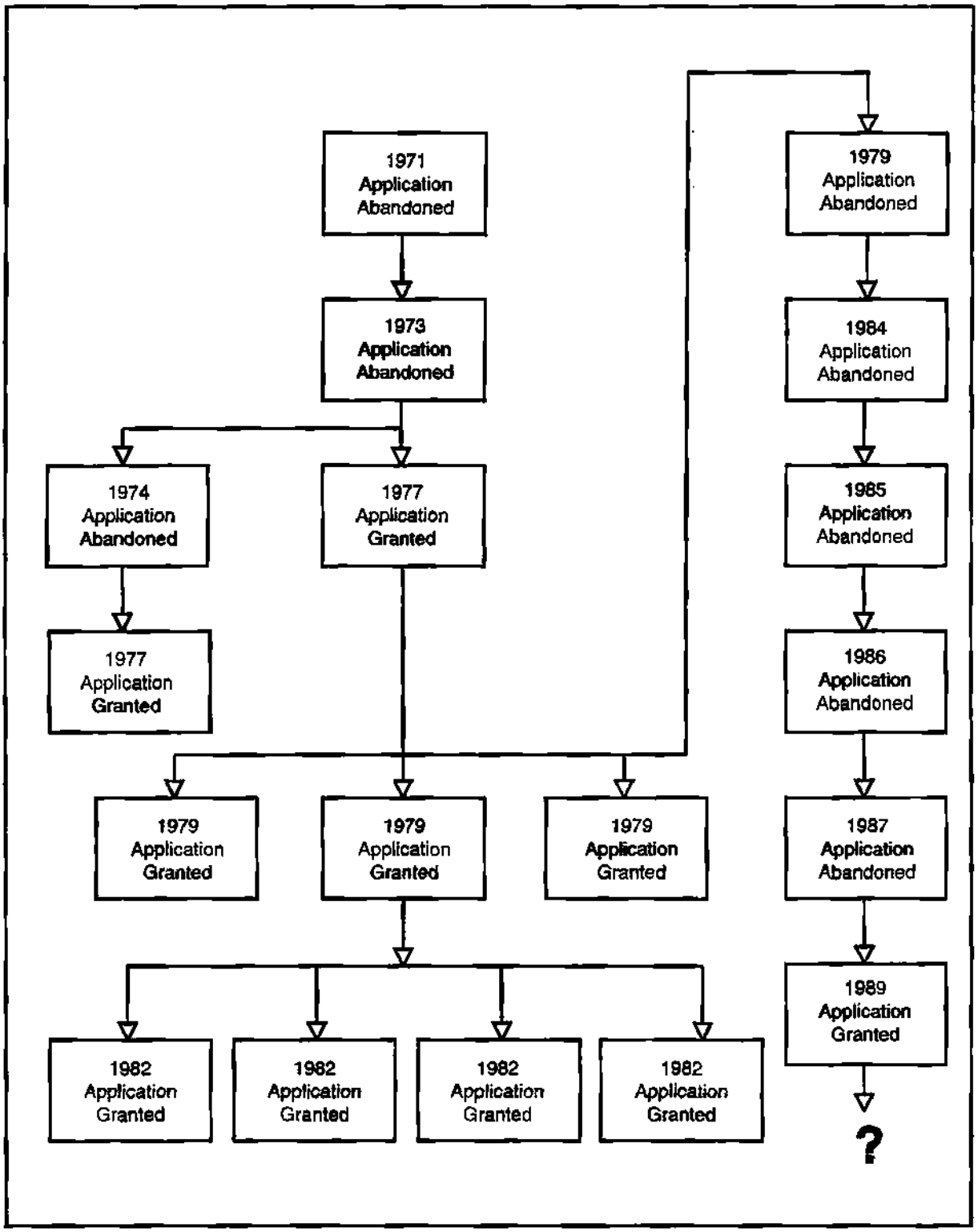
Figure 6
History of a Disclosure



Source: Brown and Bain

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He closed on the topic by saying, "In fact, if your company is listening to customers, taking care of employees and maintaining good relationships with suppliers, everything else will fall into place."

Anyone who has thought of starting a business would have enjoyed listening to Mr. Packard's entrepreneurial exploits, which all began in 1939 in a garage in Palo Alto, California. Because this type of success story seems much harder to come by in today's business environment, after hearing a legend such as Dave Packard speak, future leaders of high-tech and other industries may be compelled to continue the quest for innovation and a better quality of life.

Dataquest Perspective

The Dataquest Semiconductor Conference is really about people. Industry experts come together to share ideas and expertise, and it is hoped that everyone walks away with something they did not have coming in. During the breaks throughout the two days, there were lots of mingling and the buzz of conversation in the air. The mood seemed upbeat, almost electric, which is a positive sign for the industry.

U.S. companies have always been extremely competitive. That competitive mind-set must be maintained. But it appears that a new era is imminent, an era of companies splitting R&D costs by setting up joint research and development centers overseas, forming alliances and whole new subsidiaries, and sharing design, manufacturing, and marketing expertise. This is happening in North America and Japan as well as in Europe and Asia. Many markets of tomorrow will be new and complex, and few companies will successfully travel solo.

Now, more than ever, little details count. Keeping a shop in order, protecting intellectual property, aligning with the right partners, responding to and not just listening to clients, and focusing on quality while jumping on these new emerging markets will be the keys to success in the 1990s.

By Rick Spence

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Dataquest Perspective

Semiconductors
Extra Edition

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In This Issue...

Market Analysis

Worldwide Semiconductor Industry Forecast: 1992-1993

This article details Dataquest's forecast of the worldwide semiconductor industry, with special attention to geographic regions and devices. We also revisit our forecast of October 1991 and explain the difference between the final actual numbers and those from the forecast last fall.

By Gene Norrett *Page 1*

Market Analysis

Worldwide Semiconductor Industry Forecast: 1992-1993

Dataquest expects the worldwide semiconductor industry to grow by 5.4 percent in 1992 and 15.5 percent in 1993 (see Figure 1). Over the longer term, we see 1994 growing at 13.7 percent and we see a cyclical slowdown in 1995 and 1996. The compound annual growth rate during this period will be 9.7 percent. The worldwide industry will experience vastly differing growth rates on a region-by-region basis because of region-specific economic conditions. Principal factors driving the industry include sales of the portable personal computer, networking of desktop PCs, portable communication, and the increasing pervasiveness of semiconductors into the automotive and computer peripheral markets. From a product perspective, the highest growth products will be 4Mb DRAMs, 32-bit microprocessors, a wide variety of chip sets, and mixed-signal integrated circuits.

Dataquest's Semiconductor Forecast Methodology

Dataquest publishes five-year revenue forecasts for the semiconductor market semiannually. In doing so, Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. An overview of Dataquest forecasting techniques can be found in the *Dataquest Research Methodology Guide.*

Dataquest's semiconductor forecast methodology leverages the resources of its parent company, The Dun & Bradstreet Corporation, as well as the considerable internal resources of Dataquest. Dun & Bradstreet Corporation information is used to develop the macroeconomic forecasts for the world's major economies. This forecast identifies trends in the economic health of the world's leading consumers and producers of

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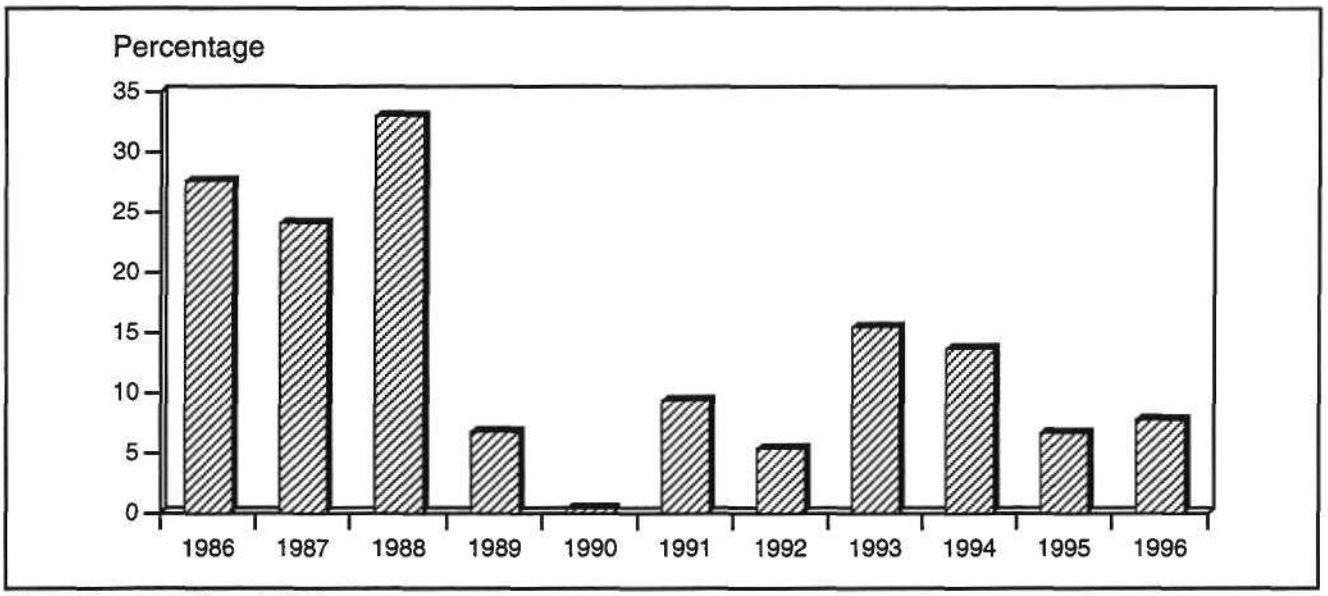
Figure 1
Worldwide Semiconductor Consumption (Factory Revenue, Dollar-Based Annual Growth)



Source: Dataquest (August 1992)

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electronic equipment. Using this forecast in conjunction with input from Dataquest's regional offices, Dataquest identifies the likelihood of whether consumption of electronic equipment in a particular region or country will increase or decrease.

Dataquest follows a four-step process to forecast the semiconductor market. First, Dataquest's Semiconductor Applications Market group, along with Dataquest's various electronic systems groups, provides a long-range outlook for the overall growth of the electronic equipment market. Semiconductor content ratios are developed by region to reflect the growing penetration of semiconductors into electronic equipment. This establishes a five-year trend growth path for total semiconductors for a five-year period from a demand-side perspective.

Second, Dataquest uses a decomposition time series model to generate forecasts of regional total semiconductor sales. The model assumes that sales are affected by factors such as long-run trends, short-run aggregate economic and industry-specific conditions, and seasonality. The forecast is made by using statistical methods to analyze each component separately, then combining them into a single aggregate. The model is especially useful for assessing market fluctuations about the trend growth path.

Third, Dataquest's worldwide semiconductor service and its Semiconductor Equipment, Materials, and Manufacturing service, in conjunction with its various regional offices, collaborate to formulate expectations of semiconductor market short-range fluctuations around the long-range trend. Tactical market issues and anticipated semiconductor materials demand significantly impact the short-range forecast out to 12 months. Semiconductor equipment purchases and semiconductor device trends drive the forecast in the 12- to 24-month time frame. Semiconductor fab facilities and long-term semiconductor device trends have the greatest impact on the forecast period covering two to five years.

