Semiconductor Procurement

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Semiconductor Market Definitions

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Chapter 1

Market Share Survey Overview

Each year, Dataquest surveys semiconductor vendors in order to estimate their annual sales. The survey covers approximately 140 semiconductor vendors worldwide (this varies according to mergers, acquisitions, liquidations, start-ups, and so on) by 56 individual semiconductor product categories (excluding subtotals), 6 application segments, and 5 world regions (Europe is split into a 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 then followed by a second survey of the same companies three months later in order 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 a research report (a *Dataquest Perspective* document), which is released on January 1 following the end of the year. Preliminary vendor rankings are featured in a Dataquest press release shortly after this date.

The second survey takes place during March. Our final semiconductor market share estimates are then 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 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 1991 survey guide.

Chapter 2

Semiconductor Companies Surveyed Worldwide 1991

North American Companies

Actel
Advanced Micro Devices
Allegro MicroSystems
Altera
Analog Devices
Appian Technology
Applied Micro Circuits Corporation
AT&T
Atmel
Brooktree
Burr-Brown
California Micro Devices
Catalyst
Cherry Semiconductor
Chips & Technologies
Cirrus Logic
Comlinear
Crystal
Cypress Semiconductor
Dallas Semiconductor
Elantec
Exar
General Instrument
Gennum
Gould AMI
Harris
Hewlett-Packard
Honeywell
Hughes
IMI
Integrated Device Technology
Intel
International CMOS Technology
International Microelectronic Products
International Rectifier
ITT
Kulite
Lattice
Linear Technology
LSI Logic
Maxim
Micro Linear
Micro Power Systems
Microchip Technology
Micron Technology
Microsemi
Mitel
MOSel
Motorola
National Semiconductor
NCR
Novasensor Inc.
Optek
Performance Semiconductor
Powerex
Quality Technologies
Raytheon
Rockwell
SEEQ Technology
Semtech
Sierra Semiconductor
Silicon General
Silicon Systems
Siliconix
Sipex
Solitron
Standard Microsystems
Supertex
Tektronix
Teledyne
Texas Instruments
TRW
Unitrode
Universal
Vitelic
VLSI Technology
VTC
WaferScale Integration
Weitek
Western Digital
Xicor
Xilinx
Zilog

Japanese Companies

Fuji Electric
Fujitsu
Hitachi
Matsushita

Mitsubishi
NEC
New JRC
NMB Semiconductor
Oki
Ricoh
Rohm
Sanken
Sanyo
Seiko Epson
Sharp
Shindengen Electric
Sony
Toko
Toshiba
Yamaha

European Companies

ABB-HAFO
ABB-IXYS
Austria Mikro Systeme
Ericsson
Eupec
European Silicon Structures
Eurosil
Fagor
GEC Plessey
Matra-MHS
MEDL
Mietec
Philips Semiconductors
Semikron
SGS-Thomson
Siemens
STC
TAG
Telefunken Electronic
TMS
Zetex

Asia/Pacific Companies

Daewoo
Goldstar
Hualon Microelectronics Corporation
Hyundai
Korean Electronic Company
MOSpec
Samsung
Silicon Integrated Systems
United Microelectronics
Winbond Electronics

Summary

83 North American Companies
20 Japanese Companies
21 European Companies
10 Asia/Pacific Companies
134 Worldwide Companies

Chapter 3

General Sales Definitions

1. **Sales to customer**. All sales are reported according to customer location, that is, the shipping destination.

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.

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.

4. **Internal semiconductor sales**. Defined as revenue from finished or unfinished semiconductor products from intracompany (internal or in-house) transfers to divisions and subsidiaries of your parent company that manufacture end equipment. *Include all such internal semiconductor sales at market price.*

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 comprises 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 value 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. This occurs 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 microcode 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.*

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 1991 exchange rates provided below. This will prevent inconsistencies in the conversion of offshore sales between each company. These are the exchange rates that will be used in the final 1991 semiconductor market share survey. Exchange rates for historical years are available on request.

Average 1991 Exchange Rates against the U.S. Dollar

Country	1991 Rate	Currency
Austria	11.67	Schillings/$
Belgium	34.13	Belgian Francs/$
Denmark	6.39	Danish Kroner/$
Finland	4.04	Markka/$
France	5.64	French Francs/$
Germany	1.66	Deutsche Marks/$
Ireland	0.62	Pounds/$
Italy	1,238.93	Lire/$
Japan	134.68	Yen/$
Luxembourg	34.13	Luxem. Francs/$
Netherlands	1.87	Gulden/$
Norway	6.49	Norwegian Kroner/$
Portugal	144.02	Escudos/$
South Korea	730.90	Won/$
Spain	103.81	Pesetas/$
Sweden	6.04	Swedish Kronor/$
Switzerland	1.43	Swiss Francs/$
Taiwan	26.50	NT$/$
United Kingdom	0.57	Pounds/$
ECU	0.81	ECU/$

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:	**IC + Discrete + Optoelectronic**
Total Integrated Circuit:	Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog/ Mixed-Signal Monolithic IC + Hybrid IC
Bipolar Digital IC:	1. Bipolar Digital TTL/Other IC + Bipolar Digital ECL IC—*technology split* 2. Bipolar Digital Memory IC + Bipolar Digital Microcomponent IC + Bipolar Digital Logic—*function split*
Bipolar Digital TTL/Other IC:	Data Point
Bipolar Digital ECL IC:	Data Point
Bipolar Digital Memory IC:	Data Point
Bipolar Digital Micro IC:	Data Point
Bipolar Digital Logic IC:	Bipolar Digital Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC
Bipolar Digital 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 + Other Nonvolatile MOS Digital Memory IC + Other MOS Digital Memory IC
DRAM:	Data Point
SRAM:	Data Point
EPROM:	Data Point
Other NV MOS Memory IC:	Data Point
Other MOS Memory IC:	Data Point
MOS Digital Microcomponent IC:	MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral
MOS Digital MPU:	Data Point
MOS Digital MCU:	Data Point
MOS Digital MPR:	Data Point
MOS Digital Logic IC:	MOS Digital Application-Specific IC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC
MOS Digital 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:	Linear IC + Mixed-Signal IC
Linear IC:	Amplifier IC + Voltage Regulator IC + Voltage Reference IC + Comparator IC + Special Function IC + Special Consumer IC + Special Automotive IC + Linear Array ASIC
Amplifier IC:	Data Point
Voltage Regulator IC:	Data Point
Voltage Reference IC:	Data Point
Comparator IC:	Data Point
Special Function IC:	Data Point
Special Consumer IC:	Data Point
Special Automotive 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
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 + Solar Cell
LED Lamp/Display:	Data Point
Optocoupler:	Data Point
CCD:	Data Point
Laser Diode:	Data Point
Photosensor:	Data Point
Solar Cell:	Data Point

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:	(IC + Discrete + Optoelectronic.) Defined as an 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 + Hybrid 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*—(TTL/Other Bipolar IC + ECL) 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.
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).
ECL IC:	Defined as a bipolar digital IC manufactured using emitter-coupled logic (ECL) semiconductor technology.
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, first-in/first-out (FIFO) memory.

Bipolar Digital Micro 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) processor architectures. Includes bipolar digital microprocessor (MPU), bipolar digital microcontroller (MCU), and bipolar digital microperipheral (MPR), where applicable.
Bipolar Digital Logic IC:	(Bipolar Digital 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 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 microcontroller 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, for example, SRAM, 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 microcomponents.
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 other family logic: TTL-compatible SSI, MSI, LSI; standard, AS, FAST, LS, ALS lines; ECL-compatible SSI, MSI, LSI. Also 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 + Other Nonvolatile MOS Digital Memory + Other MOS Digital Memory.) Defined as a MOS digital IC in which binary data are stored and electronically retrieved.
DRAM:	Defined as Dynamic RAM, Multiport-DRAM (M-DRAM), and Video-DRAM (V-DRAM). DRAMs have memory cells consisting of a single transistor, and require externally cycled memory cell refreshes on a regular basis. These are volatile memories and addressing is multiplexed.
SRAM:	Defined as 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 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. 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 are nonvolatile memories.
Other NV MOS Memory IC:	Includes EEPROM, flash memory, and mask ROM. These are all nonvolatile memories.

EEPROM is 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. Includes Nonvolatile RAM (NVRAM), also known as Shadow RAM. These semiconductor products are a combination of an SRAM and a P-EEPROM in each memory cell. The P-EEPROM functions as a shadow backup for the SRAM when power is lost.

Flash memory is defined as rapidly electrically erasable nonvolatile memory. Includes flash memory based on an EPROM cell structure (that is, single transistor) and flash memory based on an EEPROM cell structure (that is, minimum of two transistors), and does not require memory cell refreshes. Includes flash memory based on single- or dual-voltage supply. Mask ROM is defined as Mask-Programmable Read-Only Memory. Specifically, 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.

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, ferroelectric memory.

MOS Digital Microcomponent IC: (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 complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) processor architectures.

MOS Digital MPU: Defined as a MOS Digital Microprocessor. 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 developed from an ASIC design.

MOS Digital MCU: Defined as a MOS Digital Microcontroller. A semiconductor product serving as a dedicated, or embedded controller in a system. Consists of an integral MPU, some nonvolatile memory containing end-user-specified instructions, and some volatile memory for temporary storage of code or data. An MCU can perform basic computing functions without support form microperipheral (MPR) products. This category also contains members of microcontroller product families that have had the on-chip nonvolatile memory removed and instead, access the end-user program contained in external nonvolatile memory. Includes MOS digital MCUs performing a standalone digital signal processing (DSP) function. Includes MOS digital MCUs incorporating or developed from an ASIC design.

MOS Digital MPR:	Defined as a MOS Digital Microperipheral. A semiconductor product serving as a logical support function to an MPU or MCU 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: timer, interrupt control, DMA, MMU, peripheral controllers (for example, disk, graphics display, CRT, keyboard controllers), communications controllers (for example, UART), chip sets for microprocessor support, LAN coprocessors, accelerator coprocessors (for example, floating-point unit, graphics coprocessor, image processor).
MOS Digital Logic IC:	(MOS Digital 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 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 microcontroller cells that should be included in 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, for example, SRAM, EEPROM.
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.
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.) 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.
Monolithic Analog IC:	(Monolithic Linear IC + Monolithic Mixed-Signal IC.) Monolithic linear IC is defined as an analog device that has only analog I/O, therefore its characteristics are inherently linear. Monolithic mixed-signal IC is defined as an analog device that has both analog and digital I/O (see mixed-signal IC definition).
Monolithic Linear IC:	(Amplifier IC + Voltage Regulator IC + Voltage Reference IC + Comparator IC + Special Function IC + Special Consumer IC + Special Automotive IC + Linear Array ASIC.) Defined as an analog device that has 100 percent analog I/O.
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, quad, and so on), 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 analog/mixed-signal 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 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.

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.
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. Disk-drive analog ICs should be reported in their dedicated category under mixed-signal analog.
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 or mixed-signal 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.
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, diodes, and transistors 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 convertors (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 convertor 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 analog/mixed-signal ASIC.
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, dialler and ringer ICs, repeaters, cellular communications ICs, ISDN ICs, telecom filter ICs, and other telecom-specific circuits. Telecoms ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC or 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. Consumer-dedicated interface ICs are counted in special consumer ICs. Interface ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC or 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.
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.
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. May perform digital, analog, or mixed-signal functions. May be manufactured using bipolar, MOS, or BiCMOS technology. Includes hybrid implementation of all monolithic IC functions described in the preceding categories.
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, 1A current rating, or 100V operating voltage.
Power Transistor:	(Bipolar Power Transistor + MOS Power Transistor + Power IGBT.) All rated 1W power dissipation and above, 1A current rating and above, or 100V operating voltage and above.
Bipolar Power Transistor:	Defined as bipolar Darlington transistor, bipolar microwave transistor, bipolar radio frequency (RF) transistor.
MOS Power Transistor:	Defined as MOS field-effect transistor (MOS-FET), MOS Darlington transistor, MOS microwave transistor, 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 rated below 0.1A.
Power Diodes:	Defined as zener diodes and rectifier diodes. All 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.

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 onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.
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), 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.
Solar Cell:	Defined as photovoltaic or solar cells. A semiconductor device in which photons are used to generate current flow.

Worldwide Geographical Region Definitions

North America

Includes *United States* (50 states: Illinois, Indiana, Michigan, Ohio, Wisconsin, Alabama, Kentucky, Mississippi, Tennessee, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, New Jersey, New York, Pennsylvania, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, Alaska, California, Hawaii, Oregon, Washington, Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Arkansas, Louisiana, Oklahoma, Texas), Puerto Rico, and *Canada* (12 provinces: Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Labrador, Northwest Territories).

Japan

Includes Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shihoku, and Kyushu.

Europe

Includes *Benelux* (Belgium, Netherlands, Luxembourg), *France, Italy, Scandinavia* (Denmark, Finland, Norway, Sweden, Iceland), *United Kingdom and Eire* (England, Wales, Scotland, Northern Ireland, Republic of Ireland), *Germany* (including former east Germany), and *Rest of Europe* (Austria, Gibraltar, Greece, Liechtenstein, Malta, Monaco, Portugal, San Marino, Spain, Switzerland, Turkey, Andorra, Vatican City).

Asia/Pacific

Includes *East Asia* (China, Hong Kong, Macau, North and South Korea, Taiwan), *South Asia* (Bangladesh, Myanmar, India, Nepal, Maldives, Pakistan, Sri Lanka, Bhutan), *Southeast Asia* (Brunei, Timor, Indonesia, Kampuchea, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Borneo, Sumatra, Sulawesi, Java).

Rest of World

Includes Mexico, Arctic, Antarctica, Greenland, St. Pierre and Miquelon, *Australia, New Zealand* (North Island, South Island, Stewart Island), Tasmania, Christmas Island, Cocos Islands, New Zealand, Norfolk Island, *Oceania* (American Samoa, Canton and Enderbury Islands, Fiji, French Polynesia, Guam, Johnson Island, Kiribati, Midway Islands, Nauru, New Caledonia, Niue, Pacific Islands, Papua New Guinea, Pitcairn, Samoa, Solomon Islands, Toelau, Tonga, Tuvalu, Vanuatu, Wake Island, Wallis and Futuna Islands, New Britain, New Ireland, Admiralty Islands), *Africa* (Algeria, Libya, Egypt, Morocco, Mauritania, Mali, Senegal, Guinea, Sierra Leone, Liberia, Ghana, Ivory Coast, Togo, Benin, Nigeria, Niger, Chad, Sudan, Ethiopia, Central African Republic, Somalia, Zimbabwe, Uganda, Gabon, Cameroon, Congo, Zaire, Tanzania, Zambia, Malawi, Kenya, Cabinda, Namibia, Botswana, Mozambique, Rwanda, Burundi, South Africa, Swaziland, Benin, Equatorial Guinea, Burkina Faso, Djibouti, Lesotho, Ciskei, Transkei, Bophuthatswana, Venda), Madagascar, Mauritius, Comores, Réunion, *Central America* (Nicaragua, Panama, Guatemala, El Salvador, Belize, Honduras, Granada, Costa Rica), *South America* (Brazil, Chile, Uruguay, Paraguay, Argentina, Colombia, Peru, Bolivia, Venezuela, Guyana, Surinam, French Guiana, Equador, Falkland Islands), *Caribbean Islands* (Cuba, Jamaica, Haiti, Dominican Republic, Anguilla, Montserrat, Trinidad, Tobago, Dominica, Guadeloupe, Saint Lucia, Barbados, Martinique, Grenadine Islands, Bermuda, Bahamas, New Providence, Saint Vincent and The Grenadines, Saint Croix, Antilles), *Eastern Europe* (Albania, Bulgaria, Czechoslovakia, Hungary, Poland, Yugoslavia, Romania, Estonia, Latvia, Ukraine, Belorussia, Lithuania, Latvia, Georgia), *Commonwealth of Independent States* (formerly USSR: Russian Federation, Moldavia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tadjikistan, Kirghizia, Turkmenistan), *Inner Asia* (Afghanistan, Bhutan, Mongolia, Pakistan), *Middle East* (Bahrain, Cyprus, Democratic Yemen, People's Republic of Yemen, Egypt, Gaza Strip, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, United Arab Emirates, Syria).

Chapter 8

Semiconductor Application Segment Definitions

Data Processing

Defined as computer systems, terminals, smart cards, data storage devices, input/output devices, and dedicated systems:

- *Computer systems* includes supercomputers, mainframe computers, superminicomputers, minicomputers, microcomputers, workstations, personal computers.
- *Data storage devices* includes flexible/removable disk drives, fixed/rigid disk drives, optical disk drives, tape drives (streamers).
- *Terminals* includes alphanumeric terminals, graphics terminals, point-of-sales terminals, funds transfer terminals.
- *Smart cards* includes credit cards or credit card-size devices with one or more integrated circuits such as token cards, entry key cards, bank cards, medical cards, computer peripheral cards.
- *Input/output devices* includes dot matrix printers, thermal printers, ink jet printers, fully formed printers, page printers, other input/output devices such as monitors, key-entry equipment, media-to-media data conversion, magnetic ink character recognition, optical scanning equipment, plotters, voice recognition/synthesizer computer equipment, mice, keyboards, digitizers.
- *Dedicated systems* includes office equipment such as copiers, duplicators, full-color copiers, electronic calculators, dictating/transcribing equipment, electronic typewriters, word processors, banking systems and cash registers, mailing/letter-handling/addressing equipment.

Communication

Defined as premise telecom equipment, public telecom equipment, radio, and broadcast and studio:

- *Premise telecom equipment* includes image and text communication such as facsimile, video conferencing, telex, videotex, CCTV; data communications equipment such as modems, statistical multiplexers, time-division multiplexers, local area networks (LANs), private packet data switching; PBX/key telephone systems; call processing equipment such as answering machines, attendant consoles, automatic call distributors (ACDs), voice response units (VRUs), voice terminals, voice messaging systems, call management systems; desktop terminal equipment such as standard telephones, cordless telephones, cellular telephones, video telephones, answering machines.
- *Public telecom equipment* includes transmission equipment, central office switching, public packet switching, and mobile communication such as mobile radio base stations, pagers, base stations.
- *Radio* includes communications equipment transmitting and receiving sound through the use of electronic waves/signals.
- *Broadcast and studio* includes all electronic equipment used to make information public by means of radio and television.

Consumer Appliances

Defined as audio equipment, video equipment, personal electronics, and electronic/electrical:

- *Audio equipment* includes compact disc players, radio combinations, stereo hi-fi components: amplifiers, preamplifiers, tuners, cassette decks, graphic equalizers, turntables, speakers, and equipment used in studio, broadcast, and home environments (equipment that interprets frequencies corresponding to audible sound waves), musical instruments.
- *Video equipment* includes video cameras, video camcorders, videocassette recorders, videotape recorders, color televisions, black-and-white televisions.
- *Personal electronics* includes watches, clocks.
- *Electronic/electrical appliances* includes air conditioners, microwave ovens, washers and dryers, refrigerators/freezers, dishwashers, ranges, ovens.

Industrial

Defined as security/alarm management, manufacturing systems, test equipment, process control equipment, robot systems, automated material handling, instrumentation, medical equipment, vending machines, laser equipment, power supply, traffic control, industrial and scientific research equipment, and other industrial electronic equipment such as vending machines, laser systems, teaching machines, and aids.

Military and Civil Aerospace

Defined as *military electronic equipment* and *civil aerospace*. This includes radar, military/civil sonar, missile weapon, space military equipment, military/civil navigation, communication, electronic warfare, reconnaissance, aircraft systems, military computer systems, military simulation and training, miscellaneous military equipment, civilian space, civil aircraft flight systems, and miscellaneous avionic equipment.

Transportation

Defined as in-car entertainment systems, body control electronics, driver information, powertrain, and safety and convenience electronics:

- *In-car entertainment* includes FM/AM radio, cassette, compact disc player, radio cassette combination systems, two-way radio communications systems, CB radio.
- *Body control electronics* includes vehicle controls such as four-wheel steering control, 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, other multiplex systems; lighting controls including automatic headlight systems, timers, reminders, sequential signal controls, other lighting controls; other body electronics including aerodynamic aid control, power roof/window controls, other body electronics.
- *Driver information* includes electronic dashboard/instrument clusters, analog or digital clusters, electronic analog/digital clocks and compasses, electronic thermometers, head-up displays, navigation and location systems, signal and warning lights.
- *Powertrain* controls include engine management systems, powertrain sensors, ignition control, fuel injection systems, fuel flow, engine temperature, air temperature, coolant level, and wheel speed sensors.
- *Safety and convenience* includes air purifier systems, airbag control systems, antilock braking systems (ABS), active suspension, collision avoidance systems, collision warning systems, cruise control, suspension control and traction control; and other safety and convenience systems.

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Final Worldwide Semiconductor Market Share

June 30, 1992

Source: Dataquest

Market Statistics

Semiconductor Procurement

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Final Worldwide Semiconductor Market Share

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Final Worldwide Semiconductor Market Share

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Note: All tables show estimated data.

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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.

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)

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)

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.

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)

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.

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.

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)

Final Worldwide 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
- 1989-1991 market share rankings

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

Worldwide 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 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 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 standalone 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 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

North America: Includes United States and Canada

Europe: Western Europe

Japan: Japan

Asia-Pacific/Rest of World: All other countries

Line Item Definitions

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 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. ABB-IXYS was formerly the Germany-based power semiconductor division of ASEA Brown Boveri.
3. Allegro MicroSystems was formerly known as Sprague Technologies.
4. Analog Devices revenue includes Precision Monolithics revenue from 1991 forward.
5. Appian Technology was formerly known as ZyMOS.
6. In 1989, AT&T revenue previously classified as MOS Logic was reclassified as Analog.
7. Ericsson was known as Rifa prior to March 1, 1988.
8. GEC Plessey revenue includes MEDL and Plessey revenue from 1990 forward.
9. Harris revenue includes GE Solid State revenue from 1989 forward.
10. Inmos revenue is included in SGS-Thomson revenue from 1989 forward.
11. Macronix revenue is included under Asia/Pacific Companies from 1989 forward.
12. Other North American Companies and Other Asia/Pacific Companies revenue has been restated to reflect the fewer number of companies published in 1991.
13. Philips revenue includes Signetics revenue.
14. 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

Section 1: Final 1991 Worldwide Semiconductor Market Share

Table 1-1
Each 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
North American Companies	19,515	21,047	22,940	35.9	38.6	38.4
Actel	7	21	37	.0	.0	.1
Advanced Micro Devices	1,100	1,053	1,226	2.0	1.9	2.1
Allegro MicroSystems	137	116	104	.3	.2	.2
Altera	59	78	107	.1	.1	.2
Analog Devices	357	381	464	.7	.7	.8
Applan Technology	37	50	15	.1	.1	.0
Applied Micro Circuits Corp.	22	28	38	.0	.1	.1
AT&T	753	737	713	1.4	1.4	1.2
Atmel	94	123	120	.2	.2	.2
Brooktree	52	70	84	.1	.1	.1
Burr-Brown	141	145	152	.3	.3	.3
Catalyst	31	36	32	.1	.1	.1
Cherry Semiconductor	32	36	37	.1	.1	.1
Chips & Technologies	240	265	181	.4	.5	.3
Cirrus Logic	29	130	152	.1	.2	.3
Comlinear	10	13	14	.0	.0	.0
Crystal	12	15	22	.0	.0	.0
Cypress Semiconductor	196	223	281	.4	.4	.5
Dallas Semiconductor	13	17	75	.0	.0	.1
Elantec	12	13	16	.0	.0	.0
Exar	49	75	107	.1	.1	.2
General Instrument	170	214	200	.3	.4	.3
Gennum	20	18	23	.0	.0	.0
Gould AMI	68	52	54	.1	.1	.1
Harris	830	800	623	1.5	1.5	1.0
Hewlett Packard	235	445	442	.4	.8	.7
Honeywell	56	49	45	.1	.1	.1
Hughes	37	44	40	.1	.1	.1
IMI	15	15	17	.0	.0	.0
Integrated Device Technology	204	199	204	.4	.4	.3
Intel	2,430	3,171	4,019	4.5	5.8	6.7
Int'l Microelectronic Prod.	46	40	32	.1	.1	.1
International Rectifier	190	225	238	.3	.4	.4
ITT	390	371	340	.7	.7	.6
Kulite	25	28	26	.0	.1	.0

(Continued)

Table 1-1 (Continued)
Each 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
Lattice	31	62	68	.1	.1	.1
Linear Technology	70	83	107	.1	.2	.2
LSI Logic	512	598	670	.9	1.1	1.1
Maxim	43	65	80	.1	.1	.1
Microchip Technology	124	85	81	.2	.2	.1
Micro Linear	28	45	36	.1	.1	.1
Micron Technology	395	286	455	.7	.5	.8
Micro Power Systems	21	24	26	.0	.0	.0
Microsemi	NA	50	71	NA	.1	.1
Mitel	54	47	50	.1	.1	.1
MOSel	20	31	75	.0	.1	.1
Motorola	3,183	3,539	3,802	5.9	6.5	6.4
NCR	120	145	145	.2	.3	.2
National Semiconductor	1,552	1,653	1,602	2.9	3.0	2.7
Optek	77	66	52	.1	.1	.1
Performance Semiconductor	32	51	54	.1	.1	.1
Powerex	85	92	78	.2	.2	.1
Precision Monolithics	88	91	0	.2	.2	.0
Quality Technologies	38	34	34	.1	.1	.1
Raytheon	96	84	85	.2	.2	.1
Rockwell	165	200	185	.3	.4	.3
SEEQ Technology	53	45	47	.1	.1	.1
Semtech	NA	18	27	NA	.0	.0
Sierra Semiconductor	55	61	86	.1	.1	.1
Silicon General	36	36	32	.1	.1	.1
Siliconix	121	116	140	.2	.2	.2
Silicon Systems	112	165	184	.2	.3	.3
Sipex	22	21	21	.0	.0	.0
Solitron	37	33	30	.1	.1	.1
Standard Microsystems	42	49	45	.1	.1	.1
Supertex	23	27	27	.0	.0	.0
Tektronix	NA	40	70	NA	.1	.1
Teledyne	23	25	24	.0	.0	.0
Texas Instruments	2,787	2,574	2,738	5.1	4.7	4.6
TRW	27	28	28	.0	.1	.0
Unitrode	109	104	80	.2	.2	.1
Universal	13	14	14	.0	.0	.0
Vitelic	66	64	85	.1	.1	.1
VLSI Technology	286	324	414	.5	.6	.7
VTC	44	40	20	.1	.1	.0

(Continued)

Table 1-1 (Continued)
Each 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
WaferScale Integration	35	33	33	.1	.1	.1
Weitek	49	58	39	.1	.1	.1
Western Digital	135	148	209	.2	.3	.4
Xicor	90	71	94	.2	.1	.2
Xilinx	44	84	130	.1	.2	.2
Zilog	99	100	110	.2	.2	.2
Other North American Companies	374	142	177	.6	.3	.3
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
European Companies	5,300	6,108	6,336	9.8	11.2	10.6
ABB-HAFO	37	42	38	.1	.1	.1
ABB-IXYS	50	58	54	.1	.1	.1
Austria Mikro Systeme	56	59	70	.1	.1	.1
Ericsson	54	56	74	.1	.1	.1
Eupec	NA	96	93	NA	.2	.2
European Silicon Structures	18	27	28	.0	.0	.0
Eurosil	30	39	29	.1	.1	.0
Fagor	29	30	29	.1	.1	.0

(Continued)

Table 1-1 (Continued)
Each 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
GEC Plessey	0	390	392	.0	.7	.7
Matra MHS	85	100	104	.2	.2	.2
MEDL	60	0	0	.1	.0	.0
Mietec	52	92	105	.1	.2	.2
Philips	1,643	1,955	2,022	3.0	3.6	3.4
Plessey	240	0	0	.4	.0	.0
Semikron	95	106	108	.2	.2	.2
SGS-Thomson	1,271	1,441	1,436	2.3	2.6	2.4
Siemens	1,154	1,204	1,263	2.1	2.2	2.1
STC	19	24	18	.0	.0	.0
TAG	22	25	30	.0	.0	.1
Telefunken Electronic	299	295	300	.6	.5	.5
TMS	45	45	51	.1	.1	.1
Zetex	NA	24	26	NA	.0	.0
Other European Companies	41	0	66	.1	.0	.1
Asia/Pacific Companies	2,014	2,112	2,734	3.7	3.9	4.6
Daewoo	10	12	20	.0	.0	.0
Dongsung Semiconductor	NA	NA	30	NA	NA	.1
Goldstar	148	163	307	.3	.3	.5
Hualon Microelectronics Corp.	NA	50	71	NA	.1	.1
Hyundai	210	115	248	.4	.2	.4
Korean Electronic Co.	105	114	136	.2	.2	.2
Macronix	31	7	31	.1	.0	.1
Samsung	1,260	1,315	1,473	2.3	2.4	2.5
Silicon Integrated Systems	NA	33	28	NA	.1	.0
United Microelectronics	210	150	200	.4	.3	.3
Winbond Electronics	NA	50	84	NA	.1	.1
Other Asia/Pacific Companies	40	103	106	.1	.2	.2

NA = Not available
Source: Dataquest (June 1992)

Table 1-2
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	44,613	44,459	48,855	100.0	100.0	100.0
North American Companies	17,000	18,450	20,572	38.1	41.5	42.1
Actel	7	21	37	.0	.0	.1
Advanced Micro Devices	1,100	1,053	1,226	2.5	2.4	2.5
Allegro MicroSystems	114	98	93	.3	.2	.2
Altera	59	78	107	.1	.2	.2
Analog Devices	357	380	464	.8	.9	.9
Appian Technology	37	50	15	.1	.1	.0
Applied Micro Circuits Corp.	22	28	38	.0	.1	.1
AT&T	596	593	681	1.3	1.3	1.4
Atmel	94	123	120	.2	.3	.2
Brooktree	52	70	84	.1	.2	.2
Burr-Brown	141	145	152	.3	.3	.3
Catalyst	31	36	32	.1	.1	.1
Cherry Semiconductor	32	36	37	.1	.1	.1
Chips & Technologies	240	265	181	.5	.6	.4
Cirrus Logic	29	130	152	.1	.3	.3
Comlinear	10	13	14	.0	.0	.0
Crystal	12	15	22	.0	.0	.0
Cypress Semiconductor	196	223	281	.4	.5	.6
Dallas Semiconductor	13	17	75	.0	.0	.2
Elantec	12	13	16	.0	.0	.0
Exar	49	75	107	.1	.2	.2
Gennum	20	18	23	.0	.0	.0
Gould AMI	68	52	54	.2	.1	.1
Harris	692	655	507	1.6	1.5	1.0
Hewlett Packard	NA	200	206	NA	.4	.4
Honeywell	25	24	20	.1	.1	.0
Hughes	37	42	40	.1	.1	.1
IMI	15	15	17	.0	.0	.0
Integrated Device Technology	204	199	204	.5	.4	.4
Intel	2,430	3,171	4,019	5.4	7.1	8.2
Int'l Microelectronic Prod.	46	40	32	.1	.1	.1
International Rectifier	3	1	1	.0	.0	.0
ITT	235	210	230	.5	.5	.5
Kulite	25	28	26	.1	.1	.1
Lattice	31	62	68	.1	.1	.1
Linear Technology	70	83	107	.2	.2	.2
LSI Logic	512	598	670	1.1	1.3	1.4

(Continued)

Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Maxim	43	65	80	.1	.1	.2
Microchip Technology	124	85	81	.3	.2	.2
Micro Linear	28	45	36	.1	.1	.1
Micron Technology	395	286	455	.9	.6	.9
Micro Power Systems	21	24	26	.0	.1	.1
Mitel	54	47	50	.1	.1	.1
MOSel	20	31	75	.0	.1	.2
Motorola	2,392	2,714	2,980	5.4	6.1	6.1
NCR	120	145	145	.3	.3	.3
National Semiconductor	1,482	1,583	1,542	3.3	3.6	3.2
Performance Semiconductor	32	51	54	.1	.1	.1
Precision Monolithics	88	91	0	.2	.2	.0
Raytheon	82	74	77	.2	.2	.2
Rockwell	165	200	185	.4	.4	.4
SEEQ Technology	53	45	47	.1	.1	.1
Semtech	NA	2	6	NA	.0	.0
Sierra Semiconductor	55	61	86	.1	.1	.2
Silicon General	36	36	32	.1	.1	.1
Siliconix	54	54	64	.1	.1	.1
Silicon Systems	112	165	184	.3	.4	.4
Sipex	22	21	21	.0	.0	.0
Solitron	10	9	9	.0	.0	.0
Standard Microsystems	42	49	45	.1	.1	.1
Supertex	15	19	17	.0	.0	.0
Tektronix	NA	35	65	NA	.1	.1
Teledyne	23	22	21	.1	.0	.0
Texas Instruments	2,691	2,488	2,652	6.0	5.6	5.4
TRW	27	28	28	.1	.1	.1
Unitrode	50	50	41	.1	.1	.1
Universal	13	14	14	.0	.0	.0
Vitelic	66	64	85	.1	.1	.2
VLSI Technology	286	324	414	.6	.7	.8
VTC	44	40	20	.1	.1	.0
WaferScale Integration	35	33	33	.1	.1	.1
Weitek	49	57	39	.1	.1	.1
Western Digital	135	148	209	.3	.3	.4
Xicor	90	71	94	.2	.2	.2
Xilinx	44	84	130	.1	.2	.3
Zilog	99	100	110	.2	.2	.2
Other North American Companies	287	130	162	.6	.3	.3

(Continued)

Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	22,001	19,801	21,396	49.3	44.5	43.8
Fuji Electric	66	70	55	.1	.2	.1
Fujitsu	2,563	2,384	2,426	5.7	5.4	5.0
Hitachi	2,966	2,878	3,099	6.6	6.5	6.3
Matsushita	1,203	1,206	1,340	2.7	2.7	2.7
Mitsubishi	2,136	1,768	1,953	4.8	4.0	4.0
NEC	3,893	3,735	4,109	8.7	8.4	8.4
New JRC	154	123	134	.3	.3	.3
NMB Semiconductor	127	96	60	.3	.2	.1
Oki	1,044	917	942	2.3	2.1	1.9
Ricoh	84	89	97	.2	.2	.2
Rohm	333	343	438	.7	.8	.9
Sanken	153	159	171	.3	.4	.4
Sanyo	862	850	919	1.9	1.9	1.9
Seiko Epson	359	196	220	.8	.4	.5
Sharp	815	891	956	1.8	2.0	2.0
Shindengen Electric	33	26	50	.1	.1	.1
Sony	679	699	826	1.5	1.6	1.7
Toko	45	54	33	.1	.1	.1
Toshiba	3,329	3,183	3,409	7.5	7.2	7.0
Yamaha	133	134	158	.3	.3	.3
Other Japanese Companies	1,024	0	1	2.3	.0	.0
European Companies	3,772	4,302	4,414	8.5	9.7	9.0
ABB-HAFO	23	24	24	.1	.1	.0
Austria Mikro Systeme	56	59	70	.1	.1	.1
Ericsson	54	56	74	.1	.1	.2
European Silicon Structures	18	27	28	.0	.1	.1
Eurosil	30	39	29	.1	.1	.1
GEC Plessey	0	354	357	.0	.8	.7
Matra MHS	85	100	104	.2	.2	.2
MEDL	39	0	0	.1	.0	.0
Mietec	52	92	105	.1	.2	.2
Philips	1,177	1,417	1,455	2.6	3.2	3.0
Plessey	240	0	0	.5	.0	.0
SGS-Thomson	989	1,126	1,137	2.2	2.5	2.3
Siemens	807	817	829	1.8	1.8	1.7
STC	17	22	16	.0	.0	.0
Telefunken Electronic	126	141	137	.3	.3	.3

(Continued)

Table 1-2 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
TMS	33	28	33	.1	.1	.1
Other European Companies	26	0	16	.1	.0	.0
Asia/Pacific Companies	1,840	1,906	2,473	4.1	4.3	5.1
Daewoo	10	12	20	.0	.0	.0
Goldstar	147	163	307	.3	.4	.6
Hualon Microelectronics Corp.	NA	50	71	NA	.1	.1
Hyundai	210	115	248	.5	.3	.5
Korean Electronic Co.	24	28	33	.1	.1	.1
Macronix	31	7	31	.1	.0	.1
Samsung	1,182	1,238	1,381	2.6	2.8	2.8
Silicon Integrated Systems	NA	33	28	NA	.1	.1
United Microelectronics	210	150	200	.5	.3	.4
Winbond Electronics	NA	50	84	NA	.1	.2
Other Asia/Pacific Companies	26	60	70	.1	.1	.1

NA = Not available

Source: Dataquest (June 1992)

Table 1-3
Each Company's Factory Revenue from Shipments of Bipolar Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	4,314	4,173	3,628	100.0	100.0	100.0
North American Companies	2,204	2,134	1,806	51.1	51.1	49.8
Advanced Micro Devices	474	407	300	11.0	9.8	8.3
Applied Micro Circuits Corp.	20	24	32	.5	.6	.9
AT&T	56	59	48	1.3	1.4	1.3
Atmel	8	14	1	.2	.3	.0
Chips & Technologies	24	25	16	.6	.6	.4
Harris	50	60	35	1.2	1.4	1.0
Integrated Device Technology	0	0	3	.0	.0	.1
Intel	10	5	4	.2	.1	.1
Motorola	369	406	380	8.6	9.7	10.5
National Semiconductor	441	405	324	10.2	9.7	8.9
Raytheon	55	54	53	1.3	1.3	1.5
Teledyne	3	3	3	.1	.1	.1
Texas Instruments	671	663	583	15.6	15.9	16.1
TRW	7	8	7	.2	.2	.2
Other North American Companies	16	1	17	.4	.0	.5
Japanese Companies	1,612	1,627	1,454	37.4	39.0	40.1
Fujitsu	590	634	509	13.7	15.2	14.0
Hitachi	447	452	461	10.4	10.8	12.7
Matsushita	13	12	13	.3	.3	.4
Mitsubishi	122	92	81	2.8	2.2	2.2
NEC	245	240	244	5.7	5.8	6.7
New JRC	1	1	1	.0	.0	.0
Oki	46	41	39	1.1	1.0	1.1
Rohm	1	1	0	.0	.0	.0
Sanyo	56	59	0	1.3	1.4	.0
Sony	0	0	1	.0	.0	.0
Toshiba	91	95	105	2.1	2.3	2.9
European Companies	466	386	346	10.8	9.2	9.5
GEC Plessey	0	66	41	.0	1.6	1.1
Philips	270	250	245	6.3	6.0	6.8
Plessey	122	0	0	2.8	.0	.0
SGS-Thomson	7	9	1	.2	.2	.0
Siemens	54	43	41	1.3	1.0	1.1
STC	4	11	7	.1	.3	.2

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Bipolar Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Telefunken Electronic	5	7	7	.1	.2	.2
Other European Companies	4	0	4	.1	.0	.1
Asia/Pacific Companies	32	26	22	.7	.6	.6
Goldstar	32	26	22	.7	.6	.6

Source: Dataquest (June 1992)

Table 1-4
Each Company's Factory Revenue from Shipments of TTL/Other Bipolar Digital ICs to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,204	2,968	2,543	100.0	100.0	100.0
North American Companies	1,777	1,653	1,449	55.5	55.7	57.0
Advanced Micro Devices	401	306	294	12.5	10.3	11.6
AT&T	44	46	29	1.4	1.5	1.1
Chips & Technologies	24	25	16	.7	.8	.6
Harris	50	60	35	1.6	2.0	1.4
Intel	10	5	4	.3	.2	.2
Motorola	184	174	156	5.7	5.9	6.1
National Semiconductor	343	319	271	10.7	10.7	10.7
Raytheon	47	52	50	1.5	1.8	2.0
Teledyne	3	3	3	.1	.1	.1
Texas Instruments	671	663	583	20.9	22.3	22.9
Other North American Companies	0	0	8	.0	.0	.3
Japanese Companies	1,028	1,005	812	32.1	33.9	31.9
Fujitsu	252	272	201	7.9	9.2	7.9
Hitachi	308	308	250	9.6	10.4	9.8
Matsushita	9	8	8	.3	.3	.3
Mitsubishi	122	92	81	3.8	3.1	3.2
NEC	163	160	161	5.1	5.4	6.3
New JRC	1	1	1	.0	.0	.0
Oki	41	37	35	1.3	1.2	1.4
Rohm	1	1	0	.0	.0	.0
Sanyo	56	59	0	1.7	2.0	.0
Toshiba	75	67	75	2.3	2.3	2.9
European Companies	367	284	260	11.5	9.6	10.2
GEC Plessey	0	20	5	.0	.7	.2
Philips	254	236	229	7.9	8.0	9.0
Plessey	82	0	0	2.6	.0	.0
SGS-Thomson	7	9	1	.2	.3	.0
Siemens	16	12	14	.5	.4	.6
Telefunken Electronic	5	7	7	.2	.2	.3
Other European Companies	3	0	4	.1	.0	.2
Asia/Pacific Companies	32	26	22	1.0	.9	.9
Goldstar	32	26	22	1.0	.9	.9

Source: Dataquest (June 1992)

Table 1-5
Each Company's Factory Revenue from Shipments of ECL Bipolar Digital ICs to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	1,110	1,205	1,085	100.0	100.0	100.0
North American Companies	427	481	357	38.5	39.9	32.9
Advanced Micro Devices	73	101	6	6.6	8.4	.6
Applied Micro Circuits Corp.	20	24	32	1.8	2.0	2.9
AT&T	12	13	19	1.1	1.1	1.8
Atmel	8	14	1	.7	1.2	.1
Integrated Device Technology	0	0	3	.0	.0	.3
Motorola	185	232	224	16.7	19.3	20.6
National Semiconductor	98	86	53	8.8	7.1	4.9
Raytheon	8	2	3	.7	.2	.3
TRW	7	8	7	.6	.7	.6
Other North American Companies	16	1	9	1.4	.1	.8
Japanese Companies	584	622	642	52.6	51.6	59.2
Fujitsu	338	362	308	30.5	30.0	28.4
Hitachi	139	144	211	12.5	12.0	19.4
Matsushita	4	4	5	.4	.3	.5
NEC	82	80	83	7.4	6.6	7.6
Oki	5	4	4	.5	.3	.4
Sony	0	0	1	.0	.0	.1
Toshiba	16	28	30	1.4	2.3	2.8
European Companies	99	102	86	8.9	8.5	7.9
GEC Plessey	0	46	36	.0	3.8	3.3
Philips	16	14	16	1.4	1.2	1.5
Plessey	40	0	0	3.6	.0	.0
Siemens	38	31	27	3.4	2.6	2.5
STC	4	11	7	.4	.9	.6
Other European Companies	1	0	0	.1	.0	.0

Source: Dataquest (June 1992)

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

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	460	431	356	100.0	100.0	100.0
North American Companies	160	126	89	34.8	29.2	25.0
Advanced Micro Devices	85	65	52	18.5	15.1	14.6
Harris	0	5	2	.0	1.2	.6
Integrated Device Technology	0	0	3	.0	.0	.8
Motorola	4	3	3	.9	.7	.8
National Semiconductor	49	25	13	10.7	5.8	3.7
Raytheon	12	18	8	2.6	4.2	2.2
Texas Instruments	10	10	3	2.2	2.3	.8
Other North American Companies	0	0	5	.0	.0	1.4
Japanese Companies	253	259	231	55.0	60.1	64.9
Fujitsu	135	144	113	29.3	33.4	31.7
Hitachi	97	95	99	21.1	22.0	27.8
NEC	21	20	19	4.6	4.6	5.3
European Companies	47	46	36	10.2	10.7	10.1
Philips	47	45	36	10.2	10.4	10.1
SGS-Thomson	0	1	0	.0	.2	.0

Source: Dataquest (June 1992)

Table 1-7
Each Company's Factory Revenue from Shipments of Bipolar Logic ICs to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	3,854	3,633	3,179	100.0	100.0	100.0
North American Companies	2,044	1,900	1,624	53.0	52.3	51.1
Advanced Micro Devices	389	302	227	10.1	8.3	7.1
Applied Micro Circuits Corp.	20	24	32	.5	.7	1.0
AT&T	56	59	48	1.5	1.6	1.5
Atmel	8	14	1	.2	.4	.0
Chips & Technologies	24	25	16	.6	.7	.5
Harris	50	55	33	1.3	1.5	1.0
Intel	10	5	4	.3	.1	.1
Motorola	365	403	377	9.5	11.1	11.9
National Semiconductor	392	313	256	10.2	8.6	8.1
Raytheon	43	36	45	1.1	1.0	1.4
Teledyne	3	3	3	.1	.1	.1
Texas Instruments	661	653	570	17.2	18.0	17.9
TRW	7	8	7	.2	.2	.2
Other North American Companies	16	0	5	.4	.0	.2
Japanese Companies	1,359	1,368	1,223	35.3	37.7	38.5
Fujitsu	455	490	396	11.8	13.5	12.5
Hitachi	350	357	362	9.1	9.8	11.4
Matsushita	13	12	13	.3	.3	.4
Mitsubishi	122	92	81	3.2	2.5	2.5
NEC	224	220	225	5.8	6.1	7.1
New JRC	1	1	1	.0	.0	.0
Oki	46	41	39	1.2	1.1	1.2
Rohm	1	1	0	.0	.0	.0
Sanyo	56	59	0	1.5	1.6	.0
Sony	0	0	1	.0	.0	.0
Toshiba	91	95	105	2.4	2.6	3.3
European Companies	419	339	310	10.9	9.3	9.8
GEC Plessey	0	66	41	.0	1.8	1.3
Philips	223	204	209	5.8	5.6	6.6
Plessey	122	0	0	3.2	.0	.0
SGS-Thomson	7	8	1	.2	.2	.0
Siemens	54	43	41	1.4	1.2	1.3
STC	4	11	7	.1	.3	.2
Telefunken Electronic	5	7	7	.1	.2	.2
Other European Companies	4	0	4	.1	.0	.1

(Continued)

Table 1-7 (Continued)
Each Company's Factory Revenue from Shipments of Bipolar Logic ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Asia/Pacific Companies	32	26	22	.8	.7	.7
Goldstar	32	26	22	.8	.7	.7

Source: Dataquest (June 1992)

Table 1-8
Each Company's Factory Revenue from Shipments of MOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	31,140	30,152	34,315	100.0	100.0	100.0
North American Companies	10,940	12,030	14,377	35.1	39.9	41.9
Actel	7	21	37	.0	.1	.1
Advanced Micro Devices	549	570	832	1.8	1.9	2.4
Allegro MicroSystems	16	2	2	.1	.0	.0
Altera	59	78	107	.2	.3	.3
Analog Devices	20	20	20	.1	.1	.1
Appian Technology	37	50	15	.1	.2	.0
Applied Micro Circuits Corp.	2	4	6	.0	.0	.0
AT&T	291	337	391	.9	1.1	1.1
Atmel	73	98	118	.2	.3	.3
Catalyst	31	35	32	.1	.1	.1
Chips & Technologies	216	240	165	.7	.8	.5
Cirrus Logic	29	129	151	.1	.4	.4
Cypress Semiconductor	196	223	281	.6	.7	.8
Dallas Semiconductor	10	14	62	.0	.0	.2
Exar	3	0	0	.0	.0	.0
Gould AMI	52	39	40	.2	.1	.1
Harris	362	335	246	1.2	1.1	.7
Hewlett Packard	NA	200	206	NA	.7	.6
Honeywell	4	4	0	.0	.0	.0
Hughes	37	34	32	.1	.1	.1
IMI	15	14	14	.0	.0	.0
Integrated Device Technology	203	196	198	.7	.7	.6
Intel	2,420	3,157	4,006	7.8	10.5	11.7
Int'l Microelectronic Prod.	33	28	26	.1	.1	.1
ITT	185	107	195	.6	.4	.6
Lattice	31	62	68	.1	.2	.2
LSI Logic	512	596	670	1.6	2.0	2.0
Microchip Technology	124	85	81	.4	.3	.2
Micron Technology	395	286	455	1.3	.9	1.3
MOSel	20	31	75	.1	.1	.2
Motorola	1,587	1,826	2,144	5.1	6.1	6.2
NCR	94	115	117	.3	.4	.3
National Semiconductor	513	585	589	1.6	1.9	1.7
Performance Semiconductor	32	51	54	.1	.2	.2
Rockwell	42	40	20	.1	.1	.1
SEEQ Technology	53	45	39	.2	.1	.1
Sierra Semiconductor	27	6	7	.1	.0	.0