The final step in the forecast process is to reconcile expected fluctuations in the electronics market and trends in the semiconductor industry so that the fluctuations do not inexplicably diverge from semiconductor industry trends. Dataquest expects, in the absence of shocks to the market, market fluctuations to converge toward the long-term trend.

Semiconductor Industry Assumptions

The North American semiconductor market continues to strengthen. Dataquest expects the North American market to grow 15.1 percent in 1992, up from a meager 2.7 percent in 1991. The market is clearly on target midway through the

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year. According to the latest WSTS statistics, total semiconductor bookings (three-month moving average) growth for the three months ended in June was 18.0 percent above year-earlier bookings, compared with 11.9 percent in May. Total semiconductor billings growth for the same period was 14.8 percent above year-earlier billings, compared with 13.3 percent in May.

Strength in the North American market can be attributed largely to the recovery of the U.S. economy and the relaxation of household and business budget constraints for durable goods and capital equipment. In particular, chip demand stems from strong orders of portable PCs, client/server computers, and network hardware.

Dataquest expects the Japanese market to decline 9.4 percent (dollar-based) in 1992. The latest market statistics support this outlook. The dollar value of total semiconductor billings for the three months ended in May was 15.4 percent below year-earlier billings. The bookings picture is even more bleak. Total semiconductor bookings for the same period were 17.7 percent below year-earlier levels.

Japan's situation is due to more than just weakness in its principal export markets. Other factors include a heightened level of international competition in chips and systems, a glut of worldwide DRAM fab capacity, rising costs of capital in Japan, and a dearth of new, high-volume consumer electronic systems. Dataquest does not expect an improvement in Japan's export market to alleviate these structural problems in 1992.

Dataquest forecasts the European market to grow 7.2 percent in 1992, up from 5.8 percent in 1991. Total semiconductor billings for the three months ended in June were 9.0 percent above year-earlier billings. Total semiconductor bookings for the same period were 7.1 percent above year-earlier levels. We believe that the European market will show more growth in the second half of 1992 than usual, as recovery in the U.S. market starts to pull through demand in Europe later in the year.

Recovery of the U.K. and French economies will help offset decelerating growth in Germany. PC manufacturing in Ireland is strong, and much of the growth in the United Kingdom is related to multinational companies increasing their data processing and consumer equipment production. Investment in telecommunications infrastructure and the introduction of Group Speciale Mobile cellular phones also provide growth stimulus.

Dataquest forecasts the Asia/Pacific-Rest of World (ROW) market to grow 21.6 percent in 1992. Again, the latest statistics support this outlook. Total semiconductor bookings growth for the three months ended in May was 15.8 percent above year-earlier bookings. Total semiconductor billings growth for the same period was 25.5 percent above year-earlier billings. Expansion continues to be driven by foreign investment and improvement in Western export markets.

Forecast Economic Assumptions

The worldwide economy is expected to show mixed results in 1992. The Dun & Bradstreet Corporation forecast the following outlook for the Group of Seven (G7) countries:

- The U.S., Canada, and U.K. economies are expected to recover from recession in 1992. Real gross domestic product (GDP) is expected to expand 2.1, 1.6, and 0.5 percent, respectively, in 1992. (These economies contracted at rates of 0.7, 1.5, and 2.4 percent, respectively, in 1991.) Though modest in comparison to historical rates of expansion during recovery periods, the benefit is that inflationary pressures will likely be held in check, sustaining the expansion's duration. Expansion should accelerate to 2.5 percent, 4.0 percent, and 2.2 percent, respectively, in 1993.
- Real GDP growth is expected to accelerate in France and Italy during 1992, from 0.9 percent in 1991 to 2.1 percent and from 1.4 percent in 1991 to 1.5 percent, respectively. The pace of growth should pick up in 1993 to 2.7 percent and 2.2 percent, respectively.
- Real GDP growth is expected to decelerate in Germany and Japan during 1992, from 3.2 percent in 1991 to 11 percent and from 4.4 percent in 1991 to 2.0 percent, respectively. Moderating these countries' short-term growth prospects are the cost burden of Germany's reunification, the rise in Germany's cost of capital, and the recent bout of asset deflation. The respective economies are expected to reaccelerate to 2.8 percent and 3.3 percent growth in 1993.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar values. The 1991 rates are as follows:

Japan (Yen/U.S.$)	136.00
Europe (ECU/U.S.$)	0.81
France (Franc/U.S.$)	5.64
Germany (Deutsche Mark/U.S.$)	1.66
United Kingdom (U.S.$/Pound Sterling)	1.77

Variance from Previous Forecast

Dataquest reviews this forecast with our previously published forecast, we look at the variance, and explain the actuals versus our forecast.

In October 1991, we forecast that 1992 would grow 13.5 percent over 1991. Our current forecast is 5.4 percent. There are many reasons for this change in outlook. First and foremost, the Japanese market, the largest market for semiconductors, was forecast to grow 15.6 percent. Today, we believe that it will decline by 9.4 percent. Many economic indicators showed weakness in the first and second quarters that accelerated in the third and fourth quarters of 1991, and they continued their downward spiral in the first half of 1992. At the time of our October 1991 forecast, we believed that the softness in the third quarter of 1991 would be temporary and the economy and electronic industry would return to a more normal growth pattern. This was not the case, unfortunately, as is shown in Table 1 (data from the Japanese Economic Planning Agency).

We still have considerable excess business inventory today, which has caused the production cutback throughout the industry. Housing construction continued to decline in the first quarter of 1992 and flattened in the second quarter. Plant and equipment spending dropped again in the first and second quarter. However, they remain at historically high levels. Washington officials are watching the exports as the Japanese government tries to pull itself out of recession.

Other differences between this forecast and our October 1991 forecast are that we see a moderately more aggressive outlook for North America (15.1 percent versus 12.1 percent) and for Asia Pacific-ROW (21.6 percent versus 18.3 percent). For Europe, we have made almost no change (7.2 percent versus 6.7 percent).

Table 2 shows our current complete regional forecast for the period 1991 to 1996.

Semiconductor Forecast by Region

Tables 3 through 12 detail our worldwide, North America, Japan, Europe, and Asia-Pacific/ROW semiconductor consumption and growth forecasts.

North America

The North American market is experiencing a strong up cycle, which we expect to continue for several years (through 1994). Because our data show this market to be heavily dependent on the data processing industry, we believe that 45 percent of all semiconductors are consumed in data processing applications. The current trend shows this to be increasing. However, as we have said before, the growth of U.S. consumption in North America will be constrained by high penetration levels of desktop PCs (about 70 percent) and by a rapidly declining electronics manufacturing base, especially in the defense and aerospace industries.

We also look for the following emerging applications to stimulate the North American market:

- Less than 4V mobile electronics
- Airbag electronics
- High-end imaging
- Local operating networks

Japan

Japanese industry has been hit hard not only by weakness in the domestic market but also by its principal export markets. The United States and Europe have not pulled completely out of their recessions, though economic conditions are far better than they were at this time last year. The most significant device growth will be in memories, particularly DRAMs and flash, and microprocessors, specifically the 486 device. Recent court decisions favorable to Intel will enable it to experience significant growth this year. Cyrix and NexGen, which have successfully emulated the 486 and 586, respectively, will also benefit. Though NexGen's design has not yet been challenged by Intel, Cyrix's design has and the company has been successful in defending its noninfringement position.

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Table 1
Japan's Real Gross National Product at Constant 1985 Prices (Billions of Yen, Seasonally Adjusted; Quarterly Totals)

	FY1990	FY1991	4/91-6/91	7/91-9/91	10/91-12/91	1/92-3/92
Gross Domestic Product	406,615.1	420,648.2	418,446.7	420,211.8	420,104.1	423,649.6
Annual Growth Rate (%)	5.7	3.5	4.0	1.7	-0.1	3.4
Gross National Product	409,214.5	423,565.4	421,003.9	423,052.8	422,715.7	427,193.3
Annual Growth Rate (%)	5.5	3.5	2.8	2.0	-0.3	4.3
Personal Consumption Spending	234,085.0	240,619.7	238,652.2	240,449.8	240,692.7	242,690.2
Annual Growth Rate (%)	4.0	2.8	6.5	3.0	0.4	3.4
Private Residential Construction	22,848.6	20,261.2	21,110.7	20,620.8	19,621.3	19,603.6
Annual Growth Rate (%)	4.9	-11.3	-23.6	-9.0	-18.0	-0.4
Private Fixed Nonresidential Investment	88,990.7	91,683.0	91,559.7	92,225.3	91,491.3	91,440.7
Annual Growth Rate (%)	12.1	3.0	-3.0	2.9	-3.1	-0.2
Change in Business Inventories	2,901.4	3,214.6	3,172.3	3,420.9	3.075.5	3,218.1
Annual Growth Rate (%)	-20.8	10.8	13.7	35.2	-34.7	19.9
Government Current Expenditures	34,428.7	35,428.7	35,595.7	35,114.8	35,297.1	35,691.5
Annual Growth Rate (%)	2.4	2.9	6.5	-5.3	2.1	4.5
Government Fixed Investment	26,095.1	27,579.7	27,378.4	27,392.6	27,655.8	27,826.1
Annual Growth Rate (%)	4.4	5.7	20.3	0.2	3.9	2.5
Change in Government Inventories	95.1	-197.4	-199.8	240.8	-942.6	91.8
Annual Growth Rate (%)	*	*	*	*	*	*
Net External Sector	-230.1	4,975.9	3,734.7	3,587.8	5,824.6	6,631.3
Annual Growth Rate (%)	*	*	*	*	*	*
Exports of Goods and Services and Factor Income Received	73,760.4	77,175.7	74,796.4	76,671.6	77,949.8	79,214.6
Annual Growth Rate (%)	7.7	4.6	-8.7	10.4	6.8	6.7
Imports of Goods and Services and Factor Income Paid	73,990.6	72,199.8	71,061.7	73,083.8	72,125.2	72,583.3
Annual Growth Rate (%)	7.2	-2.4	-7.9	11.9	-5.1	2.6

*Cannot be calculated, or meaningless.
Source: Economic Planning Agency

Table 2
Worldwide Semiconductor Consumption by Region, 1991-1996 (Factory Revenue in U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	16,990	19,564	22,613	25,456	26,127	27,579	
Annual Growth (%)	2.7	15.1	15.6	12.6	2.6	5.6	10.2
Japan	22,496	20,371	22,975	25,870	27,810	29,645	
Annual Growth (%)	11.1	-9.4	12.8	12.6	7.5	6.6	5.7
Europe	11,014	11,809	13,663	15,603	16,493	17,828	
Annual Growth (%)	5.8	7.2	15.7	14.2	5.7	8.1	10.1
Asia/Pacific-ROW	9,194	11,181	13,417	15,698	17,692	19,939	
Annual Growth (%)	25.4	21.6	20.0	17.0	12.7	12.7	16.7
Worldwide	59,694	62,925	72,668	82,627	88,122	94,991	
Annual Growth (%)	9.4	5.4	15.5	13.7	6.7	7.8	9.7