(Continued)

Table 1-8 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Standard Microsystems	42	49	45	.1	.2	.1
Supertex	0	6	5	.0	.0	.0
Texas Instruments	1,603	1,367	1,630	5.1	4.5	4.8
TRW	5	6	7	.0	.0	.0
Universal	9	10	10	.0	.0	.0
Vitelic	66	64	85	.2	.2	.2
VLSI Technology	286	324	414	.9	1.1	1.2
VTC	17	7	0	.1	.0	.0
WaferScale Integration	35	33	33	.1	.1	.1
Weitek	49	57	39	.2	.2	.1
Western Digital	135	148	209	.4	.5	.6
Xicor	87	68	91	.3	.2	.3
Xilinx	44	84	130	.1	.3	.4
Zilog	99	100	110	.3	.3	.3
Other North American Companies	183	44	68	.6	.1	.2
Japanese Companies	16,535	14,389	15,615	53.1	47.7	45.5
Fuji Electric	26	25	24	.1	.1	.1
Fujitsu	1,822	1,602	1,738	5.9	5.3	5.1
Hitachi	2,210	2,113	2,280	7.1	7.0	6.6
Matsushita	832	798	915	2.7	2.6	2.7
Mitsubishi	1,628	1,263	1,395	5.2	4.2	4.1
NEC	3,271	3,118	3,443	10.5	10.3	10.0
New JRC	34	8	11	.1	.0	.0
NMB Semiconductor	127	96	60	.4	.3	.2
Oki	966	845	871	3.1	2.8	2.5
Ricoh	84	89	91	.3	.3	.3
Rohm	59	69	97	.2	.2	.3
Sanyo	339	324	320	1.1	1.1	.9
Seiko Epson	345	185	208	1.1	.6	.6
Sharp	756	826	890	2.4	2.7	2.6
Sony	346	348	431	1.1	1.2	1.3
Toshiba	2,729	2,553	2,692	8.8	8.5	7.8
Yamaha	121	127	148	.4	.4	.4
Other Japanese Companies	840	0	1	2.7	.0	.0
European Companies	2,028	2,082	2,130	6.5	6.9	6.2
ABB-HAFO	23	24	24	.1	.1	.1
Austria Mikro Systeme	47	37	39	.2	.1	.1
Ericsson	7	8	16	.0	.0	.0

(Continued)

Table 1-8 (Continued)
Each Company's Factory Revenue from Shipments of MOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
European Silicon Structures	18	27	28	.1	.1	.1
Eurosil	30	39	22	.1	.1	.1
GEC Plessey	0	115	131	.0	.4	.4
Matra MHS	85	96	99	.3	.3	.3
MEDL	35	0	0	.1	.0	.0
Mietec	52	20	22	.2	.1	.1
Philips	385	514	546	1.2	1.7	1.6
Plessey	83	0	0	.3	.0	.0
SGS-Thomson	589	563	558	1.9	1.9	1.6
Siemens	601	592	607	1.9	2.0	1.8
STC	8	5	4	.0	.0	.0
Telefunken Electronic	20	23	12	.1	.1	.0
TMS	26	19	22	.1	.1	.1
Other European Companies	19	0	0	.1	.0	.0
Asia/Pacific Companies	1,637	1,651	2,193	5.3	5.5	6.4
Daewoo	0	1	6	.0	.0	.0
Goldstar	106	117	273	.3	.4	.8
Hualon Microelectronics Corp.	NA	49	70	NA	.2	.2
Hyundai	210	115	248	.7	.4	.7
Macronix	31	7	31	.1	.0	.1
Samsung	1,066	1,146	1,269	3.4	3.8	3.7
Silicon Integrated Systems	NA	33	28	NA	.1	.1
United Microelectronics	210	150	200	.7	.5	.6
Winbond Electronics	NA	32	68	NA	.1	.2
Other Asia/Pacific Companies	14	1	0	.0	.0	.0

NA = Not available
Source: Dataquest (June 1992)

Table 1-9
Each Company's Factory Revenue from Shipments of N/PMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	9,663	6,547	6,005	100.0	100.0	100.0
North American Companies	3,634	2,233	1,860	37.6	34.1	31.0
Advanced Micro Devices	327	252	158	3.4	3.8	2.6
Allegro MicroSystems	4	0	0	.0	.0	.0
AT&T	39	48	40	.4	.7	.7
Gould AMI	32	7	0	.3	.1	.0
Harris	13	2	0	.1	.0	.0
Hughes	1	1	1	.0	.0	.0
Intel	1,276	1,104	1,180	13.2	16.9	19.7
Int'l Microelectronic Prod.	6	4	4	.1	.1	.1
ITT	80	43	70	.8	.7	1.2
Microchip Technology	55	24	18	.6	.4	.3
Micron Technology	298	71	0	3.1	1.1	.0
Motorola	197	66	152	2.0	1.0	2.5
NCR	14	9	1	.1	.1	.0
National Semiconductor	54	68	37	.6	1.0	.6
Rockwell	42	40	20	.4	.6	.3
SEEQ Technology	11	5	4	.1	.1	.1
Standard Microsystems	10	9	5	.1	.1	.1
Texas Instruments	1,048	371	99	10.8	5.7	1.6
Xicor	68	53	36	.7	.8	.6
Zilog	55	56	35	.6	.9	.6
Other North American Companies	4	0	0	.0	.0	.0
Japanese Companies	4,846	3,616	3,492	50.2	55.2	58.2
Fujitsu	377	330	320	3.9	5.0	5.3
Hitachi	446	426	437	4.6	6.5	7.3
Matsushita	324	290	304	3.4	4.4	5.1
Mitsubishi	870	623	603	9.0	9.5	10.0
NEC	948	841	729	9.8	12.8	12.1
Oki	319	208	189	3.3	3.2	3.1
Ricoh	34	32	29	.4	.5	.5
Rohm	1	2	2	.0	.0	.0
Sanyo	74	28	16	.8	.4	.3
Sharp	193	209	230	2.0	3.2	3.8
Sony	49	37	41	.5	.6	.7
Toshiba	811	590	592	8.4	9.0	9.9
Yamaha	1	0	0	.0	.0	.0
Other Japanese Companies	399	0	0	4.1	.0	.0

(Continued)

Table 1-9 (Continued)
Each Company's Factory Revenue from Shipments of N/PMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
European Companies	627	593	569	6.5	9.1	9.5
Austria Mikro Systeme	11	11	17	.1	.2	.3
GEC Plessey	0	15	11	.0	.2	.2
Mietec	7	7	3	.1	.1	.0
Philips	93	94	106	1.0	1.4	1.8
Plessey	12	0	0	.1	.0	.0
SGS-Thomson	228	204	183	2.4	3.1	3.0
Siemens	242	235	233	2.5	3.6	3.9
STC	2	0	0	.0	.0	.0
Telefunken Electronic	20	23	12	.2	.4	.2
TMS	5	4	4	.1	.1	.1
Other European Companies	7	0	0	.1	.0	.0
Asia/Pacific Companies	556	105	84	5.8	1.6	1.4
Goldstar	32	6	2	.3	.1	.0
Hualon Microelectronics Corp.	NA	0	10	NA	.0	.2
Hyundai	1	0	0	.0	.0	.0
Macronix	31	7	0	.3	.1	.0
Samsung	422	42	41	4.4	.6	.7
United Microelectronics	70	50	31	.7	.8	.5

NA = Not available
Source: Dataquest (June 1992)

Table 1-10
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	20,905	23,179	27,749	10.0	100.0	100.0
North American Companies	7,197	9,694	12,353	34.4	41.8	44.5
Actel	7	21	37	.0	.1	.1
Advanced Micro Devices	222	318	674	1.1	1.4	2.4
Allegro MicroSystems	4	2	2	.0	.0	.0
Altera	59	78	107	.3	.3	.4
Analog Devices	20	20	20	.1	.1	.1
Appian Technology	37	50	15	.2	.2	.1
AT&T	252	289	343	1.2	1.2	1.2
Atmel	73	98	118	.3	.4	.4
Catalyst	31	35	32	.1	.2	.1
Chips & Technologies	216	240	165	1.0	1.0	.6
Cirrus Logic	29	129	151	.1	.6	.5
Cypress Semiconductor	195	222	271	.9	1.0	1.0
Dallas Semiconductor	10	14	62	.0	.1	.2
Exar	3	0	0	.0	.0	.0
Gould AMI	20	32	40	.1	.1	.1
Harris	340	318	231	1.6	1.4	.8
Hewlett Packard	NA	200	206	NA	.9	.7
Honeywell	4	4	0	.0	.0	.0
Hughes	36	33	31	.2	.1	.1
IMI	15	14	14	.1	.1	.1
Integrated Device Technology	202	191	191	1.0	.8	.7
Intel	1,144	2,053	2,826	5.5	8.9	10.2
Int'l Microelectronic Prod.	27	24	22	.1	.1	.1
ITT	105	64	125	.5	.3	.5
Lattice	31	62	68	.1	.3	.2
LSI Logic	507	591	665	2.4	2.5	2.4
Microchip Technology	69	61	63	.3	.3	.2
Micron Technology	97	215	455	.5	.9	1.6
MOSel	20	31	75	.1	.1	.3
Motorola	1,387	1,737	1,954	6.6	7.5	7.0
NCR	80	106	116	.4	.5	.4
National Semiconductor	429	483	501	2.1	2.1	1.8
Performance Semiconductor	32	51	54	.2	.2	.2
SEEQ Technology	42	40	35	.2	.2	.1
Sierra Semiconductor	27	6	7	.1	.0	.0
Standard Microsystems	32	40	40	.2	.2	.1
Supertex	0	6	5	.0	.0	.0

(Continued)

Table 1-10 (Continued)
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Texas Instruments	539	980	1,507	2.6	4.2	5.4
TRW	5	6	7	.0	.0	.0
Universal	9	10	10	.0	.0	.0
Vitelic	66	64	85	.3	.3	.3
VLSI Technology	286	324	414	1.4	1.4	1.5
VTC	17	7	0	.1	.0	.0
WaferScale Integration	35	33	33	.2	.1	.1
Weitek	49	57	39	.2	.2	.1
Western Digital	135	148	209	.6	.6	.8
Xicor	19	15	55	.1	.1	.2
Xilinx	44	84	130	.2	.4	.5
Zilog	44	44	75	.2	.2	.3
Other North American Companies	145	44	68	.7	.2	.2
Japanese Companies	11,276	10,467	11,741	53.9	45.2	42.3
Fuji Electric	23	22	22	.1	.1	.1
Fujitsu	1,342	1,182	1,311	6.4	5.1	4.7
Hitachi	1,665	1,591	1,728	8.0	6.9	6.2
Matsushita	508	508	611	2.4	2.2	2.2
Mitsubishi	758	640	792	3.6	2.8	2.9
NEC	2,242	2,188	2,600	10.7	9.4	9.4
New JRC	34	8	11	.2	.0	.0
NMB Semiconductor	127	96	60	.6	.4	.2
Oki	585	613	656	2.8	2.6	2.4
Ricoh	49	56	61	.2	.2	.2
Rohm	58	67	95	.3	.3	.3
Sanyo	265	296	301	1.3	1.3	1.1
Seiko Epson	345	185	208	1.7	.8	.7
Sharp	563	617	660	2.7	2.7	2.4
Sony	297	308	386	1.4	1.3	1.4
Toshiba	1,854	1,963	2,090	8.9	8.5	7.5
Yamaha	120	127	148	.6	.5	.5
Other Japanese Companies	441	0	1	2.1	.0	.0
European Companies	1,365	1,472	1,547	6.5	6.4	5.6
ABB-HAFO	23	24	24	.1	.1	.1
Austria Mikro Systeme	36	26	22	.2	.1	.1
Ericsson	7	8	16	.0	.0	.1
European Silicon Structures	18	27	28	.1	.1	.1
Eurosil	30	39	22	.1	.2	.1

(Continued)

Table 1-10 (Continued)
Each Company's Factory Revenue from Shipments of CMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
GEC Plessey	0	100	120	.0	.4	.4
Matra MHS	85	96	99	.4	.4	.4
MEDL	35	0	0	.2	.0	.0
Mietec	22	13	19	.1	.1	.1
Philips	292	420	440	1.4	1.8	1.6
Plessey	71	0	0	.3	.0	.0
SGS-Thomson	351	347	361	1.7	1.5	1.3
Siemens	359	357	374	1.7	1.5	1.3
STC	3	0	4	.0	.0	.0
TMS	21	15	18	.1	.1	.1
Other European Companies	12	0	0	.1	.0	.0
Asia/Pacific Companies	1,067	1,546	2,108	5.1	6.7	7.6
Daewoo	0	1	6	.0	.0	.0
Goldstar	74	111	271	.4	.5	1.0
Hualon Microelectronics Corp.	NA	49	60	NA	.2	.2
Hyundai	209	115	248	1.0	.5	.9
Macronix	0	0	31	.0	.0	.1
Samsung	644	1,104	1,228	3.1	4.8	4.4
Silicon Integrated Systems	NA	33	28	NA	.1	.1
United Microelectronics	140	100	169	.7	.4	.6
Winbond Electronics	NA	32	67	NA	.1	.2
Other Asia/Pacific Companies	0	1	0	.0	.0	.0

NA = Not available
Source: Dataquest (June 1992)

Table 1-11
Each Company's Factory Revenue from Shipments of BiCMOS Digital ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	572	426	561	100.0	100.0	100.0
North American Companies	109	103	164	19.1	24.2	29.2
Allegro MicroSystems	8	0	0	1.4	.0	.0
Applied Micro Circuits Corp.	2	4	6	.3	.9	1.1
AT&T	0	0	8	.0	.0	1.4
Cypress Semiconductor	1	1	10	.2	.2	1.8
Harris	9	15	15	1.6	3.5	2.7
Integrated Device Technology	1	5	7	.2	1.2	1.2
LSI Logic	5	5	5	.9	1.2	.9
Motorola	3	23	38	.5	5.4	6.8
National Semiconductor	30	34	51	5.2	8.0	9.1
Texas Instruments	16	16	24	2.8	3.8	4.3
Other North American Companies	34	0	0	5.9	.0	.0
Japanese Companies	413	306	382	72.2	71.8	68.1
Fuji Electric	3	3	2	.5	.7	.4
Fujitsu	103	90	107	18.0	21.1	19.1
Hitachi	99	96	115	17.3	22.5	20.5
NEC	81	89	114	14.2	20.9	20.3
Oki	62	24	26	10.8	5.6	4.6
Ricoh	1	1	1	.2	.2	.2
Sanyo	0	0	3	.0	.0	.5
Sony	0	3	4	.0	.7	.7
Toshiba	64	0	10	11.2	.0	1.8
European Companies	36	17	14	6.3	4.0	2.5
Mietec	23	0	0	4.0	.0	.0
SGS-Thomson	10	12	14	1.7	2.8	2.5
STC	3	5	0	.5	1.2	.0
Asia/Pacific Companies	14	0	1	2.4	.0	.2
Winbond Electronics	NA	0	1	NA	.0	.2
Other Asia/Pacific Companies	14	0	0	2.4	.0	.0

NA = Not available
Source: Dataquest (June 1992)

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

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	15,405	12,128	12,841	100.0	100.0	100.0
North American Companies	3,651	2,977	3,298	23.7	24.5	25.7
Advanced Micro Devices	258	253	270	1.7	2.1	2.1
AT&T	13	13	4	.1	.1	.0
Atmel	47	54	78	.3	.4	.6
Catalyst	31	35	32	.2	.3	.2
Cypress Semiconductor	149	166	186	1.0	1.4	1.4
Dallas Semiconductor	10	14	21	.1	.1	.2
Gould AMI	25	14	11	.2	.1	.1
Harris	37	24	23	.2	.2	.2
Honeywell	2	2	0	.0	.0	.0
Integrated Device Technology	158	132	128	1.0	1.1	1.0
Intel	433	371	395	2.8	3.1	3.1
Int'l Microelectronic Prod.	17	8	6	.1	.1	.0
ITT	10	0	10	.1	.0	.1
Microchip Technology	94	60	57	.6	.5	.4
Micron Technology	395	286	455	2.6	2.4	3.5
MOSel	20	31	75	.1	.3	.6
Motorola	407	395	412	2.6	3.3	3.2
NCR	8	4	3	.1	.0	.0
National Semiconductor	132	137	112	.9	1.1	.9
Performance Semiconductor	16	19	18	.1	.2	.1
SEEQ Technology	40	33	33	.3	.3	.3
Texas Instruments	1,095	741	738	7.1	6.1	5.7
Vitelic	66	64	85	.4	.5	.7
VLSI Technology	23	8	0	.1	.1	.0
WaferScale Integration	28	27	23	.2	.2	.2
Xicor	87	68	91	.6	.6	.7
Other North American Companies	50	18	32	.3	.1	.2
Japanese Companies	9,678	7,095	7,141	62.8	58.5	55.6
Fujitsu	1,188	913	909	7.7	7.5	7.1
Hitachi	1,396	1,224	1,330	9.1	10.1	10.4
Matsushita	362	265	217	2.3	2.2	1.7
Mitsubishi	1,117	745	762	7.3	6.1	5.9
NEC	1,594	1,233	1,242	10.3	10.2	9.7
NMB Semiconductor	127	96	60	.8	.8	.5
Oki	441	350	380	2.9	2.9	3.0
Ricoh	28	26	8	.2	.2	.1

(Continued)

Table 1-12 (Continued)
Each Company's Factory Revenue from Shipments of MOS Memory ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Rohm	5	13	28	.0	.1	.2
Sanyo	118	86	82	.8	.7	.6
Seiko Epson	137	55	37	.9	.5	.3
Sharp	434	454	476	2.8	3.7	3.7
Sony	215	204	183	1.4	1.7	1.4
Toshiba	1,681	1,431	1,425	10.9	11.8	11.1
Yamaha	0	0	2	.0	.0	.0
Other Japanese Companies	835	0	0	5.4	.0	.0
European Companies	716	731	682	4.6	6.0	5.3
Eurosil	0	0	1	.0	.0	.0
GEC Plessey	0	8	0	.0	.1	.0
Matra MHS	31	37	35	.2	.3	.3
MEDL	7	0	0	.0	.0	.0
Philips	60	96	75	.4	.8	.6
Plessey	3	0	0	.0	.0	.0
SGS-Thomson	239	278	273	1.6	2.3	2.1
Siemens	376	312	298	2.4	2.6	2.3
Asia/Pacific Companies	1,360	1,325	1,720	8.8	10.9	13.4
Goldstar	82	96	249	.5	.8	1.9
Hualon Microelectronics Corp.	NA	39	27	NA	.3	.2
Hyundai	210	115	248	1.4	.9	1.9
Macronix	31	7	31	.2	.1	.2
Samsung	935	971	1,066	6.1	8.0	8.3
Silicon Integrated Systems	NA	17	15	NA	.1	.1
United Microelectronics	102	66	58	.7	.5	.5
Winbond Electronics	NA	14	26	NA	.1	.2

NA = Not available
Source: Dataquest (June 1992)

Table 1-13
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	7,808	9,584	11,774	100.0	100.0	100.0
North American Companies	4,367	5,743	7,256	55.9	59.9	61.6
Advanced Micro Devices	172	178	395	2.2	1.9	3.4
Analog Devices	20	20	20	.3	.2	.2
Appian Technology	30	38	8	.4	.4	.1
AT&T	21	21	33	.3	.2	.3
Atmel	0	0	2	.0	.0	.0
Chips & Technologies	216	240	165	2.8	2.5	1.4
Cirrus Logic	29	129	151	.4	1.3	1.3
Cypress Semiconductor	11	15	48	.1	.2	.4
Dallas Semiconductor	0	0	41	.0	.0	.3
Harris	115	110	65	1.5	1.1	.6
Hughes	2	2	2	.0	.0	.0
Integrated Device Technology	13	20	20	.2	.2	.2
Intel	1,929	2,726	3,578	24.7	28.4	30.4
ITT	25	28	35	.3	.3	.3
LSI Logic	67	93	115	.9	1.0	1.0
Microchip Technology	18	16	15	.2	.2	.1
Motorola	767	970	1,171	9.8	10.1	9.9
NCR	22	31	39	.3	.3	.3
National Semiconductor	169	242	286	2.2	2.5	2.4
Performance Semiconductor	13	24	28	.2	.3	.2
Rockwell	42	40	20	.5	.4	.2
SEEQ Technology	0	12	6	.0	.1	.1
Sierra Semiconductor	1	1	1	.0	.0	.0
Standard Microsystems	34	40	40	.4	.4	.3
Supertex	0	0	2	.0	.0	.0
Texas Instruments	252	320	419	3.2	3.3	3.6
TRW	5	6	7	.1	.1	.1
VLSI Technology	94	105	165	1.2	1.1	1.4
WaferScale Integration	2	2	7	.0	.0	.1
Weitek	49	57	39	.6	.6	.3
Western Digital	135	148	209	1.7	1.5	1.8
Zilog	99	100	110	1.3	1.0	.9
Other North American Companies	15	9	14	.2	.1	.1
Japanese Companies	2,955	3,236	3,824	37.8	33.8	32.5
Fuji Electric	0	1	1	.0	.0	.0
Fujitsu	197	213	244	2.5	2.2	2.1

(Continued)

Table 1-13 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponent ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Hitachi	505	546	583	6.5	5.7	5.0
Matsushita	218	250	321	2.8	2.6	2.7
Mitsubishi	431	441	543	5.5	4.6	4.6
NEC	841	981	1,149	10.8	10.2	9.8
Oki	142	131	137	1.8	1.4	1.2
Ricoh	21	22	62	.3	.2	.5
Rohm	17	17	23	.2	.2	.2
Sanyo	63	71	69	.8	.7	.6
Seiko Epson	11	10	16	.1	.1	.1
Sharp	104	124	134	1.3	1.3	1.1
Sony	43	43	88	.6	.4	.7
Toshiba	361	386	454	4.6	4.0	3.9
Other Japanese Companies	1	0	0	.0	.0	.0
European Companies	433	538	567	5.5	5.6	4.8
Eurosil	2	4	0	.0	.0	.0
GEC Plessey	0	8	5	.0	.1	.0
Matra MHS	28	33	37	.4	.3	.3
MEDL	3	0	0	.0	.0	.0
Philips	131	192	212	1.7	2.0	1.8
Plessey	3	0	0	.0	.0	.0
SGS-Thomson	161	175	167	2.1	1.8	1.4
Siemens	92	116	134	1.2	1.2	1.1
TMS	13	10	12	.2	.1	.1
Asia/Pacific Companies	53	67	127	.7	.7	1.1
Goldstar	2	3	11	.0	.0	.1
Hualon Microelectronics Corp.	NA	0	9	NA	.0	.1
Samsung	8	22	27	.1	.2	.2
Silicon Integrated Systems	NA	3	4	NA	.0	.0
United Microelectronics	43	39	62	.6	.4	.5
Winbond Electronics	NA	0	14	NA	.0	.1

NA = Not available
Source: Dataquest (June 1992)

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

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	7,927	8,440	9,700	100.0	100.0	100.0
North American Companies	2,922	3,310	3,823	36.9	39.2	39.4
Actel	7	21	37	.1	.2	.4
Advanced Micro Devices	119	139	167	1.5	1.6	1.7
Allegro MicroSystems	16	2	2	.2	.0	.0
Altera	59	78	107	.7	.9	1.1
Appian Technology	7	12	7	.1	.1	.1
Applied Micro Circuits Corp.	2	4	6	.0	.0	.1
AT&T	257	303	354	3.2	3.6	3.6
Atmel	26	44	38	.3	.5	.4
Cypress Semiconductor	36	42	47	.5	.5	.5
Exar	3	0	0	.0	.0	.0
Gould AMI	27	25	29	.3	.3	.3
Harris	210	201	158	2.6	2.4	1.6
Hewlett Packard	NA	200	206	NA	2.4	2.1
Honeywell	2	2	0	.0	.0	.0
Hughes	35	32	30	.4	.4	.3
IMI	15	14	14	.2	.2	.1
Integrated Device Technology	32	44	50	.4	.5	.5
Intel	58	60	33	.7	.7	.3
Int'l Microelectronic Prod.	16	20	20	.2	.2	.2
ITT	150	79	150	1.9	.9	1.5
Lattice	31	62	68	.4	.7	.7
LSI Logic	445	503	555	5.6	6.0	5.7
Microchip Technology	12	9	9	.2	.1	.1
Motorola	413	461	561	5.2	5.5	5.8
NCR	64	80	75	.8	.9	.8
National Semiconductor	212	206	191	2.7	2.4	2.0
Performance Semiconductor	3	8	8	.0	.1	.1
SEEQ Technology	13	0	0	.2	.0	.0
Sierra Semiconductor	26	5	6	.3	.1	.1
Standard Microsystems	8	9	5	.1	.1	.1
Supertex	0	6	3	.0	.1	.0
Texas Instruments	256	306	473	3.2	3.6	4.9
Universal	9	10	10	.1	.1	.1
VLSI Technology	169	211	249	2.1	2.5	2.6
VTC	17	7	0	.2	.1	.0
WaferScale Integration	5	4	3	.1	.0	.0
Xilinx	44	84	130	.6	1.0	1.3
Other North American Companies	118	17	22	1.5	.2	.2

(Continued)

Table 1-14 (Continued)
Each Company's Factory Revenue from Shipments of MOS Logic ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Japanese Companies	3,902	4,058	4,650	49.2	48.1	47.9
Fuji Electric	26	24	23	.3	.3	.2
Fujitsu	437	476	585	5.5	5.6	6.0
Hitachi	309	343	367	3.9	4.1	3.8
Matsushita	252	283	377	3.2	3.4	3.9
Mitsubishi	80	77	90	1.0	.9	.9
NEC	836	904	1,052	10.5	10.7	10.8
New JRC	34	8	11	.4	.1	.1
Oki	383	364	354	4.8	4.3	3.6
Ricoh	35	41	21	.4	.5	.2
Rohm	37	39	46	.5	.5	.5
Sanyo	158	167	169	2.0	2.0	1.7
Seiko Epson	197	120	155	2.5	1.4	1.6
Sharp	218	248	280	2.8	2.9	2.9
Sony	88	101	160	1.1	1.2	1.6
Toshiba	687	736	813	8.7	8.7	8.4
Yamaha	121	127	146	1.5	1.5	1.5
Other Japanese Companies	4	0	1	.1	.0	.0
European Companies	879	813	881	11.1	9.6	9.1
ABB-HAFO	23	24	24	.3	.3	.2
Austria Mikro Systeme	47	37	39	.6	.4	.4
Ericsson	7	8	16	.1	.1	.2
European Silicon Structures	18	27	28	.2	.3	.3
Eurosil	28	35	21	.4	.4	.2
GEC Plessey	0	99	126	.0	1.2	1.3
Matra MHS	26	26	27	.3	.3	.3
MEDL	25	0	0	.3	.0	.0
Mietec	52	20	22	.7	.2	.2
Philips	194	226	259	2.4	2.7	2.7
Plessey	77	0	0	1.0	.0	.0
SGS-Thomson	189	110	118	2.4	1.3	1.2
Siemens	133	164	175	1.7	1.9	1.8
STC	8	5	4	.1	.1	.0
Telefunken Electronic	20	23	12	.3	.3	.1
TMS	13	9	10	.2	.1	.1
Other European Companies	19	0	0	.2	.0	.0

(Continued)

Table 1-14 (Continued)
Each Company's Factory Revenue from Shipments of MOS Logic ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Asia/Pacific Companies	224	259	346	2.8	3.1	3.6
Daewoo	0	1	6	.0	.0	.1
Goldstar	22	18	13	.3	.2	.1
Hualon Microelectronics Corp.	NA	10	34	NA	.1	.4
Samsung	123	153	176	1.6	1.8	1.8
Silicon Integrated Systems	NA	13	9	NA	.2	.1
United Microelectronics	65	45	80	.8	.5	.8
Winbond Electronics	NA	18	28	NA	.2	.3
Other Asia/Pacific Companies	14	1	0	.2	.0	.0

NA = Not available
Source: Dataquest (June 1992)

Table 1-15
Each Company's Factory Revenue from Shipments of Analog ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	9,159	10,134	10,912	100.0	100.0	100.0
North American Companies	3,856	4,286	4,389	42.1	42.3	40.2
Advanced Micro Devices	77	76	94	.8	.7	.9
Allegro MicroSystems	98	96	91	1.1	.9	.8
Analog Devices	337	360	444	3.7	3.6	4.1
AT&T	249	197	242	2.7	1.9	2.2
Atmel	13	11	1	.1	.1	.0
Brooktree	52	70	84	.6	.7	.8
Burr-Brown	141	145	152	1.5	1.4	1.4
Catalyst	0	1	0	.0	.0	.0
Cherry Semiconductor	32	36	37	.3	.4	.3
Cirrus Logic	0	1	1	.0	.0	.0
Comlinear	10	13	14	.1	.1	.1
Crystal	12	15	22	.1	.1	.2
Dallas Semiconductor	3	3	13	.0	.0	.1
Elantec	12	13	16	.1	.1	.1
Exar	46	75	107	.5	.7	1.0
Gennum	20	18	23	.2	.2	.2
Gould AMI	16	13	14	.2	.1	.1
Harris	280	260	226	3.1	2.6	2.1
Honeywell	21	20	20	.2	.2	.2
Hughes	0	8	8	.0	.1	.1
IMI	0	1	3	.0	.0	.0
Integrated Device Technology	1	3	3	.0	.0	.0
Intel	0	9	9	.0	.1	.1
Int'l Microelectronic Prod.	13	12	6	.1	.1	.1
International Rectifier	3	1	1	.0	.0	.0
ITT	50	103	35	.5	1.0	.3
Kulite	25	28	26	.3	.3	.2
Linear Technology	70	83	107	.8	.8	1.0
LSI Logic	0	2	0	.0	.0	.0
Maxim	43	65	80	.5	.6	.7
Micro Linear	28	45	36	.3	.4	.3
Micro Power Systems	21	24	26	.2	.2	.2
Mitel	54	47	50	.6	.5	.5
Motorola	436	482	456	4.8	4.8	4.2
NCR	26	30	28	.3	.3	.3
National Semiconductor	528	593	629	5.8	5.9	5.8
Precision Monolithics	88	91	0	1.0	.9	.0

(Continued)

Table 1-15 (Continued)
Each Company's Factory Revenue from Shipments of Analog ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Raytheon	27	20	24	.3	.2	.2
Rockwell	123	160	165	1.3	1.6	1.5
SEEQ Technology	0	0	8	.0	.0	.1
Semtech	NA	2	6	NA	.0	.1
Sierra Semiconductor	28	55	79	.3	.5	.7
Silicon General	36	36	32	.4	.4	.3
Siliconix	54	54	64	.6	.5	.6
Silicon Systems	112	165	184	1.2	1.6	1.7
Sipex	22	21	21	.2	.2	.2
Solitron	10	9	9	.1	.1	.1
Supertex	15	13	12	.2	.1	.1
Tektronix	NA	35	65	NA	.3	.6
Teledyne	20	19	18	.2	.2	.2
Texas Instruments	417	458	439	4.6	4.5	4.0
TRW	15	14	14	.2	.1	.1
Unitrode	50	50	41	.5	.5	.4
Universal	4	4	4	.0	.0	.0
VTC	27	33	20	.3	.3	.2
Xicor	3	3	3	.0	.0	.0
Other North American Companies	88	85	77	1.0	.8	.7
Japanese Companies	3,854	3,785	4,327	42.1	37.3	39.7
Fuji Electric	40	45	31	.4	.4	.3
Fujitsu	151	148	179	1.6	1.5	1.6
Hitachi	309	313	358	3.4	3.1	3.3
Matsushita	358	396	412	3.9	3.9	3.8
Mitsubishi	386	413	477	4.2	4.1	4.4
NEC	377	377	422	4.1	3.7	3.9
New JRC	119	114	122	1.3	1.1	1.1
Oki	32	31	32	.3	.3	.3
Ricoh	0	0	6	.0	.0	.1
Rohm	273	273	341	3.0	2.7	3.1
Sanken	153	159	171	1.7	1.6	1.6
Sanyo	467	467	599	5.1	4.6	5.5
Seiko Epson	14	11	12	.2	.1	.1
Sharp	59	65	66	.6	.6	.6
Shindengen Electric	33	26	50	.4	.3	.5
Sony	333	351	394	3.6	3.5	3.6
Toko	45	54	33	.5	.5	.3
Toshiba	509	535	612	5.6	5.3	5.6

(Continued)

Table 1-15 (Continued)
Each Company's Factory Revenue from Shipments of Analog ICs to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Yamaha	12	7	10	.1	.1	.1
Other Japanese Companies	184	0	0	2.0	.0	.0
European Companies	1,278	1,834	1,938	14.0	18.1	17.8
Austria Mikro Systeme	9	22	31	.1	.2	.3
Ericsson	47	48	58	.5	.5	.5
Eurosil	0	0	7	.0	.0	.1
GEC Plessey	0	173	185	.0	1.7	1.7
Matra MHS	0	4	5	.0	.0	.0
MEDL	4	0	0	.0	.0	.0
Mietec	0	72	83	.0	.7	.8
Philips	522	653	664	5.7	6.4	6.1
Plessey	35	0	0	.4	.0	.0
SGS-Thomson	393	554	578	4.3	5.5	5.3
Siemens	152	182	181	1.7	1.8	1.7
STC	5	6	5	.1	.1	.0
Telefunken Electronic	101	111	118	1.1	1.1	1.1
TMS	7	9	11	.1	.1	.1
Other European Companies	3	0	12	.0	.0	.1
Asia/Pacific Companies	171	229	258	1.9	2.3	2.4
Daewoo	10	11	14	.1	.1	.1
Goldstar	9	20	12	.1	.2	.1
Hualon Microelectronics Corp.	NA	1	1	NA	.0	.0
Korean Electronic Co.	24	28	33	.3	.3	.3
Samsung	116	92	112	1.3	.9	1.0
Winbond Electronics	NA	18	16	NA	.2	.1
Other Asia/Pacific Companies	12	59	70	.1	.6	.6

NA = Not available

Source: Dataquest (June 1992)

Table 1-16
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	7,320	7,674	8,035	100.0	100.0	100.0
North American Companies	2,091	2,174	1,919	28.6	28.3	23.9
Allegro MicroSystems	23	17	11	.3	.2	.1
Analog Devices	0	1	0	.0	.0	.0
AT&T	147	130	0	2.0	1.7	.0
General Instrument	170	214	200	2.3	2.8	2.5
Harris	120	130	107	1.6	1.7	1.3
Hewlett Packard	56	56	45	.8	.7	.6
International Rectifier	187	224	237	2.6	2.9	2.9
ITT	155	161	110	2.1	2.1	1.4
Microsemi	NA	50	71	NA	.7	.9
Motorola	766	799	794	10.5	10.4	9.9
National Semiconductor	70	70	60	1.0	.9	.7
Powerex	85	92	78	1.2	1.2	1.0
Raytheon	14	10	8	.2	.1	.1
Semtech	NA	16	21	NA	.2	.3
Siliconix	67	62	76	.9	.8	.9
Solitron	27	24	21	.4	.3	.3
Supertex	8	8	10	.1	.1	.1
Teledyne	0	3	3	.0	.0	.0
Texas Instruments	60	53	28	.8	.7	.3
Unitrode	59	54	39	.8	.7	.5
Other North American Companies	77	0	0	1.1	.0	.0
Japanese Companies	3,778	3,783	4,296	51.6	49.3	53.5
Fuji Electric	243	248	263	3.3	3.2	3.3
Fujitsu	100	107	152	1.4	1.4	1.9
Hitachi	594	575	598	8.1	7.5	7.4
Matsushita	314	339	379	4.3	4.4	4.7
Mitsubishi	337	311	325	4.6	4.1	4.0
NEC	489	479	544	6.7	6.2	6.8
New JRC	4	4	3	.1	.1	.0
Oki	9	9	9	.1	.1	.1
Rohm	297	314	374	4.1	4.1	4.7
Sanken	211	221	259	2.9	2.9	3.2
Sanyo	199	197	250	2.7	2.6	3.1
Shindengen Electric	130	133	134	1.8	1.7	1.7
Sony	89	76	91	1.2	1.0	1.1
Toko	5	6	31	.1	.1	.4

(Continued)

Table 1-16 (Continued)
Each Company's Factory Revenue from Shipments of Discrete Semiconductors to the World
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Toshiba	724	764	884	9.9	10.0	11.0
Other Japanese Companies	33	0	0	.5	.0	.0
European Companies	1,284	1,539	1,588	17.5	20.1	19.8
ABB-HAFO	5	8	6	.1	.1	.1
ABB-IXYS	50	58	54	.7	.8	.7
Eupec	NA	96	93	NA	1.3	1.2
Fagor	29	30	29	.4	.4	.4
GEC Plessey	0	36	35	.0	.5	.4
MEDL	21	0	0	.3	.0	.0
Philips	442	507	531	6.0	6.6	6.6
Semikron	95	106	108	1.3	1.4	1.3
SGS-Thomson	282	315	299	3.9	4.1	3.7
Siemens	232	256	245	3.2	3.3	3.0
STC	2	2	2	.0	.0	.0
TAG	22	25	30	.3	.3	.4
Telefunken Electronic	95	76	89	1.3	1.0	1.1
TMS	2	1	1	.0	.0	.0
Zetex	NA	23	25	NA	.3	.3
Other European Companies	7	0	41	.1	.0	.5
Asia/Pacific Companies	167	178	232	2.3	2.3	2.9
Dongsung Semiconductor	NA	NA	30	NA	NA	.4
Goldstar	1	0	0	.0	.0	.0
Korean Electronic Co.	74	79	95	1.0	1.0	1.2
Samsung	78	77	92	1.1	1.0	1.1
Other Asia/Pacific Companies	14	22	15	.2	.3	.2

NA = Not available
Source: Dataquest (June 1992)

Table 1-17
Each Company's Factory Revenue from Shipments of Optoelectronic Semiconductors to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Total Market	2,406	2,412	2,804	100.0	100.0	100.0
North American Companies	424	423	449	17.6	17.5	16.0
Allegro MicroSystems	0	1	0	.0	.0	.0
AT&T	10	14	32	.4	.6	1.1
Harris	18	15	9	.7	.6	.3
Hewlett Packard	179	189	191	7.4	7.8	6.8
Honeywell	31	25	25	1.3	1.0	.9
Hughes	0	2	0	.0	.1	.0
Motorola	25	26	28	1.0	1.1	1.0
Optek	77	66	52	3.2	2.7	1.9
Quality Technologies	38	34	34	1.6	1.4	1.2
Tektronix	NA	5	5	NA	.2	.2
Texas Instruments	36	33	58	1.5	1.4	2.1
Weitek	0	1	0	.0	.0	.0
Other North American Companies	10	12	15	.4	.5	.5
Japanese Companies	1,731	1,694	1,992	71.9	70.2	71.0
Fuji Electric	1	1	1	.0	.0	.0
Fujitsu	107	108	127	4.4	4.5	4.5
Hitachi	62	63	68	2.6	2.6	2.4
Matsushita	287	281	318	11.9	11.7	11.3
Mitsubishi	27	29	25	1.1	1.2	.9
NEC	107	108	121	4.4	4.5	4.3
New JRC	13	13	14	.5	.5	.5
Oki	30	28	30	1.2	1.2	1.1
Rohm	93	102	122	3.9	4.2	4.4
Sanken	17	19	21	.7	.8	.7
Sanyo	136	149	193	5.7	6.2	6.9
Sharp	292	303	362	12.1	12.6	12.9
Sony	228	235	279	9.5	9.7	10.0
Toshiba	257	255	286	10.7	10.6	10.2
Other Japanese Companies	74	0	25	3.1	.0	.9
European Companies	244	267	334	10.1	11.1	11.9
ABB-HAFO	9	10	8	.4	.4	.3
Philips	24	31	36	1.0	1.3	1.3
Siemens	115	131	189	4.8	5.4	6.7
Telefunken Electronic	78	78	74	3.2	3.2	2.6
TMS	10	16	17	.4	.7	.6

(Continued)

Table 1-17 (Continued)
Each Company's Factory Revenue from Shipments of Optoelectronic Semiconductors to the World (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1989	1990	1991	1989	1990	1991
Zetex	NA	1	1	NA	.0	.0
Other European Companies	8	0	9	.3	.0	.3
Asia/Pacific Companies	7	28	29	.3	1.2	1.0
Korean Electronic Co.	7	7	8	.3	.3	.3
Other Asia/Pacific Companies	0	21	21	.0	.9	.7

NA = Not available
Source: Dataquest (June 1992)

Section 2: Final 1991 Worldwide Semiconductor Market Share Rankings

Table 2-1
Top 40 Companies' Factory Revenue from Shipments of Semiconductors to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	NEC	4,322	4,774	10	8.0
2	2	Toshiba	4,202	4,579	9	7.7
3	5	Intel	3,171	4,019	27	6.7
4	3	Motorola	3,539	3,802	7	6.4
5	4	Hitachi	3,516	3,765	7	6.3
6	7	Texas Instruments	2,574	2,738	6	4.6
7	6	Fujitsu	2,599	2,705	4	4.5
8	8	Mitsubishi	2,108	2,303	9	3.9
9	10	Matsushita	1,826	2,037	12	3.4
10	9	Philips	1,955	2,022	3	3.4
11	11	National Semiconductor	1,653	1,602	-3	2.7
12	13	Samsung	1,315	1,473	12	2.5
13	12	SGS-Thomson	1,441	1,436	-0	2.4
14	15	Sanyo	1,196	1,362	14	2.3
15	16	Sharp	1,194	1,318	10	2.2
16	14	Siemens	1,204	1,263	5	2.1
17	17	Advanced Micro Devices	1,053	1,226	16	2.1
18	18	Sony	1,010	1,196	18	2.0
19	19	Oki	954	981	3	1.6
20	21	Rohm	759	934	23	1.6
21	22	AT&T	737	713	-3	1.2
22	23	LSI Logic	598	670	12	1.1
23	20	Harris	800	623	-22	1.0
24	27	Analog Devices	381	464	22	.8
25	32	Micron Technology	286	455	59	.8
26	25	Sanken	399	451	13	.8
27	24	Hewlett Packard	445	442	-1	.7
28	29	VLSI Technology	324	414	28	.7
29	26	GEC Plessey	390	392	1	.7
30	28	ITT	371	340	-8	.6
31	30	Fuji Electric	319	319	0	.5
32	41	Goldstar	163	307	88	.5
33	31	Telefunken Electronic	295	300	2	.5
34	35	Cypress Semiconductor	223	281	26	.5
35	53	Hyundai	115	248	116	.4
36	34	International Rectifier	225	238	6	.4

(Continued)

Table 2-1 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Semiconductors to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
37	39	Seiko Epson	196	220	12	.4
38	44	Western Digital	148	209	41	.4
39	38	Integrated Device Technology	199	204	3	.3
40	36	General Instrument	214	200	-7	.3
40	43	United Microelectronics	150	200	33	.3
		All Others	5,976	6,469	8	10.8
		North American Companies	21,047	22,940	9	38.4
		Japanese Companies	25,278	27,684	10	46.4
		European Companies	6,108	6,336	4	10.6
		Asia/Pacific Companies	2,112	2,734	29	4.6
		Total Market	54,545	59,694	9	100.0

Source: Dataquest (June 1992)

Table 2-2
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	NEC	3,735	4,109	10	8.4
2	3	Intel	3,171	4,019	27	8.2
3	2	Toshiba	3,183	3,409	7	7.0
4	4	Hitachi	2,878	3,099	8	6.3
5	5	Motorola	2,714	2,980	10	6.1
6	6	Texas Instruments	2,488	2,652	7	5.4
7	7	Fujitsu	2,384	2,426	2	5.0
8	8	Mitsubishi	1,768	1,953	10	4.0
9	9	National Semiconductor	1,583	1,542	-3	3.2
10	10	Philips	1,417	1,455	3	3.0
11	11	Samsung	1,238	1,381	12	2.8
12	12	Matsushita	1,206	1,340	11	2.7
13	14	Advanced Micro Devices	1,053	1,226	16	2.5
14	13	SGS-Thomson	1,126	1,137	1	2.3
15	16	Sharp	891	956	7	2.0
16	15	Oki	917	942	3	1.9
17	17	Sanyo	850	919	8	1.9
18	18	Siemens	817	829	1	1.7
19	19	Sony	699	826	18	1.7
20	22	AT&T	593	681	15	1.4
21	21	LSI Logic	598	670	12	1.4
22	20	Harris	655	507	-23	1.0
23	23	Analog Devices	380	464	22	.9
24	27	Micron Technology	286	455	59	.9
25	25	Rohm	343	438	28	.9
26	26	VLSI Technology	324	414	28	.8
27	24	GEC Plessey	354	357	1	.7
28	36	Goldstar	163	307	88	.6
29	29	Cypress Semiconductor	223	281	26	.6
30	47	Hyundai	115	248	116	.5
31	30	ITT	210	230	10	.5
32	34	Seiko Epson	196	220	12	.5
33	39	Western Digital	148	209	41	.4
34	32	Hewlett Packard	200	206	3	.4
35	33	Integrated Device Technology	199	204	3	.4
36	38	United Microelectronics	150	200	33	.4
37	31	Rockwell	200	185	-8	.4
38	35	Silicon Systems	165	184	12	.4

(Continued)

Table 2-2 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	28	Chips & Technologies	265	181	-32	.4
40	37	Sanken	159	171	8	.4
		All Others	4,415	4,843	10	9.9
		North American Companies	18,450	20,572	12	42.1
		Japanese Companies	19,801	21,396	8	43.8
		European Companies	4,302	4,414	3	9.0
		Asia/Pacific Companies	1,906	2,473	30	5.1
		Total Market	44,459	48,855	10	100.0

Source: Dataquest (June 1992)

Table 2-3
Top 20 Companies' Factory Revenue from Shipments of Bipolar Digital ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Texas Instruments	663	583	-12	16.1
2	2	Fujitsu	634	509	-20	14.0
3	3	Hitachi	452	461	2	12.7
4	5	Motorola	406	380	-6	10.5
5	6	National Semiconductor	405	324	-20	8.9
6	4	Advanced Micro Devices	407	300	-26	8.3
7	7	Philips	250	245	-2	6.8
8	8	NEC	240	244	2	6.7
9	9	Toshiba	95	105	11	2.9
10	10	Mitsubishi	92	81	-12	2.2
11	15	Raytheon	54	53	-2	1.5
12	14	AT&T	59	48	-19	1.3
13	11	GEC Plessey	66	41	-38	1.1
13	16	Siemens	43	41	-5	1.1
15	17	Oki	41	39	-5	1.1
16	12	Harris	60	35	-42	1.0
17	20	Applied Micro Circuits Corp.	24	32	33	.9
18	18	Goldstar	26	22	-15	.6
19	19	Chips & Technologies	25	16	-36	.4
20	22	Matsushita	12	13	8	.4
		All Others	119	56	-53	.6
		North American Companies	2,134	1,806	-15	49.8
		Japanese Companies	1,627	1,454	-11	40.1
		European Companies	386	346	-10	9.5
		Asia/Pacific Companies	26	22	-15	.6
		Total Market	4,173	3,628	-13	100.0

Source: Dataquest (June 1992)