Source: Dataquest (August 1992)

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Table 3
Worldwide Semiconductor Consumption (Millions of Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Semiconductor	38,250	50,859	54,339	54,545	59,694	62,925	72,668	82,627	88,122	94,991
Total Integrated Circuit	29,886	41,068	44,613	44,459	48,855	52,074	60,902	70,002	74,609	80,720
Bipolar Digital	4,760	5,200	4,314	4,173	3,628	3,271	2,989	2,733	2,498	2,252
Bipolar Memory	621	689	460	431	356	339	274	209	185	176
Bipolar Logic	4,139	4,511	3,854	3,742	3,272	2,932	2,715	2,524	2,313	2,076
MOS Digital	17,473	26,988	31,140	30,152	34,315	37,287	45,007	53,063	56,540	61,713
MOS Memory	6,056	11,692	15,405	12,128	12,841	14,683	18,927	22,888	21,978	23,661
MOS Microcomponent	5,108	7,144	7,808	9,584	11,774	12,985	14,804	17,258	20,016	21,920
MOS Logic	6,309	8,152	7,927	8,440	9,700	9,619	11,276	12,917	14,545	16,132
Analog	7,654	8,880	9,159	10,134	10,912	11,516	12,907	14,206	15,571	16,754
Total Discrete	6,655	7,612	7,320	7,674	8,035	8,126	8,730	9,290	9,868	10,403
Total Optoelectronic	1,709	2,179	2,406	2,412	2,804	2,725	3,036	3,335	3,645	3,868

Source: Dataquest (August 1992)

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Table 4
Worldwide Semiconductor Consumption Growth (Percentage)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	24.1	33.0	6.8	0.4	9.4	5.4	15.5	13.7	6.7	7.8	9.7
Total Integrated Circuit	26.5	37.4	8.6	-0.3	9.9	6.6	17.0	14.9	6.6	8.2	10.6
Bipolar Digital	10.1	9.2	-17.0	-3.3	-13.1	-9.8	-8.6	-8.6	-8.6	-9.8	-9.1
Bipolar Memory	2.5	10.9	-33.2	-6.3	-17.4	-4.9	-19.1	-23.7	-11.6	-4.9	-13.2
Bipolar Logic	11.3	9.0	-14.6	-2.9	-12.6	-10.4	-7.4	-7.0	-8.4	-10.2	-8.7
MOS Digital	36.3	54.5	15.4	-3.2	13.8	8.7	20.7	17.9	6.6	9.1	12.5
MOS Memory	34.2	93.1	31.8	-21.3	5.9	14.3	28.9	20.9	-4.0	7.7	13.0
MOS Microcomponent	46.4	39.9	9.3	22.7	22.9	10.3	14.0	16.6	16.0	9.5	13.2
MOS Logic	31.0	29.2	-2.8	6.5	14.9	-0.8	17.2	14.6	12.6	10.9	10.7
Analog	18.2	16.0	3.1	10.6	7.7	5.5	12.1	10.1	9.6	7.6	9.0
Total Discrete	16.1	14.4	-3.8	4.8	4.7	1.1	7.4	6.4	6.2	5.4	5.3
Total Optoelectronic	15.0	27.5	10.4	0.2	16.3	-2.8	11.4	9.8	9.3	6.1	6.6

Source: Dataquest (August 1992)

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Table 5
North American Semiconductor Consumption (Millions of Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Semiconductor	12,858	15,844	17,070	16,540	16,990	19,564	22,613	25,456	26,127	27,579
Total Integrated Circuit	10,886	13,815	15,102	14,616	15,269	17,674	20,603	23,331	23,887	25,229
Bipolar Digital	2,099	2,012	1,635	1,577	1,331	1,332	1,170	1,042	935	828
Bipolar Memory	271	235	180	160	131	147	109	75	65	62
Bipolar Logic	1,828	1,777	1,455	1,417	1,200	1,185	1,061	967	870	766
MOS Digital	6,738	9,606	10,988	10,390	11,296	13,342	16,003	18,449	18,722	19,801
MOS Memory	2,497	4,298	5,772	4,325	4,510	5,477	7,133	8,360	7,507	7,820
MOS Microcomponent	2,012	2,707	2,796	3,381	3,916	4,698	5,149	5,847	6,464	6,754
MOS Logic	2,229	2,601	2,420	2,684	2,870	3,167	3,721	4,242	4,751	5,227
Analog	2,049	2,197	2,479	2,649	2,642	3,000	3,430	3,840	4,230	4,600
Total Discrete	1,642	1,676	1,639	1,611	1,389	1,530	1,630	1,725	1,820	1,915
Total Optoelectronic	330	353	329	313	332	360	380	400	420	435

Source: Dataquest (August 1992)

August 24, 1992

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Table 6
North American Semiconductor Consumption Growth (Percentage)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	18.6	23.2	7.7	-3.1	2.7	15.1	15.6	12.6	2.6	5.6	10.2
Total Integrated Circuit	21.1	26.9	9.3	-3.2	4.5	15.8	16.6	13.2	2.4	5.6	10.6
Bipolar Digital	3.4	-4.1	-18.7	-3.6	-15.6	0.1	-12.2	-10.9	-10.3	-11.4	-9.1
Bipolar Memory	1.5	-13.3	-23.4	-11.1	-18.1	12.2	-25.9	-31.2	-13.3	-4.6	-13.9
Bipolar Logic	3.7	-2.8	-18.1	-2.6	-15.3	-1.2	-10.5	-8.9	-10.0	-12.0	-8.6
MOS Digital	37.2	42.6	14.4	-5.4	8.7	18.1	19.9	15.3	1.5	5.8	11.9
MOS Memory	40.7	72.1	34.3	-25.1	4.3	21.4	30.2	17.2	-10.2	4.2	11.6
MOS Microcomponent	47.7	34.5	3.3	20.9	15.8	20.0	9.6	13.6	10.6	4.5	11.5
MOS Logic	25.6	16.7	-7.0	10.9	6.9	10.3	17.5	14.0	12.0	10.0	12.7
Analog	0.2	7.2	12.8	6.9	-0.3	13.5	14.3	12.0	10.2	8.7	11.7
Total Discrete	6.5	2.1	-2.2	-1.7	-13.8	10.2	6.5	5.8	5.5	5.2	6.6
Total Optoelectronic	4.4	7.0	-6.8	-4.9	6.1	8.4	5.6	5.3	5.0	3.6	5.6

Source: Dataquest (August 1992)

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Table 7
Japanese Semiconductor Consumption (Millions of Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Semiconductor	14,927	20,772	21,491	20,257	22,496	20,371	22,975	25,870	27,810	29,645
Total Integrated Circuit	11,263	16,127	16,860	15,794	17,277	15,650	17,836	20,343	21,941	23,499
Bipolar Digital	1,523	1,906	1,648	1,635	1,442	1,121	1,078	1,016	951	880
Bipolar Memory	227	348	191	194	165	137	118	94	84	82
Bipolar Logic	1,296	1,558	1,457	1,441	1,277	984	960	922	867	797
MOS Digital	6,424	10,501	11,636	10,660	11,881	10,707	12,743	15,038	16,454	17,801
MOS Memory	2,268	4,424	5,629	4,196	4,228	4,150	5,163	6,295	6,379	6,784
MOS Microcomponent	1,902	2,573	2,662	2,974	3,579	3,252	3,807	4,405	5,127	5,477
MOS Logic	2,254	3,504	3,345	3,490	4,074	3,304	3,773	4,338	4,947	5,540
Analog	3,316	3,720	3,576	3,499	3,954	3,823	4,015	4,289	4,536	4,819
Total Discrete	2,693	3,282	3,080	2,969	3,432	3,125	3,353	3,543	3,695	3,860
Total Optoelectronic	971	1,363	1,551	1,494	1,787	1,596	1,785	1,984	2,174	2,286

Source: Dataquest (August 1992)

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Table 8
Japanese Semiconductor Consumption Growth (Percentage)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	25.9	39.2	3.5	-5.7	11.1	-9.4	12.8	12.6	7.5	6.6	5.7
Total Integrated Circuit	28.0	43.2	4.5	-6.3	9.4	-9.4	14.0	14.1	7.9	7.1	6.3
Bipolar Digital	17.6	25.1	-13.5	-0.8	-11.8	-22.3	-3.8	-5.8	-6.4	-7.5	-9.4
Bipolar Memory	34.3	53.3	-45.1	1.6	-14.9	-17.1	-13.7	-20.8	-10.1	-2.3	-13.0
Bipolar Logic	15.1	20.2	-6.5	-1.1	-11.4	-23.0	-2.4	-3.9	-6.0	-8.0	-9.0
MOS Digital	34.9	63.5	10.8	-8.4	11.5	-9.9	19.0	18.0	9.4	8.2	8.4
MOS Memory	30.5	95.1	27.2	-25.5	0.8	-1.8	24.4	21.9	1.3	6.3	9.9
MOS Microcomponent	39.0	35.3	3.5	11.7	20.3	-9.1	17.0	15.7	16.4	6.8	8.9
MOS Logic	36.1	55.5	-4.5	4.3	16.7	-18.9	14.2	15.0	14.0	12.0	6.3
Analog	20.8	12.2	-3.9	-2.2	13.0	-3.3	5.0	6.8	5.8	6.2	4.0
Total Discrete	20.1	21.9	-6.2	-3.6	15.6	-8.9	7.3	5.6	4.3	4.4	2.4
Total Optoelectronic	19.7	40.4	13.8	-3.7	19.6	-10.7	11.9	11.1	9.6	5.2	5.1

Source: Dataquest (August 1992)

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Table 9
European Semiconductor Consumption (Millions of Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Semiconductor	6,498	8,491	9,498	10,415	11,014	11,809	13,663	15,603	16,493	17,828
Total Integrated Circuit	4,840	6,669	7,570	8,115	8,701	9,428	11,163	12,985	13,756	14,974
Bipolar Digital	727	772	627	565	486	452	408	376	338	301
Bipolar Memory	88	74	71	55	43	42	36	32	28	25
Bipolar Logic	639	698	556	510	443	410	372	345	310	277
MOS Digital	2,761	4,364	5,251	5,224	5,853	6,614	7,999	9,537	10,021	11,080
MOS Memory	854	1,797	2,417	2,050	2,129	2,418	3,100	3,824	3,825	4,275
MOS Microcomponent	805	1,212	1,442	1,802	2,082	2,377	2,713	3,215	3,508	3,867
MOS Logic	1,102	1,355	1,392	1,372	1,642	1,819	2,186	2,498	2,688	2,938
Analog	1,352	1,533	1,692	2,326	2,362	2,362	2,756	3,071	3,397	3,592
Total Discrete	1,377	1,516	1,574	1,895	1,828	1,869	1,939	2,018	2,097	2,165
Total Optoelectronic	281	306	354	405	485	511	561	600	640	689