Table 2-4
Top 10 Companies' Factory Revenue from Shipments of Bipolar Memory ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Fujitsu	144	113	-22	31.7
2	2	Hitachi	95	99	4	27.8
3	3	Advanced Micro Devices	65	52	-20	14.6
4	4	Philips	45	36	-20	10.1
5	6	NEC	20	19	-5	5.3
6	5	National Semiconductor	25	13	-48	3.7
7	7	Raytheon	18	8	-56	2.2
8	8	Texas Instruments	10	3	-70	.8
8	10	Motorola	3	3	0	.8
8	NM	Integrated Device Technology	0	3	NM	.8
		All Others	6	7	17	2.0
		North American Companies	126	89	-29	25.0
		Japanese Companies	259	231	-11	64.9
		European Companies	46	36	-22	10.1
		Asia/Pacific Companies	0	0	0	.0
		Total Market	431	356	-17	100.0

NM = Not meaningful
Source: Dataquest (June 1992)

Table 2-5
Top 20 Companies' Factory Revenue from Shipments of Bipolar Logic ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Texas Instruments	653	570	-13	17.9
2	2	Fujitsu	490	396	-19	12.5
3	3	Motorola	403	377	-6	11.9
4	4	Hitachi	357	362	1	11.4
5	5	National Semiconductor	313	256	-18	8.1
6	6	Advanced Micro Devices	302	227	-25	7.1
7	7	NEC	220	225	2	7.1
8	8	Philips	204	209	2	6.6
9	9	Toshiba	95	105	11	3.3
10	10	Mitsubishi	92	81	-12	2.5
11	13	AT&T	59	48	-19	1.5
12	17	Raytheon	36	45	25	1.4
13	11	GEC Plessey	66	41	-38	1.3
13	15	Siemens	43	41	-5	1.3
15	16	Oki	41	39	-5	1.2
16	14	Harris	55	33	-40	1.0
17	20	Applied Micro Circuits Corp.	24	32	33	1.0
18	18	Goldstar	26	22	-15	.7
19	19	Chips & Technologies	25	16	-36	.5
20	22	Matsushita	12	13	8	.4
		All Others	117	41	-65	1.3
		North American Companies	1,900	1,624	-15	51.1
		Japanese Companies	1,368	1,223	-11	38.5
		European Companies	339	310	-9	9.8
		Asia/Pacific Companies	26	22	-15	.7
		Total Market	3,633	3,179	-12	100.0

Source: Dataquest (June 1992)

Table 2-6
Top 40 Companies' Factory Revenue from Shipments of MOS Digital ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Intel	3,157	4,006	27	11.7
2	2	NEC	3,118	3,443	10	10.0
3	3	Toshiba	2,553	2,692	5	7.8
4	4	Hitachi	2,113	2,280	8	6.6
5	5	Motorola	1,826	2,144	17	6.2
6	6	Fujitsu	1,602	1,738	8	5.1
7	7	Texas Instruments	1,367	1,630	19	4.8
8	8	Mitsubishi	1,263	1,395	10	4.1
9	9	Samsung	1,146	1,269	11	3.7
10	12	Matsushita	798	915	15	2.7
11	11	Sharp	826	890	8	2.6
12	10	Oki	845	871	3	2.5
13	16	Advanced Micro Devices	570	832	46	2.4
14	13	LSI Logic	596	670	12	2.0
15	14	Siemens	592	607	3	1.8
16	15	National Semiconductor	585	589	1	1.7
17	17	SGS-Thomson	563	558	-1	1.6
18	18	Philips	514	546	6	1.6
19	24	Micron Technology	286	455	59	1.3
20	19	Sony	348	431	24	1.3
21	22	VLSI Technology	324	414	28	1.2
22	20	AT&T	337	391	16	1.1
23	23	Sanyo	324	320	-1	.9
24	26	Cypress Semiconductor	223	281	26	.8
25	34	Goldstar	117	273	133	.8
26	36	Hyundai	115	248	116	.7
27	21	Harris	335	246	-27	.7
28	31	Western Digital	148	209	41	.6
29	29	Seiko Epson	185	208	12	.6
30	27	Hewlett Packard	200	206	3	.6
31	30	United Microelectronics	150	200	33	.6
32	28	Integrated Device Technology	196	198	1	.6
33	38	ITT	107	195	82	.6
34	25	Chips & Technologies	240	165	-31	.5
35	32	Cirrus Logic	129	151	17	.4
36	33	Yamaha	127	148	17	.4
37	37	GEC Plessey	115	131	14	.4
38	45	Xilinx	84	130	55	.4

(Continued)

Table 2-6 (Continued)
Top 40 Companies' Factory Revenue from Shipments of MOS Digital ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	40	Atmel	98	118	20	.3
40	35	NCR	115	117	2	.3
		All Others	1,815	2,005	10	5.8
		North American Companies	12,030	14,377	20	41.9
		Japanese Companies	14,389	15,615	9	45.5
		European Companies	2,082	2,130	2	6.2
		Asia/Pacific Companies	1,651	2,193	33	6.4
		Total Market	30,152	34,315	14	100.0

Source: Dataquest (June 1992)

Table 2-7
Top 40 Companies' Factory Revenue from Shipments of MOS Memory ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Toshiba	1,431	1,425	-0	11.1
2	3	Hitachi	1,224	1,330	9	10.4
3	2	NEC	1,233	1,242	1	9.7
4	4	Samsung	971	1,066	10	8.3
5	5	Fujitsu	913	909	-0	7.1
6	6	Mitsubishi	745	762	2	5.9
7	7	Texas Instruments	741	738	-0	5.7
8	8	Sharp	454	476	5	3.7
9	13	Micron Technology	286	455	59	3.5
10	9	Motorola	395	412	4	3.2
11	10	Intel	371	395	6	3.1
12	11	Oki	350	380	9	3.0
13	12	Siemens	312	298	-4	2.3
14	14	SGS-Thomson	278	273	-2	2.1
15	16	Advanced Micro Devices	253	270	7	2.1
16	24	Goldstar	96	249	159	1.9
17	21	Hyundai	115	248	116	1.9
18	15	Matsushita	265	217	-18	1.7
19	18	Cypress Semiconductor	166	186	12	1.4
20	17	Sony	204	183	-10	1.4
21	20	Integrated Device Technology	132	128	-3	1.0
22	19	National Semiconductor	137	112	-18	.9
23	26	Xicor	68	91	34	.7
24	28	Vitelic	64	85	33	.7
25	25	Sanyo	86	82	-5	.6
26	31	Atmel	54	78	44	.6
27	22	Philips	96	75	-22	.6
27	36	MOSel	31	75	142	.6
29	23	NMB Semiconductor	96	60	-38	.5
30	27	United Microelectronics	66	58	-12	.5
31	29	Microchip Technology	60	57	-5	.4
32	30	Seiko Epson	55	37	-33	.3
33	33	Matra MHS	37	35	-5	.3
34	35	SEEQ Technology	33	33	0	.3
35	34	Catalyst	35	32	-9	.2
36	50	Macronix	7	31	343	.2
37	45	Rohm	13	28	115	.2
38	32	Hualon Microelectronic Corp.	39	27	-31	.2

(Continued)

Table 2-7 (Continued)
Top 40 Companies' Factory Revenue from Shipments of MOS Memory ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	42	Winbond	14	26	86	.2
40	37	Waferscale Integration	27	23	-15	.2
40	39	Harris	24	23	-4	.2
		All Others	151	131	-13	1.0
		North American Companies	2,977	3,298	11	25.7
		Japanese Companies	7,095	7,141	1	55.6
		European Companies	731	682	-7	5.3
		Asia/Pacific Companies	1,325	1,720	30	13.4
		Total Market	12,128	12,841	6	100.0

Source: Dataquest (June 1992)

Table 2-8
Top 40 Companies' Factory Revenue from Shipments of MOS Microcomponent ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Intel	2,726	3,578	31	30.4
2	3	Motorola	970	1,171	21	9.9
3	2	NEC	981	1,149	17	9.8
4	4	Hitachi	546	583	7	5.0
5	5	Mitsubishi	441	543	23	4.6
6	6	Toshiba	386	454	18	3.9
7	7	Texas Instruments	320	419	31	3.6
8	13	Advanced Micro Devices	178	395	122	3.4
9	8	Matsushita	250	321	28	2.7
10	9	National Semiconductor	242	286	18	2.4
11	11	Fujitsu	213	244	15	2.1
12	12	Philips	192	212	10	1.8
13	15	Western Digital	148	209	41	1.8
14	14	SGS-Thomson	175	167	-5	1.4
15	10	Chips & Technologies	240	165	-31	1.4
15	21	VLSI Technology	105	165	57	1.4
17	17	Cirrus Logic	129	151	17	1.3
18	16	Oki	131	137	5	1.2
19	18	Sharp	124	134	8	1.1
19	19	Siemens	116	134	16	1.1
21	23	LSI Logic	93	115	24	1.0
22	22	Zilog	100	110	10	.9
23	26	Sony	43	88	105	.7
24	24	Sanyo	71	69	-3	.6
25	20	Harris	110	65	-41	.6
26	29	United Microelectronics	39	62	59	.5
26	36	Ricoh	22	62	182	.5
28	42	Cypress Semiconductor	15	48	220	.4
29	NM	Dallas Semiconductor	0	41	NM	.3
30	27	Standard Microsystems	40	40	0	.3
31	25	Weitek	57	39	-32	.3
31	32	NCR	31	39	26	.3
33	31	Matra MHS	33	37	12	.3
34	33	ITT	28	35	25	.3
35	37	AT&T	21	33	57	.3
36	34	Performance Semiconductor	24	28	17	.2
37	35	Samsung	22	27	23	.2
38	40	Rohm	17	23	35	.2

(Continued)

Table 2-8 (Continued)
Top 40 Companies' Factory Revenue from Shipments of MOS Microcomponent ICs to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	28	Rockwell	40	20	-50	.2
39	39	Analog Devices	20	20	0	.2
39	38	Integrated Device Technology	20	20	0	.2
		All Others	125	136	9	1.2
		North American Companies	5,743	7,256	26	61.6
		Japanese Companies	3,236	3,824	18	32.5
		European Companies	538	567	5	4.8
		Asia/Pacific Companies	67	127	90	1.1
		Total Market	9,584	11,774	23	100.0

NM = Not meaningful
Source: Dataquest (June 1992)

Table 2-9
Top 40 Companies' Factory Revenue from Shipments of MOS Logic ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	NEC	904	1,052	16	10.8
2	2	Toshiba	736	813	10	8.4
3	4	Fujitsu	476	585	23	6.0
4	5	Motorola	461	561	22	5.8
5	3	LSI Logic	503	555	10	5.7
6	8	Texas Instruments	306	473	55	4.9
7	10	Matsushita	283	377	33	3.9
8	7	Hitachi	343	367	7	3.8
9	6	Oki	364	354	-3	3.6
9	9	AT&T	303	354	17	3.6
11	11	Sharp	248	280	13	2.9
12	12	Philips	226	259	15	2.7
13	13	VLSI Technology	211	249	18	2.6
14	16	Hewlett Packard	200	206	3	2.1
15	14	National Semiconductor	206	191	-7	2.0
16	19	Samsung	153	176	15	1.8
17	18	Siemens	164	175	7	1.8
18	17	Sanyo	167	169	1	1.7
19	20	Advanced Micro Devices	139	167	20	1.7
20	24	Sony	101	160	58	1.6
21	15	Harris	201	158	-21	1.6
22	22	Seiko Epson	120	155	29	1.6
23	28	ITT	79	150	90	1.5
24	21	Yamaha	127	146	15	1.5
25	26	Xilinx	84	130	55	1.3
26	25	GEC Plessey	99	126	27	1.3
27	23	SGS-Thomson	110	118	7	1.2
28	29	Altera	78	107	37	1.1
29	30	Mitsubishi	77	90	17	.9
30	33	United Microelectronics	45	80	78	.8
31	27	NCR	80	75	-6	.8
32	31	Lattice	62	68	10	.7
33	34	Integrated Device Technology	44	50	14	.5
34	36	Cypress Semiconductor	42	47	12	.5
35	38	Rohm	39	46	18	.5
36	39	Austria Mikro Systeme	37	39	5	.4
37	35	Atmel	44	38	-14	.4
38	48	Actel	21	37	76	.4

(Continued)

Table 2-9 (Continued)
Top 40 Companies' Factory Revenue from Shipments of MOS Logic ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	57	Hualon Microelectronic Corp.	10	34	240	.4
40	32	Intel	60	33	-45	.3
		All Others	487	450	-8	4.6
		North American Companies	3,310	3,823	15	39.4
		Japanese Companies	4,058	4,650	15	47.9
		European Companies	813	881	8	9.1
		Asia/Pacific Companies	259	346	34	3.6
		Total Market	8,440	9,700	15	100.0

Source: Dataquest (June 1992)

Table 2-10
Top 40 Companies' Factory Revenue from Shipments of Analog ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Philips	653	664	2	6.1
2	2	National Semiconductor	593	629	6	5.8
3	4	Toshiba	535	612	14	5.6
4	6	Sanyo	467	599	28	5.5
5	3	SGS-Thomson	554	578	4	5.3
6	8	Mitsubishi	413	477	15	4.4
7	5	Motorola	482	456	-5	4.2
8	11	Analog Devices	360	444	23	4.1
9	7	Texas Instruments	458	439	-4	4.0
10	10	NEC	377	422	12	3.9
11	9	Matsushita	396	412	4	3.8
12	12	Sony	351	394	12	3.6
13	13	Hitachi	313	358	14	3.3
14	14	Rohm	273	341	25	3.1
15	16	AT&T	197	242	23	2.2
16	15	Harris	260	226	-13	2.1
17	18	GEC Plessey	173	185	7	1.7
18	19	Silicon Systems	165	184	12	1.7
19	17	Siemens	182	181	-1	1.7
20	22	Fujitsu	148	179	21	1.6
21	21	Sanken	159	171	8	1.6
22	20	Rockwell	160	165	3	1.5
23	23	Burr-Brown	145	152	5	1.4
24	24	New JRC	114	122	7	1.1
25	25	Telefunken Electronic	111	118	6	1.1
26	28	Samsung	92	112	22	1.0
27	30	Linear Technology	83	107	29	1.0
27	32	Exar	75	107	43	1.0
29	31	Advanced Micro Devices	76	94	24	.9
30	27	Allegro MicroSystems	96	91	-5	.8
31	34	Brooktree	70	84	20	.8
32	33	Mietec	72	83	15	.8
33	36	Maxim	65	80	23	.7
34	37	Sierra Semiconductor	55	79	44	.7
35	35	Sharp	65	66	2	.6
36	47	Tektronix	35	65	86	.6
37	39	Siliconix	54	64	19	.6
38	41	Ericsson	48	58	21	.5

(Continued)

Table 2-10 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Analog ICs to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	42	Mitel	47	50	6	.5
39	53	Shindengen Electric	26	50	92	.5
		All Others	1,136	972	-14	8.9
		North American Companies	4,286	4,389	2	40.2
		Japanese Companies	3,785	4,327	14	39.7
		European Companies	1,834	1,938	6	17.8
		Asia/Pacific Companies	229	258	13	2.4
		Total Market	10,134	10,912	8	100.0

Source: Dataquest (June 1992)

Table 2-11
Top 40 Companies' Factory Revenue from Shipments of Discrete Semiconductors to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	2	Toshiba	764	884	16	11.0
2	1	Motorola	799	794	-1	9.9
3	3	Hitachi	575	598	4	7.4
4	5	NEC	479	544	14	6.8
5	4	Philips	507	531	5	6.6
6	6	Matsushita	339	379	12	4.7
7	8	Rohm	314	374	19	4.7
8	9	Mitsubishi	311	325	5	4.0
9	7	SGS-Thomson	315	299	-5	3.7
10	11	Fuji Electric	248	263	6	3.3
11	13	Sanken	221	259	17	3.2
12	15	Sanyo	197	250	27	3.1
13	10	Siemens	256	245	-4	3.0
14	12	International Rectifier	224	237	6	2.9
15	14	General Instrument	214	200	-7	2.5
16	20	Fujitsu	107	152	42	1.9
17	17	Shindengen Electric	133	134	1	1.7
18	16	ITT	161	110	-32	1.4
19	21	Semikron	106	108	2	1.3
20	18	Harris	130	107	-18	1.3
21	24	Korean Electronic Co.	79	95	20	1.2
22	22	Eupec	96	93	-3	1.2
23	25	Samsung	77	92	19	1.1
24	27	Sony	76	91	20	1.1
25	26	Telefunken Electronic	76	89	17	1.1
26	23	Powerex	92	78	-15	1.0
27	29	Siliconix	62	76	23	.9
28	34	Microsemi	50	71	42	.9
29	28	National Semiconductor	70	60	-14	.7
30	30	ABB-IXYS	58	54	-7	.7
31	31	Hewlett Packard	56	45	-20	.6
32	32	Unitrode	54	39	-28	.5
33	35	GEC Plessey	36	35	-3	.4
34	46	Toko	6	31	417	.4
35	37	TAG	25	30	20	.4
35	NM	Dongsung Semiconductor	NA	30	NM	.4
37	36	Fagor	30	29	-3	.4
38	33	Texas Instruments	53	28	-47	.3

(Continued)

Table 2-11 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Discrete Semiconductors to the World
(Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
39	39	Zetex	23	25	9	.3
40	38	Solitron	24	21	-13	.3
40	41	Semtech	16	21	31	.3
		All Others	215	109	-49	1.4
		North American Companies	2,174	1,919	-12	23.9
		Japanese Companies	3,783	4,296	14	53.5
		European Companies	1,539	1,588	3	19.8
		Asia/Pacific Companies	178	232	30	2.9
		Total Market	7,674	8,035	5	100.0

NA = Not available
NM = Not meaningful
Source: Dataquest (June 1992)

Table 2-12
Top 20 Companies' Factory Revenue from Shipments of Optoelectronic Semiconductors to the World (Millions of U.S. Dollars)

1991 Rank	1990 Rank		1990 Revenue	1991 Revenue	Percent Change	1991 Market Share (%)
1	1	Sharp	303	362	19	12.9
2	2	Matsushita	281	318	13	11.3
3	3	Toshiba	255	286	12	10.2
4	4	Sony	235	279	19	10.0
5	6	Sanyo	149	193	30	6.9
6	5	Hewlett Packard	189	191	1	6.8
7	7	Siemens	131	189	44	6.7
8	9	Fujitsu	108	127	18	4.5
9	10	Rohm	102	122	20	4.4
10	8	NEC	108	121	12	4.3
11	11	Telefunken Electronic	78	74	-5	2.6
12	13	Hitachi	63	68	8	2.4
13	15	Texas Instruments	33	58	76	2.1
14	12	Optek	66	52	-21	1.9
15	16	Philips	31	36	16	1.3
16	14	Quality Technologies	34	34	0	1.2
17	24	AT&T	14	32	129	1.1
18	18	Oki	28	30	7	1.1
19	19	Motorola	26	28	8	1.0
20	17	Mitsubishi	29	25	-14	.9
20	20	Honeywell	25	25	0	.9
		All Others	124	154	24	5.5
		North American Companies	423	449	6	16.0
		Japanese Companies	1,694	1,992	18	71.0
		European Companies	267	334	25	11.9
		Asia/Pacific Companies	28	29	4	1.0
		Total Market	2,412	2,804	16	100.0

Source: Dataquest (June 1992)

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North American Semiconductor Price Outlook

First Quarter 1993

Source: Dataquest

Market Statistics

Semiconductor Procurement

SPWW-SVC-MS-9204

December 21, 1992

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North American Semiconductor Price Outlook

First Quarter 1993

Source: Dataquest

Market Statistics

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North American Semiconductor Price Outlook: First Quarter 1993

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Table **Page**

Note: All tables show estimated data.

North American Semiconductor Price Outlook: First Quarter 1993

Methodology and Sources

This *Source: Dataquest* document provides information on and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects price information on a quarterly basis from North American suppliers and major buyers of these products. North American bookings price information is analyzed by Semiconductor Procurement (SP) service analysts for consistency and reconciliation. The information finally is rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast. This document includes associated long-range forecasts.

For SP clients that use the SP online service, the prices presented here correlate with the quarterly and long-range price tables dated December 1992 in the SP online service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery performance, volume discount, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.

Table 1
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
74LS TTL												6-12
74LS00	0.105	0.105	0.105	0.100	0.095	0.101	0.095	0.095	0.095	0.095	0.095	
74LS74	0.117	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	
74LS138	0.155	0.145	0.145	0.145	0.140	0.144	0.140	0.140	0.140	0.140	0.140	
74LS244	0.215	0.200	0.200	0.195	0.190	0.196	0.190	0.190	0.190	0.190	0.190	
74AC												6-10
74AC00	0.173	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	
74AC74	0.233	0.200	0.200	0.195	0.190	0.196	0.190	0.190	0.190	0.190	0.190	
74AC138	0.278	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	0.265	
74AC244	0.405	0.360	0.360	0.355	0.350	0.356	0.350	0.350	0.350	0.350	0.350	
74F TTL												6-10
74F00	0.099	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	
74F74	0.120	0.120	0.120	0.115	0.110	0.116	0.110	0.110	0.110	0.110	0.110	
74F138	0.153	0.150	0.150	0.145	0.140	0.146	0.140	0.140	0.140	0.140	0.140	
74F244	0.215	0.210	0.200	0.195	0.190	0.199	0.190	0.190	0.190	0.190	0.190	
74HC CMOS												6-10
74HC00	0.108	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	
74HC74	0.123	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	
74HC138	0.159	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	
74HC244	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	
74ALS TTL												6-10
74ALS00	0.117	0.115	0.115	0.110	0.110	0.113	0.110	0.110	0.110	0.110	0.110	
74ALS74	0.136	0.135	0.135	0.135	0.130	0.134	0.130	0.130	0.130	0.130	0.130	
74ALS138	0.255	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	
74ALS244	0.328	0.310	0.310	0.300	0.295	0.304	0.295	0.295	0.295	0.295	0.295	
74AS TTL												8-10
74AS00	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	
74AS74	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	
74AS138	0.421	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	
74AS244	0.723	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	
74BC*												4-8
74BC00	0.284	0.260	0.260	0.260	0.260	0.260	0.240	0.240	0.240	0.240	0.240	
74BC244	0.686	0.620	0.620	0.620	0.620	0.620	0.590	0.590	0.590	0.590	0.590	
74BC373	0.687	0.630	0.630	0.630	0.630	0.630	0.600	0.600	0.600	0.600	0.600	

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1993	1994	1995	1996	1997
74LS TTL					
74LS00	0.101	0.095	0.100	0.100	0.105
74LS74	0.110	0.110	0.110	0.110	0.118
74LS138	0.144	0.140	0.140	0.140	0.151
74LS244	0.196	0.190	0.190	0.190	0.204
74AC					
74AC00	0.165	0.165	0.165	0.165	0.165
74AC74	0.196	0.190	0.190	0.190	0.190
74AC138	0.265	0.265	0.265	0.265	0.265
74AC244	0.356	0.350	0.350	0.350	0.350
74F TTL					
74F00	0.095	0.095	0.095	0.095	0.100
74F74	0.116	0.110	0.110	0.110	0.116
74F138	0.146	0.140	0.140	0.140	0.147
74F244	0.199	0.190	0.190	0.190	0.198
74HC CMOS					
74HC00	0.110	0.110	0.110	0.110	0.116
74HC74	0.125	0.125	0.125	0.125	0.131
74HC138	0.160	0.160	0.160	0.160	0.168
74HC244	0.235	0.235	0.235	0.235	0.247
74ALS TTL					
74ALS00	0.113	0.110	0.110	0.110	0.115
74ALS74	0.134	0.130	0.125	0.125	0.130
74ALS138	0.250	0.250	0.249	0.249	0.255
74ALS244	0.304	0.295	0.295	0.295	0.300
74AS TTL					
74AS00	0.160	0.160	0.155	0.155	0.160
74AS74	0.180	0.180	0.179	0.179	0.185
74AS138	0.420	0.420	0.400	0.400	0.410
74AS244	0.720	0.720	0.690	0.690	0.700
74BC*					
74BC00	0.260	0.240	0.220	0.220	0.220
74BC244	0.620	0.590	0.560	0.560	0.560
74BC373	0.630	0.600	0.570	0.570	0.570

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

Table 3
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
68000-12	5.50	5.00	5.00	5.00	5.00	5.00	4.75	4.55	4.40	4.30	4.50	4-8
68EC000-8	2.89	2.75	2.75	2.75	2.75	2.75	2.35	2.35	2.35	2.35	2.35	4-8
68EC000-16 PLCC	NA	5.80	5.80	5.80	5.65	5.76	5.45	5.30	5.15	5.10	5.25	8-12
80186-8 PLCC	5.60	5.50	5.50	5.50	5.50	5.50	5.30	5.30	5.30	5.30	5.30	6-8
80C186-10 PLCC	9.35	8.00	8.00	8.00	8.00	8.00	7.95	7.25	7.00	6.80	7.25	5-8
80286-10 PLCC	4.50	3.75	3.75	3.75	3.75	3.75	3.50	3.50	3.50	3.50	3.50	4-8
80286-16 PLCC	7.64	5.75	5.50	5.50	5.25	5.50	5.00	5.00	5.00	5.00	5.00	3-10
68020-16 PQFP	27.00	21.00	20.00	19.50	19.00	19.88	17.00	17.00	17.00	17.00	17.00	8-12
68EC020-16 PQFP	16.06	15.00	14.20	13.50	13.00	13.93	12.00	12.00	12.00	12.00	12.00	8-12
68020-25 PQFP	35.13	33.00	32.00	31.50	31.00	31.88	31.04	31.04	31.04	31.04	31.04	8-12
68EC020-25 PQFP	19.99	18.00	18.00	18.00	18.00	18.00	17.00	17.00	17.00	17.00	17.00	8-12
68030-16 CQFP	70.00	60.00	60.00	60.00	60.00	60.00	59.00	59.00	59.00	59.00	59.00	7-12
68030-25 CQFP	108.75	95.00	93.00	90.00	90.00	92.00	88.00	86.70	85.30	84.00	86.00	5-10
68EC030-25 PQFP	35.94	34.00	34.00	34.00	34.00	34.00	33.00	32.00	32.00	31.00	32.00	8-12
68040-25	418.52	350.00	350.00	325.00	325.00	337.50	315.00	308.00	301.00	296.00	305.00	4-8
68EC040-25	112.50	95.00	95.00	90.00	90.00	92.50	90.00	86.70	85.30	84.00	86.50	8-12
386SX-16 PQFP	47.46	38.50	36.00	33.00	33.00	35.13	31.00	28.50	27.00	25.50	28.00	8-10
386SX-20 PQFP	61.60	42.50	40.00	34.00	34.00	37.63	31.00	28.50	27.00	25.50	28.00	8-10
386SX-25 PQFP	69.02	37.50	35.00	32.00	32.00	34.13	31.00	28.50	27.00	25.50	28.00	8-12
386SL-25 PQFP	113.75	60.00	55.00	50.00	47.50	53.13	47.00	44.00	42.00	39.00	43.00	NA
AM386-40	102.50	48.00	46.00	40.00	37.00	42.75	32.00	30.00	29.00	29.00	30.00	8-12
386DX-25 PQFP	103.00	65.00	57.00	52.00	47.00	55.25	48.00	45.00	43.00	40.00	44.00	8-12
80486SX-20 PQFP	157.75	93.00	90.00	86.00	82.00	87.75	78.00	75.00	73.00	70.00	74.00	8-12
80486DX-25	376.75	288.00	200.00	180.00	155.00	205.75	125.00	119.00	108.00	99.00	112.75	8-12
80486DX-33	376.75	288.00	200.00	180.00	155.00	205.75	125.00	119.00	108.00	99.00	112.75	8-12
80486DX-50	553.25	375.00	330.00	300.00	295.00	325.00	175.00	136.00	122.00	109.00	135.50	8-12
80486DX2-50	502.75	385.00	265.00	230.00	220.00	275.00	163.00	124.00	111.00	98.00	124.00	8-12
29000-25[1]	84.63	78.00	72.00	69.00	65.00	71.00	63.00	63.00	63.00	63.00	63.00	7-12
88100-25[1]	68.00	64.50	62.50	60.00	58.00	61.25	56.00	56.00	56.00	56.00	56.00	4-8
R3000-25[1]	96.31	87.00	84.00	81.00	78.00	82.50	78.00	75.00	73.00	70.00	74.00	4-12
SPARC-25[1]	71.00	64.50	63.00	61.60	60.60	62.43	59.00	59.00	59.00	59.00	59.00	4-10
80960CA-25	91.48	88.35	87.45	84.30	81.20	85.33	79.00	78.00	76.00	75.00	77.00	2-6

NA = Not available

[1] Pricing excludes accessory parts such as floating point and memory management.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (December 1992)

Table 4
Estimated Long-Range Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1993	1994	1995	1996	1997
68000-12	5.00	4.50	4.00	4.00	4.00
68EC000-8	2.75	2.35	2.30	2.30	2.30
68EC000-16 PLCC	5.76	5.25	4.95	4.75	4.75
80186-8 PLCC	5.50	5.30	5.30	5.30	5.30
80C186-10 PLCC	8.00	7.25	6.75	6.50	6.50
80286-10 PLCC	3.75	3.50	NA	NA	NA
80286-16 PLCC	5.50	5.00	4.50	NA	NA
68020-16 PQFP	19.88	17.00	17.00	17.00	17.00
68EC020-16 PQFP	13.93	12.00	11.00	10.00	10.00
68020-25 PQFP	31.88	31.04	31.00	31.00	31.00
68EC020-25 PQFP	18.00	17.00	16.00	15.50	15.50
68030-16 CQFP	60.00	59.00	58.00	53.00	50.00
68030-25 CQFP	92.00	86.00	80.75	70.00	65.00
68EC030-25 PQFP	34.00	32.00	30.12	30.00	30.00
68040-25	337.50	305.00	280.25	225.00	165.00
68EC040-25	92.50	86.50	81.00	70.00	62.00
386SX-16 PQFP	35.13	28.00	21.38	20.00	20.00
386SX-20 PQFP	37.63	28.00	21.38	20.00	20.00
386SX-25 PQFP	34.13	28.00	21.38	20.00	20.00
386SL-25 PQFP	53.13	43.00	33.00	27.00	27.00
AM386-40	42.75	30.00	23.75	22.00	22.00
386DX-25 PQFP	55.25	44.00	36.50	34.00	34.00
80486SX-20 PQFP	87.75	74.00	57.25	42.00	42.00
80486DX-25	205.75	112.75	84.89	65.00	65.00
80486DX-33	205.75	112.75	84.89	65.00	65.00
80486DX-50	325.00	135.50	90.40	65.00	65.00
80486DX2-50	275.00	124.00	85.24	62.00	65.00
29000-25[1]	71.00	63.00	57.00	45.50	42.50
88100-25[1]	61.25	56.00	51.50	50.00	50.00
R3000-25[1]	82.50	74.00	62.50	49.00	45.00
SPARC-25[1]	62.43	59.00	54.50	45.00	45.00
80960CA-25	85.33	77.00	75.16	70.00	70.00

NA = Not available
[1] Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1992)

Table 5
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
256Kx1 DRAM												
80ns DIP	1.55	1.47	1.47	1.47	1.47	1.47	1.45	1.45	1.45	1.45	1.45	1-12
64Kx4 VRAM												
120ns ZIP	2.76	2.65	2.65	2.60	2.60	2.63	2.48	2.38	2.33	2.30	2.37	3-10
1Mbx1 DRAM												
70-80ns (DIP/SOJ)	3.49	3.27	3.20	3.20	3.20	3.22	3.20	3.20	3.20	3.20	3.20	1-12
64Kx16 DRAM												
80ns SOJ	5.06	4.45	4.25	4.10	4.10	4.23	3.85	3.85	3.85	3.85	3.85	4-9
256Kx4 VRAM												
100ns ZIP	7.19	6.46	6.00	5.55	5.20	5.80	5.05	5.05	4.98	4.92	5.00	3-22
128Kx8 VRAM												
100ns SOJ	7.46	6.67	6.40	6.05	5.70	6.21	5.75	5.55	5.45	5.38	5.53	5-15
4Mbx1 DRAM												
70-80ns SOJ	11.55	10.45	9.93	9.25	8.90	9.63	8.50	7.90	7.25	6.50	7.54	2-16
1Mbx4 DRAM												
60ns SOJ	12.36	10.99	10.45	9.74	9.25	9.90	8.67	8.03	7.40	6.60	7.67	2-16
512Kx8 DRAM												
70ns	14.20	11.42	10.64	9.74	9.25	10.26	8.55	8.00	7.31	6.55	7.60	3-12
256Kx16 DRAM												
70ns SOJ	14.58	12.60	12.00	11.00	10.31	11.48	9.26	8.23	7.50	6.66	7.91	3-12
256Kx18 DRAM												
70-80ns SOJ	15.47	12.92	11.88	11.12	10.67	11.65	10.16	9.45	8.93	8.15	9.17	3-12
1Mbx8 SIMM												
100ns (2 pc)	26.81	24.17	22.63	20.40	19.40	21.65	18.49	17.00	16.00	15.50	16.75	1-8
1Mbx9 SIMM												
80ns (3 pc)	29.98	27.07	25.50	23.25	22.50	24.58	21.00	19.00	18.00	17.00	18.75	1-12
256Kx9 SIMM												
100ns	12.72	13.50	13.50	13.00	12.50	13.13	12.50	12.50	12.50	12.50	12.50	2-8
256Kx36 SIMM												
80ns[2]	42.07	35.22	32.00	32.00	28.75	31.99	24.50	23.75	23.00	21.85	23.28	2-10
512Kx36 SIMM												
80ns (24 pc)	77.79	70.86	65.05	64.00	58.00	64.48	51.45	48.88	47.00	44.00	47.83	4-12
4Mbx9 SIMM												
80ns (9pc)	113.73	98.00	95.00	85.00	81.00	89.75	79.00	76.50	71.50	67.50	73.63	2-12
1Mbx36 SIMM												
80ns (9pc)	115.81	100.00	98.17	88.00	83.00	92.29	82.00	78.00	73.00	70.00	75.75	4-12
4Mbx4 DRAM												
70ns SOJ 400 mil	138.39	81.50	64.60	54.25	45.00	61.34	40.80	37.13	33.35	28.93	35.05	10-24

[1]Contract volume = at least 100,000 per order except VRAMs.
[2]Two-piece solution for 1993.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1992)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; Dollars)[1]

Product	1993	1994	1995	1996	1997
256Kx1 DRAM 80ns DIP	1.47	1.45	1.65	1.85	1.90
64Kx4 VRAM 120ns ZIP	2.63	2.37	2.30	2.30	2.45
1Mbx1 DRAM 70-80ns (DIP/SOJ)	3.22	3.20	3.25	3.30	3.45
64Kx16 DRAM 80ns SOJ	4.23	3.85	3.80	3.80	4.00
256Kx4 VRAM 100ns ZIP	5.80	5.00	4.75	4.75	4.85
128Kx8 VRAM 100ns SOJ	6.21	5.53	5.05	4.85	4.85
4Mbx1 DRAM 70-80ns SOJ	9.63	7.54	5.50	5.50	5.60
1Mbx4 DRAM 60ns SOJ	9.90	7.67	5.61	5.61	5.60
512Kx8 DRAM 70ns	10.26	7.60	5.50	5.50	5.60
256Kx16 DRAM 70ns SOJ	11.48	7.91	5.72	5.69	5.69
256Kx18 DRAM 70-80ns SOJ	11.65	9.17	6.60	6.88	7.00
1Mbx8 SIMM 100ns (2 pc)	21.65	16.75	15.25	15.50	16.00
1Mbx9 SIMM 80ns (3 pc)	24.58	18.75	16.25	16.25	17.00
256Kx9 SIMM 100ns	13.13	12.50	13.00	NA	NA
256Kx36 SIMM 80ns[2]	31.99	23.28	22.00	21.00	21.00
512Kx36 SIMM 80ns (24 pc)	64.48	47.83	44.00	42.00	42.00
4Mbx9 SIMM 80ns (9pc)	89.75	73.63	57.00	56.00	56.00
1Mbx36 SIMM 80ns (9pc)	92.29	75.75	59.25	57.50	57.50
4Mbx4 DRAM 70ns SOJ 400 mil	61.34	35.05	18.91	14.25	12.15

NA = Not available

[1]Contract volume = at least 100,000 per order except VRAMs.

[2]Two-piece solution for 1993.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (December 1992)

Table 7
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
4Kx4 25ns	2.21	2.07	2.07	2.07	2.07	2.07	1.90	1.90	1.90	1.90	1.90	1-12
2Kx8 25ns	2.25	2.05	2.00	2.00	2.00	2.01	1.70	1.70	1.70	1.70	1.70	1-13
64Kx1 25ns	2.97	2.20	2.20	2.20	2.20	2.20	2.10	2.10	2.10	2.10	2.10	1-12
16Kx4 25ns	2.43	2.17	2.06	1.90	1.90	2.01	1.85	1.85	1.85	1.95	1.88	1-13
8Kx8 25ns	2.59	2.03	1.97	1.90	1.90	1.95	1.85	1.85	1.85	1.85	1.85	1-12
16Kx4 35ns	2.38	2.10	2.00	1.90	1.90	1.98	1.85	1.85	1.85	1.95	1.88	1-13
8Kx8 45ns	2.33	1.90	1.90	1.90	1.85	1.89	1.80	1.80	1.80	1.80	1.80	1-12
8Kx8 100-120ns	1.80	1.65	1.60	1.60	1.60	1.61	1.60	1.60	1.70	1.75	1.66	3-10
64Kx4 10ns	28.76	20.00	18.75	17.50	15.50	17.94	10.00	7.50	5.50	4.75	6.94	1-13
64Kx4 25ns	6.32	4.95	4.58	4.43	4.38	4.59	4.04	3.60	3.20	3.00	3.46	1-13
32Kx8 12ns	18.53	11.62	10.05	9.10	8.50	9.82	7.80	6.50	5.00	4.75	6.01	1-13
32Kx8 35ns	5.84	4.80	4.44	4.27	4.15	4.42	4.02	3.50	3.25	3.00	3.44	1-13
32Kx8 100ns SOJ	3.96	3.63	3.63	3.60	3.60	3.61	3.20	3.20	3.20	3.20	3.20	4-12
256Kx4 20ns	42.74	26.21	23.93	22.50	21.00	23.41	16.65	12.00	9.95	8.53	11.78	1-12
128Kx8 20ns	42.34	23.04	20.21	18.16	16.61	19.51	14.09	9.95	8.77	7.93	10.19	1-12
128Kx8 25ns	33.02	20.98	19.42	18.00	16.25	18.66	13.80	9.99	8.50	7.50	9.95	1-12
128Kx8 100ns SOJ	11.08	9.10	8.90	8.75	8.50	8.81	7.25	6.50	6.15	6.00	6.48	2-10

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 8
Estimated Long-Range Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1993	1994	1995	1996	1997
4Kx4 25ns	2.07	1.90	1.60	1.35	1.35
2Kx8 25ns	2.01	1.70	1.40	1.35	1.35
64Kx1 25ns	2.20	2.10	2.00	2.35	2.35
16Kx4 25ns	2.01	1.88	1.85	1.85	1.85
8Kx8 25ns	1.95	1.85	1.85	1.85	1.85
16Kx4 35ns	1.98	1.88	1.85	1.85	1.85
8Kx8 45ns	1.89	1.80	1.80	1.80	1.80
8Kx8 100-120ns	1.61	1.66	1.70	1.80	1.80
64Kx4 10ns	17.94	6.94	4.09	3.60	3.60
64Kx4 25ns	4.59	3.46	3.00	3.00	3.00
32Kx8 12ns	9.82	6.01	4.09	3.45	3.45
32Kx8 35ns	4.42	3.44	3.00	3.00	3.00
32Kx8 100ns SOJ	3.61	3.20	3.20	3.00	3.00
256Kx4 20ns	23.41	11.78	7.00	6.25	6.25
128Kx8 20ns	19.51	10.19	7.00	6.29	6.30
128Kx8 25ns	18.66	9.95	7.00	6.10	6.10
128Kx8 100ns SOJ	8.81	6.48	5.00	4.50	4.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 9
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and Above; 28-pin PDIP;
≥2Mb Density—200ns and Above; 32-pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
32Kx8 ROM	1.50	1.40	1.35	1.30	1.25	1.33	1.25	1.25	1.25	1.25	1.25	4-8
64Kx8 ROM	1.83	1.70	1.65	1.60	1.50	1.61	1.50	1.50	1.50	1.50	1.50	4-8
128Kx8 ROM	1.89	1.78	1.75	1.70	1.60	1.71	1.60	1.60	1.60	1.60	1.60	5-8
64Kx16 ROM	2.00	1.80	1.80	1.80	1.80	1.80	1.70	1.70	1.70	1.70	1.70	5-8
256Kx8 ROM	2.65	2.50	2.50	2.50	2.50	2.50	2.40	2.40	2.40	2.40	2.40	5-8
512Kx8 ROM	3.69	3.44	3.23	3.20	3.39	3.31	3.08	3.08	3.08	3.31	3.13	5-8
256Kx16 ROM[1]	3.75	3.57	3.35	3.35	3.57	3.46	3.20	3.13	3.10	3.31	3.18	5-8
1Mbx8 ROM[2]	5.93	5.48	5.37	5.32	5.32	5.37	5.00	4.88	4.80	4.81	4.87	5-8
1Mbx16 ROM	NA	10.05	9.68	9.45	9.34	9.63	8.30	8.00	7.90	7.75	7.99	5-8
2Mbx8 ROM	12.40	10.12	9.78	9.53	9.37	9.70	8.30	8.00	7.90	7.75	7.99	4-8

[1] 256Kx16 ROM: 150ns and above; 40-pin PDIP.
[2] 1Mbx8 ROM: 150ns and above; 32-pin SOP.
NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 10
Estimated Long-Range ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and Above; 28-pin PDIP;
≥2Mb Density—200ns and Above; 32-pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1993	1994	1995	1996	1997
32Kx8 ROM	1.33	1.25	1.30	1.30	1.30
64Kx8 ROM	1.61	1.50	1.65	1.70	1.75
128Kx8 ROM	1.71	1.60	1.60	1.70	1.75
64Kx16 ROM	1.80	1.70	1.70	1.70	1.75
256Kx8 ROM	2.50	2.40	2.20	2.15	2.15
512Kx8 ROM	3.31	3.13	2.50	2.25	2.25
256Kx16 ROM[1]	3.46	3.18	2.50	2.25	2.25
1Mbx8 ROM[2]	5.37	4.87	4.50	4.25	4.25
1Mbx16 ROM	9.63	7.99	6.55	6.25	6.25
2Mbx8 ROM	9.70	7.99	6.55	6.35	6.35

[1] 256Kx16 ROM: 150ns and Above; 40-pin PDIP.
[2] 1Mbx8 ROM: 150ns and Above; 32-pin SOP.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 11
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Times (Weeks)
16Kx8 EPROM	1.74	1.61	1.72	1.72	1.69	1.68	1.70	1.70	1.70	1.59	1.67	2-8
32Kx8 EPROM	1.64	1.60	1.62	1.62	1.57	1.60	1.63	1.63	1.63	1.52	1.60	2-12
64Kx8 EPROM	2.36	2.33	2.28	2.28	2.36	2.31	2.30	2.30	2.30	2.32	2.31	2-10
128Kx8 EPROM	3.12	2.96	3.05	3.02	2.76	2.95	2.75	2.75	2.75	2.71	2.74	2-12
256Kx8 EPROM	6.66	6.09	6.07	5.98	5.80	5.99	5.60	5.60	5.60	5.60	5.60	2-12
128Kx16 EPROM	6.99	6.14	6.15	6.05	5.90	6.06	5.70	5.69	5.69	5.69	5.69	4-10
512Kx8 EPROM	11.85	10.24	10.08	9.97	9.38	9.92	8.90	8.60	8.30	8.20	8.50	4-14
256Kx16 EPROM	14.75	12.38	11.34	10.65	10.09	11.11	9.74	9.43	9.21	9.14	9.38	4-14

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 12
Estimated Long-Range EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

Product	1993	1994	1995	1996	1997
16Kx8 EPROM	1.68	1.67	1.60	1.60	1.68
32Kx8 EPROM	1.60	1.60	1.52	1.52	1.58
64Kx8 EPROM	2.31	2.31	2.32	2.32	2.39
128Kx8 EPROM	2.95	2.74	2.58	2.60	2.65
256Kx8 EPROM	5.99	5.60	5.43	5.40	5.40
128Kx16 EPROM	6.06	5.69	5.49	5.48	5.48
512Kx8 EPROM	9.92	8.50	8.05	8.00	8.00
256Kx16 EPROM	11.11	9.38	8.56	8.50	8.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

Table 13
Estimated OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and Above; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
16Kx8	1.48	1.34	1.34	1.34	1.34	1.34	NA	NA	NA	NA	NA	1-12
32Kx8	1.56	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	2-12
64Kx8	2.05	1.95	1.95	1.95	1.95	1.95	1.85	1.85	1.85	1.85	1.85	2-12
128Kx8	2.75	2.56	2.48	2.45	2.39	2.47	2.20	2.20	2.20	2.20	2.20	6-12

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (December 1992)

Table 14
Estimated Long-Range OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and Above; Dollars)

Product	1993	1994	1995	1996	1997
16Kx8	1.34	NA	NA	NA	NA
32Kx8	1.31	1.31	1.34	1.34	1.51
64Kx8	1.95	1.85	1.97	1.97	2.20
128Kx8	2.47	2.20	2.21	2.21	2.39

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (December 1992)

Table 15
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1992	1993				1993	1994				1994	Current Lead Time
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	(Weeks)
32Kx8, PDIP/PLCC	5.36	4.79	4.63	4.49	4.39	4.57	3.71	3.49	3.39	3.30	3.47	4-16
64Kx8, PDIP/PLCC	6.54	5.64	5.45	5.35	5.20	5.41	4.69	4.46	4.24	4.04	4.36	4-16
128Kx8, PDIP/PLCC	7.73	6.97	6.73	6.33	6.29	6.58	5.48	4.97	4.63	4.25	4.83	6-20
128Kx8, TSOP	8.61	8.08	7.80	7.44	7.26	7.65	6.53	5.99	5.58	5.28	5.85	6-20
256Kx8, TSOP	13.99	13.03	12.57	12.21	12.05	12.46	9.43	8.46	7.95	6.30	8.03	6-16

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1992)

Table 16
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1993	1994	1995	1996	1997
32Kx8, PDIP/PLCC	4.57	3.47	3.12	2.90	2.90
64Kx8, PDIP/PLCC	5.41	4.36	3.54	3.25	3.15
128Kx8, PDIP/PLCC	6.58	4.83	3.95	3.65	3.25
128Kx8, TSOP	7.65	5.85	4.15	3.78	3.28
256Kx8, TSOP	12.46	8.03	5.90	5.25	6.25

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1992)

Table 17

Estimated Gate Array Pricing—North American Production Bookings (Millicents per Gate)
(Package: CMOS—84-pin PLCC for <10K gates, 160-pin PQFP for 10K-29.9K, 208-pin PQFP for ≥30K gates; ECL—CQFP)
(Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	135	135	120	120	110	102	7-12
1.2 Micron	120	115	85	88	75	75	8-12
1.0 Micron	115	110	82	80	73	71	8-12
0.8 Micron	NA	NA	90	85	75	65	10-15
ECL	4,850	4,268	3,823	3,326	3,000	3,000	12
NRE Charges ($1,000)							
CMOS							Prototypes:
1.5 Micron	16.0	14.1	21.0	20.0	26.0	25.0	3-5
1.2 Micron	13.0	12.4	17.5	16.2	20.0	20.0	2-4
1.0 Micron	19.0	18.1	21.3	23.0	27.0	27.0	2-4
0.8 Micron	NA	NA	26.0	26.0	30.0	30.0	3-4
ECL	30.0	27.0	45.0	40.5	50.0	45.0	14

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	95	95	90	77	92	85	NA	NA	7-12
1.2 Micron	70	70	76	76	93	93	NA	NA	9-12
1.0 Micron	68	62	67	62	70	62	74	67	8-12
0.8 Micron	71	66	61	57	55	69	69	56	8-16
ECL	3,300	2,790	3,200	2,784	3,050	2,654	3,050	2,654	12
NRE Charges ($1,000)									
CMOS									Prototypes:
1.5 Micron	40.5	40.5	60.0	57.0	100.0	95.0	NA	NA	3-6
1.2 Micron	40.0	38.0	58.0	55.1	102.0	96.9	NA	NA	3-8
1.0 Micron	44.0	39.0	62.5	60.0	92.8	88.9	133	130	2-5
0.8 Micron	50.2	45.0	67.5	67.0	100.0	99.7	136	133	2-5
ECL	90.0	75.0	100.0	90.0	146.7	132.0	120	115	12

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

Table 18

Estimated CBIC Pricing—North America Production Bookings (Millicents per Gate)
(Package: 84-Pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K)
(Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototypes)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	115	105	93	90	99	90	10-16
1.2 Micron	105	100	85	80	77	72	10-16
1.0 Micron	110	99	85	80	71	69	12-16
0.8 Micron	NA	175	90	88	75	65	13-14
NRE Charges ($1,000)							
CMOS							Prototypes:
1.5 Micron	35.0	33.3	38.0	36.1	47.0	44.7	5-8
1.2 Micron	32.0	30.4	35.0	33.3	43.5	41.3	5-8
1.0 Micron	41.0	40.0	49.0	45.0	51.5	47.5	5-7
0.8 Micron	NA	53.0	55.0	50.0	59.0	55.0	7

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	95	95	90	77	92	85	NA	NA	10-16
1.2 Micron	70	70	70	70	85	85	NA	NA	10-16
1.0 Micron	70	66	65	62	65	61	68	62	10-16
0.8 Micron	70	65	60	56	54	68	68	55	12-16
NRE Charges ($1,000)									
CMOS									Prototypes:
1.5 Micron	65.0	61.8	85.0	80.8	110.0	103.4	NA	NA	5-8
1.2 Micron	58.5	55.6	75.0	71.3	100.0	97.0	NA	NA	5-8
1.0 Micron	75.0	72.0	95.0	86.7	116.7	113.5	146.7	141.5	5-8
0.8 Micron	85.0	77.3	111.0	94.0	140.0	118.0	154.3	139.8	6-8

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discounts. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

Table 19
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Product	Speed* (ns)	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
≤20													
	6.1-7.5	5.11	4.60	4.55	4.45	4.40	4.50	4.10	4.00	3.95	3.95	4.00	1-18
	7.6-10.0	2.46	2.00	1.95	1.88	1.83	1.92	1.55	1.50	1.50	1.45	1.50	1-16
	10.1-14.99	1.69	1.58	1.55	1.53	1.50	1.54	1.30	1.15	1.12	1.12	1.17	1-12
	15 - <25	0.75	0.70	0.68	0.67	0.64	0.67	0.63	0.63	0.61	0.60	0.62	1-12
	≥25	0.59	0.56	0.56	0.53	0.50	0.54	0.49	0.48	0.47	0.51	0.49	1-12
24													
	6.1-7.5	7.77	6.40	6.33	6.15	6.00	6.22	5.60	5.30	5.15	5.00	5.26	1-20
	7.6-10.0	4.38	3.59	3.45	3.39	3.32	3.44	2.80	2.55	2.38	2.25	2.50	1-20
	10.1-14.99	2.59	2.39	2.29	2.29	2.23	2.30	1.70	1.50	1.40	1.40	1.50	1-12
	15 - <25	1.08	1.00	0.96	0.95	0.94	0.96	0.90	0.90	0.90	0.90	0.90	1-12
	≥25	0.91	0.83	0.85	0.79	0.78	0.81	0.79	0.77	0.75	0.75	0.77	1-12
24 (22V10)													
	6.1-7.5	19.50	18.00	17.65	17.35	17.00	17.50	16.00	15.25	14.50	14.25	15.00	1-4
	7.6-10.0	10.85	6.25	6.11	5.35	4.95	5.66	3.69	3.39	3.02	2.95	3.26	2-4
	15 - <25	3.96	3.48	3.24	3.14	2.96	3.21	2.70	2.50	2.30	2.13	2.41	1-8
	25 - <35	2.26	1.98	1.85	1.85	1.75	1.86	1.53	1.53	1.44	1.50	1.50	1-8

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume price. These prices are intended as guidelines.

Source: Dataquest (December 1992)

Table 20
Estimated Long-Range CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1993	1994	1995	1996	1997
≤20						
	6.1-7.5	4.50	4.00	3.70	3.26	3.09
	7.6-10.0	1.92	1.50	1.38	1.25	1.25
	10.1-14.99	1.54	1.17	1.11	1.03	1.03
	15 - <25	0.67	0.62	0.55	0.52	0.52
	≥25	0.54	0.49	0.44	0.42	0.42
24						
	6.1-7.5	6.22	5.26	4.50	4.05	3.85
	7.6-10.0	3.44	2.50	2.21	2.00	1.95
	10.1-14.99	2.30	1.50	1.38	1.26	1.26
	15 - <25	0.96	0.90	0.84	0.80	0.80
	≥25	0.81	0.77	0.75	0.75	0.75
24 (22V10)						
	6.1-7.5	17.50	15.00	13.43	11.51	10.65
	7.6-10.0	5.66	3.26	2.70	2.62	2.60
	15 - <25	3.21	2.41	2.03	1.95	1.95
	25 - <35	1.86	1.50	1.50	1.50	1.50

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume price. These prices are intended as guidelines.

Source: Dataquest (December 1992)

Table 21
Estimated Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
Voltage Regulators												10-12
78L05 (TO-92)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
7805 (TO-220)	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
Comparators												10-12
LM339	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
LM393	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
Op Amps												10-12
741	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
3403P	0.18	0.18	0.18	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.17	
1741CP1	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Interface ICs												6-8
1488P	0.15	0.15	0.15	0.14	0.14	0.15	0.14	0.14	0.14	0.14	0.14	
3486P	0.89	0.88	0.88	0.86	0.86	0.87	0.86	0.86	0.86	0.86	0.86	
Telecom IC												6-8
CODEC/FILTER #1	1.81	1.72	1.72	1.68	1.68	1.70	1.65	1.65	1.60	1.57	1.62	
CODEC/FILTER #2	4.23	3.91	3.91	3.72	3.72	3.82	3.72	3.60	3.48	3.40	3.55	
XR-T5683	3.55	3.41	3.41	3.33	3.33	3.37	3.33	3.20	3.17	3.10	3.20	
34017P	0.33	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30	
Video DAC												6-8
IMSG171D-35 MHz	1.75	1.60	1.60	1.50	1.50	1.55	1.50	1.45	1.42	1.40	1.44	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 22
Estimated Long-Range Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1993	1994	1995	1996	1997
Voltage Regulators					
78L05 (TO-92)	0.12	0.12	0.12	0.12	0.12
7805 (TO-220)	0.14	0.14	0.14	0.14	0.14
Comparators					
LM339	0.13	0.13	0.13	0.13	0.13
LM393	0.13	0.13	0.13	0.13	0.13
Op Amps					
741	0.13	0.13	0.13	0.13	0.13
3403P	0.18	0.17	0.17	0.17	0.17
1741CP1	0.12	0.12	0.12	0.12	0.12
Interface ICs					
1488P	0.15	0.14	0.14	0.14	0.14
3486P	0.87	0.86	0.84	0.83	0.83
Telecom IC					
CODEC/FILTER #1	1.70	1.62	1.54	1.50	1.50
CODEC/FILTER #2	3.82	3.55	3.30	3.14	3.14
XR-T5683	3.37	3.20	3.07	2.95	2.95
34017P	0.31	0.30	0.30	0.29	0.29
Video DAC					
IMSG171D-35 MHz	1.55	1.44	1.39	1.37	1.37

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 23
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	1994 Q1	1994 Q2	1994 Q3	1994 Q4	1994 Year	Current Lead Time (Weeks)
Small-Signal Transistors												2-10
2N2222A	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	
2N3904	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
2N2907A	0.068	0.066	0.066	0.066	0.066	0.066	0.064	0.064	0.062	0.062	0.063	
MPSA 43	0.050	0.047	0.047	0.047	0.047	0.047	0.047	0.046	0.046	0.046	0.046	
2N2222	0.046	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	
Bipolar Power Transistors												3-10
2N3772	1.040	1.040	1.040	1.040	1.040	1.040	1.040	1.040	1.040	1.040	1.040	
2N3055A	0.700	0.690	0.690	0.690	0.690	0.690	0.680	0.680	0.680	0.680	0.680	
2N6107	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	
Power MOSFET												3-9
IRF530	0.400	0.420	0.420	0.420	0.420	0.420	0.400	0.400	0.400	0.400	0.400	
IRF540	1.000	1.000	1.000	1.000	0.990	0.998	0.980	0.980	0.980	0.980	0.980	
IRF9531	1.035	1.028	1.028	1.028	1.028	1.028	1.022	1.022	1.022	1.022	1.022	
IRF9520	0.415	0.410	0.410	0.410	0.410	0.410	0.408	0.408	0.408	0.408	0.408	
Small-Signal Diodes												1-10
1N4002	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	
1N645	0.046	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	
Power Diodes												2-8
1N3891	0.883	0.873	0.873	0.873	0.873	0.873	0.870	0.870	0.864	0.864	0.867	
1N3737	7.105	7.035	7.035	7.035	7.035	7.035	7.000	7.000	6.990	6.990	6.995	
1N4936	0.092	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	
Zener Diodes												1-10
1N829	1.165	1.165	1.165	1.165	1.165	1.165	1.165	1.165	1.165	1.165	1.165	
1N752A	0.027	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
1N963B	0.027	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
1N4735A	0.040	0.040	0.040	0.040	0.040	0.040	0.039	0.039	0.039	0.039	0.039	
1.5KE62A	0.617	0.604	0.604	0.604	0.604	0.604	0.595	0.595	0.595	0.595	0.595	
1.5KE30CA	1.215	1.186	1.186	1.186	1.186	1.186	1.160	1.160	1.160	1.160	1.160	
P6KE30CA	0.699	0.690	0.690	0.690	0.690	0.690	0.681	0.681	0.681	0.681	0.681	
Thyristors												2-10
2N6400	0.620	0.583	0.583	0.583	0.583	0.583	0.562	0.562	0.562	0.562	0.562	
2N4186	2.270	2.260	2.260	2.260	2.260	2.260	2.250	2.250	2.250	2.250	2.250	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1992)

Table 24
Estimated Long-Range Discrete Semiconductor Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Product	1993	1994	1995	1996	1997
Small-Signal Transistors					
2N2222A	0.150	0.150	0.150	0.150	0.150
2N3904	0.030	0.030	0.030	0.030	0.030
2N2907A	0.066	0.063	0.061	0.061	0.061
MPSA 43	0.047	0.046	0.045	0.045	0.045
2N2222	0.045	0.045	0.045	0.045	0.045
Bipolar Power Transistors					
2N3772	1.040	1.040	1.040	1.040	1.040
2N3055A	0.690	0.680	0.670	0.670	0.670
2N6107	0.235	0.235	0.235	0.235	0.235
Power MOSFET					
IRF530	0.420	0.400	0.356	0.350	0.350
IRF540	0.998	0.980	0.975	0.975	0.975
IRF9531	1.028	1.022	1.020	1.020	1.020
IRF9520	0.410	0.408	0.406	0.406	0.406
Small-Signal Diodes					
1N4002	0.020	0.020	0.020	0.020	0.020
1N645	0.045	0.045	0.045	0.045	0.045
Power Diodes					
1N3891	0.873	0.867	0.860	0.860	0.860
1N3737	7.035	6.995	6.850	6.850	6.850
1N4936	0.090	0.090	0.089	0.089	0.089
Zener Diodes					
1N829	1.165	1.165	1.165	1.165	1.165
1N752A	0.030	0.030	0.026	0.025	0.025
1N963B	0.030	0.030	0.026	0.025	0.025
1N4735A	0.040	0.039	0.039	0.039	0.039
1.5KE62A	0.604	0.595	0.590	0.590	0.590
1.5KE30CA	1.186	1.160	1.155	1.155	1.155
P6KE30CA	0.690	0.681	0.671	0.671	0.671
Thyristors					
2N6400	0.583	0.562	0.556	0.556	0.556
2N4186	2.260	2.250	2.250	2.250	2.250

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (December 1992)

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North American Semiconductor Price Outlook

Fourth Quarter 1992

Source: Dataquest

Market Statistics

Semiconductor Procurement

SPWW-SVC-MS-9203

September 14, 1992

Dataquest

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North American Semiconductor Price Outlook: Fourth Quarter 1992

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Table		Page

Note: All tables show estimated data.

North American Semiconductor Price Outlook: Fourth Quarter 1992

Methodology and Sources

This *Source: Dataquest* document provides information on and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects price information on a quarterly basis from North American suppliers and major buyers of these products. North American bookings price information is analyzed by Semiconductor Procurement (SP) service analysts for consistency and reconciliation. The information finally is rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast. This document includes associated long-range forecasts.

For SP clients that use the SP online service, the prices presented here correlate with the quarterly and long-range price tables dated September 1992 in the SP online service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery performance, volume discount, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.

Table 1
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74LS TTL											6-12
74LS00	0.105	0.105	0.110	0.110	0.108	0.110	0.110	0.110	0.110	0.110	
74LS74	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.110	0.110	0.113	
74LS138	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	
74LS244	0.215	0.215	0.220	0.220	0.217	0.220	0.220	0.200	0.200	0.210	
74F TTL											6-8
74FOO	0.100	0.100	0.100	0.100	0.100	0.105	0.105	0.105	0.105	0.105	
74F74	0.120	0.120	0.120	0.120	0.120	0.115	0.115	0.115	0.115	0.115	
74F138	0.155	0.155	0.155	0.155	0.155	0.152	0.151	0.150	0.150	0.151	
74F244	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.210	0.210	0.215	
74HC CMOS											6-8
74HC00	0.105	0.105	0.110	0.110	0.108	0.110	0.110	0.110	0.110	0.110	
74HC74	0.120	0.120	0.125	0.125	0.123	0.130	0.130	0.130	0.130	0.130	
74HC138	0.158	0.158	0.160	0.160	0.159	0.165	0.165	0.165	0.165	0.165	
74HC244	0.235	0.235	0.235	0.235	0.235	0.237	0.237	0.239	0.239	0.238	
74AC CMOS											2-6
74AC00	0.180	0.175	0.170	0.170	0.174	0.170	0.170	0.170	0.170	0.170	
74AC74	0.250	0.245	0.225	0.220	0.235	0.210	0.210	0.204	0.200	0.206	
74AC138	0.295	0.280	0.280	0.280	0.284	0.280	0.280	0.280	0.280	0.280	
74AC244	0.440	0.420	0.400	0.400	0.415	0.390	0.390	0.360	0.360	0.375	
74ALS TTL											6-10
74ALS00	0.120	0.118	0.115	0.115	0.117	0.115	0.115	0.115	0.115	0.115	
74ALS74	0.140	0.135	0.135	0.135	0.136	0.135	0.135	0.135	0.135	0.135	
74ALS138	0.260	0.260	0.250	0.250	0.255	0.250	0.250	0.250	0.250	0.250	
74ALS244	0.340	0.330	0.320	0.320	0.328	0.310	0.310	0.300	0.300	0.305	
74AS TTL											8-10
74AS00	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	
74AS74	0.180	0.180	0.180	0.180	0.180	0.180	0.179	0.179	0.179	0.179	
74AS138	0.425	0.420	0.420	0.420	0.421	0.420	0.420	0.420	0.420	0.420	
74AS244	0.730	0.720	0.720	0.720	0.723	0.700	0.700	0.700	0.700	0.700	
74BC*											4-8
74BC00	0.297	0.286	0.279	0.272	0.284	0.270	0.268	0.265	0.263	0.267	
74BC244	0.725	0.698	0.672	0.648	0.686	0.645	0.641	0.638	0.636	0.640	
74BC373	0.726	0.700	0.674	0.649	0.687	0.646	0.642	0.639	0.637	0.641	

*Pricing for 74BC excludes 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1992	1993	1994	1995	1996
74LS TTL					
74LS00	0.108	0.110	0.100	0.100	0.100
74LS74	0.117	0.113	0.110	0.110	0.110
74LS138	0.155	0.155	0.145	0.140	0.140
74LS244	0.217	0.210	0.195	0.190	0.190
74F TTL					
74FOO	0.100	0.105	0.105	0.105	0.105
74F74	0.120	0.115	0.110	0.110	0.110
74F138	0.155	0.151	0.145	0.145	0.145
74F244	0.220	0.215	0.205	0.200	0.200
74HC CMOS					
74HC00	0.108	0.110	0.110	0.110	0.110
74HC74	0.123	0.130	0.128	0.128	0.128
74HC138	0.159	0.165	0.160	0.160	0.160
74HC244	0.235	0.238	0.239	0.239	0.239
74AC CMOS					
74AC00	0.174	0.170	0.173	0.170	0.170
74AC74	0.235	0.206	0.200	0.195	0.195
74AC138	0.284	0.280	0.276	0.270	0.270
74AC244	0.415	0.375	0.370	0.350	0.350
74ALS TTL					
74ALS00	0.117	0.115	0.110	0.110	0.110
74ALS74	0.136	0.135	0.125	0.125	0.125
74ALS138	0.255	0.250	0.250	0.249	0.249
74ALS244	0.328	0.305	0.305	0.300	0.300
74AS TTL					
74AS00	0.160	0.160	0.155	0.155	0.155
74AS74	0.180	0.179	0.179	0.179	0.179
74AS138	0.421	0.420	0.415	0.400	0.400
74AS244	0.723	0.700	0.700	0.690	0.690
74BC*					
74BC00	0.284	0.267	0.260	0.242	0.242
74BC244	0.686	0.640	0.611	0.587	0.587
74BC373	0.687	0.641	0.612	0.588	0.588

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.

Source: Dataquest (September 1992)

Table 3
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
68000-12	5.50	5.50	5.50	5.50	5.50	5.00	5.00	5.00	5.00	5.00	4-8
68EC000-8	3.00	2.95	2.85	2.75	2.89	2.75	2.65	2.56	2.50	2.62	4-8
68EC000-16 PLCC	NA	NA	NA	6.00	NA	5.80	5.80	5.80	5.65	5.76	8-12
80186-8 PLCC	5.75	5.65	5.50	5.50	5.60	5.50	5.50	5.50	5.50	5.50	6-8
80C186-10 PLCC	9.95	9.95	9.45	9.25	9.65	9.00	9.00	8.75	8.75	8.88	5-8
80286-10 PLCC	5.00	4.75	4.50	3.75	4.50	3.75	3.75	3.75	3.75	3.75	3-8
80286-16 PLCC	9.25	8.00	7.05	6.25	7.64	5.75	5.75	5.75	5.50	5.69	2-10
68020-16 PQFP	29.00	29.00	27.00	26.00	27.75	24.00	24.00	24.00	23.00	23.75	8-12
68EC020-16 PQFP	17.00	16.00	15.75	15.50	16.06	15.00	14.20	13.50	13.00	13.93	4-8
68020-25 PQFP	36.00	36.00	34.50	34.00	35.13	33.57	33.25	32.78	32.40	33.00	2-8
68EC020-25 PQFP	21.00	20.20	19.75	19.00	19.99	18.00	18.00	18.00	18.00	18.00	2-4
68030-16 CQFP	76.00	70.00	68.00	66.00	70.00	60.00	60.00	60.00	60.00	60.00	8-12
68030-25 CQFP	120.00	110.00	105.00	100.00	108.75	95.00	93.00	90.00	90.00	92.00	5-10
68EC030-25 PQFP	37.00	36.50	35.25	35.00	35.94	34.65	34.30	33.96	33.79	34.18	8-12
68040-25	455.08	430.10	413.90	375.00	418.52	350.00	350.00	325.00	325.00	337.50	4-8
68EC040-25	125.00	115.00	110.00	100.00	112.50	95.00	95.00	90.00	90.00	92.50	8-12
386SX-16 PQFP	53.82	49.00	44.00	42.00	47.21	39.00	36.00	35.00	34.00	36.00	2-6
386SX-20 PQFP	81.41	59.00	53.00	48.00	60.35	44.00	40.00	35.00	34.00	38.25	2-6
386SX-25 PQFP	84.00	78.50	68.00	57.00	71.88	47.00	41.00	35.00	34.00	39.25	2-6
386SL-25 PQFP	178.00	122.00	90.00	75.00	116.25	65.00	59.00	55.00	50.00	57.25	2-6
AM386-40[1]	180.00	105.00	75.00	65.00	106.25	55.00	46.00	40.00	37.00	44.50	6
386DX-25 PQFP[2]	148.00	99.00	74.00	68.00	97.25	65.00	63.00	60.00	57.00	61.25	4-8
80486SX-20 PQFP[2]	237.00	201.00	99.00	96.00	158.25	93.00	90.00	86.00	82.00	87.75	4-8
80486DX-25	409.00	405.00	365.00	325.00	376.00	288.00	200.00	180.00	155.00	205.75	6-8
80486DX-33	409.00	405.00	365.00	325.00	376.00	288.00	200.00	180.00	155.00	205.75	6-8
80486DX-50	610.00	565.00	536.00	455.00	541.50	352.00	329.00	305.00	295.00	320.25	6-8
80486DX2-50	550.00	517.00	487.00	425.00	494.75	375.00	266.67	236.25	224.00	275.48	6-8
29000-25[3]	92.00	85.50	81.00	78.00	84.13	76.00	71.00	67.00	65.10	69.78	5-12
88100-25[3]	69.50	68.05	67.45	67.00	68.00	64.50	62.20	60.20	58.10	61.25	4-8
R3000-25[3]	105.00	96.00	94.00	93.40	97.10	90.00	87.00	84.00	81.00	85.50	6-12
SPARC-25[3]	75.62	72.30	69.51	66.55	71.00	64.50	62.88	61.60	60.60	62.40	NA
80960CA-25	95.30	91.30	90.30	89.25	91.54	88.35	87.45	84.30	81.20	85.33	1-2

NA = Not available
[1]Estimated but not by survey
[2]CPGA for Q1-1992
[3]Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 4
Estimated Long-Range Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1992	1993	1994	1995	1996
68000-12	5.50	5.00	4.50	4.00	4.00
68EC000-8	2.89	2.62	2.35	2.30	2.30
68EC000-16 PLCC	NA	5.76	5.25	4.95	4.75
80186-8 PLCC	5.60	5.50	5.30	5.30	5.30
80C186-10 PLCC	9.65	8.88	7.25	6.75	6.50
80286-10 PLCC	4.50	3.75	3.50	NA	NA
80286-16 PLCC	7.64	5.69	5.00	4.50	NA
68020-16 PQFP	27.75	23.75	17.00	17.00	17.00
68EC020-16 PQFP	16.06	13.93	12.00	11.00	10.00
68020-25 PQFP	35.13	33.00	31.04	31.00	31.00
68EC020-25 PQFP	19.99	18.00	17.00	16.00	15.50
68030-16 CQFP	70.00	60.00	59.00	58.94	58.94
68030-25 CQFP	108.75	92.00	86.00	83.00	80.00
68EC030-25 PQFP	35.94	34.18	32.10	30.50	30.00
68040-25	418.52	337.50	305.00	29.00	275.00
68EC040-25	112.50	92.50	86.00	83.00	80.00
386SX-16 PQFP	47.21	36.00	28.00	24.00	20.00
386SX-20 PQFP	60.35	38.25	28.00	24.00	20.00
386SX-25 PQFP	71.88	39.25	28.00	24.00	20.00
386SL-25 CPGA	116.25	57.25	43.00	37.00	31.00
AM386-40	106.25	44.50	30.00	26.00	22.00
386DX-25 PQFP[1]	97.25	61.25	47.00	40.00	34.00
80486SX-20 PQFP[1]	NA	87.75	74.00	62.00	53.00
80486DX-25	376.00	205.75	112.75	94.86	80.19
80486DX-33	376.00	205.75	112.75	94.86	80.19
80486DX-50	541.50	320.25	135.30	109.09	84.19
80486DX2-50	494.75	275.48	124.03	101.97	80.99
29000-25[2]	84.13	69.78	63.00	58.00	55.00
88100-25[2]	68.00	61.25	56.00	51.00	50.00
R3000-25[2]	97.10	85.50	74.00	65.00	60.00
SPARC-25[2]	71.00	62.40	59.00	53.66	53.00
80960CA-25	91.54	85.33	77.14	75.21	75.21

NA = Not available
[1]CPGA for Q1-1992
[2]Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 5
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
256Kx1 DRAM 80ns DIP	1.60	1.60	1.50	1.50	1.55	1.40	1.40	1.40	1.40	1.40	1-8
64Kx4 VRAM 120ns ZIP	2.95	2.70	2.70	2.70	2.76	2.65	2.65	2.65	2.65	2.65	3-10
1Mbx1 DRAM 80ns (DIP/SOJ)	3.80	3.50	3.35	3.20	3.46	3.20	3.20	3.20	3.20	3.20	1-6
64Kx16 DRAM 80ns SOJ	5.65	5.19	4.93	4.67	5.11	4.49	4.33	4.22	4.13	4.29	4-8
256Kx4 VRAM 100ns ZIP	7.75	7.30	6.85	6.60	7.13	6.18	5.95	5.55	5.25	5.73	3-20
128Kx8 VRAM 100ns SOJ	8.05	7.65	7.25	6.91	7.47	6.58	6.50	6.40	6.30	6.45	6-16
4Mbx1 DRAM 80ns SOJ	13.13	12.05	10.80	9.85	11.46	9.00	8.25	7.60	7.20	8.01	2-12
1Mbx4 DRAM 60ns SOJ	14.45	12.95	11.34	10.34	12.27	9.00	8.54	7.83	7.42	8.20	2-12
512Kx8 DRAM 70ns	NA	15.08	13.25	12.36	NA	11.23	10.56	9.89	9.27	10.24	3-12
256Kx16 DRAM 70ns SOJ	16.00	15.50	13.60	12.40	14.38	10.35	9.49	8.51	7.92	9.07	3-8
256Kx18 DRAM 80ns SOJ	17.07	16.75	14.36	12.75	15.23	11.45	10.25	9.25	8.60	9.89	3-6
1Mbx8 SIMM 100ns (2 pc)	30.00	27.00	24.98	24.00	26.49	22.00	20.90	20.18	19.25	20.58	1-8
1Mbx9 SIMM 80ns (3 pc)	33.27	30.45	27.85	26.00	29.39	25.00	23.77	22.00	20.75	22.88	1-8
256Kx9 SIMM 100ns	12.70	12.53	12.65	12.50	12.59	12.50	12.50	12.50	12.50	12.50	2-8
256Kx36 SIMM 80ns[2]	47.00	44.40	41.00	38.00	42.60	32.68	31.11	29.85	28.75	30.60	2-8
512Kx36 SIMM 80ns (24 pc)	82.00	80.40	77.75	72.00	78.04	67.00	63.00	60.00	57.50	61.88	4-8
4Mbx9 SIMM 80ns (9pc)	130.2	116.8	107.0	98.25	113.0	92.25	87.00	82.00	77.00	84.56	2-8
1Mbx36 SIMM 80ns (12 pc)	131.0	122.0	107.0	100.0	115.0	94.00	87.00	80.00	76.00	84.25	4-8
4Mbx4 DRAM 70ns SOJ	180.0	149.0	119.6	95.0	135.9	74.00	58.00	48.00	42.00	55.50	12-24

NA = Not available

[1]Contract volume = at least 100,000 per order except VRAMs

[2]2-piece solution for 1993

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount.

Source: Dataquest (September 1992)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; Dollars)[1]

Product	1992	1993	1994	1995	1996
256Kx1 DRAM 80ns DIP	1.55	1.40	1.55	1.65	1.80
64Kx4 VRAM 120ns ZIP	2.76	2.65	2.24	2.40	2.40
1Mbx1 DRAM 80ns (DIP/SOJ)	3.46	3.20	3.20	3.30	3.55
64Kx16 DRAM 80ns SOJ	5.11	4.29	4.12	4.12	4.15
256Kx4 VRAM 100ns ZIP	7.13	5.73	5.00	4.75	4.75
128Kx8 VRAM 100ns SOJ	7.47	6.45	5.50	5.15	5.15
4Mbx1 DRAM 80ns SOJ	11.46	8.01	6.06	5.50	5.50
1Mbx4 DRAM 60ns SOJ	12.27	8.20	6.15	5.56	5.55
512Kx8 DRAM 70ns	NA	10.24	6.21	5.69	5.60
256Kx16 DRAM 70ns SOJ	11.46	9.07	6.36	5.72	5.72
256Kx18 DRAM 80ns SOJ	15.23	9.89	6.54	5.91	5.90
1Mbx8 SIMM 100ns (2 pc)	26.49	20.58	15.44	15.00	14.00
1Mbx9 SIMM 80ns (3 pc)	29.39	22.88	16.44	16.00	15.00
256Kx9 SIMM 100ns	12.59	12.50	12.00	NA	NA
256Kx36 SIMM 80ns[2]	42.60	30.60	23.71	21.50	21.00
512Kx36 SIMM 80ns (24 pc)	78.04	61.88	46.41	43.00	42.00
4Mbx9 SIMM 80ns (9pc)	113.04	84.56	59.19	55.43	56.00
1Mbx36 SIMM 80ns (12 pc)	115.0	84.25	58.98	57.75	56.10
4Mbx4 DRAM 70ns SOJ 400 mil	135.9	55.50	27.00	18.00	14.00

NA = Not available
[1]Contract volume = at least 100,000 per order except VRAMs
[2]2-piece solution for 1993
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 7
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year) (Package: PDIP; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
4Kx4 25ns	2.30	2.25	2.18	2.18	2.23	2.05	2.05	2.05	2.05	2.05	1-12
2Kx8 25ns	2.40	2.35	2.20	2.15	2.28	2.05	2.00	2.00	2.00	2.01	1-13
64Kx1 25ns	3.55	3.20	2.80	2.30	2.96	2.20	2.20	2.10	2.10	2.15	1-12
16Kx4 25ns	2.70	2.50	2.25	2.25	2.43	2.00	2.00	1.90	1.90	1.95	1-10
8Kx8 25ns	3.30	2.60	2.35	2.15	2.60	2.00	2.00	1.90	1.90	1.95	1-10
16Kx4 35ns	2.60	2.40	2.25	2.25	2.38	2.00	2.00	1.90	1.90	1.95	1-10
8Kx8 45ns	2.55	2.45	2.35	2.15	2.38	2.00	2.00	1.90	1.90	1.95	1-10
8Kx8 100-120ns	2.05	1.85	1.65	1.65	1.80	1.55	1.55	1.55	1.55	1.55	1-10
64Kx4 10ns	36.90	32.80	24.84	22.00	29.14	20.00	18.75	17.50	15.50	17.94	1-12
64Kx4 25ns	7.50	6.50	6.04	5.50	6.39	5.00	4.65	4.45	4.39	4.62	1-12
32Kx8 12ns	23.58	21.53	16.54	14.80	19.11	13.61	12.00	11.45	10.95	12.00	1-10
32Kx8 35ns	6.28	6.10	5.75	5.50	5.91	5.10	4.74	4.49	4.43	4.69	1-12
32Kx8 100ns SOJ	4.05	4.05	3.95	3.90	3.99	3.85	3.75	3.75	3.75	3.78	4-9
256Kx4 20ns	58.83	51.04	32.77	30.50	43.28	27.83	26.50	24.50	23.33	25.54	1-12
128Kx8 20ns	58.64	50.16	34.00	30.94	43.43	27.87	26.12	24.50	23.33	25.45	1-12
128Kx8 25ns	44.00	37.50	27.08	23.50	33.02	21.75	19.42	18.00	16.25	18.85	1-12
128Kx8 100ns SOJ	13.50	11.55	10.00	9.20	11.06	9.00	8.85	8.65	8.45	8.74	2-10

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (September 1992)

Table 8

Estimated Long-Range Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1992	1993	1994	1995	1996
4Kx4 25ns	2.23	2.05	1.70	1.50	1.35
2Kx8 25ns	2.28	2.01	1.70	1.50	1.35
64Kx1 25ns	2.96	2.15	1.90	1.80	1.70
16Kx4 25ns	2.43	1.95	1.85	1.60	1.50
8Kx8 25ns	2.60	1.95	1.85	1.60	1.50
16Kx4 35ns	2.38	1.95	1.85	1.60	1.50
8Kx8 45ns	2.38	1.95	1.85	1.55	1.50
8Kx8 100-120ns	1.80	1.55	1.35	1.35	1.65
64Kx4 10ns	29.14	17.94	8.25	5.95	4.50
64Kx4 25ns	6.39	4.62	3.95	3.45	2.99
32Kx8 12ns	19.11	12.00	7.25	5.50	4.00
32Kx8 35ns	5.91	4.69	3.98	3.45	2.95
32Kx8 100ns SOJ	3.99	3.78	3.50	3.00	3.00
256Kx4 20ns	43.28	25.54	11.25	7.75	6.25
128Kx8 20ns	43.43	25.45	11.25	7.75	6.25
128Kx8 25ns	33.02	18.85	9.70	7.25	6.20
128Kx8 100ns SOJ	11.06	8.74	6.50	5.50	5.25

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 9
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above; 28-Pin PDIP;
≥2Mb Density—200ns and above; 32-Pin PDIP)
(Volume: 50,000 per Year; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
CMOS											
32Kx8 ROM	1.50	1.50	1.50	1.50	1.50	1.40	1.35	1.30	1.25	1.33	4-8
64Kx8 ROM	1.90	1.85	1.80	1.75	1.83	1.70	1.65	1.60	1.50	1.61	4-8
128Kx8 ROM	2.01	1.95	1.80	1.80	1.89	1.80	1.75	1.70	1.60	1.71	5-8
64Kx16 ROM	2.20	2.20	1.80	1.80	2.00	1.80	1.80	1.80	1.80	1.80	5-8
256Kx8 ROM	2.76	2.73	2.55	2.55	2.65	2.50	2.50	2.50	2.50	2.50	5-8
512Kx8 ROM	3.95	3.79	3.50	3.35	3.65	3.30	3.25	3.20	3.20	3.24	5-8
256Kx16 ROM[1]	4.05	3.86	3.50	3.50	3.73	3.50	3.50	3.50	3.50	3.50	5-8
1Mbx8 ROM[2]	6.33	6.20	5.65	5.60	5.95	5.55	5.50	5.45	5.40	5.48	5-8
1Mbx16 ROM	NA	NA	10.55	10.30	NA	10.00	9.75	9.50	9.25	9.63	5-8
2Mbx8 ROM	15.25	13.00	10.90	10.50	12.41	10.10	9.95	9.65	9.30	9.75	4-8

NA = Not available

[1]256Kx16 ROM: 150ns and above; 40-Pin PDIP

[2]1Mbx8 ROM: 150ns and above; 32-Pin SOP

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (September 1992)

Table 10
Estimated Long-Range ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above; 28-Pin PDIP;
≥2Mb Density—200ns and above; 32-Pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
CMOS					
32Kx8 ROM	1.50	1.33	1.25	NA	NA
64Kx8 ROM	1.83	1.61	1.50	1.60	NA
128Kx8 ROM	1.89	1.71	1.60	1.60	1.70
64Kx16 ROM	2.00	1.80	1.70	1.70	1.70
256Kx8 ROM	2.65	2.50	2.40	2.34	2.34
512Kx8 ROM	3.65	3.24	3.10	3.05	3.00
256Kx16 ROM[1]	3.73	3.50	3.20	3.10	3.05
1Mbx8 ROM[2]	5.95	5.48	5.00	4.50	4.15
1Mbx16 ROM	NA	9.63	8.00	6.55	6.35
2Mbx8 ROM	12.41	9.75	8.00	6.55	6.35

NA = Not available
[1]256Kx16 ROM: 150ns and above; 40-Pin PDIP
[2]1Mbx8 ROM: 150ns and above; 32-Pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates to Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 11
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
TTL											
4K PROM PDIP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM PDIP	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM PDIP	4.70	4.60	4.50	4.50	4.58	4.50	4.50	4.50	4.50	4.50	6-8
64K PROM PDIP	6.62	6.47	6.36	6.23	6.42	6.05	5.93	5.85	5.83	5.92	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 12
Estimated Long-Range Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

Product	1992	1993	1994	1995	1996
TTL					
4K PROM	1.00	1.00	NA	NA	NA
16K PROM	2.40	2.40	NA	NA	NA
32K PROM	4.58	4.50	4.50	NA	NA
64K PROM	6.42	5.92	5.54	5.45	5.45

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This price forecast coordinates to Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 13
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

	1992				1992	1993				1993	Current Lead
Family/Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time Weeks
8Kx8 EPROM	1.75	1.67	1.60	1.55	1.64	1.45	1.45	1.45	1.45	1.45	2-12
16Kx8 EPROM	1.83	1.75	1.75	1.75	1.77	1.60	1.60	1.60	1.60	1.60	2-8
32Kx8 EPROM	1.80	1.62	1.57	1.53	1.63	1.45	1.45	1.45	1.45	1.45	2-12
64Kx8 EPROM	2.37	2.36	2.34	2.31	2.34	2.20	2.20	2.20	2.20	2.20	2-10
128Kx8 EPROM	3.25	3.15	3.03	3.00	3.11	2.80	2.70	2.65	2.60	2.69	2-12
256Kx8 EPROM	7.27	6.68	6.49	6.10	6.64	6.00	5.90	5.75	5.60	5.81	2-12
128Kx16 EPROM	7.90	7.11	6.61	6.22	6.96	6.09	5.99	5.89	5.80	5.94	4-8
512Kx8 EPROM	14.00	11.75	11.05	10.70	11.88	10.06	9.70	9.36	9.00	9.53	4-14
256Kx16 EPROM	15.50	15.00	14.50	14.00	14.75	12.00	10.72	10.34	9.98	10.76	4-14

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 14
Estimated Long-Range EPROM Pricing—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

Product	1992	1993	1994	1995	1996
8Kx8 EPROM	1.64	1.45	1.45	1.50	1.50
16Kx8 EPROM	1.77	1.60	1.60	1.60	1.60
32Kx8 EPROM	1.63	1.45	1.45	1.45	1.50
64Kx8 EPROM	2.34	2.20	2.20	2.20	2.30
128Kx8 EPROM	3.11	2.69	2.60	2.60	2.65
256Kx8 EPROM	6.64	5.81	5.60	5.40	5.40
128Kx16 EPROM	6.96	5.94	5.69	5.48	5.48
512Kx8 EPROM	11.88	9.53	8.60	8.00	7.80
256Kx16 EPROM	14.75	10.76	9.50	8.60	8.25

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 15
Estimated OTP ROM Price Trends-North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.49	1.49	1.49	1.49	1.49	1.34	1.34	1.34	1.34	1.34	1-12
32Kx8	1.56	1.56	1.56	1.56	1.56	1.31	1.31	1.31	1.31	1.31	2-12
64Kx8	2.19	2.10	2.01	1.98	2.07	1.95	1.95	1.95	1.95	1.95	2-12
128Kx8	2.85	2.76	2.73	2.70	2.76	2.56	2.48	2.45	2.39	2.47	6-12

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended as guidelines.
Source: Dataquest (September 1992)

Table 16
Estimated Long-Range OTP ROM Prices-North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

Product	1992	1993	1994	1995	1996
16Kx8	1.49	1.34	1.34	NA	NA
32Kx8	1.56	1.31	1.31	NA	NA
64Kx8	2.07	1.95	1.85	1.80	1.80
128Kx8	2.76	2.47	2.20	2.10	2.00

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended as guidelines. These prices coordinate with Dataquest's quarterly forecast dated September 1992.

Source: Dataquest (September 1992)

Table 17
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

	1992				1992	1993				1993	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
32Kx8, PDIP	5.80	5.50	5.20	4.94	5.36	4.75	4.56	4.40	4.30	4.50	4-8
64Kx8, PDIP	7.15	6.80	6.30	6.00	6.56	5.60	5.35	5.25	5.05	5.31	4-8
128Kx8, PDIP	8.50	8.00	7.50	7.00	7.75	6.75	6.55	6.35	6.05	6.43	6-10
128Kx8, TSOP	9.18	8.86	8.25	7.56	8.46	7.22	6.94	6.73	6.41	6.83	6-10
256Kx8, TSOP	15.00	14.00	13.50	13.10	13.90	12.55	12.15	11.80	11.60	12.03	6-10

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (September 1992)

Table 18
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1992	1993	1994	1995	1996
32Kx8, PDIP	5.36	4.50	3.24	3.02	2.90
64Kx8, PDIP	6.56	5.31	4.06	3.52	3.25
128Kx8, PDIP	7.75	6.43	4.50	3.90	3.65
128Kx8, TSOP	8.46	6.83	4.68	4.06	3.80
256Kx8, TSOP	13.90	12.03	6.70	5.90	5.00

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.

Source: Dataquest (September 1992)

Table 19
Estimated Gate Array Pricing—North American Production Bookings
(Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K gates, 160-Pin PQFP for 10K-29.9K, 208-Pin PQFP for ≥30K Gates; ECL—CQFP) (Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	135	135	120	120	110	110	10-12
1.2 Micron	120	115	90	88	75	75	8-12
1.0 Micron	115	110	85	78	70	62	8-12
0.8 Micron	NA	NA	87	79	70	62	10-16
ECL	4850	4268	3823	3326	3000	3000	12
NRE Charges ($1,000s)							
CMOS							Prototypes:
1.5 Micron	16.0	15.2	21.0	20.0	26.0	24.7	3-5
1.2 Micron	13.0	12.4	17.0	16.2	20.0	20.0	2-4
1.0 Micron	19.0	18.1	24.0	24.0	28.0	28.0	2-4
0.8 Micron	NA	NA	26.0	26.0	30.0	30.0	3-5
ECL	30.0	27.0	45.0	40.5	50.0	45.0	14

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	100	100	90	78	95	95	NA	NA	10-12
1.2 Micron	65	65	76	76	93	93	NA	NA	8-12
1.0 Micron	65	60	69	59	73	63	79	70	10-12
0.8 Micron	65	58	65	58	72	62	77	66	10-16
ECL	3300	2790	3200	2784	3050	2654	3050	2654	12
NRE Charges ($1,000s)									
CMOS									Prototypes:
1.5 Micron	40.5	40.0	60.0	57.0	100.0	95.0	NA	NA	3-6
1.2 Micron	40.0	38.0	58.0	55.1	102.0	96.9	NA	NA	3-8
1.0 Micron	44.0	42.9	60.0	57.0	96.7	90.9	140.0	135.0	3-5
0.8 Micron	51.7	50.4	65.0	64.0	105.0	104.5	142.0	137.0	3-5
ECL	70.0	65.0	100.0	90.0	146.7	132.0	NA	NA	14

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (September 1992)

Table 20
Estimated CBIC Pricing—North America Production Bookings
(Millicents per Gate) (Package: 84-Pin PLCC for <10K Gates; 160-Pin PQFP for 10K-29.9K;
208-Pin PQFP for ≥30K) (Based on Utilized Gates Only; Volume: 10,000 per Year;
NRE = Netlist to Prototypes)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	112	100	90	88	107	107	10-14
1.2 Micron	100	100	90	80	79	77	8-15
1.0 Micron	110	100	90	85	70	69	10-16
0.8 Micron	NA	NA	91	85	70	65	13-16
NRE Charges ($1,000s)							Protypes:
1.5 Micron	35.0	33.3	38.0	36.1	47.0	44.7	5-8
1.2 Micron	32.0	30.4	35.0	33.3	43.5	41.3	5-8
1.0 Micron	42.0	41.2	49.00	45.00	53.00	47.50	5-8
0.8 Micron	NA	NA	75.00	55.00	77.00	57.00	6-8

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	105	105	95	80	99	96	NA	NA	10-14
1.2 Micron	70	70	77	76	95	95	NA	NA	9-15
1.0 Micron	69	66	68	62	75	67	73	62	10-16
0.8 Micron	69	63	67	60	74	65	75	61	13-16
NRE Charges ($1,000s)									Protypes:
1.5 Micron	65.0	61.8	85.0	80.8	110.0	103.4	NA	NA	5-8
1.2 Micron	58.5	55.6	75.0	71.3	100.0	97.0	NA	NA	5-8
1.0 Micron	77.50	77.50	100.0	90.0	125.0	115.0	155.0	140.0	5-8
0.8 Micron	95.0	85.0	125.0	105.0	155.0	133.0	159.0	143.5	6-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 21
Estimated TTL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20						
	≤6	6.25	5.85	5.50	5.15	2-10
	6.1 - 7.5	2.35	2.10	2.00	1.85	2-12
	7.6 - 10.0	1.35	1.20	1.15	1.05	2-12
	10.1 - 14.99	1.27	1.15	1.05	1.05	2-8
	15 - <25	0.60	0.57	0.55	0.55	2-4
	≥25	0.46	0.43	0.42	0.42	2-4
24	≤6	9.20	8.80	7.25	6.95	2-12
	6.1 - 7.5	4.35	4.06	3.60	3.25	2-12
	7.6 - 10.0	2.60	2.50	2.15	2.05	2-12
	10.1 - 14.99	2.43	2.18	2.09	1.99	3-6
	15 - <25	1.00	0.96	0.94	0.90	2-4
	≥25	0.72	0.71	0.68	0.66	2-4
24						
22V10						
	15 - <25	4.00	3.80	3.30	3.10	3-8
	25 - <35	2.15	1.90	1.60	1.50	2-8

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (September 1992)

Table 22
Estimated Long-Range TTL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed*(ns)	1992	1993	1994	1995	1996
≤20						
	≤6	6.05	5.33	4.79	4.55	4.44
	6.1 - 7.5	2.23	1.93	1.76	1.73	1.70
	7.6 - 10.0	1.28	1.10	0.99	0.94	0.89
	10.1 - 14.99	1.21	1.05	1.05	1.00	1.00
	15 - <25	0.59	0.55	0.51	0.50	0.50
	≥25	0.45	0.42	0.40	0.40	0.40
24						
	≤6	9.00	7.10	6.00	5.50	5.45
	6.1 - 7.5	4.20	3.43	3.15	3.00	2.85
	7.6 - 10.0	2.55	2.10	1.89	1.84	1.81
	10.1 - 14.99	2.30	2.04	1.95	1.90	1.90
	15 - <25	0.98	0.92	0.90	0.87	0.85
	≥25	0.72	0.67	0.65	0.65	0.65
24						
22V10						
	15 - <25	3.90	3.20	2.88	2.74	2.67
	25 - <35	2.03	1.55	1.43	1.40	1.40

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.

Source: Dataquest (September 1992)

Table 23
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20	6.1 - 7.5	5.50	4.95	4.65	4.35	1-18
	7.6 - 10.0	3.05	2.20	2.00	1.83	1-12
	10.1 - 14.99	1.75	1.66	1.58	1.50	1-8
	15 - <25	0.78	0.73	0.70	0.68	1-8
	≥25	0.61	0.58	0.56	0.55	1-8
24						
	6.1 - 7.5	9.07	6.50	6.63	5.75	1-20
	7.6 - 10.0	5.25	3.85	3.48	3.18	1-18
	10.1 - 14.99	2.70	2.54	2.39	2.23	1-6
	15 - <25	1.15	0.99	0.94	0.94	1-8
	≥25	0.95	0.90	0.94	0.94	1-6
24						
22V10						
	6.1 - 7.5	20.00	19.00	18.00	17.00	1-4
	7.6 - 10.0	14.00	10.50	7.25	6.00	2-4
	15 - <25	4.25	3.63	3.00	2.63	1-6
	25 - <35	2.47	1.95	1.70	1.60	1-6

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended as guidelines.