Source: Dataquest (August 1992)

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Table 10
European Semiconductor Consumption Growth (Percentage)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	16.3	30.7	11.9	9.7	5.8	7.2	15.7	14.2	5.7	8.1	10.1
Total Integrated Circuit	17.6	37.8	13.5	7.2	7.2	8.4	18.4	16.3	5.9	8.9	11.5
Bipolar Digital	1.1	6.2	-18.8	-9.9	-14.0	-7.0	-9.6	-7.9	-10.2	-10.8	-9.1
Bipolar Memory	-40.1	-15.9	-4.1	-22.5	-21.8	-1.5	-14.0	-13.5	-12.5	-10.7	-10.6
Bipolar Logic	11.7	9.2	-20.3	-8.3	-13.1	-7.5	-9.2	-7.4	-10.0	-10.8	-9.0
MOS Digital	21.6	58.1	20.3	-0.5	12.0	13.0	20.9	19.2	5.1	10.6	13.6
MOS Memory	5.0	110.4	34.5	-15.2	3.9	13.6	28.2	23.3	0	11.8	15.0
MOS Microcomponent	40.2	50.6	19.0	25.0	15.5	14.2	14.1	18.5	9.1	10.2	13.2
MOS Logic	24.8	23.0	2.7	-1.4	19.7	10.8	20.2	14.3	7.6	9.3	12.3
Analog	20.0	13.4	10.4	37.5	1.5	0	16.7	11.4	10.6	5.8	8.7
Total Discrete	14.1	10.1	3.8	20.4	-3.5	2.3	3.7	4.1	3.9	3.2	3.4
Total Optoelectronic	6.4	8.9	15.7	14.4	19.8	5.4	9.7	7.0	6.6	7.7	7.3

Source: Dataquest (August 1992)

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Table 11
Asia-Pacific/ROW Semiconductor Consumption (Millions of Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Semiconductor	3,967	5,752	6,280	7,333	9,194	11,181	13,417	15,698	17,692	19,939
Total Integrated Circuit	2,898	4,457	5,081	5,934	7,608	9,322	11,300	13,344	15,026	17,018
Bipolar Digital	411	510	404	396	369	366	333	300	275	243
Bipolar Memory	35	32	18	22	17	12	10	9	8	7
Bipolar Logic	376	478	386	374	352	354	322	291	267	236
MOS Digital	1,550	2,517	3,265	3,878	5,285	6,624	8,261	10,038	11,343	13,031
MOS Memory	437	1,173	1,587	1,557	1,974	2,638	3,530	4,408	4,267	4,782
MOS Microcomponent	389	652	908	1,427	2,197	2,657	3,136	3,791	4,917	5,822
MOS Logic	724	692	770	894	1,114	1,329	1,596	1,839	2,159	2,426
Analog	937	1,430	1,412	1,660	1,954	2,332	2,706	3,006	3,408	3,744
Total Discrete	943	1,138	1,027	1,199	1,386	1,601	1,807	2,004	2,255	2,463
Total Optoelectronic	127	157	172	200	200	258	310	351	411	458

Source: Dataquest (August 1992)

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Table 12
Asia-Pacific/ROW Semiconductor Consumption Growth (Percentage)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	55.7	45.0	9.2	16.8	25.4	21.6	20.0	17.0	12.7	12.7	16.7
Total Integrated Circuit	69.0	53.8	14.0	16.8	28.2	22.5	21.2	18.1	12.6	13.3	17.5
Bipolar Digital	46.2	24.1	-20.8	-2.0	-6.8	-0.7	-9.2	-9.9	-8.3	-11.4	-8.0
Bipolar Memory	52.1	-8.5	-43.8	22.3	-22.8	-27.0	-16.7	-12.8	-11.1	-14.0	-16.5
Bipolar Logic	45.7	27.1	-19.2	-3.1	-5.9	0.6	-9.0	-9.8	-8.2	-11.3	-7.7
MOS Digital	77.9	62.4	29.7	18.8	36.3	25.3	24.7	21.5	13.0	14.9	19.8
MOS Memory	136.2	168.4	35.3	-1.9	26.8	33.6	33.8	24.9	-3.2	12.1	19.4
MOS Microcomponent	110.0	67.8	39.3	57.2	54.0	20.9	18.0	20.9	29.7	18.4	21.5
MOS Logic	44.5	-4.4	11.3	16.1	24.6	19.4	20.0	15.2	17.4	12.4	16.9
Analog	66.7	52.6	-1.3	17.6	17.7	19.3	16.0	11.1	13.4	9.9	13.9
Total Discrete	27.6	20.7	-9.8	16.7	15.6	15.5	12.9	10.9	12.5	9.2	12.2
Total Optoelectronic	33.7	23.6	9.6	16.3	0	28.9	20.2	13.2	17.2	11.5	18.0

Source: Dataquest (August 1992)

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Europe

Europe has not yet experienced a return to more normal growth rates (that is, 10 to 15 percent per year). Political turmoil and weak profits from the electronics sector are limiting the semiconductor industry. The telecom industry, which is the largest semiconductor application, is weak and is forecast to remain that way. But there are bright spots worth mentioning, as follows:

- Infrastructure development in Eastern Europe is stimulating telecom systems, cellular phones, and fiber-optic links, among others.
- Transportation is being upgraded, which is helping the computer and industrial electronics.

On the negative side, consumer electronics, usually a bright spot . . an Olympic year, is weak and there are significant excess inventories of television sets, audio, and VCRs.

Asia-Pacific/Rest of World

The year 1992 will again be a boom year for Asia-Pacific/ROW. We expect growth of more than 20 percent. This region, which grew largely because of exports, has the added stimulus of high levels of domestic consumption of electronic systems resulting from the last 10 years of growth in personal disposable income. Clearly, the desktop PC is a pervasive tool and laptops are getting to be ubiquitous. Taiwan and Singapore are becoming information technology centers of the region, with Korea and Hong Kong following not far behind. Although we do see this growth, a considerable number of companies will be forced out of these industries because of high levels of price and profit attrition. Microprocessors and memories will see high growth rates.

Unit production of PCs in Taiwan appears strong at the moment, with 9 million motherboards and PCs to be shipped in 1992, up from 7 million in 1991.

Semiconductor Forecast: Devices

Table 13 summarizes our product forecasts. We are less aggressive than our October 1991 forecast in our worldwide product outlook because of the decline in the Japanese market. On the other hand, we have not significantly changed our opinions for the other regions of the world.

Bipolar Digital

Bipolar digital products continue their long-term downward trend as system manufacturers phase out older products and redesign in MOS and BiCMOS digital products for newer systems. In some selected cases we see GaAs digital ICs being used as replacements for silicon. We had forecast this category to decline in 1992 by 1.7 percent. We now estimate a decline of 9.8 percent.

MOS Memory

We are very bullish in 1992 for MOS memory. Overall growth in the industry is currently being fueled by the demand for workstations, portable PCs, and software such as Windows and OS/2 that require greater amounts of system memory. We expect 4Mb DRAM sales to soar as more of these devices are adapted. In 1991, we saw a DRAM market that had slow bit growth as well as fierce price attrition. This year we expect a 75 percent increase in DRAM bit growth, and ASP growth of 7 percent. Lingering excess capacity still exists, more in the older 256K and 1Mb level and less so at 4Mb. Several new applications are adding to the health of DRAMs, including user-friendly graphical user interfaces and digital video.

In the SRAM market, we see a continuation of the past five-year migration trend toward faster devices and "wider" parts. PC caches will continue to consume the bulk of the fast SRAMs, even as battery-operated PCs grow in importance. We expect the 1992 SRAM market to grow 12 percent over 1991, and the ASP to increase by 5 percent.

Flash memories will have a minor impact on DRAMs over the long term, and only in those applications where software is downloaded into DRAM and read repeatedly. Over the longer term, flash has the potential for significant cost-per-bit advantages because of superior scaling and reduced cell complexity. These flash devices will replace high-density EEPROMS and EPROMS. Their greatest usage will be in portable applications, which will have explosive growth in the years to come.

MOS Microcomponents

MOS microcomponents include microprocessors, microcontrollers, and microperipherals.

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Table 13
Worldwide Semiconductor Consumption by Device, 1991-1996 (Factory Revenue in Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Semiconductor	59,694	62,925	72,668	82,627	88,122	94,991	
Annual Growth (%)	9.4	5.4	15.5	13.7	6.7	7.8	9.7
Total Integrated Circuit	48,855	52,074	60,902	70,002	74,609	80,720	
Annual Growth (%)	9.9	6.6	17.0	14.9	6.6	8.2	10.6
Bipolar Digital	3,628	3,271	2,989	2,733	2,498	2,252	
Annual Growth (%)	-13.1	-9.8	-8.6	-8.6	-8.6	-9.8	-9.1
Bipolar Memory	356	339	274	209	185	176	
Annual Growth (%)	-17.4	-4.9	-19.1	-23.7	-11.6	-4.9	-13.2
Bipolar Logic	3,272	2,932	2,715	2,524	2,313	2,076	
Annual Growth (%)	-12.6	-10.4	-7.4	-7.0	-8.4	-10.2	-8.7
MOS Digital	34,315	37,287	45,007	53,063	56,540	61,713	
Annual Growth (%)	13.8	8.7	20.7	17.9	6.6	9.1	12.5
MOS Memory	12,841	14,683	18,927	22,888	21,978	23,661	
Annual Growth (%)	5.9	14.3	28.9	20.9	-4.0	7.7	13.0
MOS Microcomponent	11,774	12,985	14,804	17,258	20,016	21,920	
Annual Growth (%)	22.9	10.3	14.0	16.6	16.0	9.5	13.2
MOS Logic	9,700	9,619	11,276	12,917	14,545	16,132	
Annual Growth (%)	14.9	-0.8	17.2	14.6	12.6	10.9	10.7
Analog	10,912	11,516	12,907	14,206	15,571	16,754	
Annual Growth (%)	7.7	5.5	12.1	10.1	9.6	7.6	9.0
Total Discrete	8,035	8,126	8,730	9,290	9,868	10,403	
Annual Growth (%)	4.7	1.1	7.4	6.4	6.2	5.4	5.3
Total Optoelectronic	2,804	2,725	3,036	3,335	3,645	3,868	
Annual Growth (%)	16.3	-2.8	11.4	9.8	9.3	6.1	6.6

Source: Dataquest (August 1992)

With the projected strong growth in portable PCs and workstations, this broad family of semiconductors will have growth of 10 percent. However, this aggregation causes some blurring of high-growth opportunities in the more detailed products such as 32-bit MPUs. These devices are estimated to grow by 37 percent. Leading the growth will be the 486 family, which has received wide acceptance. Because of Intel's near-monopoly position, we see a floor underneath prices that will cause this family to experience the fastest growth of any device group over the next four year. These devices will also be fueled by multimedia computing entering its growth phase.