Source: Dataquest (September 1992)

Table 24
Estimated Long-Range CMOS PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992	1993	1994	1995	1996
≤20						
	6.1 - 7.5	5.23	4.50	4.00	3.75	3.54
	7.6 - 10.0	2.63	1.91	1.50	1.40	1.32
	10.1 - 14.99	1.70	1.54	1.17	1.12	1.06
	15 - <25	0.75	0.69	0.60	0.56	0.52
	≥25	0.60	0.55	0.44	0.42	0.42
24						
	6.1 - 7.5	7.79	6.19	5.25	4.95	4.50
	7.6 - 10.0	4.55	3.33	2.50	2.25	2.10
	10.1 - 14.99	2.62	2.31	1.50	1.40	1.30
	15 - <25	1.07	0.94	0.90	0.85	0.80
	≥25	0.92	0.94	0.90	0.85	0.80
24						
22V10						
	6.1 - 7.5	19.50	17.50	15.30	13.77	13.08
	7.6 - 10.0	12.25	6.63	6.00	5.50	5.15
	15 - <25	3.94	2.81	2.25	2.05	1.95
	25 - <35	2.21	1.65	1.60	1.50	1.50

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.

Source: Dataquest (September 1992)

Table 25
Estimated Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Voltage Regulators					
78L05 (TO-92)	0.120	0.118	0.117	0.117	10-12
7805 (TO-220)	0.138	0.137	0.137	0.137	
Comparators					
LM339	0.137	0.137	0.132	0.130	10-12
LM393	0.129	0.127	0.127	0.127	
Op Amps					
741	0.130	0.125	0.128	0.128	10-12
3403P	0.182	0.178	0.176	0.174	
1741CP1	0.124	0.120	0.119	0.117	
Interface ICs					
1488P	0.150	0.150	0.146	0.144	6-8
3486P	0.895	0.885	0.880	0.860	
Telecom IC					6-8
CODEC/FILTER #1	1.850	1.776	1.723	1.680	
CODEC/FILTER #2	4.330	4.121	3.915	3.719	
XR-T5683	3.600	3.500	3.413	3.327	
34017P	0.330	0.320	0.315	0.305	
Video DAC					
IMSG171D-35MHz	1.800	1.700	1.600	1.500	NA

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (September 1992)

Table 26
Estimated Long-Range Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
Voltage Regulators					
78L05 (TO-92)	0.119	0.117	0.117	0.116	0.116
7805 (TO-220)	0.138	0.137	0.137	0.137	0.137
Comparators					
LM339	0.137	0.131	0.130	0.130	0.130
LM393	0.128	0.127	0.127	0.126	0.126
Op Amps					
3403P	0.180	0.175	0.174	0.171	0.171
1741CP1	0.122	0.118	0.117	0.116	0.116
Interface ICs					
1488P	0.150	0.145	0.144	0.137	0.137
3486P	0.890	0.870	0.860	0.840	0.830
Telecom IC					
CODEC/FILTER 1	1.813	1.701	1.616	1.535	1.500
CODEC/FILTER 2	4.225	3.817	3.550	3.301	3.136
XR-T5683	3.550	3.370	3.201	3.073	2.950
34017P	0.325	0.310	0.305	0.298	0.290
Video DAC					
IMSG171D-35MHz	1.750	1.550	1.440	1.390	1.370

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

Table 27
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Small-Signal Transistors					2-8
2N2222A	0.140	0.140	0.139	0.139	
2N3904	0.030	0.030	0.029	0.029	
2N2907A	0.068	0.068	0.066	0.066	
MPSA 43	0.052	0.049	0.048	0.046	
2N2222	0.046	0.045	0.045	0.045	
Bipolar Power Transistors					3-8
2N3772	1.040	1.040	1.040	1.040	
2N3055A	0.700	0.700	0.690	0.690	
2N6107	0.235	0.235	0.235	0.235	
Power MOSFET					3-8
IRF530	0.400	0.380	0.370	0.370	
IRF540	1.000	1.000	0.990	0.990	
IRF9531	1.040	1.030	1.029	1.027	
IRF9520	0.416	0.414	0.411	0.409	
Small-Signal Diodes					1-8
1N4002	0.020	0.020	0.020	0.020	
1N645	0.047	0.046	0.045	0.045	
Power Diodes					2-8
1N3891	0.888	0.878	0.875	0.871	
1N3737	7.120	7.090	7.070	6.999	
1N4936	0.095	0.094	0.093	0.092	
Zener Diodes					2-8
1N829	1.165	1.165	1.165	1.165	
1N752A	0.026	0.025	0.025	0.025	
1N963B	0.026	0.025	0.025	0.025	
1N4735A	0.040	0.039	0.039	0.039	
1.5KE62A	0.625	0.610	0.608	0.600	
1.5KE30CA	1.230	1.200	1.192	1.180	
P6KE30CA	0.708	0.690	0.690	0.690	
Thyristors					2-8
2N6400	0.620	0.620	0.593	0.573	
2N4186	2.275	2.265	2.270	2.250	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (September 1992)

Table 28
Estimated Long-Range Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
Small-Signal Transistors					
2N2222A	0.140	0.139	0.138	0.138	0.138
2N3904	0.030	0.029	0.028	0.028	0.028
2N2907A	0.068	0.066	0.062	0.061	0.060
MPSA 43	0.050	0.047	0.046	0.045	0.045
2N2222	0.046	0.045	0.045	0.045	0.045
Bipolar Power Transistors					
2N3772	1.040	1.040	1.040	1.040	1.040
2N3055A	0.700	0.690	0.680	0.670	0.670
2N6107	0.235	0.235	0.235	0.235	0.235
Power MOSFET					
IRF530	0.390	0.370	0.360	0.350	0.350
IRF540	1.000	0.990	0.980	0.975	0.970
IRF9531	1.035	1.028	1.022	1.020	1.018
IRF9520	0.415	0.410	0.408	0.406	0.405
Small-Signal Diodes					
1N4002	0.020	0.020	0.020	0.020	0.020
1N645	0.046	0.045	0.045	0.045	0.045
Power Diodes					
1N3891	0.883	0.873	0.864	0.860	0.858
1N3737	7.105	7.035	6.990	6.850	6.800
1N4936	0.094	0.092	0.090	0.089	0.088
Zener Diodes					
1N829	1.165	1.165	1.165	1.165	1.165
1N752A	0.026	0.025	0.025	0.025	0.025
1N963B	0.026	0.025	0.025	0.025	0.025
1N4735A	0.040	0.039	0.039	0.039	0.039
1.5KE62A	0.617	0.604	0.595	0.590	0.585
1.5KE30CA	1.215	1.186	1.160	1.155	1.150
P6KE30CA	0.699	0.690	0.681	0.671	0.665
Thyristors					
2N6400	0.620	0.583	0.562	0.556	0.556
2N4186	2.270	2.260	2.250	2.250	2.250

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast coordinates with Dataquest's quarterly forecast dated September 1992.
Source: Dataquest (September 1992)

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North American Semiconductor Price Outlook

Third Quarter 1992

Source: Dataquest

Market Statistics

Semiconductor Procurement

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North American Semiconductor Price Outlook

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North American Semiconductor Price Outlook: Third Quarter 1992

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Note: All tables show estimated data.

North American Semiconductor Price Outlook: Third Quarter 1992

Methodology and Sources

This *Source: Dataquest* document provides information on and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects price information on a quarterly basis from North American suppliers and major buyers of these products. North American bookings price information is analyzed by Semiconductor Procurement (SP) service analysts for consistency and reconciliation. The information finally is rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast. This document includes associated long-range forecasts.

For SP clients that use the SP online service, the prices presented here correlate with the quarterly and long-range price tables dated June 1992 in the SP online service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery performance, volume discount, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.

Table 1
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74LS TTL												6
74LS00	0.100	0.105	0.105	0.110	0.110	0.108	0.110	0.110	0.110	0.110	0.110	
74LS74	0.115	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.110	0.110	0.113	
74LS138	0.150	0.155	0.155	0.155	0.155	0.155	0.160	0.160	0.150	0.150	0.155	
74LS244	0.215	0.215	0.215	0.220	0.220	0.217	0.220	0.220	0.200	0.200	0.210	
74S TTL												8
74S00	0.140	0.145	0.145	0.145	0.145	0.145	0.150	0.150	0.150	0.150	0.150	
74S74	0.174	0.170	0.170	0.175	0.175	0.173	0.175	0.175	0.175	0.175	0.175	
74S138	0.259	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	
74S244	0.505	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	
74F TTL												6
74FOO	0.100	0.100	0.100	0.100	0.100	0.100	0.105	0.105	0.105	0.105	0.105	
74F74	0.118	0.120	0.120	0.120	0.120	0.120	0.115	0.115	0.115	0.115	0.115	
74F138	0.165	0.155	0.155	0.155	0.155	0.155	0.152	0.151	0.150	0.150	0.151	
74F244	0.228	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.210	0.210	0.215	
74HC CMOS												6
74HC00	0.105	0.105	0.105	0.110	0.110	0.108	0.110	0.110	0.110	0.110	0.110	
74HC74	0.120	0.120	0.120	0.125	0.125	0.123	0.130	0.130	0.130	0.130	0.130	
74HC138	0.156	0.158	0.158	0.160	0.160	0.159	0.165	0.165	0.165	0.165	0.165	
74HC244	0.230	0.235	0.235	0.235	0.235	0.235	0.237	0.237	0.239	0.239	0.238	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1992	1993	1994	1995	1996
74LS TTL					
74LS00	0.108	0.110	0.100	0.100	0.100
74LS74	0.117	0.113	0.110	0.110	0.110
74LS138	0.155	0.155	0.145	0.140	0.140
74LS244	0.217	0.210	0.195	0.190	0.190
74S TTL					
74S00	0.145	0.150	0.145	0.145	0.145
74S74	0.173	0.175	0.174	0.174	0.174
74S138	0.260	0.260	0.259	0.259	0.259
74S244	0.500	0.500	0.495	0.495	0.495
74F TTL					
74FOO	0.100	0.105	0.105	0.105	0.105
74F74	0.120	0.115	0.110	0.110	0.110
74F138	0.155	0.151	0.145	0.145	0.145
74F244	0.220	0.215	0.205	0.200	0.200
74HC CMOS					
74HC00	0.108	0.110	0.110	0.110	0.110
74HC74	0.123	0.130	0.128	0.128	0.128
74HC138	0.159	0.165	0.160	0.160	0.160
74HC244	0.235	0.238	0.239	0.239	0.239

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

Table 3
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
74AC CMOS												2-6
74AC00	0.192	0.180	0.175	0.170	0.170	0.174	0.170	0.170	0.170	0.170	0.170	
74AC74	0.263	0.250	0.245	0.225	0.220	0.235	0.210	0.210	0.204	0.200	0.206	
74AC138	0.334	0.295	0.280	0.280	0.280	0.284	0.280	0.280	0.280	0.280	0.280	
74AC244	0.484	0.440	0.420	0.400	0.400	0.415	0.390	0.390	0.360	0.360	0.375	
74ALS TTL												6
74ALS00	0.128	0.120	0.118	0.115	0.115	0.117	0.115	0.115	0.115	0.115	0.115	
74ALS74	0.154	0.140	0.135	0.135	0.135	0.136	0.135	0.135	0.135	0.135	0.135	
74ALS138	0.278	0.260	0.260	0.250	0.250	0.255	0.250	0.250	0.250	0.250	0.250	
74ALS244	0.382	0.340	0.330	0.320	0.320	0.328	0.310	0.310	0.300	0.300	0.305	
74AS TTL												8
74AS00	0.170	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	
74AS74	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.179	0.179	0.179	0.179	
74AS138	0.460	0.425	0.420	0.420	0.420	0.421	0.420	0.420	0.420	0.420	0.420	
74AS244	0.755	0.730	0.720	0.720	0.720	0.723	0.700	0.700	0.700	0.700	0.700	
74BC*												4-8
74BC00	0.328	0.297	0.286	0.279	0.272	0.284	0.270	0.268	0.265	0.263	0.267	
74BC244	0.796	0.725	0.698	0.672	0.648	0.686	0.645	0.641	0.638	0.636	0.640	
74BC373	0.799	0.726	0.700	0.674	0.649	0.687	0.646	0.642	0.639	0.637	0.641	
10KH ECL												6
10H102	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	
10H173	1.200	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 4
Estimated Long-Range Standard Logic Price Trends—North American Bookings (Volume: 100,000 per Year; Package; PLCC; Dollars)

Product	1992	1993	1994	1995	1996
74AC CMOS					
74AC00	0.174	0.170	0.173	0.170	0.170
74AC74	0.235	0.206	0.200	0.195	0.195
74AC138	0.284	0.280	0.276	0.270	0.270
74AC244	0.415	0.375	0.370	0.350	0.350
74ALS TTL					
74ALS00	0.117	0.115	0.110	0.110	0.110
74ALS74	0.136	0.135	0.125	0.125	0.125
74ALS138	0.255	0.250	0.250	0.249	0.249
74ALS244	0.328	0.305	0.305	0.300	0.300
74AS TTL					
74AS00	0.160	0.160	0.155	0.155	0.155
74AS74	0.180	0.179	0.179	0.179	0.179
74AS138	0.421	0.420	0.415	0.400	0.400
74AS244	0.723	0.700	0.700	0.690	0.690
74BC*					
74BC00	0.284	0.267	0.260	0.242	0.242
74BC244	0.686	0.640	0.611	0.587	0.587
74BC373	0.687	0.641	0.612	0.588	0.588
10KH ECL					
10H102	0.490	0.490	0.490	0.490	0.490
10H173	1.100	1.100	1.100	1.100	1.100

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 5
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
68000-12	5.58	5.50	5.50	5.50	5.50	5.50	5.00	5.00	5.00	5.00	5.00	2-4
68EC000-8	NA	3.00	2.95	2.85	2.75	2.89	2.75	2.65	2.56	2.50	2.62	4-8
80186-8 PLCC	6.33	5.75	5.65	5.50	5.50	5.60	5.50	5.50	5.50	5.50	5.50	6-8
80C186-10 PLCC	NA	9.95	9.95	9.45	9.25	9.65	9.00	9.00	8.75	8.75	8.88	5-8
80286-10 PLCC	6.54	5.00	4.75	4.50	3.75	4.50	3.75	3.75	3.75	3.75	3.75	3-10
80286-16 PLCC	13.50	9.25	8.00	7.05	6.25	7.64	5.75	5.75	5.75	5.50	5.69	2-10
68020-16 PQFP	35.69	29.00	29.00	27.00	26.00	27.75	24.00	24.00	24.00	23.00	23.75	2-4
68EC020-16 PQFP	NA	17.00	16.00	15.75	15.50	16.06	15.00	14.20	13.50	13.00	13.93	4-8
68020-25 PQFP	NA	36.00	36.00	34.50	34.00	35.13	33.57	33.25	32.78	32.40	33.00	2-8
68EC020-25 PQFP	NA	21.00	20.20	19.75	19.00	19.99	18.00	18.00	18.00	18.00	18.00	2-4
68030-16 CQFP	NA	76.00	70.00	68.00	66.00	70.00	60.00	60.00	60.00	60.00	60.00	2-8
68030-25 CQFP	161.00	120.00	110.00	105.00	100.00	108.75	95.00	95.00	95.00	95.00	95.00	5-10
68EC030-25 PQFP	NA	37.00	36.50	35.25	35.00	35.94	34.65	34.30	33.96	33.79	34.18	4-8
68040-25	538.85	455.08	430.10	413.90	400.90	425.00	388.00	376.00	364.00	352.00	370.00	4-8
68EC040-25	NA	125.00	115.00	110.00	108.00	114.50	97.00	97.00	97.00	97.00	97.00	4-8
386SX-16 PQFP	57.74	53.82	49.00	45.12	42.00	47.49	39.00	36.00	35.00	34.00	36.00	2-6
386SX-20 PQFP	89.21	81.41	59.00	55.60	51.00	61.75	44.00	40.00	35.00	34.00	38.25	2-6
386SX-25 PQFP	NA	84.00	78.50	68.99	57.75	72.31	47.00	41.00	35.00	34.00	39.25	2-6
386SL-25 CPGA	NA	178.00	122.00	90.00	79.00	117.25	69.00	59.00	56.00	53.00	59.25	2-6
AM386-40	NA	180.00	150.00	92.50	78.20	125.18	69.88	66.15	62.10	58.43	64.14	6
386DX-25 PQFP[1]	157.61	148.00	99.00	74.00	68.00	97.25	65.00	63.00	60.00	57.00	61.25	4-8
80486SX-20 PQFP[1]	NA	237.00	201.00	99.00	96.00	158.25	93.00	90.00	86.00	82.00	87.75	4-8
80486DX-25[2]	533.75	409.00	405.00	365.00	325.00	376.00	300.00	200.00	180.00	160.00	210.00	6-8
80486DX-50	NA	610.00	565.00	505.00	455.00	533.75	357.18	339.32	325.00	305.00	331.62	6-8
80486DX2-50	NA	550.00	517.00	465.00	415.00	486.75	375.00	266.67	236.25	224.00	275.48	6-8
29000-25[3]	111.25	92.00	85.50	81.00	78.00	84.13	76.00	71.00	67.00	65.10	69.78	5-12
88100-25[3]	76.06	69.50	68.05	67.45	67.00	68.00	64.50	62.20	60.20	58.10	61.25	4-8
R3000-25[3]	131.75	105.00	96.00	94.00	93.40	97.10	90.00	87.00	84.00	81.00	85.50	6-9
SPARC-25[3]	88.74	75.62	72.30	69.51	66.55	71.00	64.50	62.88	61.60	60.60	62.40	NA
80960CA-25	NA	95.30	91.30	90.30	89.25	91.54	88.35	87.45	84.30	81.20	85.33	1-2

NA = Not available
[1] CPGA for 1991, Q1-1992.
[2] Pricing for 80486DX-33 is the same as the 25-MHz version, except for 1991
[3] Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 6
Estimated Long-Range Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
68000-12	5.50	5.00	4.50	4.00	4.00
68EC000-8	2.89	2.62	2.35	2.30	2.30
80186-8 PLCC	5.60	5.50	5.30	5.30	5.30
80C186-10 PLCC	9.65	8.88	7.25	6.75	6.50
80286-10 PLCC	4.50	3.75	NA	NA	NA
80286-16 PLCC	7.64	5.69	5.00	4.50	NA
68020-16 PQFP	27.75	23.75	17.00	17.00	17.00
68EC020-16 PQFP	16.06	13.93	12.00	11.00	10.00
68020-25 PQFP	35.13	33.00	31.04	31.00	31.00
68EC020-25 PQFP	19.99	18.00	17.00	16.00	15.50
68030-16 CQFP	70.00	60.00	59.00	58.94	58.94
68030-25 CQFP	108.75	95.00	94.00	94.09	93.15
68EC030-25 PQFP	35.94	34.18	32.10	30.50	30.00
68040-25	425.00	370.00	332.50	325.00	325.00
68EC040-25	114.50	97.00	92.00	87.00	83.00
386SX-16 PQFP	47.49	36.00	28.00	24.00	20.00
386SX-20 PQFP	61.75	38.25	28.00	24.00	20.00
386SX-25 PQFP	72.31	39.25	28.00	24.00	20.00
386SL-25 CPGA	117.25	59.25	43.00	37.00	31.00
AM386-40	125.18	64.14	47.00	40.00	34.00
386DX-25 PQFP[1]	97.25	61.25	47.00	40.00	34.00
80486SX-20 PQFP[1]	158.25	87.75	74.00	62.00	53.00
80486DX-25	376.00	210.00	112.75	94.86	80.19
80486DX-33	376.00	210.00	112.75	94.86	80.19
80486DX-50	533.75	331.62	135.30	109.09	84.19
80486DX2-50	486.75	275.48	124.03	101.97	80.99
29000-25[2]	84.13	69.78	63.00	58.00	55.00
88100-25[2]	68.00	61.25	56.00	51.00	50.00
R3000-25[2]	97.10	85.50	74.00	65.00	60.00
SPARC-25[2]	71.00	62.40	59.00	53.66	53.00
80960CA-25	91.54	85.33	77.14	75.21	75.21

NA = Not available

[1]CPGA for 1991, Q1-1992.

[2]Pricing excludes accessory parts such as floating point and memory management.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 7
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
256Kx1 DRAM 80ns DIP	1.75	1.60	1.60	1.50	1.50	1.55	1.50	1.50	1.50	1.50	1.50	1-6
64Kx4 VRAM 120ns ZIP	3.20	2.95	2.70	2.70	2.70	2.76	2.65	2.65	2.65	2.65	2.65	5-10
1Mbx1 DRAM 80ns (DIP/SOJ)	4.35	3.80	3.50	3.45	3.40	3.54	3.40	3.40	3.40	3.40	3.40	1-6
64Kx16 DRAM 80ns SOJ	6.90	5.65	5.19	4.93	4.67	5.11	4.49	4.33	4.22	4.13	4.29	4-8
256Kx4 VRAM 100ns ZIP	9.31	7.75	7.30	6.85	6.56	7.12	6.18	5.95	5.55	5.25	5.73	4-13
128Kx8 VRAM 100ns SOJ	10.01	8.05	7.65	7.25	6.91	7.47	6.58	6.30	5.90	5.60	6.10	2-8
4Mbx1 DRAM 80ns SOJ	16.96	13.13	12.05	11.05	10.15	11.60	9.50	8.90	8.40	7.90	8.68	1-12
1Mbx4 DRAM 60ns SOJ	NA	14.45	13.25	11.96	10.91	12.64	10.17	9.35	8.78	8.18	9.12	2-9
512Kx8 DRAM 70ns	NA	NA	15.08	13.78	12.36	NA	11.23	10.56	9.89	9.27	10.24	4-8
256Kx16 DRAM 70ns SOJ	NA	16.00	15.50	13.99	12.79	14.57	11.75	11.00	10.30	9.75	10.70	4-8
256Kx18 DRAM 80ns SOJ	NA	17.07	16.75	15.55	14.70	16.02	13.75	13.00	12.40	12.00	12.79	1-6
1Mbx8 SIMM 100ns (2 pc)	NA	30.00	27.00	24.98	24.00	26.49	22.00	20.90	20.18	19.25	20.58	1-8
1Mbx9 SIMM 80ns (3 pc)	NA	33.27	30.45	28.79	27.72	30.06	25.00	23.77	22.00	20.75	22.88	1-8
256Kx9 SIMM 100ns	13.85	12.70	12.53	12.65	12.50	12.59	12.50	12.50	12.50	12.50	12.50	1-8
256Kx36 SIMM 80ns[2]	49.86	47.00	44.40	42.20	40.00	43.40	37.17	35.50	34.30	33.81	35.19	1-8
512Kx36 SIMM 80ns (24 pc)	NA	82.00	80.40	77.75	75.39	78.88	73.00	71.00	69.00	68.00	70.25	2-8
4Mbx9 SIMM 80ns (9pc)	NA	130.2	116.8	112.5	107.4	116.7	96.35	88.00	82.00	77.50	85.96	2-8
1Mbx36 SIMM 80ns (9pc)	NA	131.0	122.0	107.0	100.0	115.0	97.00	87.00	80.00	76.00	85.00	2-8
4Mbx4 DRAM 70ns SOJ 400 mil	NA	180.0	149.0	119.6	95.0	135.9	83.25	74.18	66.09	57.25	70.19	12-24

NA = Not available
[1]Contract volume = at least 100,000 per order except VRAMs.
[2]Two-piece solution for 1993.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 8
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; Dollars)[1]

Product	1992 Year	1993 Year	1994 Year	1995 Year	Year 1996
256Kx1 DRAM 80ns DIP	1.55	1.50	1.65	1.85	2.00
64Kx4 VRAM 120ns ZIP	2.76	2.65	2.40	2.40	2.40
1Mbx1 DRAM 80ns (DIP/SOJ)	3.54	3.40	3.55	3.55	3.70
64Kx16 DRAM 80ns SOJ	5.11	4.29	4.12	4.12	4.15
256Kx4 VRAM 100ns ZIP	7.12	5.73	5.00	4.95	4.95
128Kx8 VRAM 100ns SOJ	7.47	6.10	5.25	5.15	5.15
4Mbx1 DRAM 80ns SOJ	11.60	8.68	6.06	5.50	5.50
1Mbx4 DRAM 60ns SOJ	12.64	9.12	6.15	5.56	5.55
512Kx8 DRAM 70ns	NA	10.24	6.21	5.69	5.60
256Kx16 DRAM 70ns SOJ	14.57	10.70	6.36	5.72	5.72
256Kx18 DRAM 80ns SOJ	16.02	12.79	6.54	5.91	5.90
1Mbx8 SIMM 100ns (2 pc)	26.49	20.58	15.44	15.00	14.00
1Mbx9 SIMM 80ns (3 pc)	30.06	22.88	16.44	16.00	15.00
256Kx9 SIMM 100ns	12.59	12.50	12.00	NA	NA
256Kx36 SIMM 80ns[2]	43.40	35.19	27.28	23.07	20.91
512Kx36 SIMM 80ns (24 pc)	78.88	70.25	56.20	45.54	45.00
4Mbx9 SIMM 80ns (9pc)	116.71	85.96	60.17	56.35	56.00
1Mbx36 SIMM 80ns (9pc)	115.0	85.00	59.50	57.75	56.10
4Mbx4 DRAM 70ns SOJ 400 mil	135.9	70.19	30.00	18.50	14.00

NA = Not available

[1]Contract volume = at least 100,000 per order except VRAMs.

[2]Two-piece solution for 1993-1996.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 9
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
4Kx4 25ns	2.39	2.30	2.25	2.10	2.10	2.19	2.00	2.00	2.00	2.00	2.00	3-12
2Kx8 25ns	2.49	2.40	2.35	2.20	2.20	2.29	2.00	2.00	2.00	2.00	2.00	2-13
64Kx1 25ns	3.55	3.55	3.30	3.25	3.20	3.33	3.00	3.00	3.00	3.00	3.00	3-12
16Kx4 25ns	3.52	2.70	2.50	2.38	2.32	2.48	2.20	2.20	2.20	2.20	2.20	7-14
8Kx8 25ns	3.69	3.30	2.60	2.35	2.25	2.63	2.17	2.17	2.17	2.17	2.17	1-10
16Kx4 35ns	3.13	2.60	2.40	2.37	2.33	2.43	2.22	2.22	2.20	2.20	2.21	6-11
8Kx8 45ns	3.17	2.55	2.45	2.35	2.25	2.40	2.15	2.15	2.15	2.15	2.15	8
8Kx8 100-120ns	2.01	2.05	1.85	1.65	1.65	1.80	1.55	1.55	1.55	1.55	1.55	1-10
64Kx4 10ns	NA	36.90	32.80	23.34	20.84	28.47	18.80	17.04	15.42	14.02	16.32	2
64Kx4 25ns	9.71	7.50	6.50	6.04	5.67	6.43	5.18	4.99	4.80	4.60	4.89	1-12
32Kx8 12ns	NA	23.58	21.53	16.54	14.80	19.11	13.61	12.50	11.31	10.60	12.01	2-10
32Kx8 35ns	8.54	6.28	6.10	5.75	5.60	5.93	5.16	5.06	4.91	4.65	4.95	5-10
32Kx8 100ns SOJ	4.18	4.05	4.05	4.00	4.00	4.03	4.00	4.00	4.00	4.00	4.00	4-9
256Kx4 20ns	NA	58.83	51.04	37.30	34.50	45.42	30.50	27.00	25.25	23.00	26.44	8-12
128Kx8 20ns	NA	58.64	50.16	41.00	35.81	46.40	30.60	27.35	25.50	23.25	26.68	8-12
128Kx8 25ns	67.53	44.00	37.50	31.75	27.00	35.06	24.00	21.25	19.00	17.00	20.31	8-12
128Kx8 100ns SOJ	16.22	13.50	11.55	10.46	9.25	11.19	9.00	8.85	8.65	8.45	8.74	2-10

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (June 1992)

Table 10
Estimated Long-Range Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1992	1993	1994	1995	1996
4Kx4 25ns	2.19	2.00	1.70	1.50	1.35
2Kx8 25ns	2.29	2.00	1.72	1.51	1.35
64Kx1 25ns	3.33	3.00	2.67	2.35	2.35
16Kx4 25ns	2.48	2.20	1.90	1.60	1.35
8Kx8 25ns	2.63	2.17	1.87	1.58	1.33
16Kx4 35ns	2.43	2.21	1.90	1.60	1.35
8Kx8 45ns	2.40	2.15	1.85	1.55	1.33
8Kx8 100-120ns	1.80	1.55	1.35	1.35	1.75
64Kx4 10ns	28.47	16.32	9.25	7.05	5.20
64Kx4 25ns	6.43	4.89	4.45	3.68	2.99
32Kx8 12ns	19.11	12.01	8.60	6.70	5.00
32Kx8 35ns	5.93	4.95	4.35	3.63	2.95
32Kx8 100ns SOJ	4.03	4.00	3.50	3.00	3.00
256Kx4 20ns	45.42	26.44	11.75	9.00	6.25
128Kx8 20ns	46.40	26.68	11.95	9.22	6.30
128Kx8 25ns	35.06	20.31	10.06	8.00	6.10
128Kx8 100ns SOJ	11.19	8.74	5.75	4.74	4.25

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 11
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above, 28-Pin PDIP;
≥2Mb Density—200ns and above, 32-Pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1991 Year	Q1	1992 Q2	Q3	Q4	1992 Year	Q1	1993 Q2	Q3	Q4	1993 Year	Current Lead Time (Weeks)
CMOS												
32Kx8 ROM	1.59	1.50	1.50	1.50	1.50	1.50	1.45	1.45	1.45	1.45	1.45	4-8
64Kx8 ROM	2.08	1.90	1.85	1.80	1.75	1.83	1.80	1.75	1.75	1.75	1.76	4-8
128Kx8 ROM	2.26	2.01	1.95	1.80	1.80	1.89	1.80	1.80	1.80	1.75	1.79	5-8
64Kx16 ROM	2.84	2.20	2.20	1.80	1.80	2.00	1.80	1.80	1.80	1.80	1.80	5-8
256Kx8 ROM	3.18	2.76	2.73	2.55	2.55	2.65	2.50	2.50	2.50	2.50	2.50	5-8
512Kx8 ROM	4.01	3.95	3.79	3.50	3.50	3.69	3.50	3.50	3.50	3.50	3.50	5-8
256Kx16 ROM[1]	5.01	4.05	3.86	3.50	3.50	3.73	3.50	3.50	3.50	3.50	3.50	5-8
1Mbx8 ROM[2]	NA	6.33	6.20	5.65	5.60	5.95	5.55	5.50	5.45	5.40	5.48	6-8
1Mbx16 ROM	NA	NA	NA	10.65	10.35	NA	10.05	9.80	9.55	9.30	9.68	6-8
2Mbx8 ROM	NA	15.25	13.00	11.90	11.50	12.91	11.15	10.70	9.75	9.35	10.24	4-8

NA = Not available
[1]150ns and above; 40-Pin PDIP.
[2]150ns and above; 32-Pin SOP.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 12
Estimated Long-Range ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above, 28-Pin PDIP;
≥2Mb Density—200ns and above, 32-Pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
CMOS					
32Kx8 ROM	1.50	1.45	1.45	NA	NA
64Kx8 ROM	1.83	1.76	1.70	1.70	NA
128Kx8 ROM	1.89	1.79	1.70	1.70	1.70
64Kx16 ROM	2.00	1.80	1.70	1.70	1.70
256Kx8 ROM	2.65	2.50	2.40	2.34	2.34
512Kx8 ROM	3.69	3.50	3.30	3.10	3.05
256Kx16 ROM[1]	3.73	3.50	3.32	3.11	3.05
1Mbx8 ROM[2]	5.95	5.48	5.00	4.50	4.15
1Mbx16 ROM	NA	9.68	8.00	6.55	6.35
2Mbx8 ROM	12.91	10.24	8.25	6.75	6.50

NA = Not available
[1]150ns and above; 40-Pin PDIP.
[2]150ns and above; 32-Pin SOP.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

Table 13
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
TTL												
4K PROM PDIP	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM PDIP	2.26	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM PDIP	5.05	4.70	4.60	4.50	4.50	4.58	4.50	4.50	4.50	4.50	4.50	6-8
64K PROM PDIP	6.95	6.62	6.47	6.36	6.23	6.42	6.05	5.93	5.85	5.83	5.92	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 14
Estimated Long-Range Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

Product	1992	1993	1994	1995	1996
TTL					
4K PROM	1.00	1.00	NA	NA	NA
16K PROM	2.40	2.40	NA	NA	NA
32K PROM	4.58	4.50	4.50	NA	NA
64K PROM	6.42	5.92	5.54	5.45	5.45

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This price forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

Table 15
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8Kx8 EPROM	1.73	1.75	1.67	1.60	1.55	1.64	1.45	1.45	1.45	1.45	1.45	2-12
16Kx8 EPROM	1.82	1.83	1.75	1.75	1.75	1.77	1.60	1.60	1.60	1.60	1.60	2-8
32Kx8 EPROM	1.91	1.80	1.62	1.57	1.53	1.63	1.50	1.48	1.43	1.40	1.45	2-8
64Kx8 EPROM	2.73	2.37	2.36	2.34	2.31	2.34	2.26	2.22	2.18	2.20	2.21	2-8
128Kx8 EPROM	4.41	3.25	3.15	3.03	3.00	3.11	2.80	2.70	2.65	2.60	2.69	2-8
256Kx8 EPROM	9.88	7.27	6.68	6.49	6.10	6.64	6.00	5.90	5.75	5.60	5.81	2-8
128Kx16 EPROM	NA	7.90	7.11	6.61	6.22	6.96	6.09	5.99	5.89	5.80	5.94	4-8
512Kx8 EPROM	NA	14.00	11.75	11.05	10.70	11.88	10.06	9.70	9.36	9.00	9.53	4-14
256Kx16 EPROM	NA	15.50	15.00	14.50	14.00	14.75	12.00	10.72	10.34	9.98	10.76	4-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 16
Estimated Long-Range EPROM Pricing—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

Product	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
8Kx8 EPROM	1.64	1.45	1.45	1.50	1.50
16Kx8 EPROM	1.77	1.60	1.60	1.60	1.60
32Kx8 EPROM	1.63	1.45	1.40	1.45	1.50
64Kx8 EPROM	2.34	2.21	2.20	2.25	2.30
128Kx8 EPROM	3.11	2.69	2.60	2.80	2.85
256Kx8 EPROM	6.64	5.81	5.60	5.40	5.40
128Kx16 EPROM	6.96	5.94	5.69	5.48	5.48
512Kx8 EPROM	11.88	9.53	8.60	8.00	7.80
256Kx16 EPROM	14.75	10.76	9.75	8.90	8.25

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

Table 17
Estimated OTP ROM Price Trends-North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
16Kx8	1.45	1.49	1.49	1.49	1.49	1.49	1.34	1.34	1.34	1.34	1.34	1-12
32Kx8	1.51	1.56	1.56	1.56	1.56	1.56	1.31	1.31	1.31	1.31	1.31	2-12
64Kx8	2.51	2.19	2.10	2.01	1.98	2.07	1.95	1.95	1.95	1.95	1.95	2-12
128Kx8	4.23	2.85	2.76	2.73	2.70	2.76	2.56	2.48	2.45	2.39	2.47	6-12

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 18
Estimated Long-Range OTP ROM Prices-North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

Product	1992	1993	1994	1995	1996
16Kx8	1.49	1.34	1.34	NA	NA
32Kx8	1.56	1.31	1.31	NA	NA
64Kx8	2.07	1.95	1.85	1.80	1.80
128Kx8	2.76	2.47	2.20	2.10	2.00

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 19
Estimated EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
2Kx8 EEPROM	3.09	2.85	2.60	2.40	2.30	2.54	2.00	1.90	1.85	1.80	1.89	1-5
8Kx8 EEPROM	4.64	4.00	3.80	3.61	3.43	3.71	3.29	3.16	3.04	2.91	3.10	1-8
32Kx8 EEPROM	19.80	14.00	12.40	11.00	9.78	11.80	9.25	9.01	8.78	8.50	8.89	1-4
64Kx8 EEPROM	56.00	21.25	19.13	17.21	15.84	18.36	14.90	14.00	14.00	14.00	14.23	1-6
128Kx8 EEPROM	127.50	100.00	87.00	75.00	65.00	81.75	56.00	51.50	48.00	44.00	49.88	5-12

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, or volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 20
Estimated Long-Range EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

Product	1992	1993	1994	1995	1996
2Kx8 EEPROM	2.54	1.89	1.70	1.70	1.70
8Kx8 EEPROM	3.71	3.10	2.60	2.40	2.25
32Kx8 EEPROM	11.80	8.89	8.00	7.00	6.50
64Kx8 EEPROM	18.36	14.23	12.00	10.39	9.80
128Kx8 EEPROM	81.75	49.88	38.72	34.46	30.67

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, or volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 21
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
32Kx8, PDIP	6.08	5.80	5.50	5.20	4.94	5.36	4.75	4.56	4.40	4.30	4.50	4-8
64Kx8, PDIP	NA	7.15	6.80	6.30	6.00	6.56	5.60	5.25	5.10	4.95	5.23	4-8
128Kx8, PDIP	NA	8.50	8.00	7.50	7.00	7.75	6.75	6.50	6.25	5.95	6.36	4-8
128Kx8, TSOP	13.50	9.18	8.86	8.59	8.37	8.75	8.08	7.86	7.64	7.44	7.75	4-8
256Kx8, TSOP	24.88	15.00	14.00	13.50	13.10	13.90	12.55	12.15	11.80	11.60	12.03	4-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 22
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
32Kx8, PDIP	5.36	4.50	3.60	3.24	3.08
64Kx8, PDIP	6.56	5.23	4.18	3.76	3.57
128Kx8, PDIP	7.75	6.36	4.26	4.13	3.72
128Kx8, TSOP	8.75	7.75	4.65	4.25	4.22
256Kx8, TSOP	13.90	12.03	7.22	6.70	6.54

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

Table 23
Estimated Gate Array Pricing—North American Production Bookings
(Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K gates, 160-Pin PQFP for 10K-29.9K, 208-Pin PQFP for ≥30K gates; ECL—CQFP) (Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test) (Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	135	135	120	120	110	110	10-12
1.2 Micron	120	115	90	88	75	75	8-12
1.0 Micron	115	110	85	78	70	62	8-12
0.8 Micron	NA	NA	87	79	70	62	10-16
ECL	4850	4268	3823	3326	3000	3000	12
NRE Charges ($1,000s)							
CMOS							Prototypes:
1.5 Micron	16.0	15.2	21.0	20.0	26.0	24.7	3-5
1.2 Micron	13.0	12.4	17.0	16.2	20.0	20.0	2-4
1.0 Micron	19.0	18.1	24.0	24.0	28.0	28.0	2-4
0.8 Micron	NA	NA	26.0	26.0	30.0	30.0	3-5
ECL	30.0	27.0	45.0	40.5	50.0	45.0	14

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	100	100	90	78	95	95	NA	NA	10-12
1.2 Micron	65	65	76	76	93	93	NA	NA	8-12
1.0 Micron	65	60	69	59	73	63	79	70	10-12
0.8 Micron	65	58	65	58	72	62	77	66	10-16
ECL	3300	2790	3200	2784	3050	2654	3050	2654	12
NRE Charges ($1,000s)									
CMOS									Prototypes:
1.5 Micron	40.5	40.0	60.0	57.0	100.0	95.0	NA	NA	3-6
1.2 Micron	40.0	38.0	58.0	55.1	102.0	96.9	NA	NA	3-8
1.0 Micron	44.0	42.9	60.0	57.0	96.7	90.9	140.0	135.0	3-5
0.8 Micron	51.7	50.4	65.0	64.0	105.0	104.5	142.0	137.0	3-5
ECL	70.0	65.0	100.0	90.0	146.7	132.0	NA	NA	14

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discounts. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 24
Estimated CBIC Pricing—North American Production Bookings
(Millicents per Gate) (Package: 84-Pin PLCC for <10K Gates; 160-Pin PQFP for 10K-29.9K; 208-Pin PQFP for ≥30K) (Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototypes) (Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates		2-4.99K Gates		5-9.99K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS							Production:
1.5 Micron	112	100	90	88	107	107	10-14
1.2 Micron	100	100	90	80	79	77	8-15
1.0 Micron	110	100	90	85	70	69	10-16
0.8 Micron	NA	NA	91	85	70	65	13-16
NRE Charges ($1,000s)							Prototypes:
1.5 Micron	35.0	33.3	38.0	36.1	47.0	44.7	5-8
1.2 Micron	32.0	30.4	35.0	33.3	43.5	41.3	5-8
1.0 Micron	42.0	41.2	49.0	45.0	53.0	47.5	5-8
0.8 Micron	NA	NA	75.0	55.0	77.0	57.0	6-8

Gate Count	10-19.99K Gates		20-29.99K Gates		30-59.9K Gates		60-100K Gates		Current Lead
Technology	1992	1993	1992	1993	1992	1993	1992	1993	Time (Weeks)
CMOS									Production:
1.5 Micron	105	105	95	80	99	96	NA	NA	10-14
1.2 Micron	70	70	77	76	95	95	NA	NA	9-15
1.0 Micron	69	66	68	62	75	67	73	62	10-16
0.8 Micron	69	63	67	60	74	65	75	61	13-16
NRE Charges ($1,000s)									Prototypes:
1.5 Micron	65.0	61.8	85.0	80.8	110.0	103.4	NA	NA	5-8
1.2 Micron	58.5	55.6	75.0	71.3	100.0	97.0	NA	NA	5-8
1.0 Micron	77.5	77.5	100.0	90.0	125.0	115.0	155.0	140.0	5-8
0.8 Micron	95.0	85.0	125.0	105.0	155.0	133.0	159.0	143.5	6-8

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 25
Estimated TTL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20						
	< or = 6	6.25	5.85	5.50	5.15	2-10
	6.1 - 7.5	2.35	2.10	2.00	1.85	2-12
	7.6 - 10.0	1.35	1.20	1.15	1.05	2-12
	10.1 - 14.99	1.27	1.15	1.05	1.05	2-8
	15 - <25	0.60	0.57	0.55	0.55	2-4
	> or = 25	0.46	0.43	0.42	0.42	2-4
24	< or = 6	9.20	8.80	7.25	6.95	2-12
	6.1 - 7.5	4.35	4.06	3.60	3.25	2-12
	7.6 - 10.0	2.60	2.50	2.15	2.05	2-12
	10.1 - 14.99	2.43	2.18	2.09	1.99	3-6
	15 - <25	1.00	0.96	0.94	0.90	2-4
	> or = 25	0.72	0.71	0.68	0.66	2-4
24						
22V10						
	15 - <25	4.00	3.80	3.30	3.10	3-8
	25 - <35	2.15	1.90	1.60	1.50	2-8

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 26
Estimated Long-Range TTL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992	1993	1994	1995	1996
≤20						
	< or = 6	6.05	5.33	4.79	4.55	4.44
	6.1 - 7.5	2.23	1.93	1.76	1.73	1.70
	7.6 - 10.0	1.28	1.10	0.99	0.94	0.89
	10.1 - 14.99	1.21	1.05	1.05	1.00	1.00
	15 - <25	0.59	0.55	0.51	0.50	0.50
	> or = 25	0.45	0.42	0.40	0.40	0.40
24						
	< or = 6	9.00	7.10	6.00	5.50	5.45
	6.1 - 7.5	4.20	3.43	3.15	3.00	2.85
	7.6 - 10.0	2.55	2.10	1.89	1.84	1.81
	10.1 - 14.99	2.30	2.04	1.95	1.90	1.90
	15 - <25	0.98	0.92	0.90	0.87	0.85
	> or = 25	0.72	0.67	0.65	0.65	0.65
24						
22V10						
	15 - <25	3.90	3.20	2.88	2.74	2.67
	25 - <35	2.03	1.55	1.43	1.40	1.40

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 27
Estimated ECL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
24						
	≤2.0	30.00	28.00	25.00	23.00	4
	2.01-4.0	27.90	25.00	23.00	21.00	4
	4.1-6.0	5.80	5.71	5.58	5.50	4
	6.1-15.0	5.80	5.71	5.58	5.50	4

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 28
Estimated Long-Range ECL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1992	1993	1994	1995	1996
24						
	≤2.0	29.00	24.00	22.00	20.00	19.00
	2.01-4.0	26.45	22.00	21.00	19.00	18.00
	4.1-6.0	5.76	5.54	5.40	5.30	5.20
	6.1-15.0	5.76	5.54	5.40	5.30	5.20

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 29
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20	6.1 - 7.5	5.50	4.95	4.65	4.35	1-18
	7.6 - 10.0	3.05	2.20	2.00	1.83	1-12
	10.1 - 14.99	1.75	1.66	1.58	1.50	1-6
	15 - <25	0.78	0.73	0.70	0.68	1-6
	> or = 25	0.61	0.58	0.56	0.55	1-6
24						
	6.1 - 7.5	9.07	6.50	6.63	5.75	1-20
	7.6 - 10.0	5.25	3.85	3.48	3.18	1-18
	10.1 - 14.99	2.70	2.54	2.39	2.23	1-6
	15 - <25	1.15	0.99	0.94	0.94	1-8
	> or = 25	0.95	0.90	0.94	0.94	1-6
24						
22V10						
	6.1 - 7.5	20.00	19.00	18.00	17.00	1-4
	7.6 - 10.0	14.00	10.50	7.25	6.00	2-4
	15 - <25	4.25	3.63	3.00	2.63	1-4
	25 - <35	2.47	1.95	1.70	1.60	1-4

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume price. These prices are intended as guidelines.

Source: Dataquest (June 1992)

Table 30
Estimated Long-Range CMOS PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992	1993	1994	1995	1996
≤20						
	6.1 - 7.5	5.23	4.50	4.00	3.75	3.54
	7.6 - 10.0	2.63	1.91	1.50	1.40	1.32
	10.1 - 14.99	1.70	1.54	1.17	1.12	1.06
	15 - <25	0.75	0.69	0.60	0.56	0.52
	> or = 25	0.60	0.55	0.44	0.42	0.42
24						
	6.1 - 7.5	7.79	6.19	5.25	4.95	4.50
	7.6 - 10.0	4.55	3.33	2.50	2.25	2.10
	10.1 - 14.99	2.62	2.31	1.50	1.40	1.30
	15 - <25	1.07	0.94	0.90	0.85	0.80
	> or = 25	0.92	0.94	0.90	0.85	0.80
24						
22V10						
	6.1 - 7.5	19.50	17.50	15.30	13.77	13.08
	7.6 - 10.0	12.25	6.63	6.00	5.50	5.15
	15 - <25	3.94	2.81	2.25	2.05	1.95
	25 - <35	2.21	1.65	1.60	1.50	1.50

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume price. These prices are intended as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 31
Estimated Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Times (Weeks)
Voltage Regulators					
78L05 (TO-92)	0.120	0.118	0.117	0.117	10-12
7805 (TO-220)	0.138	0.137	0.137	0.137	
Comparators					
LM339	0.137	0.137	0.132	0.130	10-12
LM393	0.129	0.127	0.127	0.127	
Op Amps					
741	0.130	0.125	0.128	0.128	10-12
3403P	0.182	0.178	0.176	0.174	
1741CP1	0.124	0.120	0.119	0.117	
Interface ICs					
1488P	0.150	0.150	0.146	0.144	6-8
3486P	0.895	0.885	0.880	0.860	
Telecom IC					6-8
CODEC/FILTER #1	1.850	1.776	1.723	1.680	
CODEC/FILTER #2	4.330	4.121	3.915	3.719	
XR-T5683	3.60	3.50	3.41	3.33	
34017P	0.330	0.320	0.315	0.305	
Video DAC					
IMSG171D-35 MHz	1.800	1.700	1.600	1.500	NA

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (June 1992)

Table 32
Estimated Long-Range Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
Voltage Regulators					
78L05 (TO-92)	0.119	0.117	0.117	0.116	0.116
7805 (TO-220)	0.138	0.137	0.137	0.137	0.137
Comparators					
LM339	0.137	0.131	0.130	0.130	0.130
LM393	0.128	0.127	0.127	0.126	0.126
Op Amps					
741	0.128	0.128	0.128	0.128	0.128
3403P	0.180	0.175	0.174	0.171	0.171
1741CP1	0.122	0.118	0.117	0.116	0.116
Interface ICs					
1488P	0.150	0.145	0.144	0.137	0.137
3486P	0.890	0.870	0.860	0.840	0.830
Telecom IC					
CODEC/FILTER 1	1.813	1.701	1.616	1.535	1.500
CODEC/FILTER 2	4.225	3.817	3.550	3.301	3.136
XR-T5683	3.550	3.370	3.201	3.073	2.950
34017P	0.325	0.310	0.305	0.298	0.290
Video DAC					
IMSG171D-35 MHz	1.750	1.550	1.440	1.390	1.370

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 33
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Small-Signal Transistors					2-8
2N2222A	0.140	0.140	0.139	0.139	
2N3904	0.030	0.030	0.029	0.029	
2N2907A	0.068	0.068	0.066	0.066	
MPSA 43	0.052	0.049	0.048	0.046	
2N2222	0.046	0.045	0.045	0.045	
Bipolar Power Transistors					3-8
2N3772	1.040	1.040	1.040	1.040	
2N3055A	0.700	0.700	0.690	0.690	
2N6107	0.235	0.235	0.235	0.235	
Power MOSFET					3-8
IRF530	0.400	0.380	0.370	0.370	
IRF540	1.000	1.000	0.990	0.990	
IRF9531	1.040	1.030	1.029	1.027	
IRF9520	0.416	0.414	0.411	0.409	
Small-Signal Diodes					1-8
1N4002	0.020	0.020	0.020	0.020	
1N645	0.047	0.046	0.045	0.045	
Power Diodes					2-8
1N3891	0.888	0.878	0.875	0.871	
1N3737	7.120	7.090	7.070	6.999	
1N4936	0.095	0.094	0.093	0.092	
Zener Diodes					2-8
1N829	1.165	1.165	1.165	1.165	
1N752A	0.026	0.025	0.025	0.025	
1N963B	0.026	0.025	0.025	0.025	
1N4735A	0.040	0.039	0.039	0.039	
1.5KE62A	0.625	0.610	0.608	0.600	
1.5KE30CA	1.230	1.200	1.192	1.180	
P6KE30CA	0.708	0.690	0.690	0.690	
Thyristors					2-8
2N6400	0.620	0.620	0.593	0.573	
2N4186	2.275	2.265	2.270	2.250	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 34
Estimated Long-Range Discrete Semiconductor Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Product	1992	1993	1994	1995	1996
Small-Signal Transistors					
2N2222A	0.140	0.139	0.138	0.138	0.138
2N3904	0.030	0.029	0.028	0.028	0.028
2N2907A	0.068	0.066	0.062	0.061	0.060
MPSA 43	0.050	0.047	0.046	0.045	0.045
2N2222	0.046	0.045	0.045	0.045	0.045
Bipolar Power Transistors					
2N3772	1.040	1.040	1.040	1.040	1.040
2N3055	0.700	0.690	0.680	0.670	0.670
2N6107	0.235	0.235	0.235	0.235	0.235
Power MOSFET					
IRF530	0.390	0.370	0.360	0.350	0.350
IRF540	1.000	0.990	0.980	0.975	0.970
IRF9531	1.035	1.028	1.022	1.020	1.018
IRF9520	0.415	0.410	0.408	0.406	0.405
Small-Signal Diodes					
1N4002	0.020	0.020	0.020	0.020	0.020
1N645	0.046	0.045	0.045	0.045	0.045
Power Diodes					
1N3891	0.883	0.873	0.864	0.860	0.858
1N3737	7.105	7.035	6.990	6.850	6.800
1N4936	0.094	0.092	0.090	0.089	0.088
Zener Diodes					
1N829	1.165	1.165	1.165	1.165	1.165
1N752A	0.026	0.025	0.025	0.025	0.025
1N963B	0.026	0.025	0.025	0.025	0.025
1N4735A	0.040	0.039	0.039	0.039	0.039
1.5KE62A	0.617	0.604	0.595	0.590	0.585
1.5KE30CA	1.215	1.186	1.160	1.155	1.150
P6KE30CA	0.699	0.690	0.681	0.671	0.665
Thyristors					
2N6400	0.620	0.583	0.562	0.556	0.556
2N4186	2.270	2.260	2.250	2.250	2.250

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.

Source: Dataquest (June 1992)

Table 35
Estimated Optoelectronic IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Round LED Lamps					6
T1 STD RED	0.052	0.052	0.050	0.049	
T1 3/4 STD RED	0.052	0.052	0.052	0.050	
T1 3/4 H.EF.RED	0.065	0.065	0.063	0.063	
Mold Frame LED					6
0.3 Digital Display	0.490	0.480	0.475	0.470	
0.6 Digital Display	0.500	0.500	0.480	0.470	
Optical Couplers					8-10
4N25	0.160	0.160	0.159	0.158	
4N36	0.200	0.200	0.200	0.200	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1992)

Table 36
Estimated Long-Range Optoelectronic IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

	1992	1993	1994	1995	1996
Optoelectronic					
Round LED Lamps					
T1 STD RED	0.052	0.050	0.048	0.047	0.047
T1 3/4 STD RED	0.052	0.051	0.050	0.048	0.048
T1 3/4 H.EF.RED	0.065	0.063	0.062	0.061	0.060
Mold Frame LED					
0.3 Digital Display	0.485	0.473	0.467	0.460	0.460
0.6 Digital Display	0.500	0.475	0.470	0.465	0.462
Optical Couplers					
4N25	0.160	0.159	0.158	0.156	0.155
4N36	0.200	0.200	0.200	0.200	0.200

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (June 1992)

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North American Semiconductor Price Outlook

Second Quarter 1992

Source: Dataquest

Market Statistics

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Semiconductor Procurement

North American Semiconductor Price Outlook

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North American Semiconductor Price Outlook: Second Quarter 1992

March 1992

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North American Semiconductor Price Outlook: Second Quarter 1992

Methodology and Sources

This *Source: Dataquest* document provides information on and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects price information on a quarterly basis from North American suppliers and major buyers of these products. North American bookings price information is analyzed by Semiconductor Procurement (SP) service analysts for consistency and reconciliation. The information finally is rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast. This document includes associated long-range forecasts.

For SP clients that use the SP online service, the prices presented here correlate with the quarterly and long-range price tables dated March 1992 in the SP online service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery performance, volume discount, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.

Table 1
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1991 Year	Q1	1992 Q2	Q3	Q4	1992 Year	Q1	1993 Q2	Q3	Q4	1993 Year	Current Lead Time (Weeks)
74LS TTL												1-6
74LS00	.100	.105	.105	.110	.110	.108	.110	.110	.110	.110	.110	
74LS74	.115	.117	.117	.117	.117	.117	.117	.117	.117	.117	.117	
74LS138	.150	.155	.155	.155	.155	.155	.155	.155	.155	.155	.155	
74LS244	.215	.215	.215	.215	.215	.215	.213	.213	.213	.213	.213	
74S TTL												1-6
74S00	.140	.145	.145	.145	.145	.145	.150	.150	.150	.150	.150	
74S74	.174	.170	.170	.170	.170	.170	.174	.174	.174	.174	.174	
74S138	.259	.259	.259	.259	.259	.259	.259	.259	.259	.259	.259	
74S244	.505	.500	.500	.500	.500	.500	.495	.495	.495	.495	.495	
74F TTL												1-6
74FOO	.100	.100	.100	.100	.100	.100	.101	.101	.101	.103	.102	
74F74	.118	.120	.120	.120	.120	.120	.115	.115	.115	.115	.115	
74F138	.165	.155	.155	.155	.155	.155	.152	.151	.150	.150	.151	
74F244	.228	.218	.218	.218	.218	.218	.212	.212	.212	.212	.212	
74HC CMOS												1-8
74HC00	.105	.105	.105	.110	.110	.108	.110	.110	.110	.110	.110	
74HC74	.120	.120	.120	.125	.125	.123	.128	.128	.128	.128	.128	
74HC138	.156	.158	.158	.158	.158	.158	.160	.160	.160	.160	.160	
74HC244	.230	.235	.235	.235	.235	.235	.237	.237	.239	.239	.238	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1991	1992	1993	1994	1995	1996
74LS TTL						
74LS00	.100	.108	.110	.110	.110	.110
74LS74	.115	.117	.117	.117	.117	.117
74LS138	.150	.155	.155	.152	.152	.152
74LS244	.215	.215	.213	.199	.195	.195
74S TTL						
74S00	.140	.145	.150	.145	.145	.145
74S74	.174	.170	.174	.174	.174	.174
74S138	.259	.259	.259	.259	.259	.259
74S244	.505	.500	.495	.495	.495	.495
74F TTL						
74FOO	.100	.100	.102	.107	.107	.107
74F74	.118	.120	.115	.110	.110	.110
74F138	.165	.155	.151	.149	.147	.147
74F244	.228	.218	.212	.212	.212	.212
74HC CMOS						
74HC00	.105	.108	.110	.110	.110	.110
74HC74	.120	.123	.128	.128	.128	.128
74HC138	.156	.158	.160	.160	.162	.162
74HC244	.230	.235	.238	.240	.242	.242

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 3
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1991	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
74AC CMOS												1-6
74AC00	.192	.183	.182	.181	.180	.181	.175	.175	.175	.175	.175	
74AC74	.263	.255	.254	.253	.253	.254	.247	.243	.240	.240	.243	
74AC138	.334	.305	.300	.295	.290	.298	.285	.280	.280	.280	.281	
74AC244	.484	.455	.445	.435	.425	.440	.419	.414	.410	.406	.412	
74ALS TTL												1-6
74ALS00	.128	.120	.118	.115	.115	.117	.115	.115	.115	.115	.115	
74ALS74	.154	.140	.135	.135	.135	.136	.135	.135	.135	.135	.135	
74ALS138	.278	.260	.260	.260	.260	.260	.260	.258	.254	.254	.257	
74ALS244	.382	.345	.345	.345	.345	.345	.340	.330	.330	.320	.330	
74AS TTL												1-6
74AS00	.170	.160	.160	.160	.160	.160	.160	.160	.160	.160	.160	
74AS74	.180	.180	.180	.180	.180	.180	.180	.179	.179	.179	.179	
74AS138	.460	.430	.430	.430	.430	.430	.420	.420	.420	.420	.420	
74AS244	.755	.740	.740	.740	.740	.740	.730	.730	.730	.730	.730	
74BC*												4-6
74BC00	.328	.297	.286	.279	.272	.284	.270	.268	.265	.263	.267	
74BC244	.796	.725	.698	.672	.648	.686	.645	.641	.638	.636	.640	
74BC373	.799	.726	.700	.674	.649	.687	.646	.642	.639	.637	.641	
10KH ECL												6
10H102	.490	.490	.490	.490	.490	.490	.490	.490	.490	.490	.490	
10H173	1.200	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	

*Pricing for 74BC excludes 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 4
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Product	1991	1992	1993	1994	1995	1996
74AC CMOS						
74AC00	.192	.181	.175	.173	.170	.170
74AC74	.263	.254	.243	.235	.225	.225
74AC138	.334	.298	.281	.276	.270	.270
74AC244	.484	.440	.412	.403	.395	.395
74ALS TTL						
74ALS00	.128	.117	.115	.115	.115	.115
74ALS74	.154	.136	.135	.135	.135	.135
74ALS138	.278	.260	.257	.252	.249	.249
74ALS244	.382	.345	.330	.320	.320	.320
74AS TTL						
74AS00	.170	.160	.160	.160	.160	.160
74AS74	.180	.180	.179	.179	.179	.179
74AS138	.460	.430	.420	.415	.400	.400
74AS244	.755	.740	.730	.700	.690	.690
74BC*						
74BC00	.328	.284	.267	.260	.242	.242
74BC244	.796	.686	.640	.611	.587	.587
74BC373	.799	.687	.641	.612	.588	.588
10KH ECL						
10H102	.490	.490	.490	.490	.490	.490
10H173	1.200	1.100	1.100	1.100	1.100	1.100

*Pricing for 74BC excludes 74ABT, 74BCT.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 5
Estimated Microprocessor and Peripheral Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8- and 16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
Z84C00-6	.98	.94	.94	.92	.92	.93	.92	.92	.92	.92	.92	5-8
68000-8	3.81	3.50	3.50	3.30	3.25	3.39	3.25	3.25	3.25	3.25	3.25	2-4
68000-12	5.58	5.50	5.50	5.50	5.50	5.50	5.45	5.45	5.45	5.45	5.45	2-4
68EC000-8	NA	3.00	2.95	2.85	2.75	2.89	2.75	2.65	2.56	2.50	2.62	4-8
68302-16	NA	28.00	26.00	22.00	21.00	24.25	21.00	20.69	20.48	20.27	20.61	4-8
80186-8 PLCC	6.33	5.75	5.65	5.50	5.50	5.60	5.50	5.50	5.50	5.50	5.50	6-8
80C186-10 PLCC	NA	9.95	9.95	9.45	9.25	9.65	9.00	9.00	8.75	8.75	8.88	5-8
80286-10 PLCC	6.54	5.25	4.75	4.50	4.00	4.63	4.00	4.00	4.00	4.00	4.00	3-10
80286-12 PLCC	6.87	5.25	4.75	4.50	4.00	4.63	4.00	4.00	4.00	4.00	4.00	2-10
80286-16 PLCC	13.50	9.25	8.00	7.05	6.25	7.64	6.00	6.00	6.00	6.00	6.00	2-10
80287-12	NA	77.00	70.00	63.00	59.00	67.25	59.00	59.00	59.00	59.00	59.00	1-10
68020-16 PQFP	35.69	29.00	29.00	27.00	26.00	27.75	24.00	24.00	24.00	23.00	23.75	2-4
68881-16 PLCC	21.88	15.00	15.00	14.25	14.00	14.56	13.50	13.00	12.50	12.00	12.75	2-4
68EC020-16 PQFP	NA	17.00	16.00	15.75	15.50	16.06	15.00	14.20	13.50	13.00	13.93	4-8
68020-25 PQFP	NA	36.00	36.00	34.50	34.00	35.13	33.57	33.25	32.78	32.40	33.00	2-8
68030-16 CQFP	NA	76.00	75.00	74.00	73.00	74.50	70.00	67.00	65.00	62.00	66.00	2-8
68882-16	50.00	31.00	30.50	29.50	29.00	30.00	28.72	28.57	28.37	28.33	28.50	2-4
68030-25 CQFP	161.00	120.00	118.00	116.00	115.00	117.25	114.10	110.00	105.00	100.00	107.28	5-10
68EC030-25 PQFP	NA	37.00	36.50	35.25	35.00	35.94	34.65	34.30	33.96	33.79	34.18	4-8
68040-25	538.85	455.08	430.10	413.90	400.90	425.00	388.00	376.00	364.00	352.00	370.00	4-8
68330-16	NA	18.00	18.00	17.50	17.50	17.75	17.50	16.00	15.00	14.00	15.63	4-8
68340-16	NA	24.00	23.25	22.50	22.25	23.00	22.03	21.81	21.59	21.48	21.73	2-4

(Continued)

Table 5 (Continued)
Estimated Microprocessor and Peripheral Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8- and 16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
80386SX-16 PQFP	57.74	53.82	49.24	49.12	48.30	50.12	47.84	47.84	47.38	46.92	47.50	2-8
80386SX-20 PQFP	89.21	81.41	63.57	61.60	60.00	66.65	57.60	56.00	54.40	52.00	55.00	2-8
AM386-40	NA	216.00	205.00	195.00	185.00	200.25	176.00	167.00	159.00	151.00	163.25	6
80386-25	157.61	148.00	99.00	92.07	85.63	106.17	80.00	75.00	75.00	75.00	76.25	6-8
80387-25*	257.08	189.00	183.33	178.75	175.17	181.56	171.67	168.24	164.87	161.57	166.59	4-8
80486SX-20	NA	218.83	198.00	179.00	150.00	186.46	125.00	110.33	105.00	100.00	110.08	12
80486-25	533.75	405.00	390.00	375.00	360.00	382.50	355.00	350.00	350.00	350.00	351.25	6-8
80486-50	NA	615.00	555.00	505.00	465.00	535.00	395.25	355.73	355.00	355.00	365.24	6-8
29000-25**	111.25	92.00	88.00	84.00	81.00	86.25	79.00	77.40	76.70	75.80	77.23	8
88100-25**	76.06	69.50	68.05	67.45	67.00	68.00	64.50	62.20	60.20	58.10	61.25	4-8
R3000-25**	131.75	112.00	106.00	100.00	95.00	103.25	91.50	88.76	86.52	85.20	88.00	6-9
SPARC-25**	88.74	75.62	72.30	69.51	66.55	71.00	64.50	62.88	61.60	60.60	62.40	NA
80960CA-25	NA	95.30	91.30	90.30	89.25	91.54	88.35	87.45	84.30	81.20	85.33	1-2

*Volume of <1,000 pieces for 80387-25

**Pricing excludes accessory parts such as floating point and memory management.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 6
Estimated Long-Range Microprocessor and Peripheral Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8- and 16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
Z84C00-6	.98	.93	.92	.89	.88	.88
68000-8	3.81	3.39	3.25	3.25	3.25	3.25
68000-12	5.58	5.50	5.45	5.45	5.45	5.45
68EC000-8	NA	2.89	2.62	2.35	2.30	2.30
68302-16	NA	24.25	20.61	19.46	18.97	18.97
80186-8 PLCC	6.33	5.60	5.50	5.30	5.30	5.30
80C186-10 PLCC	NA	9.65	8.88	8.31	8.15	8.15
80286-10 PLCC	6.54	4.63	4.00	NA	NA	NA
80286-12 PLCC	6.87	4.63	4.00	4.00	NA	NA
80286-16 PLCC	13.50	7.64	6.00	5.00	4.50	NA
80287-12	NA	67.25	59.00	59.00	59.00	59.00
68020-16 PQFP	35.69	27.75	23.75	22.00	21.00	21.00
68881-16 PLCC	21.88	14.56	12.75	12.00	12.00	12.00
68EC020-16 PQFP	NA	16.06	13.93	12.00	11.00	10.00
68020-25 PQFP	NA	35.13	33.00	31.04	31.00	31.00
68030-16 PQFP	NA	74.50	66.00	60.14	58.94	58.94
68882-16	50.00	30.00	28.50	28.00	27.75	27.75
68030-25 PQFP+	161.00	117.25	107.28	97.00	94.09	93.15
68EC030-25 PQFP	NA	35.94	34.18	32.10	30.50	30.00
68040-25	538.85	425.00	370.00	332.50	325.00	325.00
68330-16	NA	17.75	15.63	13.30	12.97	12.97
68340-16	NA	23.00	21.73	20.62	20.11	20.00
80386SX-16 PQFP	57.74	50.12	47.50	NA	NA	NA
80386SX-20 PQFP	89.21	66.65	55.00	45.00	45.00	NA
AM386-40	NA	200.25	163.25	140.00	134.00	134.00
80386-25	157.61	106.17	76.25	75.00	75.00	75.00
80387-25*	257.08	181.56	166.59	161.57	161.57	161.57
80486SX-20*	NA	186.46	110.08	100.00	99.00	99.00
80486-25	533.75	382.50	351.25	350.00	350.00	350.00
80486-50	NA	535.00	365.24	355.00	350.00	350.00
29000-25**	111.25	86.25	77.23	74.50	70.00	68.00
88100-25**	76.06	68.00	61.25	56.00	51.00	50.00
R3000-25**	131.75	103.25	88.00	84.50	79.90	77.00
SPARC-25**	88.74	71.00	62.40	59.00	53.66	53.00
80960CA-25	NA	91.54	85.33	77.14	75.21	75.21

NA = Not available
+CPGA for 1991.
*Volume of <1,000 pieces for 80387-25 and 80486SX-20.
**Pricing excludes accessory parts such as floating point and memory management.
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 7
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)

Product	1991	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
256Kx1 DRAM 80ns DIP	1.75	1.60	1.60	1.50	1.50	1.55	1.50	1.50	1.50	1.50	1.50	1-6
64Kx4 VRAM 120ns ZIP	3.20	2.95	2.70	2.70	2.70	2.76	2.48	2.48	2.48	2.48	2.48	5-10
1Mbx1 DRAM 80ns (DIP/SOJ)	4.35	3.80	3.56	3.55	3.55	3.62	3.55	3.55	3.55	3.55	3.55	1-6
64Kx16 DRAM 80ns SOJ	6.90	5.65	5.25	5.01	4.77	5.17	4.54	4.35	4.22	4.13	4.31	4-8
256Kx4 VRAM 100ns ZIP	9.31	7.75	7.25	6.84	6.45	7.07	6.05	5.75	5.45	5.25	5.63	4-8
128Kx8 VRAM 100ns SOJ	10.01	8.05	7.55	7.14	6.75	7.37	6.30	6.00	5.70	5.45	5.86	1-8
4Mbx1 DRAM 80ns SOJ	16.96	13.13	12.02	11.02	10.10	11.57	9.80	9.55	9.30	8.95	9.40	1-8
512Kx8 DRAM 70ns	NA	NA	15.08	13.78	12.36	NA	11.23	10.56	9.89	9.27	10.24	4-8
256Kx16 DRAM 70ns SOJ	NA	16.00	15.50	13.99	12.79	14.57	11.75	11.00	10.30	9.75	10.70	4-8
256Kx18 DRAM 80ns SOJ	NA	17.07	16.75	15.55	14.70	16.02	13.75	13.00	12.40	12.00	12.79	1-6
1Mbx8 SIMM 100ns (2 pc)	NA	30.00	27.00	24.98	24.00	26.49	22.00	20.90	19.86	18.86	20.40	1-8
1Mbx9 SIMM 80ns (3 pc)	NA	33.83	30.45	28.17	27.50	29.99	25.00	23.25	21.62	20.11	22.50	1-8
256Kx9 SIMM 100ns	13.85	12.70	12.53	12.50	12.50	12.56	12.50	12.50	12.50	12.50	12.50	1-8
256Kx36 SIMM 80ns++	49.86	47.00	45.40	44.20	43.00	44.90	37.17	35.50	34.30	33.81	35.19	1-8
512Kx36 SIMM 80ns	NA	81.00	80.80	80.00	79.39	80.30	77.20	76.23	75.06	74.26	75.69	1-8
4Mbx9 SIMM 80ns	NA	135.0	125.0	120.0	115.0	123.8	100.0	90.0	82.0	78.0	87.50	NA

NA = Not available
*Contract volume = at least 100,000 per order except VRAMs
++Two-piece solution for 1993
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Source: Dataquest (March 1992)

Table 8
Estimated Long-Range DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)

Product	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year	Year 1996
256Kx1 DRAM 80ns DIP	1.75	1.55	1.50	1.65	1.85	2.00
64Kx4 VRAM 120ns ZIP	3.20	2.76	2.48	2.40	2.40	2.40
1Mbx1 DRAM 80ns (DIP/SOJ)	4.35	3.62	3.55	3.59	3.59	3.70
64Kx16 DRAM 80ns SOJ	6.90	5.17	4.31	4.12	4.12	4.15
256Kx4 VRAM 100ns ZIP	9.31	7.07	5.63	5.25	5.25	5.25
128Kx8 VRAM 100ns SOJ	10.01	7.37	5.86	5.35	5.25	5.25
4Mbx1 DRAM 80ns SOJ	16.96	11.57	9.40	7.60	6.80	6.80
512Kx8 DRAM 70ns	NA	NA	10.24	7.75	6.87	6.87
256Kx16 DRAM 70ns SOJ	NA	14.57	10.70	7.75	6.87	6.87
256Kx18 DRAM 80ns SOJ	NA	16.02	12.79	8.51	7.21	6.97
1Mbx8 SIMM 100ns (2 pc)	NA	26.49	20.40	16.00	15.00	14.00
1Mbx9 SIMM 80ns (3 pc)	NA	29.99	22.50	17.00	16.00	15.00
256Kx9 SIMM 100ns	13.85	12.56	12.50	12.00	NA	NA
256Kx36 SIMM 80ns++	49.86	44.90	35.19	27.28	23.07	20.91
512Kx36 SIMM 80ns	NA	80.30	75.69	60.55	48.44	47.23
4Mbx9 SIMM 80ns	NA	123.75	87.50	NA	NA	NA

NA = Not available
*Contract volume = at least 100,000 per order except VRAMs
++Two-piece solution for 1993-1996
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 9
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

		1992				1992	1993				1993	Current Lead
Product	1991	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
4Kx4 25ns	2.39	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	3-12
2Kx8 25ns	2.49	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2-13
64Kx1 25ns	3.55	3.55	3.45	3.43	3.40	3.46	3.38	3.38	3.38	3.38	3.38	3-12
16Kx4 25ns	3.52	2.70	2.50	2.50	2.50	2.55	2.50	2.50	2.50	2.50	2.50	7-14
8Kx8 25ns	3.69	3.30	2.60	2.50	2.50	2.73	2.50	2.50	2.50	2.50	2.50	1-10
16Kx4 35ns	3.13	2.60	2.40	2.40	2.40	2.45	2.40	2.40	2.40	2.40	2.40	6-11
8Kx8 45ns	3.17	2.55	2.35	2.35	2.35	2.40	2.35	2.35	2.35	2.35	2.35	8
8Kx8 100-120ns	2.01	2.05	1.85	1.55	1.55	1.75	1.55	1.55	1.55	1.55	1.55	1-10
64Kx4 10ns	NA	36.90	32.80	28.56	25.50	30.94	23.46	22.08	20.71	19.60	21.46	2
64Kx4 25ns	9.71	7.50	6.50	6.45	6.20	6.66	5.50	5.25	5.05	4.85	5.16	1-12
32Kx8 12ns	NA	23.58	21.53	19.38	17.34	20.46	15.95	15.01	14.08	13.33	14.59	2-10
32Kx8 35ns	8.54	6.28	6.10	5.95	5.65	6.00	5.45	5.30	5.10	5.05	5.23	5-10
32Kx8 100ns SOJ	4.18	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4-9
256Kx4 20ns	NA	58.83	51.04	42.30	37.00	47.29	34.09	30.17	28.41	28.10	30.19	8-12
128Kx8 20ns	NA	58.64	50.16	41.94	36.62	46.84	34.13	30.24	28.86	28.12	30.34	8-12
128Kx8 25ns	67.53	44.00	37.50	31.75	27.00	35.06	24.00	21.25	19.00	17.00	20.31	8-12
128Kx8 100ns SOJ	16.22	13.50	12.50	11.10	10.45	11.89	10.05	9.68	9.21	8.84	9.45	2-10

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.

Source: Dataquest (March 1992)

Table 10
Estimated Long-Range Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1991	1992	1993	1994	1995	1996
4Kx4 25ns	2.39	2.30	2.30	2.35	2.55	2.95
2Kx8 25ns	2.49	2.40	2.40	2.45	2.57	2.95
64Kx1 25ns	3.55	3.46	3.38	3.40	3.45	3.50
16Kx4 25ns	3.52	2.55	2.50	2.51	2.52	2.95
8Kx8 25ns	3.69	2.73	2.50	2.51	2.55	2.95
16Kx4 35ns	3.13	2.45	2.40	2.40	2.40	2.95
8Kx8 45ns	3.17	2.40	2.35	2.35	2.35	2.90
8Kx8 100-120ns	2.01	1.75	1.55	1.75	2.00	2.25
64Kx4 10ns	NA	30.94	21.46	16.17	13.34	11.34
64Kx4 25ns	9.71	6.66	5.16	4.25	4.05	4.05
32Kx8 12ns	NA	20.46	14.59	11.33	9.63	8.67
32Kx8 35ns	8.54	6.00	5.23	4.90	4.55	4.50
32Kx8 100ns SOJ	4.18	4.05	4.05	4.05	4.15	4.20
256Kx4 20ns	NA	47.29	30.19	23.18	19.70	17.73
128Kx8 20ns	NA	46.84	30.34	23.20	19.72	17.75
128Kx8 25ns	67.53	35.06	20.31	10.63	7.70	8.00
128Kx8 100ns SOJ	16.22	11.89	9.45	7.68	6.90	6.75

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 11
Estimated ROM Price Trends—North American Bookings (Speed/Package: ≤1Mb Density—150ns and above, 28-pin PDIP; ≥2Mb Density—200ns and above, 32-pin PDIP) (Volume: 50,000 per Year; Dollars)

Product	1991	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
CMOS												
32Kx8 ROM	1.59	1.50	1.50	1.50	1.50	1.50	1.45	1.45	1.45	1.45	1.45	4-8
64Kx8 ROM	2.08	1.90	1.85	1.83	1.80	1.85	1.80	1.75	1.75	1.75	1.76	4-8
128Kx8 ROM	2.26	2.01	1.95	1.95	1.90	1.95	1.90	1.90	1.90	1.85	1.89	4-8
64Kx16 ROM	2.84	2.20	2.20	2.10	2.00	2.13	1.95	1.90	1.90	1.85	1.90	4-8
256Kx8 ROM	3.18	2.76	2.73	2.70	2.67	2.71	2.65	2.61	2.58	2.55	2.60	4-8
512Kx8 ROM	4.01	3.95	3.79	3.75	3.70	3.80	3.60	3.60	3.60	3.60	3.60	4-8
256Kx16 ROM*	5.01	4.05	3.86	3.80	3.75	3.86	3.65	3.65	3.60	3.60	3.63	4-8
1Mbx8 ROM**	NA	6.33	6.20	5.98	5.82	6.08	5.55	5.48	5.43	5.38	5.46	4-8
2Mbx8 ROM	NA	15.25	14.25	13.15	12.20	13.71	11.15	10.10	9.50	9.05	9.95	4-8

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
**1Mbx8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 12
Estimated Long-Range ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above, 28-pin PDIP; ≥2Mb Density—200ns and above, 32-pin PDIP) (Volume: 50,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995	1996
CMOS						
32Kx8 ROM	1.59	1.50	1.45	1.45	NA	NA
64Kx8 ROM	2.08	1.85	1.76	1.72	1.72	NA
128Kx8 ROM	2.26	1.95	1.89	1.80	1.80	1.80
64Kx16 ROM	2.84	2.13	1.90	1.85	1.85	1.85
256Kx8 ROM	3.18	2.71	2.60	2.40	2.34	2.34
512Kx8 ROM	4.01	3.80	3.60	3.30	3.10	3.05
256Kx16 ROM*	5.01	3.86	3.63	3.32	3.11	3.05
1Mbx8 ROM**	NA	6.08	5.46	5.00	4.50	4.15
2Mbx16 ROM	NA	13.71	9.95	8.15	7.33	6.60

NA = Not available
*256Kx16 ROM: 150ns and above; 40-pin PDIP
**1Mbx8 ROM: 150ns and above; 32-pin SOP
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 13
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

		1992				1992	1993				1993	Current Lead
Product	1991	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
TTL												
4K PROM PDIP	.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM PDIP	2.26	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM PDIP	5.05	4.70	4.60	4.50	4.50	4.58	4.50	4.50	4.50	4.50	4.50	6-8
64K PROM PDIP	6.95	6.62	6.47	6.36	6.23	6.42	6.05	5.93	5.85	5.83	5.92	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 14
Estimated Long-Range Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

Product	1991	1992	1993	1994	1995	1996
TTL						
4K PROM	.97	1.00	1.00	NA	NA	NA
16K PROM	2.26	2.40	2.40	NA	NA	NA
32K PROM	5.05	4.58	4.50	4.50	NA	NA
64K PROM	6.95	6.42	5.92	5.54	5.45	5.45

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This price forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 15
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

		1992				1992	1993				1993	Current Lead
Product	1991	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8Kx8 EPROM	1.73	1.75	1.67	1.60	1.55	1.64	1.45	1.45	1.45	1.45	1.45	2-12
16Kx8 EPROM	1.82	1.83	1.75	1.68	1.63	1.72	1.55	1.55	1.55	1.55	1.55	2-8
32Kx8 EPROM	1.91	1.80	1.72	1.65	1.60	1.69	1.50	1.48	1.43	1.40	1.45	2-8
64Kx8 EPROM	2.73	2.47	2.42	2.37	2.32	2.39	2.28	2.23	2.20	2.20	2.23	2-8
128Kx8 EPROM	4.41	3.50	3.36	3.26	3.16	3.32	3.07	2.97	2.89	2.80	2.93	2-8
256Kx8 EPROM	9.88	7.37	6.93	6.51	6.12	6.73	6.00	5.90	5.80	5.71	5.85	2-8
128Kx16 EPROM	NA	7.90	7.11	6.61	6.22	6.96	6.09	5.99	5.89	5.80	5.94	4-8
512Kx8 EPROM	NA	16.00	14.83	13.72	12.78	14.33	12.01	11.59	11.18	10.78	11.39	4-14
256Kx16 EPROM	NA	18.05	16.58	15.34	14.22	16.05	12.94	11.78	11.36	10.96	11.76	4-14

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 16
Estimated Long-Range EPROM Pricing—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

Product	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
8Kx8 EPROM	1.73	1.64	1.45	1.45	1.50	1.50
16Kx8 EPROM	1.82	1.72	1.55	1.55	1.60	1.60
32Kx8 EPROM	1.91	1.69	1.45	1.40	1.45	1.50
64Kx8 EPROM	2.73	2.39	2.23	2.20	2.25	2.30
128Kx8 EPROM	4.41	3.32	2.93	2.80	2.80	2.85
256Kx8 EPROM	9.88	6.73	5.85	5.60	5.40	5.40
128Kx16 EPROM	NA	6.96	5.94	5.69	5.48	5.48
512Kx8 EPROM	NA	14.33	11.39	10.30	9.85	9.85
256Kx16 EPROM	NA	16.05	11.76	10.47	9.95	9.95

NA = Not available

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 17
Estimated OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

	1991	1992				1992	1993				1993	Current Lead
Product	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16Kx8	1.45	1.49	1.49	1.49	1.49	1.49	1.34	1.34	1.34	1.34	1.34	1-12
32Kx8	1.51	1.52	1.52	1.52	1.52	1.52	1.31	1.31	1.31	1.31	1.31	2-12
64Kx8	2.51	2.19	2.10	2.10	2.10	2.12	2.01	2.01	2.01	2.01	2.01	2-12
128Kx8	4.23	2.85	2.76	2.73	2.70	2.76	2.56	2.48	2.45	2.39	2.47	6-12

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 18
Estimated Long-Range OTP ROM Prices—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

Product	1991	1992	1993	1994	1995	1996
16Kx8	1.45	1.49	1.34	1.34	NA	NA
32Kx8	1.51	1.52	1.31	1.31	NA	NA
64Kx8	2.51	2.12	2.01	2.01	2.01	NA
128Kx8	4.23	2.76	2.47	2.27	2.12	NA

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

Table 19
Estimated EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

Product	1991	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
16K EEPROM	3.09	2.85	2.78	2.69	2.61	2.73	2.23	2.16	2.08	2.01	2.12	1-7
8Kx8 EEPROM	4.64	4.00	3.80	3.61	3.43	3.71	3.29	3.16	3.04	2.91	3.10	1-8
32Kx8 EEPROM	19.80	14.00	12.40	11.00	9.78	11.80	9.25	9.01	8.78	8.50	8.89	1-4
64Kx8 EEPROM	56.00	21.25	19.13	17.21	15.84	18.36	14.60	13.70	13.00	12.52	13.46	1-6
128Kx8 EEPROM	127.50	100.00	87.00	75.00	65.0	81.75	56.0	51.5	48.00	44.00	49.88	4-10

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 20
Estimated Long-Range EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

Product	1991	1992	1993	1994	1995	1996
16K EEPROM	3.09	2.73	2.12	2.01	2.01	2.01
8Kx8 EEPROM	4.64	3.71	3.10	2.60	2.40	2.25
32Kx8 EEPROM	19.80	11.80	8.89	8.00	7.00	6.50
64Kx8 EEPROM	56.00	18.36	13.46	11.20	10.39	9.80
128Kx8 EEPROM	127.50	81.75	49.88	38.72	34.46	30.67

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 21
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1991	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year	Current Lead Time (Weeks)
32Kx8, PDIP	6.08	5.80	5.50	5.20	4.94	5.36	4.75	4.56	4.40	4.30	4.50	4-8
64Kx8, PDIP	NA	7.15	6.80	6.30	6.00	6.56	5.60	5.25	5.10	4.95	5.23	4-8
128Kx8, PDIP	NA	9.75	9.00	8.25	7.60	8.65	7.00	6.60	6.25	5.95	6.45	4-8
128Kx8, TSOP	13.50	9.18	8.86	8.59	8.37	8.75	8.08	7.86	7.64	7.44	7.75	4-8
256Kx8, TSOP	24.88	16.00	14.95	13.98	13.10	14.51	12.55	12.15	11.80	11.60	12.03	4-8

NA = Not available

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 22
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1991 Year	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
32Kx8, PDIP	6.08	5.36	4.50	3.60	3.24	3.08
64Kx8, PDIP	NA	6.56	5.23	4.18	3.76	3.57
128Kx8, PDIP	NA	8.65	6.45	5.16	4.13	3.72
128Kx8, TSOP	13.50	8.75	7.75	6.20	4.96	4.22
256Kx8, TSOP	24.88	14.51	12.03	9.62	7.70	6.54

NA = Not available

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates to Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 23

Estimated Gate Array Pricing—North American Production Bookings
(Millicents per Gate) (Package: CMOS—84-pin PLCC for <10K Gates, 160-pin PQFP for 10K-29.9K, 208-pin PQFP for ≥30K Gates; ECL—CQFP) (Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test) (Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL)

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1991	1992	1993	1991	1992	1993	1991	1992	1993	Times (Weeks)
CMOS										Production:
1.5 Micron	127	121	102	94	87	87	82	77	77	10-12
1.2 Micron	117	109	92	81	80	80	78	75	75	12
1.0 Micron	115	104	87	82	80	80	78	70	62	9-12
0.8 Micron	NA	NA	NA	NA	71	62	NA	70	62	10-12
ECL	5360	4850	4268	4588	3823	3326	3500	3000	3000	12-14
NRE Charges ($1,000s)										
CMOS										Prototypes:
1.5 Micron	16	16	15.2	21	21	20	26	26	24.7	3-5
13	13	12.4	18	17	16.2	23		21	20	3-4
1.0 Micron	23	19	18.1	24	24	24	29	27.5	27.1	3-4
0.8 Micron	NA	NA	NA	NA	27	26.8	NA	35.5	32.1	3-5
ECL	32	30	27	50	45	40.5	55	50	45	14

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1991	1992	1993	1991	1992	1993	1991	1992	1993	Times (Weeks)
CMOS										Production:
1.5 Micron	81	77	77	83	78	78	98	95	95	10-12
1.2 Micron	77	75	75	79	76	76	98	93	93	7-12
1.0 Micron	77	69	61	79	69	62	94	73	62	9-12
0.8 Micron	NA	68	60	NA	68	60	NA	75	61	10-12
ECL	4550	3300	2790	3838	3200	2784	3600	3050	2654	12-14
NRE Charges ($1,000s)										
CMOS										Prototypes:
1.5 Micron	41	40.5	40	60	60	57	100	100	95	3-6
1.2 Micron	40	40	38	58	58	55.1	102	102	96.9	4-8
1.0 Micron	47.5	44	42.9	61	61	57	98.3	96.7	90.9	3-5
0.8 Micron	NA	51.7	50.4	NA	72.6	66.1	140	111.2	104.5	3-5
ECL	71	70	65	105	100	90	170	146.7	132	9-14

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discounts. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 24

Estimated CBIC Pricing—North American Production Bookings (Millicents per Gate)
(Package: 84-pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K) (Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototypes)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K Gates			2-4.99K Gates			5-9.99K Gates			Current Lead
Technology	1991	1992	1993	1991	1992	1993	1991	1992	1993	Times (Weeks)
CMOS										Production:
1.5 Micron	129	123	102	110	89	88	92	82	78	10-14
1.2 Micron	118	110	92	85	80	80	80	76	76	8-15
1.0 Micron	116	105	87	97	80	80	80	70	62	9-16
0.8 Micron	NA	NA	NA	NA	71	62	NA	70	62	12-16
NRE Charges ($K)										Prototypes:
1.5 Micron	35	35	33.3	38	38	36.1	48	47	44.7	5-8
1.2 Micron	33	32	30.4	35.5	35	33.3	45	43.5	41.3	5-8
1.0 Micron	42	40	39.3	50	50	47.5	53	51	49.5	5-8
0.8 Micron	NA	NA	NA	NA	80	62.5	NA	76	57	6-8

Gate Count	10-19.99K Gates			20-29.99K Gates			30-60K Gates			Current Lead
Technology	1991	1992	1993	1991	1992	1993	1991	1992	1993	Times (Weeks)
CMOS										Production:
1.5 Micron	84	79	77	86	79	79	99	97	96	10-14
1.2 Micron	79	76	75	82	77	76	100	94	94	9-15
1.0 Micron	79	69	61	81	69	62	96	73	62	10-18
0.8 Micron	NA	68	60	NA	68	60	NA	75	61	13-18
NRE Charges ($K)										Prototypes:
1.5 Micron	66	65	61.8	89	85	80.8	112	110	103.4	5-8
1.2 Micron	62	58.5	55.6	80	75	71.3	110	100	97	5-8
1.0 Micron	59	56.8	55	62.5	62.5	62.5	115	115	110	6-8
0.8 Micron	NA	90	82.5	NA	120	115	NA	145.5	140	6-8

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 25
Estimated TTL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20						
	< or = 6	6.25	5.85	5.50	5.15	2-9
	6.1 - 7.5	2.35	2.10	2.00	1.90	2-8
	7.6 - 10.0	1.35	1.20	1.15	1.05	2-8
	10.1 - 14.99	1.27	1.15	1.05	1.05	2-8
	15 - <25	.60	.57	.55	.55	2-4
	> or = 25	.46	.43	.42	.42	2-4
24	< or = 6	9.20	8.80	7.25	6.95	3-8
	6.1 - 7.5	4.35	4.05	4.00	3.80	2-6
	7.6 - 10.0	2.50	2.25	2.15	2.05	2-4
	10.1 - 14.99	2.43	2.18	2.09	1.99	3-6
	15 - <25	1.00	.96	.94	.90	2-4
	> or = 25	.72	.71	.68	.66	2-4
24						
22V10						
	15 - <25	4.00	3.60	3.30	3.10	3-8
	25 - <35	2.15	2.00	1.90	1.85	2-8

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 26
Estimated Long-Range TTL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
≤20							
	< or = 6	7.75	6.05	5.33	4.79	4.55	4.44
	6.1 - 7.5	3.32	2.23	1.95	1.81	1.75	1.70
	7.6 - 10.0	1.77	1.28	1.10	.99	.94	.89
	10.1 - 14.99	1.37	1.21	1.05	1.05	1.00	1.00
	15 - <25	.72	.59	.55	.55	.55	.55
	> or = 25	.53	.45	.42	.40	.40	.40
24							
	< or = 6	10.78	9.00	7.10	6.39	6.07	5.92
	6.1 - 7.5	5.90	4.20	3.90	3.59	3.48	3.38
	7.6 - 10.0	3.63	2.38	2.10	1.89	1.84	1.81
	10.1 - 14.99	3.20	2.30	2.04	1.99	1.99	1.99
	15 - < 25	1.23	.98	.92	.90	.87	.86
	> or = 25	.82	.72	.67	.65	.65	.65
24							
	22V10						
	15 - <25	5.97	3.80	3.20	2.88	2.74	2.67
	25 - <35	2.81	2.08	1.88	1.73	1.67	1.62

*Nanosecond speed is the TPD for the combinatorial device.

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 27
Estimated ECL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
24						
	≤2.0	33.75	32.75	30.75	29.24	4
	2.01-4.0	27.90	26.40	25.00	23.92	4
	4.1-6.0	6.83	6.71	6.35	6.19	4
	6.1-15.0	5.80	5.71	5.58	5.50	4

NA = Not available

*Nanosecond speed is the TPD for the combinatorial device.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (March 1992)

Table 28
Estimated Long-Range ECL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
24							
	≤ 2.0	37.50	33.25	30.00	27.40	25.07	23.82
	2.01-4.0	31.50	27.15	24.46	21.99	20.24	19.73
	4.1-6.0	7.50	6.77	6.27	5.86	5.68	5.68
	6.1-15.0	6.25	5.76	5.54	5.32	5.32	5.32

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 March 1992.
Source: Dataquest (March 1992)

Table 29
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20	6.1 - 7.5	5.50	5.16	4.80	4.40	1-4
	7.6 - 10.0	3.05	2.60	2.35	2.10	1-4
	10.1 - 14.99	2.19	2.06	1.93	1.81	1-4
	15 - <25	.80	.77	.76	.75	1-4
	> or = 25	.68	.65	.64	.63	1-4
24						
	6.1 - 7.5	9.07	8.40	7.90	7.45	1-4
	7.6 - 10.0	5.25	4.40	3.95	3.60	1-4
	10.1 - 14.99	3.29	3.12	2.97	2.81	1-6
	15 - <25	1.34	1.25	1.24	1.23	1-8
	> or = 25	.99	.94	.94	.94	1-6
24						
	22V10					
	6.1 - 7.5	20.00	19.00	18.00	17.00	1-2
	7.6 - 10.0	16.00	14.25	13.50	12.85	2-4
	15 - <25	5.99	5.47	5.42	5.37	1-4
	25 - <35	2.47	2.01	1.95	1.80	1-4

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service and volume price. These prices are intended as guidelines.
Source: Dataquest (March 1992)

Table 30
Estimated Long-Range CMOS PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
≤20							
	6.1 - 7.5	6.41	5.33	4.60	4.20	4.00	3.84
	7.6 - 10.0	3.82	2.83	2.23	2.10	2.00	1.90
	10.1 - 14.99	2.66	2.13	1.87	1.60	1.40	1.25
	15 - <25	.91	.79	.76	.70	.65	.65
	> or = 25	.75	.67	.64	.56	.50	.50
24							
	6.1 - 7.5	NA	8.74	7.68	7.00	6.70	6.50
	7.6 - 10.0	6.70	4.83	3.78	3.00	2.65	2.35
	10.1 - 14.99	3.65	3.20	2.89	2.50	2.26	2.06
	15 - <25	1.53	1.30	1.24	1.10	1.00	1.00
	> or = 25	1.13	.97	.94	.90	.85	.85
24							
22V10							
	6.1 - 7.5	NA	19.50	17.50	15.30	13.77	13.08
	7.6 - 10.0	22.00	15.13	13.18	12.00	11.04	10.49
	15 - <25	7.01	5.73	5.40	5.20	4.85	4.85
	25 - <35	3.04	2.24	1.88	1.80	1.60	1.60

NA = Not available

*Nanosecond speed is the TPD for the combinatorial device.