Microcontrollers will grow at a modest 2 percent in 1992 because of the economic slowdown in Japan. The 4- and 8-bit devices will be hit particularly hard by this slump because their traditional markets of consumer and telecom have fallen off rapidly. Higher-complexity microcontrollers and DSP chips will see stronger growth rates. However, their rather modest revenue base will not offset declines in the lower-complexity products.

MOS ASICs

The 1992 worldwide ASIC market is expected to experience its lowest growth rate in recent

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history, 3.5 percent. This category, of course, includes full custom, which will decline in revenue this year. The overall growth has been significantly affected by the decline in the Japanese market, a market that accounts for more than 40 percent of the total market for ASICs. Our very positive outlook for 1993 is largely based on Japan recovering in the third and fourth quarters of the year.

Gate arrays, cell-based ICs, and PLDs will have widely varying growth rates because of the number of industry participants, the amount of customer investment in available tools, the end applications that they support, and because of the maturity of the products themselves.

Analog

The analog market is and will continue to experience a significant transition from linear to mixed-signal devices. Mixed-signal is in fact the highest growth segment, growing at 10 to 11 percent in 1992 while the traditional linear market will be up slightly at 2 percent. These varying growth rates will continue through the forecast period. From the end-product perspective, telecom, portable information, and communications devices and multimedia are the engines driving mixed-signal. Although many of these mixed-signal devices are in the infancy of their total life cycle, we expect them to have significant impact today on the systems that incorporate them. Some of the most important areas are speech recognition, music synthesis, signal processors, Codecs, and modems. The consumer markets in Japan and the telecom markets in Europe, though lagging this year, will cause an acceleration in mixed-signal next year as these end markets recover. Over the longer term, the integration of analog functions to MPU and DSP chips will provide an upward boost to analog technology.

Dataquest Perspective

Our current five-year forecast of 9.7 percent CAGR growth in the worldwide semiconductor market is 2.1 percentage points lower than our last forecast in October 1991. The main reason for the revised forecast is the depth of the Japanese recession in 1992. We believe that Japan will recover in the second half of 1992 and grow strongly in 1993 and that it also will experience the highest CAGR of the three major regions. One important observation that we must make is that Asia-Pacific/ROW semiconductor consumption will exceed that of Europe for the first time in the fourth quarter of 1992 because of the aggressive build-up of the computer and information technology industries in the land of the four tigers. Asia-Pacific/ROW and Europe will continue to be nip and tuck until 1995, when Asia-Pacific/ROW will jump into the third position among the world's major semiconductor consuming regions. The semiconductor industry in Europe will have a chance at higher grow rates if electronics investment in Central and Eastern Europe and the former Soviet Union are successful and their products become exportable. Clearly, this is a big unknown. The growth of the Chinese electronics industry is also a big unknown and could be a significant swing factor in the battle for third position between Asia-Pacific/ROW and Europe. We will watch this and report on the ongoing saga.

Many new applications will emerge, grow, and decline over the course of this forecast period. It is a fact of the electronic industry that product life cycles are getting shorter and shorter with the passing of each year. We believe that portability, connectivity, and user-friendly software will be the fundamental engines for growth of the semiconductor industry.

When the class of new technologies, systems, and software emerging today versus that of yesterday is reviewed, a key difference is apparent. Much of the new technology today is targeted at the large consumer market—mobile professionals (most obvious in the case of pen-based computing and personal digital assistants) and people who have never used a computer before. Today's hardware packaging and software technologies (even with graphical user interfaces) are still fairly confined to the traditional information industry user of the 1980s. These users are but a tiny fraction of the total available market for the next generation of smart, radioed-to-the-world, nomadic devices.

This significant trend is dictating the type of semiconductors that will be successful over the time frame of our forecast. Of course, low-voltage and low-power devices, as well as highly integrated single- and mixed-technology devices, will be the enabler of these portable industries of the future. However, there are also significant opportunities in microsensors, micromotors, fuzzy logic, neural nets, and three-dimensional devices. These are the emerging devices we will be watching.

By Gene Norrett

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Dataquest Perspective

Semiconductors
Extra Edition

SCWW-MKT-DP-9201 March 30, 1992

1992 Semiconductor Supplier-of-the-Year Awards Go to Motorola, Analog Devices, and Dallas Semiconductor

The fourth annual Dataquest Semiconductor Supplier-of-the-Year Awards were presented at the Forecast '92 Conference on March 19 at Dataquest headquarters in San Jose, California, before an audience of more than 175 people. Awards were made in three categories of semiconductor suppliers. The Major Supplier Award went to Motorola for the fourth consecutive year; the Midsize Supplier Award again went to Analog Devices; and the Niche Market Supplier Award went to newcomer Dallas Semiconductor. The worldwide semiconductor user sample that we polled chose these three companies as the overall best in supporting their requirements of quality, price, delivery, technical support, and customer service.

Methodology

The Semiconductor Supplier-of-the-Year Award is based on data collected from electronics companies around the world that purchase semiconductors. Using telephone surveys, Dataquest collected data from companies listed in *Electronic Business* (EB) magazine's Top 200 U.S. Electronics Companies, and the respective EB Top 50 Electronics Companies for Europe and Japan. Dataquest reviewed this list and deleted software companies and companies that manufactured or distributed semiconductors in order to ensure that the sample consisted of semiconductor users.

We identified the main semiconductor purchasing location for each company and sent a letter explaining the survey and a list of eligible semiconductor suppliers from our worldwide supplier database. The survey asked the respondents for their choice of Semiconductor Supplier of the Year in three size categories, as follows:

- Major suppliers (annual revenue of more than $500 million)
- Midsize suppliers (annual revenue between $50 million and $499 million)
- Niche market suppliers (annual revenue of less than $50 million)

For each category, the respondent was asked which supplier ranked highest in each of the following areas:

- On-time delivery
- Quality
- Price
- Technical support
- Customer service

In the event that an electronics company named its own captive semiconductor source as the preferred supplier, the respondent was asked to exclude that choice and vote again.

There was one respondent per company. If the first respondent contacted at a company did not care to participate, a second respondent was chosen at random for that company from our procurement site database. If the second choice did not participate, a third site was chosen, and if the third respondent did not respond, the company was dropped from the survey. Scores were calculated for each of the five performance areas in each category. For each category, the five performance scores were combined into one aggregate score to determine the supplier of the year for that category.

Survey Results

The 144 company sites responding to this year's survey represent about 20.5 percent of the world's consumption of semiconductors, both in 1991 and estimated in 1992 (see Figure 1). The concentration of purchasing power highlighted here reinforces the need for sound strategic supplier links and how, by meeting the needs of the largest semiconductor users, suppliers are

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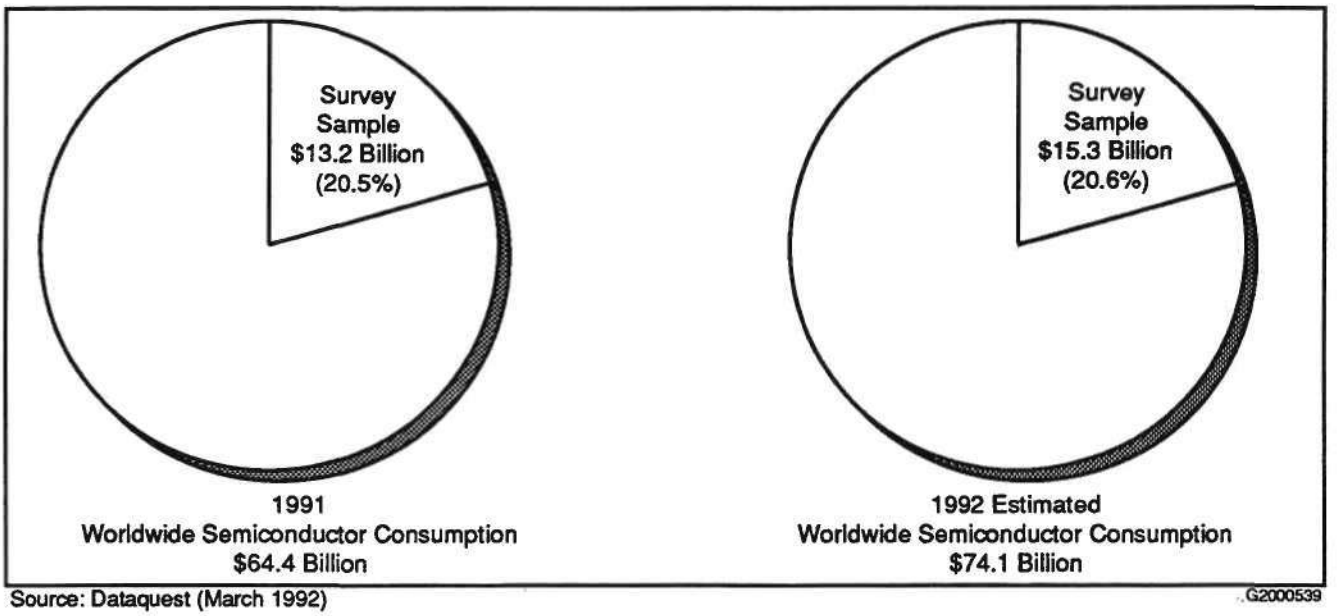
guided to meet the rest of the market's requirements.

Table 1 summarizes the rankings of each size category's top five suppliers as voted by the worldwide EB sample. The relatively high percentage of votes received by the top seven major suppliers, compared with the other two categories, indicates the large number of these smaller suppliers and their fragmented markets and that the larger companies often have a broader product line and higher market awareness.

This year we asked our sample to rank in importance the five categories that determined the winners. Table 2 shows that, to procurement managers, the overall top-ranked category was not price, but quality. Delivery was second, price was third overall, technical support was fourth, and customer service was last. Semiconductor companies that want to focus on areas of importance to their customers should closely review Table 2.

It is impressive that the top three winners in each category garnered at least a combined

Figure 1
Worldwide Purchasing Power



Source: Dataquest (March 1992)

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Table 1
1992 Semiconductor Supplier-of-the-Year Rankings

Rank	Major	Vote (%)	Midsize	Vote (%)	Niche Market	Vote (%)
1	Motorola	30	Analog Devices	17	Dallas Semiconductor	26
2	Texas Inst.	13	Cypress	14	Waferscale	8
3	National	11	IDT	6	Mosel	6
4	Intel	10	International Rectifier	5	SEEQ	4
5	AMD	8	NCR	5	Actel	4
6	Philips	4	Allegro	4	Cherry	3
7	Toshiba	4	Maxim	4	Micro Linear	3
	Others	20	Others	45	Others	46
	Total	100	Total	100	Total	100

Source: Dataquest (March 1992)

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Table 2
Supplier-of-the-Year Criteria Rankings

Criterion	Percentage
Quality	48
Delivery	25
Price	11
Technical Support	8
Customer Service	8
Total	100

Source: Dataquest (March 1992)

37 percent of the vote. In the major category, the top three gathered more than half (54 percent) of the votes. It was also interesting to note that, despite our worldwide sample, this sample did not perceive Japanese and European semiconductor suppliers to have improved.

Dataquest Perspective

This year's award winners exemplify what the current market demands: excellent quality and on-time delivery at a fair price. The service aspects of the total cost equation still remain very important, but the inclination of the current market is for tangible returns to the bottom line. By winning the Major Supplier Award for the fourth consecutive year, Motorola has earned the right to be acknowledged as the semiconductor company to be compared with or emulated. Analog Devices earned its customers' votes again because of its across-the-board strengths both in product and in support in the demanding analog semiconductor market. Maxim, the No. 1 niche market supplier last year, graduated into the midsize category for this year's voting and was ranked a strong No. 7 there primarily because of its level of customer support. The newcomer to the top spot in the niche market category, Dallas Semiconductor, was recognized among the many smaller suppliers primarily for supplying excellent service and for its high-quality, fairly priced products.

This year's ranking of the five criteria tangibly confirms what has been espoused in books, seminars, and journals: a quality product and its delivery to the customer's schedule are the qualifiers in today's electronics market. This year's winners successfully used the differentiators of price, technical support, and customer support to increase their customers' loyalty, despite a sluggish market. As the electronics market begins to improve, quality will remain an absolute sourcing criteria with delivery, and the other differentiators becoming even more important. This year's awards were earned by best meeting customer needs in a challenging economic environment. Those aspiring to win the award next year should focus on the key areas as prioritized in this article and execute on exceeding customer requirements.

By Mark Giudici

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Semiconductor Consumption and Shipment Forecast

June 29, 1992

Source: Dataquest

Market Statistics

Semiconductors *Worldwide*

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Semiconductor Consumption and Shipment Forecast

June 29, 1992

Source: Dataquest

Market Statistics

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File behind the *Market Statistics* tab inside the binder labeled Semiconductors *Worldwide*

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Semiconductor Consumption and Shipment Forecast

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Note: All tables show estimated data.

Semiconductor Consumption and Shipment Forecast

Introduction

This document contains detailed information on Dataquest's view of the semiconductor device market. Included in this document are the following:

- 1987-1991 historical data
- 1992-1996 forecast data

Worldwide market revenue estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

The average exchange rate for a quarter is estimated as the simple arithmetic mean of the average monthly values for the three months of the quarter. Similarly, the average exchange rate for a year is estimated as the simple arithmetic mean of the average monthly values for the 12 months of the year.

Dataquest does not forecast exchange rates per se; however, we do forecast semiconductor markets in several regions of the world, and we use the U.S. dollar as a common currency for market comparisons. In the forecast period, Dataquest assumes that the most recent actual month's exchange rate will apply throughout all future months of the forecast. For example, the current semiconductor forecast uses actual exchange rates through June 1992, and assumes that the June rate applies throughout all future months. Then the quarterly and annual exchange rates are estimated as described in the previous paragraph.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of these data is provided in the *Dataquest Perspectives* located in the binder of the same name.

Segmentation

This section outlines the market segments specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For a detailed explanation of Dataquest's market segmentation, refer to the *Dataquest Research and Forecast Methodology* document located in the *Dataquest* binder. For a complete listing of all market segments tracked by Dataquest, please refer to the *Dataquest High-Technology Guide: Segmentation and Glossary.*

Dataquest defines the semiconductor industry as the group of competing companies primarily engaged in manufacturing semiconductors and related solid-state devices. Important products of the semiconductor industry include integrated circuits, discrete devices, and optoelectronic devices.

For forecasting purposes, Dataquest defines the semiconductor market according to the following functional segmentation scheme:

- Total Semiconductor
  - Total Integrated Circuit
    - Bipolar Digital
      - Bipolar Memory
      - Bipolar Logic
    - MOS Digital
      - MOS Memory
      - MOS Microcomponents
      - MOS Logic
    - Analog
  - Total Discrete
  - Total Optoelectronic

Definitions

This section lists the definitions used by Dataquest to present the data in this document. Complete definitions for all terms associated

with Dataquest's segmentation of the high-technology marketplace can be found in the *Dataquest High-Technology Guide: Segmentation and Glossary*. Definitions for semiconductor devices can be found in the *Dataquest Semiconductor Market Share Survey Guide*.

Total Semiconductor (IC + Discrete + Optoelectronic). Defined as any active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.

Total Integrated Circuit (Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog Monolithic IC). An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package. In a monolithic IC, discrete circuits are integrated onto a small number of dice.

Bipolar Digital (Bipolar Digital Memory IC + Bipolar Digital Logic IC). A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data carrying signals vary in discrete values.

Bipolar Memory. Defined as a bipolar digital semiconductor product in which binary data are stored and electronically retrieved. Includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), and first-in/first-out (FIFO) memory.

Bipolar Logic (Bipolar Application-Specific IC + Other Bipolar Logic IC + Bipolar Digital Microcomponent). Defined as a bipolar digital semiconductor product in which more than 50 percent of the die area performs logic functions. Includes bipolar digital microcomponent ICs.

MOS Digital (MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC). Defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, any portion of the die area is manufactured using metal oxide semiconductor (MOS) technology. A digital function is one in which data carrying signals vary in discrete values. Includes mixed technology manufacturing, such as BiMOS and BiCMOS, where some MOS technology is employed.

MOS Memory (DRAM + SRAM + EPROM + Other Nonvolatile MOS Digital Memory + Other MOS Digital Memory). Defined as an MOS digital IC in which binary data are stored and electronically retrieved.

MOS Microcomponents (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral). Defined as an MOS digital IC that contains a data processing unit or serves as an interface to such a unit. Includes both CISC and RISC.

MOS Digital Logic (MOS Digital Application-Specific IC + Other MOS Logic IC). Defined as an MOS digital semiconductor product in which more than 50 percent of the die area performs logic functions. Excludes MOS digital microcomponent ICs.

Analog IC. Defined as monolithic analog ICs plus hybrid ICs. (A monolithic analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes all monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package. A hybrid IC is a semiconductor product that consists of more than one die contained in a single package. A hybrid IC may perform 100 percent linear, 100 percent digital, or mixed-signal (both linear and digital) functions. Note that hybrid digital ICs are reported in this category, and not under the earlier category of monolithic digital ICs. Includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies.)

Total Discrete (Transistor + Diode + Thyristor + Other Discrete). A discrete semiconductor is defined as a unit building block performing a fundamental semiconductor function.

Total Optoelectronic (LED Lamp/Display + Optocoupler + CCD + Laser Diode +

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Photosensor + Solar Cell). Defined as a semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

Regional Definitions

North America: Includes United States and Canada

United States: Includes 48 contiguous states, Washington, D.C., Alaska, Hawaii, and Puerto Rico

Canada: Canada

Europe: Western Europe includes Benelux (Belgium, Netherlands, and Luxembourg), France, Italy, Scandinavia (Denmark, Finland, Norway, Sweden, and Iceland), United Kingdom and Eire (England, Wales, Scotland, Northern Ireland, and Ireland), Germany (including former East Germany), and Rest of Europe (Austria, Gibraltar, Greece, Liechtenstein, Malta, Monaco, Portugal, San Marino, Spain, Switzerland, Turkey, Andorra, and Vatican City)

Japan: Japan

Asia/Pacific: Includes East Asia (People's Republic of China, Hong Kong, Macau, North and South Korea, and Republic of China), South Asia (Bangladesh, Myanmar, India, Nepal, Maldives, Pakistan, Sri Lanka, and Bhutan), Southeast Asia (Brunei, Timor, Indonesia, Kampuchea, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Borneo, Sumatra, Sulawesi, and Java)

Rest of World: All other countries

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its goods. Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the marchant market. The data exclude completely captive suppliers where devices are manufacturered solely for the company's own use. A product that is used internally is valued at the market price rather than at the transfer or factory price.

Revenue estimates for 1989 and 1990 have been restated from previous publication to reflect minor modifications to the market share and market size methodology.

Forecast Methodology and Assumptions

Dataquest publishes five-year revenue forecasts for the semiconductor market during the second and fourth quarters of each year. In doing so, Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. An overview of Dataquest forecasting techniques can be found in the *Dataquest Research and Forecast Methodology Guide.*

Dataquest's semiconductor forecast methodology leverages the resources of its parent, The Dun & Bradstreet Corporation, as well as the considerable internal resources of Dataquest.

Dun & Bradstreet Corporation information is used to develop the macroeconomic forecasts for the world's major economies. This forecast identifies trends in the economic health of the world's leading consumers and producers of electronic equipment. Using this forecast in conjunction with input from Dataquest's regional offices, Dataquest identifies the likelihood of whether a particular region or country will increase or decrease its consumption of electronic equipment.

Dataquest follows a four-step process to forecast the semiconductor market. First, Dataquest's Semiconductor Applications Market group, along with Dataquest's various electronics systems groups, provides a long-range outlook for the overall growth of the electronic equipment market. Semiconductor content ratios are developed by region to reflect the growing penetration of semiconductors into electronic equipment. This establishes a five-year trend growth path for total semiconductors for a five-year period from a demand-side perspective.

Second, Dataquest uses a decomposition time series model to generate forecasts of regional

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total semiconductor sales. The model assumes that sales are affected by factors such as long-run trends, short-run aggregate economic and industry-specific conditions, and seasonality. The forecast is made by using statistical methods to analyze each of the components separately, then combining them into a single aggregate. The model is especially useful for assessing market fluctuations about the trend growth path.

Third, Dataquest's worldwide semiconductor service and its Semiconductor Equipment, Materials, and Manufacturing service, in conjunction with its various regional offices, collaborate to formulate expectations of semiconductor market short-range fluctuations around the long-range trend. Tactical market issues and anticipated semiconductor materials demand significantly impact the short-range forecast out to 12 months. Semiconductor equipment purchases and semiconductor device trends drive the forecast in the 12- to 24-month time frame. Semiconductor fab facilities and long-term semiconductor device trends have the greatest impact on the forecast period covering two to five years.

The final step in the forecast process is to reconcile expected fluctuations in the electronics market and trends in the semiconductor industry so that the fluctuations do not inexplicably diverge from semiconductor industry trends. Dataquest anticipates that, in the absence of shocks to the market, market fluctuations converge toward the long-term trend.

Semiconductor Industry Assumptions

The North American semiconductor market continues to strengthen. Dataquest expects the North American market to grow 15.1 percent in 1992, up from a meager 2.7 percent in 1991. The market is clearly on target midway through the year. According to the latest WSTS statistics, total semiconductor bookings (three-month moving average) growth for the three months ended in June was 18.0 percent above year-earlier bookings, compared with 11.9 percent in May. Total semiconductor billings growth for the same period was 14.8 percent above year-earlier billings, compared with 13.3 percent in May.

Strength in the North American market can be attributed largely to the recovery of the U.S. economy and the relaxation of household and business budget constraints for durable goods and capital equipment. In particular, however, chip demand stems from strong orders of portable PCs, client/server computers, and network hardware.

Dataquest expects the Japanese market to decline 9.4 percent (dollar-based) in 1992, the first yearly decline since 1985. The latest market statistics support this outlook. The dollar value of total semiconductor billings for the three months ended in May was 14.5 percent below year-earlier billings. The bookings picture is even more bleak. Total semiconductor bookings for the same period were 17.7 percent below year-earlier levels.