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume price. These prices are intended as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 31
Estimated Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Times (Weeks)
Voltage Regulators					
78L05 (TO-92)	.120	.118	.117	.117	3-6
7805 (TO-220)	.138	.137	.137	.137	
Comparators					
LM339	.137	.137	.132	.130	4-6
LM393	.129	.127	.127	.127	
Op Amps					
741	.130	.125	.128	.128	4-6
3403P	.182	.178	.176	.174	
1741CP1	.124	.120	.119	.117	
Interface ICs					
1488P	.150	.150	.146	.144	4-6
3486P	.895	.885	.880	.860	
Telecom IC					4-7
CODEC/FILTER #1	1.850	1.776	1.723	1.680	
CODEC/FILTER #2	4.330	4.121	3.915	3.719	
XR-T5683	3.60	3.50	3.41	3.33	
34017P	.330	.320	.315	.305	
Video DAC					
IMSG171D-35 MHz	1.800	1.700	1.600	1.500	NA

NA = Not available

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Source: Dataquest (March 1992)

Table 32
Estimated Long-Range Analog IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995	1996
Voltage Regulators						
78L05 (TO-92)	.122	.119	.117	.117	.116	.116
7805 (TO-220)	.140	.138	.137	.137	.137	.137
Comparators						
LM339	.139	.137	.131	.130	.130	.130
LM393	.130	.128	.127	.127	.126	.126
Op Amps						
741	.132	.128	.128	.128	.128	.128
3403P	.186	.180	.175	.174	.171	.171
1741CP1	.125	.122	.118	.117	.116	.116
Interface ICs						
1488P	.155	.150	.145	.144	.137	.137
3486P	.918	.890	.870	.860	.840	.830
Telecom IC						
CODEC/FILTER 1	2.080	1.813	1.701	1.616	1.535	1.500
CODEC/FILTER 2	NA	4.225	3.817	3.550	3.301	3.136
XR-T5683	NA	3.550	3.370	3.201	3.073	2.950
34017P	.346	.325	.310	.305	.298	.290
Video DAC						
IMSG171D-35 MHz	NA	1.750	1.550	1.440	1.390	1.370

NA = Not available

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 33
Estimated Discrete Semiconductor Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Small-Signal Transistors					2-8
2N2222A	.140	.140	.139	.139	
2N3904	.030	.030	.029	.029	
2N2907A	.068	.068	.066	.066	
MPSA 43	.052	.049	.048	.046	
2N2222	.046	.045	.045	.045	
Bipolar Power Transistors					3-8
2N3772	1.040	1.040	1.040	1.040	
2N3055A	.700	.700	.690	.690	
2N6107	.235	.235	.235	.235	
Power MOSFET					3-8
IRF530	.400	.380	.370	.370	
IRF540	1.000	1.000	.990	.990	
IRF9531	1.040	1.030	1.029	1.027	
IRF9520	.416	.414	.411	.409	
Small-Signal Diodes					1-8
1N4002	.020	.020	.020	.020	
1N645	.047	.046	.045	.045	
Power Diodes					2-8
1N3891	.888	.878	.875	.871	
1N3737	7.120	7.090	7.070	6.999	
1N4936	.095	.094	.093	.092	
Zener Diodes					2-8
1N829	1.165	1.165	1.165	1.165	
1N752A	.026	.025	.025	.025	
1N963B	.026	.025	.025	.025	
1N4735A	.040	.039	.039	.039	
1.5KE62A	.625	.610	.608	.600	
1.5KE30CA	1.230	1.200	1.192	1.180	
P6KE30CA	.708	.690	.690	.690	
Thyristors					2-8
2N6400	.620	.620	.593	.573	
2N4186	2.275	2.265	2.270	2.250	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 34

Estimated Long-Range Discrete Semiconductor Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995	1996
Small-Signal Transistors						
2N2222A	.140	.140	.139	.138	.138	.138
2N3904	.031	.030	.029	.028	.028	.028
2N2907A	.070	.068	.066	.062	.061	.060
MPSA 43	.057	.050	.047	.046	.045	.045
2N2222	.049	.046	.045	.045	.045	.045
Bipolar Power Transistors						
2N3772	1.040	1.040	1.040	1.040	1.040	1.040
2N3055	.700	.700	.690	.680	.670	.670
2N6107	.235	.235	.235	.235	.235	.235
Power MOSFET						
IRF530	.413	.390	.370	.360	.350	.350
IRF540	1.025	1.000	.990	.980	.975	.970
IRF9531	1.058	1.035	1.028	1.022	1.020	1.018
IRF9520	.425	.415	.410	.408	.406	.405
Small-Signal Diodes						
1N4002	.020	.020	.020	.020	.020	.020
1N645	.047	.046	.045	.045	.045	.045
Power Diodes						
1N3891	.900	.883	.873	.864	.860	.858
1N3737	7.161	7.105	7.035	6.990	6.850	6.800
1N4936	.096	.094	.092	.090	.089	.088
Zener Diodes						
1N829	1.165	1.165	1.165	1.165	1.165	1.165
1N752A	.027	.026	.025	.025	.025	.025
1N963B	.026	.026	.025	.025	.025	.025
1N4735A	.040	.040	.039	.039	.039	.039
1.5KE62A	.659	.617	.604	.595	.590	.585
1.5KE30CA	1.304	1.215	1.186	1.160	1.155	1.150
P6KE30CA	.748	.699	.690	.681	.671	.665
Thyristors						
2N6400	.650	.620	.583	.562	.556	.556
2N4186	2.290	2.270	2.260	2.250	2.250	2.250

NA = Not available

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.

Source: Dataquest (March 1992)

Table 35
Estimated Optoelectronic IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Product	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Round LED Lamps					4
T1 STD RED	.052	.052	.050	.049	
T1 3/4 STD RED	.052	.052	.052	.050	
T1 3/4 H.EF.RED	.065	.065	.063	.063	
Mold Frame LED					4
0.3 Digital Display	.490	.480	.475	.470	
0.6 Digital Display	.500	.500	.480	.470	
Optical Couplers					6-8
4N25	.160	.160	.159	.158	
4N36	.200	.200	.200	.200	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (March 1992)

Table 36
Estimated Long-Range Optoelectronic IC Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995
Optoelectronic					
Round LED Lamps					
T1 STD RED	.054	.052	.050	.048	.047
T1 3/4 STD RED	.054	.052	.051	.050	.048
T1 3/4 H.EF.RED	.074	.065	.063	.062	.061
Mold Frame LED					
0.3 Digital Display	.500	.485	.473	.467	.460
0.6 Digital Display	.550	.500	.475	.470	.465
Optical Couplers					
4N25	.195	.160	.159	.158	.156
4N36	.228	.200	.200	.200	.200

Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated March 1992.
Source: Dataquest (March 1992)

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North American Semiconductor Price Outlook
First Quarter 1992

Source: Dataquest

Market Statistics

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Source: Dataquest

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Methodology and Sources

This *Source: Dataquest* document provides information on and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects price information on a quarterly basis from North American suppliers and major buyers of these products. North American bookings price information is analyzed by Semiconductor Procurement (SP) service analysts for consistency and reconciliation. The information finally is rationalized with worldwide billings price data in association with product analysts, resulting in the current forecast. This document includes associated long-range forecasts.

For SP clients that use the SP on-line service, the prices presented here correlate with the quarterly and long-range price tables dated December 1991 in the SP on-line service. For additional product coverage and more detailed product specifications, please refer to those sources.

Price Variations

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as product quality, special features, service, delivery performance, or other factors that may enhance or detract from the value of a company's product. These prices are intended for use as price guidelines.

Table 1 a
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Family	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
74LS TTL						1-6
74LS00	.105	.105	.110	.110	.108	
74LS74	.117	.117	.117	.117	.117	
74LS138	.155	.155	.155	.155	.155	
74LS244	.215	.215	.215	.215	.215	
74S TTL						1-6
74S00	.145	.145	.145	.145	.145	
74S74	.170	.170	.170	.170	.170	
74S138	.259	.259	.259	.259	.259	
74S244	.500	.500	.500	.500	.500	
74F TTL						1-6
74FOO	.100	.100	.100	.100	.100	
74F74	.120	.120	.120	.120	.120	
74F138	.155	.155	.155	.155	.155	
74F244	.218	.218	.218	.218	.218	
74HC CMOS						1-8
74HC00	.105	.105	.110	.110	.108	
74HC74	.120	.120	.125	.125	.123	
74HC138	.158	.158	.158	.158	.158	
74HC244	.235	.235	.235	.235	.235	
74AC CMOS						1-6
74AC00	.183	.182	.181	.180	.181	
74AC74	.255	.254	.253	.253	.254	
74AC138	.305	.300	.295	.290	.298	
74AC244	.455	.445	.435	.425	.440	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 1 b
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1993				1993
Family	Q1	Q2	Q3	Q4	Year
74LS TTL					
74LS00	.110	.110	.110	.110	.110
74LS74	.117	.117	.117	.117	.117
74LS138	.155	.155	.155	.155	.155
74LS244	.213	.213	.213	.213	.213
74S TTL					
74S00	.150	.150	.150	.150	.150
74S74	.174	.174	.174	.174	.174
74S138	.259	.259	.259	.259	.259
74S244	.495	.495	.495	.495	.495
74F TTL					
74FOO	.101	.101	.101	.103	.102
74F74	.115	.115	.115	.115	.115
74F138	.152	.151	.150	.150	.151
74F244	.212	.212	.212	.212	.212
74HC CMOS					
74HC00	.110	.110	.110	.110	.110
74HC74	.128	.128	.128	.128	.128
74HC138	.160	.160	.160	.160	.160
74HC244	.237	.237	.239	.239	.238
74AC CMOS					
74AC00	.175	.175	.175	.175	.175
74AC74	.247	.243	.240	.240	.243
74AC138	.285	.280	.280	.280	.281
74AC244	.419	.414	.410	.406	.412

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 2 a
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1992				1992	Current Lead
Family	Q1	Q2	Q3	Q4	Year	Time (Weeks)
74ALS TTL						1-6
74ALS00	.120	.118	.115	.115	.117	
74ALS74	.140	.135	.135	.135	.136	
74ALS138	.260	.260	.260	.260	.260	
74ALS244	.345	.345	.345	.345	.345	
74AS TTL						1-6
74AS00	.160	.160	.160	.160	.160	
74AS74	.180	.180	.180	.180	.180	
74AS138	.430	.430	.430	.430	.430	
74AS244	.740	.740	.740	.740	.740	
74BC[1]						4-6
74BC00	.297	.286	.279	.272	.284	
74BC244	.725	.698	.672	.648	.686	
74BC373	.726	.700	.674	.649	.687	
10KH ECL						6
10H102	.490	.490	.490	.490	.490	
10H173	1.100	1.100	1.100	1.100	1.100	

[1]Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 2 b
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

	1993				1993
Family	Q1	Q2	Q3	Q4	Year
74ALS TTL					
74ALS00	.115	.115	.115	.115	.115
74ALS74	.135	.135	.135	.135	.135
74ALS138	.260	.258	.254	.254	.257
74ALS244	.340	.330	.330	.320	.330
74AS TTL					
74AS00	.160	.160	.160	.160	.160
74AS74	.180	.179	.179	.179	.179
74AS138	.420	.420	.420	.420	.420
74AS244	.730	.730	.730	.730	.730
74BC[1]					
74BC00	.270	.268	.265	.263	.267
74BC244	.645	.641	.638	.636	.640
74BC373	.646	.642	.639	.637	.641
10KH ECL					
10H102	.490	.490	.490	.490	.490
10H173	1.100	1.100	1.100	1.100	1.100

[1] Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 3
Estimated Long-Range Standard Logic Price Trends—North American Bookings
(Volume: 100,000 per Year; Package: PLCC; Dollars)

Family	1991	1992	1993	1994	1995	1996
74LS TTL						
74LS00	.100	.108	.110	.110	.110	.110
74LS74	.115	.117	.117	.117	.117	.117
74LS138	.150	.155	.155	.152	.152	.152
74LS244	.215	.215	.213	.199	.195	.195
74S TTL						
74S00	.140	.145	.150	.145	.145	.145
74S74	.174	.170	.174	.174	.174	.174
74S138	.259	.259	.259	.259	.259	.259
74S244	.505	.500	.495	.495	.495	.495
74F TTL						
74FOO	.100	.100	.102	.107	.107	.107
74F74	.118	.120	.115	.110	.110	.110
74F138	.165	.155	.151	.149	.147	.147
74F244	.228	.218	.212	.212	.212	.212
74HC CMOS						
74HC00	.105	.108	.110	.110	.110	.110
74HC74	.120	.123	.128	.128	.128	.128
74HC138	.156	.158	.160	.160	.162	.162
74HC244	.230	.235	.238	.240	.242	.242
74AC CMOS						
74AC00	.192	.181	.175	.173	.170	.170
74AC74	.263	.254	.243	.235	.225	.225
74AC138	.334	.298	.281	.276	.270	.270
74AC244	.484	.440	.412	.403	.395	.395
74ALS TTL						
74ALS00	.128	.117	.115	.115	.115	.115
74ALS74	.154	.136	.135	.135	.135	.135
74ALS138	.278	.260	.257	.252	.249	.249
74ALS244	.382	.345	.330	.320	.320	.320
74AS TTL						
74AS00	.170	.160	.160	.160	.160	.160
74AS74	.180	.180	.179	.179	.179	.179
74AS138	.460	.430	.420	.415	.400	.400
74AS244	.755	.740	.730	.700	.690	.690
74BC[1]						
74BC00	.328	.284	.267	.260	.242	.242
74BC244	.796	.686	.640	.611	.587	.587
74BC373	.799	.687	.641	.612	.588	.588
10KH ECL						
10H102	.490	.490	.490	.490	.490	.490
10H173	1.200	1.100	1.100	1.100	1.100	1.100

[1]Prices for 74BC exclude 74ABT, 74BCT.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 4 a
Estimated Microprocessor and Peripheral Price Trends—North American Bookings (Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars) (Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1992				1992	Current Lead
Family	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8-Bit MPUs						
Z84C00-6	.94	.94	.92	.92	.93	5-8
16-Bit MPUs						
68000-8	3.50	3.50	3.30	3.25	3.39	2-4
68000-12	5.50	5.50	5.50	5.50	5.50	2-4
68EC000-8	3.00	2.95	2.85	2.75	2.89	4-8
68302-16	28.00	26.00	22.00	21.00	24.25	4-8
80186-8 PLCC	5.75	5.65	5.50	5.50	5.60	6-8
80C186-10 PLCC	9.95	9.95	9.45	9.25	9.65	5-8
80286-10 PLCC	6.20	6.00	5.75	5.50	5.86	3-10
80286-12 PLCC	5.95	5.75	5.45	5.20	5.59	2-10
80286-16 PLCC	9.25	8.00	7.05	6.40	7.68	2-10
80287-12	77.00	70.00	63.00	59.00	67.25	1-10
CISC 32-Bit MPUs/Peripherals						
68020-16 PQFP	29.00	29.00	27.00	26.00	27.75	2-4
68881-16 PLCC	15.00	15.00	14.25	14.00	14.56	2-4
68EC020-16 PQFP	17.00	16.00	15.75	15.50	16.06	4-8
68020-25 PQFP	36.00	36.00	34.50	34.00	35.13	2-8
68030-16 CQFP	77.00	76.00	75.00	74.00	75.50	2-8
68882-16	31.00	30.50	29.50	29.00	30.00	2-4
68030-25 CQFP[1]	120.00	118.00	116.00	115.00	117.25	5-10
68EC030-25 PQFP	37.00	36.50	35.25	35.00	35.94	4-8
68040-25	455.08	430.10	413.90	400.90	425.00	4-8
68330-16	18.00	18.00	17.50	17.50	17.75	4-8
68340-16	24.00	23.25	22.50	22.25	23.00	2-4
80386SX-16 PQFP	53.82	53.52	53.32	52.93	53.40	2-12
80386SX-20 PQFP	81.41	79.46	77.01	75.03	78.23	2-12
AM386-40	216.00	205.00	195.00	185.00	200.25	6
80386-25	148.00	144.00	140.00	137.00	142.25	6-8
80387-25[2]	189.00	183.33	178.75	175.17	181.56	4-8
80486-25	405.00	390.00	375.00	360.00	382.50	6-8
80486-33	405.00	390.00	375.00	360.00	382.50	6-8
80486SX-20[2]	218.83	210.07	205.87	203.81	209.65	12
RISC 32-Bit MPUs						
29000-25[3]	92.00	88.00	84.00	81.00	86.25	8
88100-25[3]	69.50	68.05	67.45	67.00	68.00	4-8
R3000-25[3]	112.00	106.00	100.00	95.00	103.25	6-9
SPARC-25[3]	75.62	72.30	69.51	66.55	71.00	NA
80960[3]	95.30	91.30	90.30	89.25	91.54	1-2

NA = Not available
[1]CPGA for 1991.
[2]Volume of <1,000 pieces for 80387-25 and 80486SX-20
[3]Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 4 b
Estimated Microprocessor and Peripheral Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1993				1993
Family	Q1	Q2	Q3	Q4	Year
8-Bit MPUs					
Z84C00-6	.92	.92	.92	.92	.92
16-Bit MPUs					
68000-8	3.25	3.25	3.25	3.25	3.25
68000-12	5.45	5.45	5.45	5.45	5.45
68EC000-8	2.75	2.65	2.56	2.50	2.62
68302-16	21.00	20.69	20.48	20.27	20.61
80186-8 PLCC	5.50	5.50	5.50	5.50	5.50
80C186-10 PLCC	9.00	9.00	8.75	8.75	8.88
80286-10 PLCC	5.50	5.50	5.50	5.50	5.50
80286-12 PLCC	5.10	5.05	5.00	4.95	5.03
80286-16 PLCC	6.25	6.15	6.10	6.25	6.19
80287-12	59.00	59.00	59.00	59.00	59.00
CISC 32-Bit MPUs/Peripherals					
68020-16 PQFP	24.00	24.00	24.00	23.00	23.75
68881-16 PLCC	13.50	13.00	12.50	12.00	12.75
68EC020-16 PQFP	15.00	14.20	13.50	13.00	13.93
68020-25 PQFP	33.57	33.25	32.78	32.40	33.00
68030-16 CQFP	70.00	67.00	65.00	62.00	66.00
68882-16	28.72	28.57	28.37	28.33	28.50
68030-25 CQFP[1]	114.00	110.00	105.00	100.00	107.25
68EC030-25 PQFP	34.65	34.30	33.96	33.79	34.18
68040-25	388.00	376.00	364.00	352.00	370.00
68330-16	17.50	16.00	15.00	14.00	15.63
68340-16	22.03	21.81	21.59	21.48	21.73
80386SX-16 PQFP	52.40	52.36	51.43	51.43	51.90
80386SX-20 PQFP	73.03	70.80	69.36	68.66	70.46
AM386-40	176.00	167.00	159.00	151.00	163.25
80386-25	136.54	134.78	134.63	134.07	135.00
80387-25[2]	171.67	168.24	164.87	161.57	166.59
80486-25	355.00	355.00	355.00	355.00	355.00
80486-33	355.00	355.00	355.00	355.00	355.00
80486SX-20[2]	201.83	199.87	198.00	197.00	199.18
RISC 32-Bit MPUs					
29000-25[3]	79.00	77.40	76.70	75.80	77.23
88100-25[3]	64.50	62.20	60.20	58.10	61.25
R3000-25[3]	91.50	88.76	86.52	85.20	88.00
SPARC-25[3]	64.50	62.88	61.60	60.60	62.40
80960[3]	88.35	87.45	84.30	81.20	85.33

[1]CPGA for 1991.
[2]Volume of <1,000 pieces for 80387-25 and 80486SX-20
[3]Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 5
Estimated Long-Range Microprocessor and Peripheral Price Trends—North American Bookings (Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars) (Package: 8/16-bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

Family	1991	1992	1993	1994	1995	1996
8-Bit MPUs						
Z84C00-6	.98	.93	.92	.89	.88	.88
16-Bit MPUs						
68000-8	3.81	3.39	3.25	3.25	3.25	3.25
68000-12	5.58	5.50	5.45	5.45	5.45	5.45
68EC000-8	NA	2.89	2.62	2.35	2.30	2.30
68302-16	NA	24.25	20.61	19.46	18.97	18.97
80186-8 PLCC	6.33	5.60	5.50	5.30	5.30	5.30
80C186-10 PLCC	NA	9.65	8.88	8.31	8.15	8.15
80286-10 PLCC	6.54	5.86	5.50	5.50	NA	NA
80286-12 PLCC	6.87	5.59	5.03	4.95	4.50	4.50
80286-16 PLCC	13.50	7.68	6.19	5.70	5.24	5.14
80287-12	NA	67.25	59.00	59.00	59.00	59.00
CISC 32-Bit MPUs/Peripherals						
68020-16 PQFP	35.69	27.75	23.75	22.00	21.00	21.00
68881-16 PLCC	21.88	14.56	12.75	12.00	12.00	12.00
68E020-16 PQFP	NA	16.06	13.93	12.00	11.00	10.00
68020-25 PQFP	NA	35.13	33.00	31.04	31.00	31.00
68030-16 PQFP	NA	75.50	66.00	60.14	58.94	58.94
68882-16	50.00	30.00	28.50	28.00	27.75	27.75
68030-25 CQFP[1]	161.00	117.25	107.28	97.00	94.09	93.15
68EC030-25 PQFP	NA	35.94	34.18	32.10	30.50	30.00
68040-25	538.85	425.00	370.00	332.50	325.00	325.00
68330-16	NA	17.75	15.63	13.30	12.97	12.97
68340-16	NA	23.00	21.73	20.62	20.11	20.00
80386SX-16 PQFP	57.74	53.40	51.90	NA	NA	NA
80386SX-20 PQFP	89.21	78.23	70.46	65.22	65.22	65.22
AM386-40	NA	200.25	163.25	140.00	134.00	134.00
80386-25	157.61	142.25	135.00	133.00	133.00	133.00
80387-25[2]	257.08	181.56	166.59	161.57	161.57	161.57
80486-25	533.75	382.50	355.00	355.00	355.00	355.00
80486-33	560.96	382.50	355.00	355.00	355.00	355.00
80486SX-20[2]	NA	209.65	199.18	194.74	194.74	194.74
RISC 32-Bit MPUs						
29000-25[3]	111.25	86.25	77.23	74.50	70.00	68.00
88100-25[3]	76.06	68.00	61.25	56.00	51.00	50.00
R3000-25[3]	131.75	103.25	88.00	84.50	79.90	77.00
SPARC-25[3]	88.74	71.00	62.40	59.00	53.66	53.00
80960[3]	NA	91.54	85.33	77.14	75.21	75.21

NA = Not available
[1]CPGA for 1991.
[2]Volume of <1,000 pieces for 80387-25 and 80486SX-20
[3]Pricing excludes accessory parts such as floating point and memory management.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 6 a
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
256K×1 DRAM 80ns (DIP)	1.60	1.60	1.60	1.60	1.60	1-8
64K×4 VRAM 120ns (ZIP)	3.01	2.95	2.90	2.86	2.93	5-10
1Mb×1 DRAM 80ns (DIP/SOJ)	3.90	3.80	3.75	3.70	3.79	1-8
64K×16 DRAM 80ns (SOJ)	5.60	5.50	5.40	5.20	5.43	4-8
256K×4 VRAM 120ns (ZIP)	8.15	7.95	7.70	7.44	7.81	6-12
128K×8 VRAM 100ns (SOJ)	8.40	8.15	7.83	7.55	7.98	6-12
4Mb×1 DRAM 80ns (SOJ)	13.72	13.00	12.30	11.60	12.65	1-8
256K×18 DRAM 80ns (SOJ)	17.15	16.25	15.37	14.95	15.93	6-12
1Mb×8 SIMM 100ns	34.60	33.75	33.03	33.00	33.60	4-10
1Mb×9 SIMM 80ns[2]	36.04	34.27	32.60	30.94	33.46	4-10
256K×9 SIMM 100ns	12.70	12.53	12.50	12.50	12.56	1-8
256K×36 SIMM 80ns	45.95	45.40	45.00	44.55	45.23	4-8
512K×36 SIMM 80ns	81.00	80.80	80.00	79.39	80.30	4-8

[1] Contract volume equals at least 100,000 units per order except for VRAMs.
[2] 3-piece solution for 1992
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 6 b
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

	1993				1993
Product	Q1	Q2	Q3	Q4	Year
256K×1 DRAM 80ns (DIP)	1.70	1.70	1.70	1.70	1.70
64K×4 VRAM 120ns (ZIP)	2.80	2.80	2.80	2.80	2.80
1Mb×1 DRAM 80ns (DIP/SOJ)	3.65	3.60	3.60	3.60	3.61
64K×16 DRAM 80ns (SOJ)	4.90	4.65	4.37	4.13	4.51
256K×4 VRAM 120ns (ZIP)	7.13	6.95	6.77	6.55	6.85
128K×8 VRAM 100ns (SOJ)	7.25	6.96	6.75	6.55	6.88
4Mb×1 DRAM 80ns (SOJ)	11.20	10.75	10.41	9.99	10.59
256K×18 DRAM 80ns (SOJ)	14.00	13.44	13.01	12.48	13.23
1Mb×8 SIMM 100ns	32.80	32.80	32.80	32.82	32.81
1Mb×9 SIMM 80ns	29.96	28.87	28.07	28.00	28.73
256K×9 SIMM 100ns	12.55	12.55	12.55	12.55	12.55
256K×36 SIMM 80ns[2]	40.89	39.75	38.70	37.84	39.29
512K×36 SIMM 80ns	77.20	76.23	75.06	74.26	75.69

[1] Contract volume equals at least 100,000 units per order except for VRAMs.
[2] 3-piece solution for 1993
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 7
Estimated Long-Range DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1991	1992	1993	1994	1995	1996
256K×1 DRAM 80ns (DIP)	1.75	1.60	1.70	1.90	2.00	2.10
64K×4 VRAM 120ns (ZIP)	3.20	2.93	2.80	2.80	2.85	2.95
1Mb×1 DRAM 80ns (DIP/SOJ)	4.35	3.79	3.61	3.65	3.80	3.90
64K×16 DRAM 80ns (SOJ)	6.90	5.43	4.51	4.12	4.12	4.15
256K×4 VRAM 120ns (ZIP)	9.31	7.81	6.85	6.35	6.35	6.55
128K×8 VRAM 100ns (SOJ)	10.01	7.98	6.88	6.35	6.45	6.65
4Mb×1 DRAM 80ns (SOJ)	16.96	12.65	10.59	8.75	7.90	7.65
256K×18 DRAM 80ns (SOJ)	NA	15.93	13.23	11.23	10.11	9.91
1Mb×8 SIMM 100ns	38.21	33.60	32.81	32.82	NA	NA
1Mb×9 SIMM 80ns[2]	42.71	33.46	28.72	22.74	20.48	19.78
256K×9 SIMM 100ns	13.85	12.56	12.55	12.00	22.00	NA
256K×36 SIMM 80ns[3]	49.86	45.23	39.29	32.58	28.71	27.74
512K×36 SIMM 80ns	NA	80.30	75.69	65.15	57.42	55.48

NA = Not available
[1]Contract volume equals at least 100,000 units per order except for VRAMs.
[2]3-piece solution for 1992
[3]3-piece solution for 1993
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 8 a
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
Fast 4K×4 25ns	2.30	2.30	2.30	2.30	2.30	3-12
Fast 2K×8 25ns	2.40	2.40	2.40	2.40	2.40	2-13
Fast 64K×1 25ns	3.55	3.45	3.43	3.40	3.46	3-12
Fast 16K×4 25ns	3.20	3.13	3.05	3.05	3.11	7-14
Fast 8K×8 25ns	3.30	3.23	3.18	3.15	3.21	1-10
Fast 16K×4 35ns	3.00	2.90	2.65	2.50	2.76	6-11
Fast 8K×8 45ns	2.75	2.55	2.50	2.50	2.58	7-Allocation
Slow 8K×8 100-120ns	2.05	2.05	2.05	2.05	2.05	1-10
Fast BiCMOS 64K×4 10ns	40.00	37.20	35.00	32.06	36.07	2
Fast 64K×4 25ns	8.08	7.99	7.74	7.50	7.83	1-10
Fast 32K×8 12ns	26.00	22.50	20.00	17.25	21.44	2-10
Fast 32K×8 35ns	6.75	6.50	6.25	5.95	6.36	5-10
Slow 32K×8 100ns (SOJ)	4.05	4.05	4.05	4.05	4.05	4-9
Fast 256K×4 20ns	58.83	51.04	42.30	37.00	47.29	8-12
Fast 128K×8 20ns	58.64	50.16	41.94	36.62	46.84	8-12
Fast 128K×8 25ns	49.00	40.00	35.67	30.00	38.67	8-12
Slow 128K×8 100ns (SOJ)	13.75	12.90	12.00	11.25	12.48	2-10

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (January 1992)

Table 8 b
Estimated Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

	1993				1993
Product	Q1	Q2	Q3	Q4	Year
Fast 4K×4 25ns	2.30	2.30	2.30	2.30	2.30
Fast 2K×8 25ns	2.40	2.40	2.40	2.40	2.40
Fast 64K×1 25ns	3.38	3.38	3.38	3.38	3.38
Fast 16K×4 25ns	3.00	3.00	3.00	3.00	3.00
Fast 8K×8 25ns	3.13	3.10	3.00	2.95	3.04
Fast 16K×4 35ns	2.50	2.50	2.50	2.50	2.50
Fast 8K×8 45ns	2.50	2.50	2.50	2.50	2.50
Slow 8K×8 100-120ns	2.15	2.15	2.15	2.15	2.15
Fast BiCMOS 64K×4 10ns	28.00	25.50	22.16	20.49	24.04
Fast 64K×4 25ns	7.25	7.03	6.88	6.53	6.92
Fast 32K×8 12ns	15.50	14.25	12.88	11.75	13.59
Fast 32K×8 35ns	5.70	5.47	5.24	5.05	5.37
Slow 32K×8 100ns (SOJ)	4.15	4.15	4.15	4.15	4.15
Fast 256K×4 20ns	34.09	30.17	28.41	28.10	30.19
Fast 128K×8 20ns	34.13	30.24	28.86	28.12	30.34
Fast 128K×8 25ns	28.95	27.50	25.20	23.15	26.20
Slow 128K×8 100ns (SOJ)	10.90	10.40	9.90	9.50	10.18

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (January 1992)

Table 9
Estimated Long-Range Static RAM Price Trends—North American Bookings
(Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Product	1991	1992	1993	1994	1995	1996
Fast 4K×4 25ns	2.39	2.30	2.30	2.35	2.55	2.55
Fast 2K×8 25ns	2.49	2.40	2.40	2.45	2.57	2.67
Fast 64K×1 25ns	3.55	3.46	3.38	3.40	3.45	3.50
Fast 16K×4 25ns	3.52	3.11	3.00	3.00	3.10	3.10
Fast 8K×8 25ns	3.69	3.21	3.04	2.95	3.00	3.00
Fast 16K×4 35ns	3.13	2.76	2.50	2.50	2.55	2.55
Fast 8K×8 45ns	3.17	2.58	2.50	2.54	2.59	2.60
Slow 8K×8 100-120ns	2.01	2.05	2.15	2.30	2.40	2.40
Fast BiCMOS 64K×4 10ns	NA	36.07	24.04	18.03	NA	NA
Fast 64K×4 25ns	9.71	7.83	6.92	6.01	5.41	5.29
Fast 32K×8 12ns	NA	21.44	13.59	10.22	NA	NA
Fast 32K×8 35ns	8.54	6.36	5.37	4.80	4.55	4.50
Slow 32K×8 100ns (SOJ)	4.18	4.05	4.15	4.25	4.25	4.25
Fast 256K×4 20ns	NA	47.29	30.19	17.50	NA	NA
Fast 128K×8 20ns	NA	46.84	30.34	14.75	NA	NA
Fast 128K×8 25ns	67.53	38.67	26.20	13.25	12.26	11.64
Slow 128K×8 100ns (SOJ)	16.22	12.48	10.18	7.75	7.50	7.50

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as price guidelines.
Source: Dataquest (January 1992)

Table 10 a
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above; 28-pin PDIP ≥2Mb Density—200ns and above; 32-pin PDIP)
(Volume: 50,000 per Year; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
CMOS						
32K×8 ROM	1.50	1.50	1.50	1.50	1.50	4-10
64K×8 ROM	1.90	1.75	1.70	1.70	1.76	4-10
128K×8 ROM	2.01	2.01	1.92	1.92	1.96	4-10
64K×16 ROM	2.32	2.25	2.17	2.12	2.21	4-10
256K×8 ROM	2.76	2.73	2.65	2.63	2.69	4-10
512K×8 ROM	3.85	3.79	3.75	3.70	3.77	4-10
256K×16 ROM[1]	4.33	4.04	4.00	3.95	4.08	4-10
1Mb×8 ROM[2]	6.33	6.20	5.98	5.82	6.08	4-10

[1] 256K×16 ROM: 150ns and above; 40-pin PDIP
[2] 1Mb×8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 10 b
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above; 28-pin PDIP ≥2Mb Density—200ns and above; 32-pin PDIP)
(Volume: 50,000 per Year; Dollars)

	1993				1993
Product	Q1	Q2	Q3	Q4	Year
CMOS					
32K×8 ROM	1.45	1.45	1.45	1.45	1.45
64K×8 ROM	1.70	1.70	1.70	1.70	1.70
128K×8 ROM	1.85	1.85	1.80	1.80	1.82
64K×16 ROM	2.03	2.00	2.00	1.95	2.00
256K×8 ROM	2.55	2.55	2.50	2.50	2.53
512K×8 ROM	3.62	3.60	3.60	3.55	3.59
256K×16 ROM[1]	3.87	3.85	3.84	3.80	3.84
1Mb×8 ROM[2]	5.55	5.48	5.43	5.38	5.46

[1] 256K×16 ROM: 150ns and above; 40-pin PDIP
[2] 1Mb×8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 11
Estimated ROM Price Trends—North American Bookings
(Speed/Package: ≤1Mb Density—150ns and above; 28-pin PDIP ≥2Mb Density—200ns and above; 32-pin PDIP)
(Volume: 50,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995	1996
CMOS						
32K×8 ROM	1.59	1.50	1.45	NA	NA	NA
64K×8 ROM	2.08	1.76	1.70	1.72	2.00	NA
128K×8 ROM	2.26	1.96	1.82	1.80	1.90	2.00
64K×16 ROM	2.84	2.21	2.00	1.90	1.90	2.05
256K×8 ROM	3.18	2.69	2.53	2.44	2.44	2.49
512K×8 ROM	4.01	3.77	3.59	3.30	3.22	3.20
256K×16 ROM[1]	5.01	4.08	3.84	3.56	3.40	3.40
1Mb×8 ROM[2]	NA	6.08	5.46	5.06	4.81	4.56

NA = Not available
[1] 256K×16 ROM: 150ns and above; 40-pin PDIP
[2] 1Mb×8 ROM: 150ns and above; 32-pin SOP
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 12 a
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
TTL						
4K PROM PDIP	1.00	1.00	1.00	1.00	1.00	6-8
16K PROM PDIP	2.40	2.40	2.40	2.40	2.40	6-8
32K PROM PDIP	4.70	4.60	4.50	4.50	4.58	6-8
64K PROM PDIP	6.62	6.47	6.36	6.23	6.42	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 12 b
Estimated Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; PDIP; Dollars)

				1993	1993
Product	Q1	Q2	Q3	Q4	Year
TTL					
4K PROM PDIP	1.00	1.00	1.00	1.00	1.00
16K PROM PDIP	2.40	2.40	2.40	2.40	2.40
32K PROM PDIP	4.50	4.50	4.50	4.50	4.50
64K PROM PDIP	6.05	5.93	5.85	5.83	5.92

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 13
Estimated Long-Range Programmable ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Dollars)

Product	1991	1992	1993	1994	1995	1996
TTL						
4K PROM PDIP	.97	1.00	1.00	NA	NA	NA
16K PROM PDIP	2.26	2.40	2.40	NA	NA	NA
32K PROM PDIP	5.05	4.58	4.50	4.50	NA	NA
64K PROM PDIP	6.95	6.42	5.92	5.54	5.45	5.45

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 14 a
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
8K×8 EPROM	1.81	1.83	1.84	1.85	1.83	2-8
16K×8 EPROM	1.99	1.99	2.01	2.01	2.00	2-8
32K×8 EPROM	1.89	1.89	1.89	1.89	1.89	2-10
64K×8 EPROM	2.63	2.55	2.49	2.49	2.54	3-12
128K×8 EPROM	3.85	3.75	3.70	3.65	3.74	3-12
256K×8 EPROM	7.67	7.05	6.51	6.12	6.84	4-14
128K×16 EPROM	8.05	7.37	6.77	6.33	7.13	4-14
512K×8 EPROM	16.00	14.83	13.72	12.78	14.33	4-14
256K×16 EPROM	17.19	15.79	14.61	13.55	15.29	4-14

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 14 b
Estimated EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

				1993	1993
Product	Q1	Q2	Q3	Q4	Year
8K×8 EPROM	2.20	2.30	2.50	2.50	2.38
16K×8 EPROM	2.35	2.46	2.69	2.70	2.55
32K×8 EPROM	2.15	2.20	2.28	2.28	2.23
64K×8 EPROM	2.49	2.49	2.49	2.49	2.49
128K×8 EPROM	3.65	3.65	3.65	3.65	3.65
256K×8 EPROM	6.05	6.02	5.97	5.93	5.99
128K×16 EPROM	6.23	6.17	6.09	6.05	6.14
512K×8 EPROM	12.27	11.90	11.54	11.20	11.73
256K×16 EPROM	12.94	12.43	12.00	11.64	12.26

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 15
Estimated Long-Range EPROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and above; Dollars)

Product	1991	1992	1993	1994	1995	1996
8K×8 EPROM	1.73	1.83	2.38	2.50	2.75	3.00
16K×8 EPROM	1.82	2.00	2.55	3.00	3.05	3.05
32K×8 EPROM	1.91	1.89	2.23	2.28	2.50	2.75
64K×8 EPROM	2.73	2.54	2.49	2.49	2.60	2.85
128K×8 EPROM	4.41	3.74	3.65	3.65	3.75	3.75
256K×8 EPROM	9.88	6.84	5.99	5.60	5.40	5.40
128K×16 EPROM	NA	7.13	6.14	5.75	5.60	5.49
512K×8 EPROM	NA	14.33	11.73	10.30	9.85	9.85
256K×16 EPROM	NA	15.29	12.26	10.60	10.01	9.95

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 16 a
Estimated OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K×8	1.55	1.55	1.55	1.55	1.55	1-12
32K×8	1.56	1.56	1.56	1.56	1.56	2-12
64K×8	2.45	2.42	2.41	2.40	2.42	2-12
128K×8	3.86	3.76	3.67	3.57	3.72	6-12

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 16 b
Estimated OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

	1993				1993
Product	Q1	Q2	Q3	Q4	Year
16K×8	1.55	1.55	1.55	1.55	1.55
32K×8	1.56	1.56	1.56	1.56	1.56
64K×8	2.40	2.40	2.40	2.40	2.40
128K×8	3.55	3.53	3.48	3.45	3.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 17
Estimated Long-Range OTP ROM Price Trends—North American Bookings
(Volume: 50,000 per Year; Package: PDIP; Speed: 150ns and above; Dollars)

Product	1991	1992	1993	1994	1995	1996
16K×8	1.45	1.55	1.55	1.55	NA	NA
32K×8	1.51	1.56	1.56	1.56	NA	NA
64K×8	2.51	2.42	2.40	2.40	2.50	2.65
128K×8	4.23	3.72	3.50	3.40	3.34	3.34

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 18 a
Estimated EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

	1992				1992	Current Lead
Product	Q1	Q2	Q3	Q4	Year	Time (Weeks)
16K EEPROM	2.85	2.78	2.69	2.61	2.73	1-7
8K×8 EEPROM	4.00	3.80	3.61	3.43	3.71	1-8
32K×8 EEPROM	14.00	12.40	11.00	9.78	11.80	1-8
64K×8 EEPROM	21.25	19.13	17.21	15.84	18.36	1-8
128K×8 EEPROM	100.00	87.00	75.00	65.0	81.75	1-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 18 b
Estimated EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

	1993				1993
Product	Q1	Q2	Q3	Q4	Year
16K EEPROM	2.53	2.46	2.38	2.31	2.42
8K×8 EEPROM	3.29	3.16	3.04	2.91	3.10
32K×8 EEPROM	9.56	9.40	9.20	9.04	9.30
64K×8 EEPROM	14.60	13.70	13.00	12.52	13.46
128K×8 EEPROM	58.00	53.50	50.00	46.5	52.00

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 19
Estimated Long-Range EEPROM Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: CERDIP; Speed: 200ns and above; Dollars)

Product	1991	1992	1993	1994	1995	1996
16K EEPROM	3.09	2.73	2.42	2.31	2.43	2.43
8K×8 EEPROM	4.64	3.71	3.10	2.91	3.00	3.00
32K×8 EEPROM	19.80	11.80	9.30	8.85	8.55	8.55
64K×8 EEPROM	56.00	18.36	13.46	11.20	10.86	10.86
128K×8 EEPROM	127.50	81.75	52.00	41.60	33.77	33.77

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 20 a
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	Current Lead Time (Weeks)
32K×8, PDIP	5.95	5.75	5.60	5.45	5.69	5-10
64K×8 PDIP	7.15	7.10	6.86	6.58	6.92	5-9
128K×8 PDIP	10.14	9.69	9.35	9.13	9.58	5-9
128K×8, TSOP	10.80	10.43	10.10	9.85	10.29	5-9
256K×8, TSOP	20.00	19.00	18.50	18.00	18.88	6-14

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 20 b
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year
32K×8, PDIP	5.40	5.30	5.20	5.15	5.26
64K×8 PDIP	6.40	6.25	6.14	5.99	6.20
128K×8 PDIP	8.98	8.50	8.13	7.90	8.38
128K×8, TSOP	9.50	9.25	8.99	8.75	9.12
256K×8, TSOP	16.90	16.25	15.70	15.15	16.00

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 21
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1991	1992	1993	1994	1995	1996
32K×8, PDIP	6.08	5.69	5.26	4.75	4.75	4.95
64K×8 PDIP	NA	6.92	6.20	5.69	5.69	5.85
128K×8 PDIP	NA	9.58	8.38	7.59	7.48	7.48
128K×8, TSOP	13.50	10.29	9.12	7.88	7.48	7.48
256K×8, TSOP	24.88	18.88	16.00	8.99	8.00	7.99

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 22 a
Estimated Gate Array Price Trends—North American Production Bookings
(Millicents per Gate)
(Package: CMOS—84-pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K Gates; ECL—CQFP)
(Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL)

Gate Count	0-1.99K		2-4.99K		5.0-9.99K		Current Lead
Technology	1991	1992	1991	1992	1991	1992	Time (Weeks)
CMOS							Production:
1.5 Micron	127	121	94	87	82	72	10-12
1.2 Micron	117	109	81	74	78	70	7-10
1.0 Micron	115	104	82	71	78	70	9-12
0.8 Micron	NA	NA	NA	71	NA	70	10-12
ECL	5360	4850	4588	3823	3500	3000	12-14
NRE Charges ($1,000s)							
CMOS							Prototypes:
1.5 Micron	16.0	16.0	21.0	21.0	26.0	26.0	3-5
1.2 Micron	13.0	13.0	18.0	17.0	23.0	21.0	3-5
1.0 Micron	23.0	19.0	24.0	24.0	29.0	27.5	3-5
0.8 Micron	NA	NA	NA	27.0	NA	35.5	3-5
ECL	32.0	30.0	50.0	45.0	55.0	50.0	14

Gate Count	10-19.99K		20-29.99K		30-60K		Current Lead
Technology	1991	1992	1991	1992	1991	1992	Time (Weeks)
CMOS							Production:
1.5 Micron	81	71	83	73	98	88	10-12
1.2 Micron	77	69	79	71	98	85	7-12
1.0 Micron	77	69	79	71	78	80	9-12
0.8 Micron	NA	76	NA	78	NA	87	10-12
ECL	4550	4000	3838	3200	3600	3050	10-14
NRE Charges ($1,000s)							
CMOS							Prototypes:
1.5 Micron	41.0	40.5	60.0	60.0	100.0	100.0	3-6
1.2 Micron	40.0	40.0	58.0	58.0	102.0	102.0	4-8
1.0 Micron	47.5	44.0	61.0	61.0	98.3	96.7	3-5
0.8 Micron	NA	51.7	NA	72.6	140.0	111.2	3-5
ECL	71.0	70.0	105.0	100.0	170.0	146.7	9-14

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 22 b
Estimated Gate Array Price Trends—North American Production Bookings—1993
(Millicents per Gate)
(Package: CMOS—84-pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K Gates; ECL—CQFP)
(Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)
(Volume: 10,000 per Year/CMOS; 5,000 per Year/ECL)

Gate Count	0-1.99K	2-4.99K	5-9.99K	10-19.99K	20-29.99K	30-60K
CMOS						
1.5 Micron	102.0	77.0	63.0	62.0	64.0	77.0
1.2 Micron	92.0	65.0	62.0	61.0	62.0	75.0
1.0 Micron	87.0	62.0	62.0	61.0	62.0	69.0
0.8 Micron	NA	62.0	62.0	68.0	69.0	73.0
ECL	4268	3326	3000	4000	2784	2654
NRE Charges ($1,000s)						
CMOS						
1.5 Micron	15.2	20.0	24.7	40.0	57.0	95.0
1.2 Micron	12.4	16.2	20.0	38.0	55.1	96.9
1.0 Micron	18.1	24.0	27.1	42.9	57.0	90.9
0.8 Micron	NA	26.8	32.1	50.4	66.1	104.5
ECL	27.0	40.5	45.0	65.0	90.0	132.0

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 23 a
Estimated CBIC Price Trends—North American Production Bookings
(Millicents per Gate)
(Package: 84-pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K)
(Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K		2-4.99K		5.0-9.99K		Current Lead
Technology	1991	1992	1991	1992	1991	1992	Time (Weeks)
CMOS							Production:
1.5 Micron	129	123	110	90	92	82	10-14
1.2 Micron	118	110	85	80	80	72	8-15
1.0 Micron	116	105	97	80	80	72	9-14
0.8 Micron	NA	NA	NA	80	NA	72	12-16
NRE Charges ($1,000s)							Prototypes:
1.5 Micron	35.0	35.0	38.0	38.0	48.0	47.0	5-8
1.2 Micron	33.0	32.0	35.5	35.0	45.0	43.5	5-8
1.0 Micron	42.0	40.0	50.0	49.0	53.0	49.0	5-8
0.8 Micron	NA	NA	NA	75.0	NA	76.0	6-8

Gate Count	10-19.99K		20-29.99K		30-60K		Current Lead
Technology	1991	1992	1991	1992	1991	1992	Time (Weeks)
CMOS							Production:
1.5 Micron	84	74	86	79	99	88	10-14
1.2 Micron	79	71	82	74	100	87	9-15
1.0 Micron	79	70	81	74	96	81	10-16
0.8 Micron	NA	78	NA	80	NA	89	13-16
NRE Charges ($1,000s)							Prototypes:
1.5 Micron	66.0	65.0	89.0	85.0	112.0	110.0	5-8
1.2 Micron	62.0	58.5	80.0	75.0	110.0	100.0	5-8
1.0 Micron	59.0	56.8	62.5	62.0	115.0	113.0	5-7
0.8 Micron	NA	90.0	NA	120.0	NA	145.5	6-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 23 b
Estimated CBIC Price Trends—North American Production Bookings—1993
(Millicents per Gate)
(Package: 84-pin PLCC for <10K Gates; 160-pin PQFP for 10K-29.9K; 208-pin PQFP for ≥30K)
(Based on Utilized Gates Only; Volume: 10,000 per Year; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	0-1.99K	2-4.99K	5-9.99K	10-19.99K	20-29.99K	30-60K
CMOS						
1.5 Micron	103	79	72	65	70	77
1.2 Micron	93	71	63	62	65	77
1.0 Micron	89	71	63	62	65	71
0.8 Micron	NA	71	63	69	70	74
NRE Charges ($1,000s)						
1.5 Micron	33.3	36.1	44.7	61.8	80.8	103.4
1.2 Micron	30.4	33.3	41.3	55.6	71.3	97.0
1.0 Micron	39.3	45.0	46.6	49.0	60.0	105.0
0.8 Micron	NA	55.0	57.0	82.5	110.0	136.0

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 24
Estimated TTL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
≤20						
	≤6	6.73	6.23	6.08	5.96	2-9
	6.1-7.5	2.93	2.75	2.65	2.55	2-8
	7.6-10.0	1.60	1.56	1.44	1.40	2-8
	10.1-14.99	1.27	1.23	1.14	1.10	2-8
	15-<25	.66	.62	.61	.60	2-4
	≥25	.50	.48	.48	.48	2-4
24	≤6	9.82	9.19	8.70	8.30	3-8
	6.1-7.5	5.08	4.93	4.74	4.59	2-6
	7.6-10.0	3.15	2.85	2.80	2.76	2-4
	10.1-14.99	3.00	2.88	2.77	2.66	3-6
	15-<25	1.14	1.10	1.09	1.09	2-4
	≥25	.75	.74	.72	.72	2-4
24						
22V10						
	15-<25	5.32	5.00	4.89	4.80	3-8
	25-<35	2.55	2.43	2.25	2.12	2-8