Japan's situation is due to more than just weakness in its European export market. Other factors include a heightened level of international competition in chips and systems, a glut of worldwide DRAM fab capacity, rising costs of capital in Japan, and a dearth of new, high-volume consumer electronic systems. Dataquest does not expect an improvement in Japan's export market to alleviate these structural problems in 1992.

Dataquest forecasts the European market to grow 7.2 percent in 1992, up from 5.8 percent in 1991. Total semiconductor billings for the three months ended in June was 9.0 percent above year-earlier billings. Total semiconductor bookings for the same period were 7.1 percent above year-earlier levels. We believe that the European market will show more growth in the second half of 1992 than usual, as recovery in the U.S. market starts to pull through demand in Europe later in the year.

Recovery of the U.K. and French economies will help offset decelerating growth in Germany. PC manufacture in Ireland is strong, and much of the growth in the United Kingdom is related to multinational companies increasing their data processing and consumer equipment production. Investment in telecommunications infrastructure and the introduction of GSM mobile cellular phones also provide growth stimulus.

Dataquest forecasts the Asia/Pacific-Rest of World market to grow 21.6 percent in 1992.

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Again, the latest statistics support this outlook. Total semiconductor bookings growth for the three months ended in May was 15.8 percent above year-earlier bookings. Total semiconductor billings growth for the same period was 25.5 percent above year-earlier billings. Expansion continues to be driven by foreign investment and improvement in Western export markets.

Forecast Economic Assumptions

The worldwide economy is expected to show mixed results in 1992. The Dun & Bradstreet Corporation forecast the following outlook for the Group of Seven (G7) Countries:

- The U.S., Canada, and U.K. economies are expected to recover from recession in 1992. Real gross domestic product (GDP) is expected to expand 2.1, 1.6, and 0.5 percent, respectively, in 1992. (These economies contracted at rates of 0.7, 1.5, and 2.4 percent, respectively, in 1991.) Though modest in comparison to historical rates of expansion during recovery periods, the benefit is that inflationary pressures will likely be held in check, sustaining the expansion's duration. Expansion should accelerate to 2.5 percent, 4.0 percent, and 2.2 percent, respectively, in 1993.
- Real GDP growth is expected to accelerate in France and Italy during 1992, from 0.9 percent in 1991 to 2.1 percent and from 1.4 percent percent in 1991 to 1.5 percent, respectively. The pace of growth should pick up in 1993 to 2.7 percent and 2.2 percent, respectively.
- Real GDP growth is expected to decelerate in Germany and Japan during 1992, from 3.2 percent in 1991 to 1.1 percent and from 4.4 percent in 1991 to 2.0 percent, respectively. Moderating these countries' short-term growth prospects are the cost burden of Germany's reunification, the rise in Japan's cost of capital, and the recent bout of asset deflation. The respective economies are expected to reaccelerate to 2.8 percent and 3.3 percent growth in 1993.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar values. The following outlines these rates for 1991:

Japan (Yen/U.S.$)	136.00
Europe (Ecu/U.S.$)	0.81
France (Franc/U.S.$)	5.64
Germany (Deutsche Mark/U.S.$)	1.66
United Kingdom (U.S.$/Pound Sterling)	1.77

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Table 1
Revenue from All Semiconductors Shipped to the World for Use in All Applications, 1987-1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	38,250	50,859	54,339	54,545	59,694
Total IC	29,886	41,068	44,613	44,459	48,855
Bipolar Digital	4,760	5,200	4,314	4,173	3,628
Bipolar Memory	621	689	460	431	356
Bipolar Logic	4,139	4,511	3,854	3,742	3,272
MOS Digital	17,473	26,988	31,140	30,152	34,315
MOS Memory	6,056	11,692	15,405	12,128	12,841
MOS Microcomponent	5,108	7,144	7,808	9,584	11,774
MOS Logic	6,309	8,152	7,927	8,440	9,700
Analog	7,654	8,880	9,159	10,134	10,912
Total Discrete	6,655	7,612	7,320	7,674	8,035
Total Optoelectronic	1,709	2,179	2,406	2,412	2,804

Source: Dataquest (June 1992)

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Table 2
Revenue from All Semiconductors Shipped to the World for Use in All Applications, 1992-1996
(Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	62,925	72,668	82,627	88,122	94,991
Total IC	52,074	60,902	70,002	74,609	80,720
Bipolar Digital	3,271	2,989	2,733	2,498	2,252
Bipolar Memory	339	274	209	185	176
Bipolar Logic	2,932	2,715	2,524	2,313	2,076
MOS Digital	37,287	45,007	53,063	56,540	61,713
MOS Memory	14,683	18,927	22,888	21,978	23,661
MOS Microcomponent	12,985	14,804	17,258	20,016	21,920
MOS Logic	9,619	11,276	12,917	14,545	16,132
Analog	11,516	12,907	14,206	15,571	16,754
Total Discrete	8,126	8,730	9,290	9,868	10,403
Total Optoelectronic	2,725	3,036	3,335	3,645	3,868

Source: Dataquest (June 1992)

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Table 3
Revenue Growth from All Semiconductors Shipped to the World for Use in All Applications, 1987-1991 (Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	24.1	33.0	6.8	.4	9.4
Total IC	26.5	37.4	8.6	-.3	9.9
Bipolar Digital	10.1	9.2	-17.0	-3.3	-13.1
Bipolar Memory	2.5	10.9	-33.2	-6.3	-17.4
Bipolar Logic	11.3	9.0	-14.6	-2.9	-12.6
MOS Digital	36.3	54.5	15.4	-3.2	13.8
MOS Memory	34.2	93.1	31.8	-21.3	5.9
MOS Microcomponent	46.4	39.9	9.3	22.7	22.9
MOS Logic	31.0	29.2	-2.8	6.5	14.9
Analog	18.2	16.0	3.1	10.6	7.7
Total Discrete	16.1	14.4	-3.8	4.8	4.7
Total Optoelectronic	15.0	27.5	10.4	.2	16.3

Source: Dataquest (June 1992)

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Table 4
Revenue Growth from All Semiconductors Shipped to the World for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	5.4	15.5	13.7	6.7	7.8	9.7
Total IC	6.6	17.0	14.9	6.6	8.2	10.6
Bipolar Digital	-9.8	-8.6	-8.6	-8.6	-9.8	-9.1
Bipolar Memory	-4.9	-19.1	-23.7	-11.6	-4.9	-13.2
Bipolar Logic	-10.4	-7.4	-7.0	-8.4	-10.2	-8.7
MOS Digital	8.7	20.7	17.9	6.6	9.1	12.5
MOS Memory	14.3	28.9	20.9	-4.0	7.7	13.0
MOS Microcomponent	10.3	14.0	16.6	16.0	9.5	13.2
MOS Logic	-.8	17.2	14.6	12.6	10.9	10.7
Analog	5.5	12.1	10.1	9.6	7.6	9.0
Total Discrete	1.1	7.4	6.4	6.2	5.4	5.3
Total Optoelectronic	-2.8	11.4	9.8	9.3	6.1	6.6

Source: Dataquest (June 1992)

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Table 5
Revenue from All Semiconductors Shipped to North America for Use in All Applications, 1987-1991 (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	12,858	15,844	17,070	16,540	16,990
Total IC	10,886	13,815	15,102	14,616	15,269
Bipolar Digital	2,099	2,012	1,635	1,577	1,331
Bipolar Memory	271	235	180	160	131
Bipolar Logic	1,828	1,777	1,455	1,417	1,200
MOS Digital	6,738	9,606	10,988	10,390	11,296
MOS Memory	2,497	4,298	5,772	4,325	4,510
MOS Microcomponent	2,012	2,707	2,796	3,381	3,916
MOS Logic	2,229	2,601	2,420	2,684	2,870
Analog	2,049	2,197	2,479	2,649	2,642
Total Discrete	1,642	1,676	1,639	1,611	1,389
Total Optoelectronic	330	353	329	313	332

Source: Dataquest (June 1992)

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Table 6
Revenue from All Semiconductors Shipped to North America for Use in All Applications, 1992-1996
(Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	19,564	22,613	25,456	26,127	27,579
Total IC	17,674	20,603	23,331	23,887	25,229
Bipolar Digital	1,332	1,170	1,042	935	828
Bipolar Memory	147	109	75	65	62
Bipolar Logic	1,185	1,061	967	870	766
MOS Digital	13,342	16,003	18,449	18,722	19,801
MOS Memory	5,477	7,133	8,360	7,507	7,820
MOS Microcomponent	4,698	5,149	5,847	6,464	6,754
MOS Logic	3,167	3,721	4,242	4,751	5,227
Analog	3,000	3,430	3,840	4,230	4,600
Total Discrete	1,530	1,630	1,725	1,820	1,915
Total Optoelectronic	360	380	400	420	435

Source: Dataquest (June 1992)

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Table 7
Revenue Growth from All Semiconductors Shipped to North America for Use in All Applications, 1987-1991
(Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	18.6	23.2	7.7	-3.1	2.7
Total IC	21.1	26.9	9.3	-3.2	4.5
Bipolar Digital	3.4	-4.1	-18.7	-3.6	-15.6
Bipolar Memory	1.5	-13.3	-23.4	-11.1	-18.1
Bipolar Logic	3.7	-2.8	-18.1	-2.6	-15.3
MOS Digital	37.2	42.6	14.4	-5.4	8.7
MOS Memory	40.7	72.1	34.3	-25.1	4.3
MOS Microcomponent	47.7	34.5	3.3	20.9	15.8
MOS Logic	25.6	16.7	-7.0	10.9	6.9
Analog	.2	7.2	12.8	6.9	-.3
Total Discrete	6.5	2.1	-2.2	-1.7	-13.8
Total Optoelectronic	4.4	7.0	-6.8	-4.9	6.1

Source: Dataquest (June 1992)

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Table 8
Revenue Growth from All Semiconductors Shipped to North America for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	15.1	15.6	12.6	2.6	5.6	10.2
Total IC	15.8	16.6	13.2	2.4	5.6	10.6
Bipolar Digital	.1	-12.2	-10.9	-10.3	-11.4	-9.1
Bipolar Memory	12.2	-25.9	-31.2	-13.3	-4.6	-13.9
Bipolar Logic	-1.2	-10.5	-8.9	-10.0	-12.0	-8.6
MOS Digital	18.1	19.9	15.3	1.5	5.8	11.9
MOS Memory	21.4	30.2	17.2	-10.2	4.2	11.6
MOS Microcomponent	20.0	9.6	13.6	10.6	4.5	11.5
MOS Logic	10.3	17.5	14.0	12.0	10.0	12.7
Analog	13.5	14.3	12.0	10.2	8.7	11.7
Total Discrete	10.2	6.5	5.8	5.5	5.2	6.6
Total Optoelectronic	8.4	5.6	5.3	5.0	3.6	5.6

Source: Dataquest (June 1992)

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Table 9
Revenue from All Semiconductors Shipped to Japan for Use in All Applications, 1987-1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	14,927	20,772	21,491	20,257	22,496
Total IC	11,263	16,127	16,860	15,794	17,277
Bipolar Digital	1,523	1,906	1,648	1,635	1,442
Bipolar Memory	227	348	191	194	165
Bipolar Logic	1,296	1,558	1,457	1,441	1,277
MOS Digital	6,424	10,501	11,636	10,660	11,881
MOS Memory	2,268	4,424	5,629	4,196	4,228
MOS Microcomponent	1,902	2,573	2,662	2,974	3,579
MOS Logic	2,254	3,504	3,345	3,490	4,074
Analog	3,316	3,720	3,576	3,499	3,954
Total Discrete	2,693	3,282	3,080	2,969	3,432
Total Optoelectronic	971	1,363	1,551	1,494	1,787

Source: Dataquest (June 1992)

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Table 10
Revenue from All Semiconductors Shipped to Japan for Use in All Applications, 1992-1996
(Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	20,371	22,975	25,870	27,810	29,645
Total IC	15,650	17,836	20,343	21,941	23,499
Bipolar Digital	1,121	1,078	1,016	951	880
Bipolar Memory	137	118	94	84	82
Bipolar Logic	984	960	922	867	797
MOS Digital	10,707	12,743	15,038	16,454	17,801
MOS Memory	4,150	5,163	6,295	6,379	6,784
MOS Microcomponent	3,252	3,807	4,405	5,127	5,477
MOS Logic	3,304	3,773	4,338	4,947	5,540
Analog	3,823	4,015	4,289	4,536	4,819
Total Discrete	3,125	3,353	3,543	3,695	3,860
Total Optoelectronic	1,596	1,785	1,984	2,174	2,286

Source: Dataquest (June 1992)

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Table 11
Revenue Growth from All Semiconductors Shipped to Japan for Use in All Applications, 1987-1991
(Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	25.9	39.2	3.5	-5.7	11.1
Total IC	28.0	43.2	4.5	-6.3	9.4
Bipolar Digital	17.6	25.1	-13.5	-.8	-11.8
Bipolar Memory	34.3	53.3	-45.1	1.6	-14.9
Bipolar Logic	15.1	20.2	-6.5	-1.1	-11.4
MOS Digital	34.9	63.5	10.8	-8.4	11.5
MOS Memory	30.5	95.1	27.2	-25.5	.8
MOS Microcomponent	39.0	35.3	3.5	11.7	20.3
MOS Logic	36.1	55.5	-4.5	4.3	16.7
Analog	20.8	12.2	-3.9	-2.2	13.0
Total Discrete	20.1	21.9	-6.2	-3.6	15.6
Total Optoelectronic	19.7	40.4	13.8	-3.7	19.6

Source: Dataquest (June 1992)

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Table 12
Revenue Growth from All Semiconductors Shipped to Japan for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	-9.4	12.8	12.6	7.5	6.6	5.7
Total IC	-9.4	14.0	14.1	7.9	7.1	6.3
Bipolar Digital	-22.3	-3.8	-5.8	-6.4	-7.5	-9.4
Bipolar Memory	-17.1	-13.7	-20.8	-10.1	-2.3	-13.0
Bipolar Logic	-23.0	-2.4	-3.9	-6.0	-8.0	-9.0
MOS Digital	-9.9	19.0	18.0	9.4	8.2	8.4
MOS Memory	-1.8	24.4	21.9	1.3	6.3	9.9
MOS Microcomponent	-9.1	17.0	15.7	16.4	6.8	8.9
MOS Logic	-18.9	14.2	15.0	14.0	12.0	6.3
Analog	-3.3	5.0	6.8	5.8	6.2	4.0
Total Discrete	-8.9	7.3	5.6	4.3	4.4	2.4
Total Optoelectronic	-10.7	11.9	11.1	9.6	5.2	5.1

Source: Dataquest (June 1992)

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Table 13
Revenue from All Semiconductors Shipped to Europe for Use in All Applications, 1987-1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	6,498	8,491	9,498	10,415	11,014
Total IC	4,840	6,669	7,570	8,115	8,701
Bipolar Digital	727	772	627	565	486
Bipolar Memory	88	74	71	55	43
Bipolar Logic	639	698	556	510	443
MOS Digital	2,761	4,364	5,251	5,224	5,853
MOS Memory	854	1,797	2,417	2,050	2,129
MOS Microcomponent	805	1,212	1,442	1,802	2,082
MOS Logic	1,102	1,355	1,392	1,372	1,642
Analog	1,352	1,533	1,692	2,326	2,362
Total Discrete	1,377	1,516	1,574	1,895	1,828
Total Optoelectronic	281	306	354	405	485

Source: Dataquest (June 1992)

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Table 14
Revenue from All Semiconductors Shipped to Europe for Use in All Applications, 1992-1996
(Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	11,809	13,663	15,603	16,493	17,828
Total IC	9,428	11,163	12,985	13,756	14,974
Bipolar Digital	452	408	376	338	301
Bipolar Memory	42	36	32	28	25
Bipolar Logic	410	372	345	310	277
MOS Digital	6,614	7,999	9,537	10,021	11,080
MOS Memory	2,418	3,100	3,824	3,825	4,275
MOS Microcomponent	2,377	2,713	3,215	3,508	3,867
MOS Logic	1,819	2,186	2,498	2,688	2,938
Analog	2,362	2,756	3,071	3,397	3,592
Total Discrete	1,869	1,939	2,018	2,097	2,165
Total Optoelectronic	511	561	600	640	689

Source: Dataquest (June 1992)

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Table 15
Revenue Growth from All Semiconductors Shipped to Europe for Use in All Applications, 1987-1991 (Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	16.3	30.7	11.9	9.7	5.8
Total IC	17.6	37.8	13.5	7.2	7.2
Bipolar Digital	1.1	6.2	-18.8	-9.9	-14.0
Bipolar Memory	-40.1	-15.9	-4.1	-22.5	-21.8
Bipolar Logic	11.7	9.2	-20.3	-8.3	-13.1
MOS Digital	21.6	58.1	20.3	-.5	12.0
MOS Memory	5.0	110.4	34.5	-15.2	3.9
MOS Microcomponent	40.2	50.6	19.0	25.0	15.5
MOS Logic	24.8	23.0	2.7	-1.4	19.7
Analog	20.0	13.4	10.4	37.5	1.5
Total Discrete	14.1	10.1	3.8	20.4	-3.5
Total Optoelectronic	6.4	8.9	15.7	14.4	19.8

Source: Dataquest (June 1992)

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Table 16
Revenue Growth from All Semiconductors Shipped to Europe for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	7.2	15.7	14.2	5.7	8.1	10.1
Total IC	8.4	18.4	16.3	5.9	8.9	11.5
Bipolar Digital	-7.0	-9.6	-7.9	-10.2	-10.8	-9.1
Bipolar Memory	-1.5	-14.0	-13.5	-12.5	-10.7	-10.6
Bipolar Logic	-7.5	-9.2	-7.4	-10.0	-10.8	-9.0
MOS Digital	13.0	20.9	19.2	5.1	10.6	13.6
MOS Memory	13.6	28.2	23.3	.0	11.8	15.0
MOS Microcomponent	14.2	14.1	18.5	9.1	10.2	13.2
MOS Logic	10.8	20.2	14.3	7.6	9.3	12.3
Analog	-.0	16.7	11.4	10.6	5.8	8.7
Total Discrete	2.3	3.7	4.1	3.9	3.2	3.4
Total Optoelectronic	5.4	9.7	7.0	6.6	7.7	7.3

Source: Dataquest (June 1992)

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Table 17
Revenue from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1987-1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	3,967	5,752	6,280	7,333	9,194
Total IC	2,898	4,457	5,081	5,934	7,608
Bipolar Digital	411	510	404	396	369
Bipolar Memory	35	32	18	22	17
Bipolar Logic	376	478	386	374	352
MOS Digital	1,550	2,517	3,265	3,878	5,285
MOS Memory	437	1,173	1,587	1,557	1,974
MOS Microcomponent	389	652	908	1,427	2,197
MOS Logic	724	692	770	894	1,114
Analog	937	1,430	1,412	1,660	1,954
Total Discrete	943	1,138	1,027	1,199	1,386
Total Optoelectronic	127	157	172	200	200

Source: Dataquest (June 1992)

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Table 18
Revenue from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1992-1996
(Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	11,181	13,417	15,698	17,692	19,939
Total IC	9,322	11,300	13,344	15,026	17,018
Bipolar Digital	366	333	300	275	243
Bipolar Memory	12	10	9	8	7
Bipolar Logic	354	322	291	267	236
MOS Digital	6,624	8,261	10,038	11,343	13,031
MOS Memory	2,638	3,530	4,408	4,267	4,782
MOS Microcomponent	2,657	3,136	3,791	4,917	5,822
MOS Logic	1,329	1,596	1,839	2,159	2,426
Analog	2,332	2,706	3,006	3,408	3,744
Total Discrete	1,601	1,807	2,004	2,255	2,463
Total Optoelectronic	258	310	351	411	458

Source: Dataquest (June 1992)

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Table 19
Revenue Growth from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1987-1991
(Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	55.7	45.0	9.2	16.8	25.4
Total IC	69.0	53.8	14.0	16.8	28.2
Bipolar Digital	46.2	24.1	-20.8	-2.0	-6.8
Bipolar Memory	52.1	-8.5	-43.8	22.3	-22.8
Bipolar Logic	45.7	27.1	-19.2	-3.1	-5.9
MOS Digital	77.9	62.4	29.7	18.8	36.3
MOS Memory	136.2	168.4	35.3	-1.9	26.8
MOS Microcomponent	110.0	67.8	39.3	57.2	54.0
MOS Logic	44.5	-4.4	11.3	16.1	24.6
Analog	66.7	52.6	-1.3	17.6	17.7
Total Discrete	27.6	20.7	-9.8	16.7	15.6
Total Optoelectronic	33.7	23.6	9.6	16.3	-.0

Source: Dataquest (June 1992)

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Table 20
Revenue Growth from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	21.6	20.0	17.0	12.7	12.7	16.7
Total IC	22.5	21.2	18.1	12.6	13.3	17.5
Bipolar Digital	-.7	-9.2	-9.9	-8.3	-11.4	-8.0
Bipolar Memory	-27.0	-16.7	-12.8	-11.1	-14.0	-16.5
Bipolar Logic	.6	-9.0	-9.8	-8.2	-11.3	-7.7
MOS Digital	25.3	24.7	21.5	13.0	14.9	19.8
MOS Memory	33.6	33.8	24.9	-3.2	12.1	19.4
MOS Microcomponent	20.9	18.0	20.9	29.7	18.4	21.5
MOS Logic	19.4	20.0	15.2	17.4	12.4	16.9
Analog	19.3	16.0	11.1	13.4	9.9	13.9
Total Discrete	15.5	12.9	10.9	12.5	9.2	12.2
Total Optoelectronic	28.9	20.2	13.2	17.2	11.5	18.0

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Lam Research Corporation	June
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Nippon Sanso	-
Olin Corporation	December
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