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 25
Estimated Long-Range TTL PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PLCC or PLCC; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
≤20							
	≤6	7.75	6.48	6.02	5.75	5.50	5.25
	6.1-7.5	3.32	2.84	2.60	2.51	2.40	2.32
	7.6-10.0	1.77	1.58	1.42	1.39	1.32	1.32
	10.1-14.99	1.37	1.25	1.12	1.08	1.00	1.00
	15-<25	.72	.64	.61	.60	.60	.60
	≥25	.53	.49	.48	.48	.48	
24	≤6	10.78	9.50	8.50	7.36	6.60	6.30
	6.1-7.5	5.90	5.00	4.67	4.40	4.20	4.00
	7.6-10.0	3.63	3.00	2.78	2.69	2.60	2.50
	10.1-14.99	3.20	2.94	2.72	2.54	2.44	2.40
	15-<25	1.23	1.12	1.09	1.08	1.08	1.08
	≥25	.82	.75	.72	.70	.70	.70
24							
22V10							
	15-<25	5.97	5.16	4.85	4.65	4.49	4.40
	25-<35	2.81	2.49	2.19	2.07	1.98	1.98

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 26
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

	Speed*	1992		1993		Current Lead
Pin Count	(ns)	H1	H2	H1	H2	Time (Weeks)
≤20	6.1-7.5	5.50	5.16	4.99	4.70	2-14
	7.6-10.0	3.17	3.04	2.76	2.53	1-14
	10.1-14.99	2.19	2.06	1.93	1.81	1-4
	15-<25	.80	.77	.76	.75	1-4
	≥25	.68	.65	.64	.63	1-6
24						
	6.1-7.5	9.70	8.90	8.36	7.84	4-14
	7.6-10.0	5.73	5.33	5.04	4.82	1-14
	10.1-14.99	3.29	3.12	2.97	2.81	1-6
	15-<25	1.34	1.25	1.24	1.23	1-8
	≥25	.99	.94	.94	.94	1-6
24						
22V10						
	7.6-10.0	18.00	16.25	14.80	13.40	2-10
	15-<25	5.99	5.47	5.42	5.37	1-8
	25-<35	2.47	2.01	2.01	2.01	1-4

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 27
Estimated Long-Range CMOS PLD Price Trends—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
≤20	6.1-7.5	6.41	5.33	4.85	4.60	4.45	4.40
	7.6-10.0	3.82	3.11	2.64	2.48	2.30	2.25
	10.1-14.99	2.66	2.13	1.87	1.70	1.60	1.60
	15-<25	.91	.79	.76	.74	.73	.73
	≥25	.75	.67	.64	.62	.59	.59
24							
	6.1-7.5	NA	9.30	8.10	7.45	7.00	6.70
	7.6-10.0	6.70	5.53	4.93	4.70	4.55	4.50
	10.1-14.99	3.65	3.20	2.89	2.72	2.64	2.64
	15-<25	1.53	1.30	1.24	1.22	1.22	1.22
	≥25	1.13	.97	.94	.94	.94	.94
24							
22V10							
	7.6-10.0	22.00	17.13	14.10	12.82	11.92	11.67
	15-<25	7.01	5.73	5.40	5.10	4.90	4.90
	25-<35	3.04	2.24	2.01	2.01	2.00	2.00

NA = Not available
*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 28
Estimated ECL PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Dollars)

	Speed*	1992		1993		Current Lead
Pin Count	(ns)	H1	H2	H1	H2	Time (Weeks)
24						
	≤2.0	33.75	32.75	30.75	29.24	6-8
	2.01-4.0	27.90	26.40	25.00	23.92	8-10
	4.1-6.0	6.83	6.71	6.35	6.19	4
	6.1-15.0	5.80	5.71	5.58	5.50	4

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 29
Estimated Long-Range ECL PLD Price Trends—North American Bookings (Volume: 10,000 per Year; Dollars)

Pin Count	Speed* (ns)	1991	1992	1993	1994	1995	1996
24							
	≤2.0	37.50	33.25	30.00	27.40	25.07	23.82
	2.01-4.0	31.50	27.15	24.46	21.99	20.24	19.73
	4.1-6.0	7.50	6.77	6.27	5.86	5.68	5.68
	6.1-15.0	6.25	5.76	5.54	5.32	5.32	5.32

*Nanosecond speed is the TPD for the combinatorial device.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 30
Estimated Analog IC Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

	1992		1993		Current Lead
Device Family	H1	H2	H1	H2	Time (Weeks)
Voltage Regulators					
78L05 (TO-92)	.120	.118	.117	.117	3-6
7805 (TO-92)	.138	.137	.137	.137	
Comparators					
LM339	.137	.137	.132	.130	4-6
LM393	.129	.127	.127	.127	
Op Amps					
741	.130	.125	.128	.128	4-6
3403P	.182	.178	.176	.174	
1741CP1	.124	.120	.119	.117	
Interface ICs					
1488P	.150	.150	.146	.144	4-6
3486P	.895	.885	.880	.860	
Telecom ICs					4-7
CODEC/FILTER 1	2.030	2.000	1.970	1.941	
34017P	.330	.320	.315	.305	
Video DAC					
IMSG171D-35MHz*	1.800	1.700	1.600	1.50	NA

NA = Not available
*Estimated and not by survey.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 31
Estimated Long-Range Analog IC Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Device Family	1991	1992	1993	1994	1995	1996
Voltage Regulators						
78L05 (TO-92)	.122	.119	.117	.117	.116	.116
7805 (TO-92)	.140	.138	.137	.137	.137	.137
Comparators						
LM339	.139	.137	.131	.130	.130	.130
LM393	.130	.128	.127	.127	.126	.126
Op Amps						
741	.132	.128	.128	.128	.128	.128
3403P	.186	.180	.175	.174	.171	.171
1741CP1	.125	.122	.118	.117	.116	.116
Interface ICs						
1488P	.155	.150	.145	.144	.137	.137
3486P	.918	.890	.870	.860	.840	.840
Telecom ICs						
CODEC/FILTER 1	2.080	2.015	1.956	1.884	1.820	1.800
34017P	.346	.325	.310	.305	.298	.290
Video DAC						
IMSG171D-35MHz*	NA	1.750	1.550	1.440	1.390	1.370

NA = Not available
*Estimated and not by survey.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 32
Estimated Discrete Semiconductor Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

	1992		1993		Current Lead
Device Family	H1	H2	H1	H2	Time (Weeks)
Small Signal Transistors					2-8
2N2222A	.140	.140	.139	.139	
2N3904	.030	.030	.029	.029	
2N2907A	.068	.068	.066	.066	
MPSA 43	.052	.049	.048	.046	
2N2222	.046	.045	.045	.045	
Bipolar Power Transistor					3-8
2N3772	1.040	1.040	1.040	1.040	
2N3055A	.700	.700	.690	.690	
2N6107	.235	.235	.235	.235	
Power MOSFET					3-8
IRF530	.400	.380	.370	.370	
IRF540	1.000	1.000	.990	.990	
IRF9531	1.040	1.030	1.029	1.027	
IRF9520	.416	.414	.411	.409	
Small Signal Diodes					1-8
1N4002	.020	.020	.020	.020	
1N645	.047	.046	.045	.045	
Power Diodes					2-8
1N3891	.888	.878	.875	.871	
1N3737	7.120	7.090	7.070	6.999	
1N4936	.095	.094	.093	.092	
Zener Diodes					2-8
1N829	1.165	1.165	1.165	1.165	
1N752A	.026	.025	.025	.025	
1N963B	.026	.025	.025	.025	
1N4735A	.040	.039	.039	.039	
1.5KE62A	.625	.610	.608	.600	
1.5KE30CA	1.230	1.200	1.192	1.180	
P6KE30CA	.708	.690	.690	.690	
Thyristors					2-8
2N6400	.620	.620	.593	.573	
2N4186	2.275	2.265	2.270	2.250	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 33
Estimated Long-Range Discrete Semiconductor Price Trends—North American Bookings (Volume: 100,000 per Year; Dollars)

Device Family	1991	1992	1993	1994	1995	1996
Small Signal Transistors						
2N2222A	.140	.140	.139	.138	.138	.138
2N3904	.031	.030	.029	.028	.028	.028
2N2907A	.070	.068	.066	.062	.061	.061
MPSA 43	.057	.050	.047	.046	.045	.045
2N2222	.049	.046	.045	.045	.045	.045
Bipolar Power Transistors						
2N3772	1.040	1.040	1.040	1.040	1.040	1.040
2N3055	.700	.700	.690	.680	.670	.670
2N6107	.235	.235	.235	.235	.235	.235
Power MOSFET						
IRF530	.413	.390	.370	.370	.390	.390
IRF540	1.025	1.000	.990	.980	.975	.975
IRF9531	1.058	1.035	1.028	1.022	1.022	1.022
IRF9520	.425	.415	.410	.408	.408	.408
Small Signal Diodes						
1N4002	.020	.020	.020	.020	.020	.020
1N645	.047	.046	.045	.045	.045	.045
Power Diodes						
1N3891	.900	.883	.873	.864	.864	.864
1N3737	7.161	7.105	7.035	6.990	6.990	6.990
1N4936	.096	.094	.092	.092	.092	.092
Zener Diodes						
1N829	1.165	1.165	1.165	1.165	1.165	1.165
1N752A	.027	.026	.025	.025	.025	.025
1N963B	.026	.026	.025	.025	.025	.025
1N4735A	.040	.040	.039	.039	.039	.039
1.5KE62A	.659	.617	.604	.595	.595	.595
1.5KE30CA	1.304	1.215	1.186	1.167	1.167	1.167
P6KE30CA	.748	.699	.690	.681	.681	.681
Thyristors						
2N6400	.650	.620	.583	.562	.562	.562
2N4186	2.290	2.270	2.260	2.250	2.250	2.250

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 34
Estimated Optoelectronic IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1992 H1	1992 H2	1993 H1	1993 H2	Current Lead Time (Weeks)
Optoelectronic Round LED Lamps					6
T1 STD RED	.054	.054	.053	.052	
T1 3/4 STD RED	.054	.054	.053	.052	
T1 3/4 H.EF.RED	.073	.072	.071	.070	
Mold Frame LED					6
0.3" Digital Display	.500	.490	.486	.484	
0.6" Digital Display	.540	.530	.527	.517	
Optical Couplers					6-8
4N25	.190	.195	.193	.193	
4N36	.225	.225	.225	.225	

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

Table 35
Estimated Long-Range Optoelectronic IC Price Trends—North American Bookings
(Volume: 100,000 per Year; Dollars)

Device Family	1991	1992	1993	1994	1995	1996
Optoelectronic Round LED Lamps						
T1 STD RED	.054	.054	.053	.051	.051	.051
T1 3/4 STD RED	.054	.054	.054	.051	.051	.051
T1 3/4 H.EF.RED	.074	.073	.072	.070	.070	.070
Mold Frame LED						
0.3" Digital Display	.500	.495	.488	.480	.476	.476
0.6" Digital Display	.550	.535	.529	.512	.512	.512
Optical Couplers						
4N25	.195	.193	.194	.193	.193	.193
4N36	.228	.225	.225	.225	.229	.229

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality and service. These prices are intended for use as guidelines.
Source: Dataquest (January 1992)

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• Vendor Profiles

Dataquest

Dataquest Vendor Profile

Semiconductor Procurement
October 5, 1992

Intel Corporation

Corporate Statistics

Headquarters Location	Santa Clara, California
President and CEO	Andy Grove
Primary Business	Microcomputer components
Annual Sales (FY1991)	$4,779 million (U.S. Dollars)
Total Employees	24,600
Manufacturing Locations	10 worldwide
Founding Date	July 1968
Fiscal Year	January-December
Ownership	Public (NASDAQ ... INTC)

Corporate Overview

Over the last five years, Intel has recovered from a downhill slide capped by heavy losses in 1986 to become the kingpin of microprocessors and perhaps the most powerful semiconductor company in existence. Driven by Intel toward increased performance levels, the enormous market for 80x86-based PCs grew in 1991 to more than $2.5 billion in microprocessor revenue and about $1.0 billion in related peripheral products. Now at the pinnacle of its success, Intel faces its toughest challenge: to keep its 80x86 family ahead of competing RISC families and other 80x86 clone products while maintaining attractive profit margins.

Intel defines its mission to be the leading supplier of microcomputer building blocks at the component, module, or system level used within computers and embedded control equipment. Today, most of the company's activities are focused on growing its business derived from the IBM-compatible PC market. This direction means that Intel must remain the dominant leader in 80x86 microprocessors and microperipherals.

For more information on Intel Corporation or the semiconductor procurement industry, call Mark Giudici at (408) 437-8258.

Founded in 1968, Intel originally concentrated on semiconductor memory products, which still remain an important part of its business. Among its many innovations (see Table 1), Intel is credited with inventing the most important memory in use today, the dynamic

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Table 1
Major Milestones for Intel Corporation

Year	Description
1968	Intel Corporation founded.
1970	Introduced the first commercial DRAM (1Kb).
1971	Introduced the first commercial EPROM (1Kb). Introduced the first commercial microprocessor (4004). Goes public.
1973	Introduced the first microprocessor development system.
1974	Introduced the 8080 (initiated major growth of MPU industry). Achieved more than $100 million in net sales.
1976	Introduced the first microcontroller with EPROM.
1978	Introduced the 8086 (spawning the most successful line of MPU in history).
1979	Introduced the first 5V DRAM (previously all 12V).
1980	Introduced the 8051 microcontroller (most widely used MCU in world). Introduced the first math coprocessor (8087).
1981	Intel 8088 selected by IBM for its first personal computer (IBM PC).
1982	Introduced the 80286 (used in IBM PC AT).
1983	Achieved more than $1 billion in net sales.
1985	Exits the DRAM business (after developing 1Mb working silicon). Enters the PC enhancement market (AboveBoard memory adapters). Introduced the 80386, first 32-bit x86-compatible generation.
1987	Enters the market for parallel supercomputers.
1988	Introduced its first flash memory product. Introduced the i960 embedded RISC processor family.
1989	Introduced the first 1-million-transistor microprocessor (i860). Introduced the 80486, first MPU with integrated CPU, FPU, and cache.
1990	Exits EPROM development race (at 4Mb) to focus on flash.
1991	Achieves fastest installed supercomputer (32 gflops). Introduced the first 2.5-million-transistor microprocessor (i860XP).
1992	Introduced the first 8Mb flash memory component.

Source: Intel, Dataquest (October 1992)

random access memory (DRAM). Its strategy has always been built on innovation: invent something unique, enjoy higher profits from that uniqueness, then move on when competition crowds the market. Yet, as it entered the 1980s, Intel (like most semiconductor companies) sold a broad range of mostly commodity products. Then, in 1981, IBM chose the 8088 as the engine for its first PC, eventually changing the profile of Intel's entire business.

By 1985 it was clear that the DRAM business was, at best, a low-margin proposition where the Japanese were taking over in the midst of a chip recession. As a result, Intel accumulated operating losses of $250 million over 1985 and 1986. These and other factors drove Intel's decision to exit the commodity-oriented DRAM business in favor of the innovation-oriented microprocessor business. At that time, Intel's future hinged on the success of its proprietary 386 microprocessor, an advanced 32-bit architecture compatible with the 16-bit 8086 PC standard.

As history shows, this was the best decision Intel could have made. The 386 became the most successful logic chip in the semiconductor industry, accounting for nearly half of Intel's 1988 revenue of $2.9 billion. Intel followed up with the 387 math coprocessor and later, in 1989, with the 486, a 1.2-million-transistor chip that combined the functions of the 386 and 387 and had a primary cache yielding a twofold performance improvement at a fourfold pricing increase. As a result, the 486 now represents Intel's leading revenue generator, which will account for more than $1.4 billion in revenue for 1992.

Intel's 386 monopoly weakened in 1991 when Advanced Micro Devices (AMD) became the first of several vendors to enter the 386-compatible market, taking considerable unit volumes and effectively lowering the exceptionally high pricing structure Intel had enjoyed. At the same time, RISC microprocessors were reaching the peak of their momentum with IBM, Apple, and Motorola teaming up to create next-generation systems based on the PowerPC architecture. Meanwhile, Intel has increased its penetration into other markets, trying to balance its portfolio of products to increase its non-80x86 revenue.

Business Strategy and Segmentation

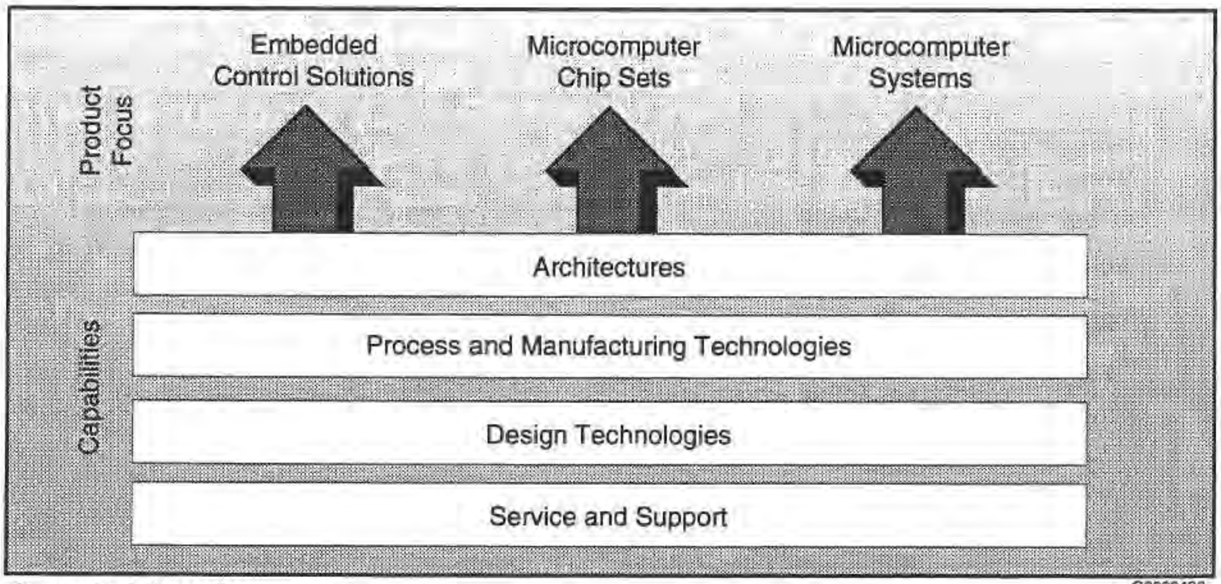
Intel's vision for the 1990s centers around a concept referred to as "computer-supported collaboration. " It believes that as the pace of competition picks up (among businesses in general) there will be a transition to a "just-in-time" business environment, where getting the right information to where it is needed quickly becomes a primary competitive advantage. This transition will be achieved through cooperative work facilitated by interconnected, interactive electronic communication in which all forms of data are shared quickly and easily. The worldwide computer infrastructure will be extended to become a communications infrastructure, hence "computer-supported collaboration." Intel integrates its product mix around this central theme, paving the way for increasing levels of processing power, miniaturization, and communications capabilities.

To realize this overall vision, Intel pursues the evolution of its primary target market, computer systems, by focusing on three main product areas supported by four key capabilities (see Figure 1). Intel's overall business strategy anticipates integration of the computer and communications industries and positions the company to pursue the additional opportunities that will result. Intel's primary product focuses are microcomputer chip sets, embedded control solutions, and microcomputer systems, the first two of which are semiconductor product businesses representing the bulk of Intel's total sales. The key capabilities developed by Intel to support its growth in these areas include proprietary architectures (mainly microprocessors), manufacturing and process technologies, design technologies, and support services.

Major Market Segments

Intel participates in a wide range of market segments. However, sales are dominated by the data processing market, which accounts for an estimated 70 percent of its total revenue. Sales into this segment include semiconductor components (microprocessors, microperipherals, and memory devices), computer upgrade modules (coprocessors, memory cards, and add-in adapters), and supercomputers—all sold to computer companies, distributors, or end users. Intel has targeted the computer systems markets since the mid-1980s because of the higher margins afforded to the components that serve that market. Other market segments served (in order of decreasing revenue) are industrial, communication, automotive, military, and consumer.

Figure 1
Intel Core Strategy



Source: Intel Corporation

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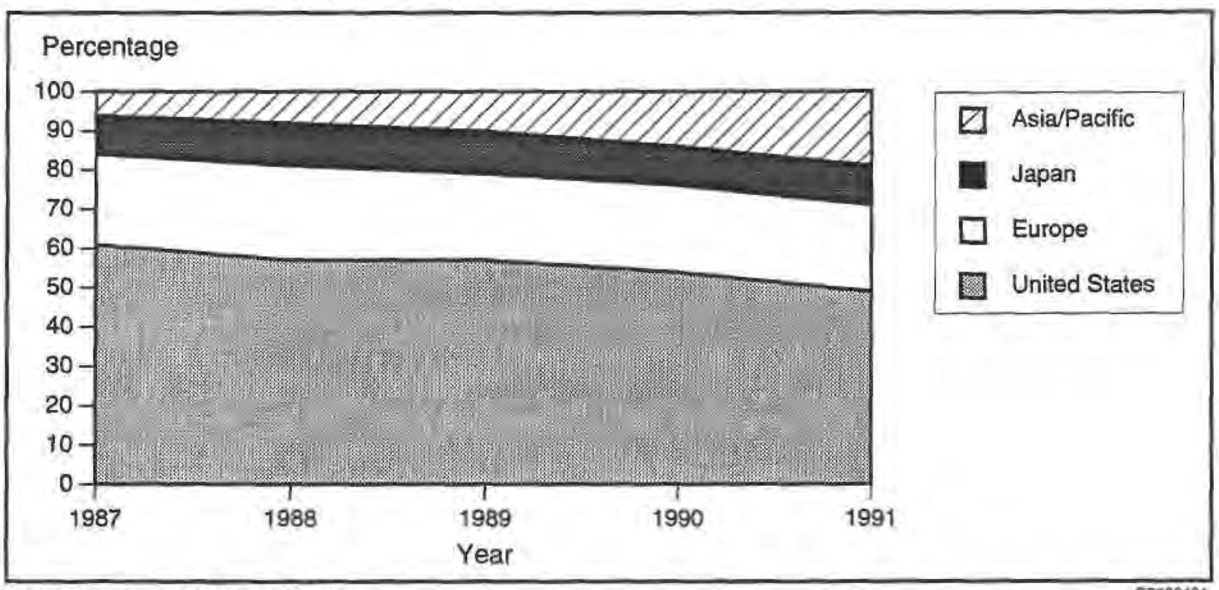
Intel sells most of its components directly to companies that incorporate them into their products. These customers primarily are computer systems manufacturers such as IBM and Compaq, but they also include producers of telecommunications equipment, industrial equipment, and automobiles. Intel maintains a broad, balanced customer base; no single customer accounted for more than 10 percent of its revenue during the last two years (in 1989, IBM accounted for 10.5 percent of Intel's revenue). Intel also sells certain products through distribution, which accounted for about 25 percent of its net revenue during 1991.

An expanding base of international customers, primarily in the Asia-Pacific region, has driven Intel's sales mix to an all-time high of 51 percent non-U.S. revenue (see Figure 2). Over the last five years, Intel's sales from the Asia-Pacific region have steadily increased from 6 percent in 1987 to 19 percent in 1991, making it the No. 1 vendor in the region, primarily driven by the growth of the PC clone industry in Taiwan. However, as a result of AMD and other x86 clones entering the 386/486 market and penetrating primarily the Asia-Pacific clone vendors, this shift in regional sales mix is expected to come to a halt during 1992. In exchange for this increase in international business, sales in the United States decreased from 61 percent in 1987 to only 49 percent in 1991, which also indicates the shift toward offshore manufacturing of PCs. During this same period, the percentage of regional sales to both Europe and Japan remained relatively constant at about 22 percent and 10 percent, respectively.

Figure 2
Intel Sales, by Geographic Region



Source: Dataquest (October 1992)

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Major Product Segments

Though its product mix includes items as diverse as supercomputers and adapter boards, Intel is primarily a semiconductor company, with microprocessors central to its entire product mix. This section will provide an overview of Intel's product mix as defined by the company. A subsequent section will provide a complete analysis of Intel's semiconductor-related businesses, which accounted for a combined total of about $4.0 billion, or 84 percent of its 1991 revenue.

The first product segment, microcomputer chip sets, feeds the bulk of Intel's growth, 65 percent of 1991 revenue or about $3.1 billion (see Figure 3). This segment includes semiconductors and integrated modules as building blocks for computer systems ranging from desktops to floortops to portables. Specifically, this segment includes the following products:

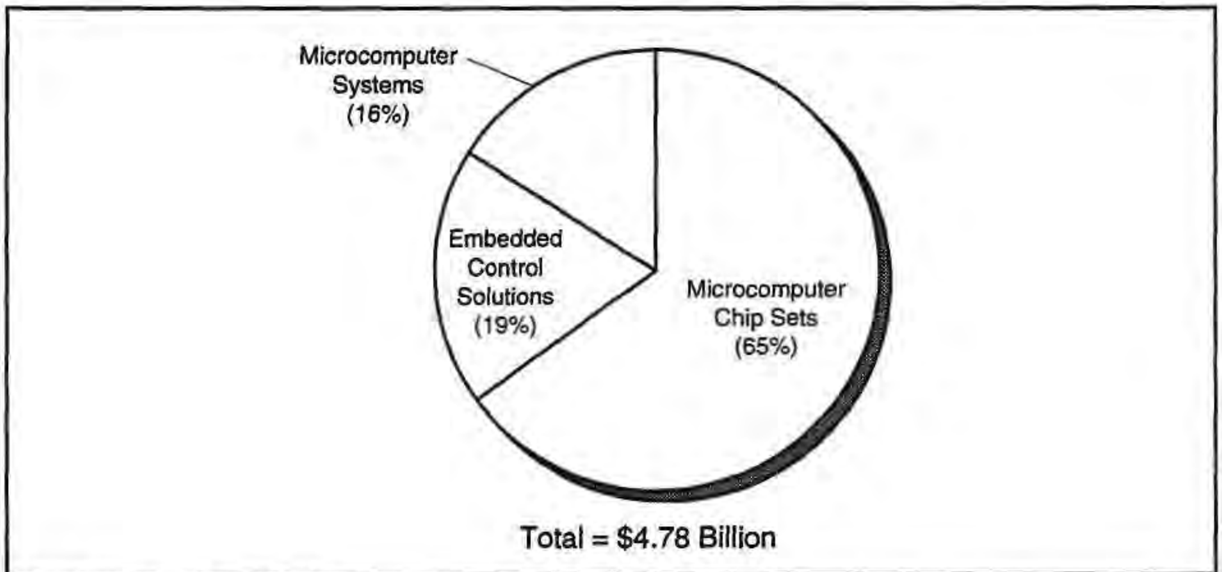
- Computer microprocessors, the central control units used for computer systems, now primarily focused on 32-bit 80x86 processors (that is, 386, 486, and P5). Also includes the older 16-bit 80x86 processors (8088/86/286) and the i860 processor for supercomputing and graphics.
- Microperipherals, which work directly with the microprocessors to handle specific I/O and processing functions. Intel's sales here are dominated by math coprocessors but also include PC core logic chips, network controller chips, multimedia, and modem chips.
- SRAM memory and CPU/cache modules (sold for the 486DX-50), which account for a small amount of revenue but represent a strategic technology for integration with the CPU.

Embedded control solutions, the second semiconductor business area, accounted for about $900 million (19 percent) of 1991 revenue. This business segment includes components used in various embedded applications such as laser printers, communications systems, and automobiles. This segment spreads out the use of Intel components as the core of intelligent noncomputer electronic systems. Specifically, this segment includes the following products:

- Microcontrollers, which represent the largest revenue source for this product segment, integrate microprocessor and memory technologies on one chip and include the 8048, 8051, and proprietary MCS-96 families of components.
- Nonvolatile memory/logic, which permanently store control programs, includes Intel's line of EPROMs, flash memory devices, and PLD devices.
- Embedded microprocessors, the processors used to control the actions and data flow in noncomputer applications, include the i960 family as well as the embedded versions of the 80x86 family (80186/188/376).

Microcomputer systems, a nonsemiconductor business area, accounted for about $800 million of Intel's 1991 revenue. This business segment supports the proliferation of the other two segments,

Figure 3
Intel Sales, by Product Segment



Source: Dataquest (October 1992) G2000482

creating and manufacturing systems designed around Intel components at both the commodity level (PC motherboards) and leading edge (supercomputers). Specifically, this segment includes the following:

- PC motherboards, based primarily on Intel microprocessor and I/O components, are manufactured by Intel for OEMs such as Digital Equipment Corporation.
- PC enhancement products, which are sold through retail computer stores, include add-in adapter boards (memory, fax/modem, network controllers), PCMCIA cards (memory, fax/modem), and component upgrades (math coprocessors, overdrive processors).
- Supercomputer systems, ultra-high-performance computers utilizing massively parallel processing primarily for scientific and engineering problems, are designed around Intel's i860 microprocessor and sold directly to large end users.
- Software products, which include microcomputer operating systems (iRMX real-time kernel for industrial control applications), development/debug support tools, and high-level networking software support.

Key Capabilities and Competencies

Intel to date has been successful in optimizing its four key capabilities around its product mix to leverage its position as the incumbent king of microprocessors.

The first of Intel's four key capabilities is proprietary architectures. Leveraging the momentum of the IBM PC legacy, Intel pushes leading-edge performance and integration while maintaining pull-through 80x86 compatibility. The 80x86 microcomputer architecture is the most widely used in the industry, representing more than 80 percent of the PC units shipped. Intel works closely with major software vendors to ensure that the 80x86 family maintains the largest complement of operating systems and application packages available. Intel also maintains two proprietary RISC microprocessor architectures, the i960 for the 32-bit embedded processing market and the i860 for supercomputers and graphics/imaging subsystems.

Intel's next emphasis is advanced process and manufacturing technology. Intel's strength in manufacturing capability is underscored by its enormous capital investment (nearly $1 billion in 1991) used for continually upgrading facilities. Intel's process technology developments have enabled it to double the number of transistors it can integrate on one chip about every 18 months since the early 1970s. Its strategy is to gain a twofold leverage from the following leading-edge processes:

- Enable state-of-the-art products not possible or economical without the investment in fabrication expertise
- Lower unit cost through smaller die sizes and higher yields as older products become commodities, affording them higher margins

Intel's third key capability is design technology, where it has long been recognized that design time is a bottleneck in bringing new chips to the market. Intel's level of design technology is reinforced by its continued high spending in R&D, which represented 13 percent of total sales in 1990 and 1991. As a result, Intel expects to reduce its time to market for next-generation chips while significantly increasing their complexity. Thus, as the P5 is introduced in early 1993, the P6 generation should be out in mid-1994 and the P7 in early 1996.

Intel's fourth key capability is service and support. As with most major companies, service is a key element in the overall marketing mix. At Intel, the differential advantage focuses on extensive documentation, training programs, and hardware/software development tools that make its components easy to design with.

Marketing Strategy and Alliances

Though not included under key capabilities, another key Intel strength is its marketing program, which is an integrated mix of brand promotion, competitive counterattacks, and high-impact product introductions. Combined with its position in the 80x86 microprocessor market, Intel delivers the image of leadership within the PC industry through its marketing programs.

Intel's brand promotion program has been aimed at increasing the awareness of its brand products and their advantages at the end-user level. To date, more than 340 manufacturers have participated in the "Intel Inside" cooperative advertising program. Intel hopes to use this program to develop preference for PCs with Intel microprocessors because of their absolute compatibility, upgradability paths, and other features.

Intel has also begun strengthening its relationships with key customers and third parties because it faces increasing competition on its mainstream microprocessors. As a result, Intel is forming more and more strategic alliances, such as its recent cross-licensing agreement with VLSI Technology. This agreement establishes a program for developing highly integrated 386-based processors for the handheld market through a vendor that leads in PC logic chip sets and excels in customization services. In addition, it focuses VLSI's development and marketing efforts on Intel's microprocessors, rather than on AMD, Cyrix, or others.

Intel's 1992 alliances were as follows:

- VLSI Technology and Intel entered into a cross-licensing and equity exchange agreement (Intel now owns 16 percent of VLSI) to design integrated 386-based products primarily for the handheld market.
- IBM and Intel entered into a licensing agreement for IBM's XGA graphics architecture in which Intel will integrate XGA features into IBM's multimedia and microcomputer products.
- Defense Advanced Research Projects Agency (DARPA) and Intel announced a joint research program to produce a 1-teraflop-level supercomputer system.

Intel's 1991 alliances were as follows:

- IBM and Intel jointly announced the formation of the Noyce Development Center, a 100-engineer design center to develop very highly integrated 80x86 microprocessors.
- Digital and Intel entered into an agreement in which Digital would introduce a new family of PC products based on Intel 386/486 microprocessors and manufactured by Intel.
- NMB Semiconductor and Intel entered into a supply agreement in which NMB will turn one of its plants into a flash memory foundry (for die only) dedicated to Intel.
- Pacific Bell and Intel signed an agreement to market network integration services and equipment in conjunction with Pacific Bell's Data Communications Group.
- Tartan Laboratories and Intel's military division signed an agreement to jointly market Tartan's i960 Ada compilation system.

In 1990, IBM and Intel entered into an agreement providing Intel exclusive rights to its parallel interface (PI) bus interface unit, currently used in IBM's Common Avionics Modules.

Intel's 1989 alliances were as follows:

- AT&T, Convergent Technologies, Ing. C. Olivetti S.p.A., Prime Computer, and Intel announced a joint engineering effort to create a multiprocessing version of UNIX for the i860.
- AT&T Microelectronics and Intel signed a five-year agreement to provide OEMs with an array of products supporting ISDN and LANs from a common source.
- (DARPA) and Intel signed a $7.6 million research agreement to develop prototypes of a CRAY-1-level supercomputer.
- IBM and Intel signed an agreement in which Intel would develop an MCA board to utilize DVI for the IBM PS/2 computer.

Company Organization and Operations

Intel is organized around a business unit structure (see Figure 4) that focuses on the development and marketing of its product segments while relying on centralized departments for all of the support functions including manufacturing, sales, finance, and administration. There are five product groups, four of which focus strictly on one product segment while the fifth splits attention between two product segments. At the top is an executive office shared by Chairman Gordon Moore, President Andy Grove, and Executive Vice President Craig Barrett. As the company's chief strategist and visionary, Andy Grove maintains the most visible role of the three executives in shaping Intel's direction. Craig Barrett, currently positioned as the heir-apparent, primarily focuses on day-to-day operations.

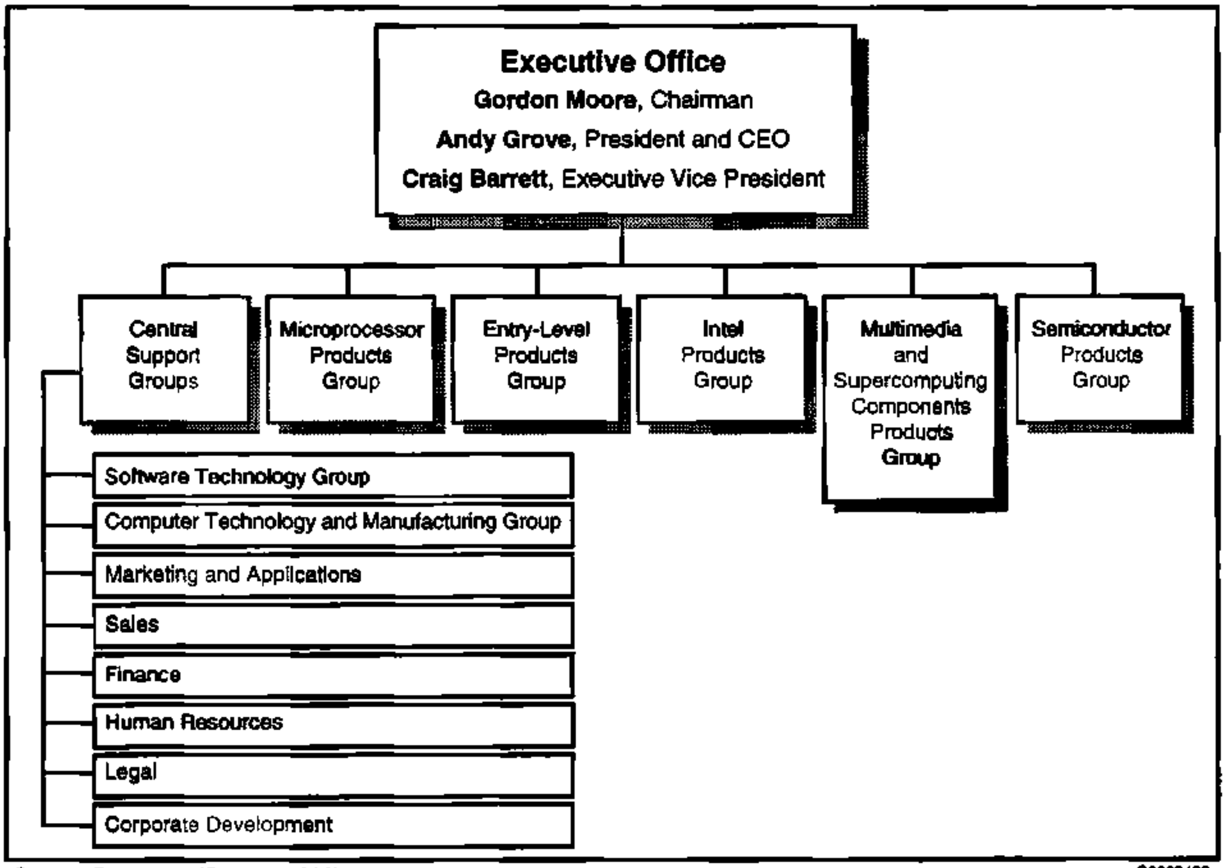
Development of the 80x86 product line is split between two separate operating groups based on both product and market focus, the first of which is the Microprocessor Products Group. This group is responsible for the development of high-performance 80x86 processors targeted primarily for office systems (PC desktops, workstations, and servers). The group is headed by Paul Otellini and Albert Yu, both vice presidents who share the general manager position. Specific products under this group include the following:

- i486 product line (SX, DX, and other desktop versions)
- Future 80x86 architectures including P5 (due out in the first quarter of 1993), P6, and P7

Intel's second 80x86 group is Entry-Level Products, which is responsible for development of highly integrated 80x86 microprocessors and standard microperipheral chips used to manufacture mainstream PC systems. This group is headed by Mike Aymar, vice president and general manager. Specific products under this group include the following:

- Intel's SL product line of integrated architectures, including i386SL and H4C (486SL)

Figure 4
Intel Organization Structure



Source: Dataquest (October 1992)
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- Core logic chip sets including EISA, cache controllers, PCI, and other related chips
- I/O modules including Intel's ExCA (Exchange Cards) and other I/O chips and adapters

Multimedia and Supercomputing Component Products was formed in May 1991 to pursue non-80x86 architectures that extend the current bounds of computing. This group is headed by Ken Fine, vice president and general manager. Specific products under this group include the following:

- Digital Video Interactive (DVI) product line (i750 series)
- i860 family of supercomputer microprocessors
- i960 family of embedded microprocessors

The Intel Products Group is actually a collection of separate divisions, each focused on a different line of Intel-branded components, software, or systems. This group is headed by Frank Gill, senior vice president and general manager. Included in this product group are the following divisions and specific products:

- PC Enhancement Division, which includes adapter products such as fax/modems and network controllers
- End-User Components Division, which includes math coprocessors and overdrive processors
- OEM Products Division, which includes multibus products, iRMX software, and PC platforms
- Supercomputer Systems Division, which includes the iPSC/860 supercomputer products
- Networks and Services Division, which includes other deliverable software and services

The Semiconductor Products Group is responsible for the development of nonvolatile memories, microcontrollers, and related products. This group is headed by Robert Reed, senior vice president and general manager. Specific products under this group include the following:

- Nonvolatile memories, which includes standard EPROMs and flash products
- Microcontrollers, which includes 8048, 8051, and MCS-96 families

Sales Channels and Distribution

Most of Intel's products are sold or licensed directly to OEMs through a network of 68 sales offices located in 20 nations. Intel also uses distributors and representatives to sell products indirectly to smaller OEMs and end users. Intel's sales channels and distributors are managed directly by a centralized sales department.

In North America, Intel maintains 43 direct sales offices; 39 are located throughout the United States and 4 are in various parts of Canada. Intel also has the following distributors throughout the United States and Canada:

- Alliance Electronics
- Almac Electronics (United States and Canada)
- Arrow Commercial Systems and Arrow/Schweber (United States and Canada)
- Avnet Computer and Hamilton/Avnet Electronics (United States and Canada)
- MTI Systems
- North Atlantic Industries
- Pioneer-Standard and Pioneer Technologies Group
- WYLE Laboratories
- Zentronics (Canada only)

In Europe, Intel has 9 direct sales offices and 28 distributors providing complete regional coverage on a country-by-country basis. Direct Intel sales offices are located in the following countries:

- Germany
- United Kingdom
- France
- Italy
- Sweden
- Finland
- Netherlands
- Spain
- Israel

In Japan, Asia, and the Rest-of-Word (ROW), Intel maintains 16 direct sales offices and a host of distributors. Direct Intel sales offices are located in the following countries:

- Japan (7)
- Australia (2)
- Brazil
- China
- Hong Kong
- India
- Korea
- Singapore
- Taiwan

Manufacturing Plants and Subsidiaries

Intel operates 10 major manufacturing facilities throughout the world, 6 in the United States, 1 in Europe, and 3 in ROW. Intel also has 25 subsidiaries throughout the world, 20 of which are direct sales/service operations in various countries. The other 5 are primarily holding companies or acquisitions and include Intel Electronics Ltd. (United States), Intel International Inc. (United States), Intel Investment Ltd. (United States), Intel Overseas Corporation (United States), Intel Puerto Rico (Puerto Rico), and Jupiter Technology Inc. (United States). Table 2 lists the locations and describes the major semiconductor fabrication facilities.

Intel closed its oldest fabrication facility, located in Livermore, California, in the third quarter of 1991. This 17-year-old facility was reportedly last used for producing 386 microprocessors; its closing was delayed by more than a year because of parts shortages.

Table 2
Intel Semiconductor Fabrication Facilities

Plant Location	Fab Name	Began Operating	Technology and Products Produced	Line Width (µm)	Wafer Size
Aloha, OR	Fab 4	1981	High-volume commodity, logic	2.0	4
	D1(Fab 5)	1987	MPU: 386, 486, SRAM, logic	1.0	6
Chandler, AZ	Fab 6	1984	MCU, MPU: 286, 186	1.5	6
Jerusalem, Israel	Fab 8	1985	MPU: 286, 386	0.8	6
Rio Rancho, NM	Fab 7	1984	EPROM, MCU: military standard	1.0	6
	Fab 9.1	1988	MPU: 386, 486	0.8	6
	Fab 9.2	1991	MPU: 486, EPROM	1.0	6
	Fab 9.3	1992	MPU: P5, EPROM	0.8	6
Santa Clara, CA	Fab 1	1987	EPROM, flash, MCU, logic	1.5	4
	R1*	1986	NA	NA	6
	D2*	1989	EPROM development	0.8	8
	PED*	NA	NA	1.0	6

NA = Not available
Notes: All fab facilities are full production unless noted with an asterisk (*). All process technology used is CMOS unless noted under products.
Source: Dataquest (October 1992)

Intel is spending more than $1 billion a year in plant and capital equipment to build new fabrication plants and refurbish existing ones. This investment is focused on development of the following facilities:

- Aloha, Oregon D1A Fab: Intel started construction in June 1991 and plans to bring this facility online in the second quarter of 1993. This 430,000-square-foot facility will cost $200 million to $300 million and will offer capabilities of running 8-inch wafers, from 0.6 to 0.35 µm, aimed at supporting the P5 and future processors. The present D1 facility will simultaneously be converted to 0.6 µm and 8-inch wafers.
- Dublin, Ireland: Intel will spend about $500 million to build this state-of-the-art facility to support the European market. This plant is scheduled to go online by the end of 1992.
- New Mexico: Intel is reportedly expanding fab lines to accommodate the P5 as it goes into volume production.

Intel also operates the following manufacturing plants for component and board-level assembly operations:

- Hillsboro, Oregon: Memory boards and microcomputer systems.
- Las Piedras, Puerto Rico: Memory boards and microcomputer systems.
- Leixlip, Ireland: Memory boards and microcomputer systems.
- Manila, Philippines: Component assembly and final testing.
- Penang, Malaysia: Component assembly and final testing.

Adding to its list of operations, in 1991 Intel acquired the Network Products Division of New York-based LANSystems Inc. as a part of an ongoing thrust into the market for LAN software and hardware. In 1990, Intel acquired Jupiter Technology, a supplier of data communications computers, operating systems, and networking products, to broaden its technology and offerings in the connectivity market.

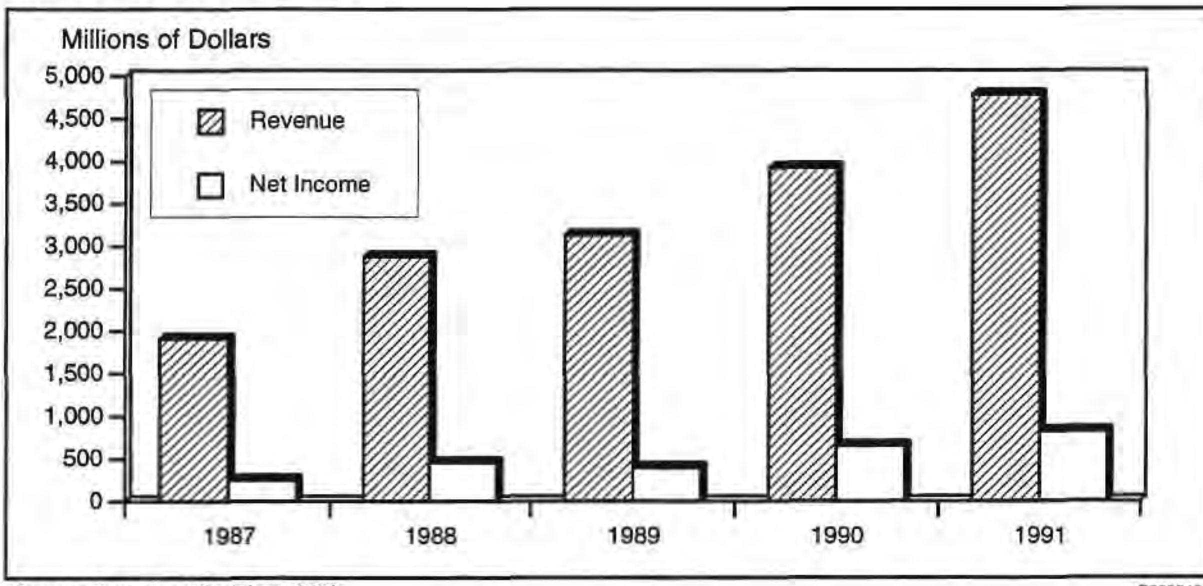
Financial Performance and Conditions

Five-Year Financial Highlights

Over the last five years, Intel's revenue has continued to grow at an industry leading pace with a five-year compound annual growth rate (CAGR) of 20 percent (see Figure 5). Despite increasing competition in its primary product segments (386/486 microprocessors), Intel still enjoys healthy financial growth and is expected to turn in about 15 percent growth in revenue for 1992.

Net income has generally kept pace with revenue growth, with the exception of 1989, when a slowdown in revenue growth resulted in a decrease in net income (see Table 3). This is a direct result of the high gross margins Intel is able to sustain because of its monopoly in the 386/486 microprocessor market, which is just now coming into fierce competition. As a result, average selling prices have

Figure 5
Intel Historical Growth



Source: Dataquest (October 1992)

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Table 3
Intel's Five-Year Financial Summary

	1987	1988	1989	1990	1991
Revenue ($M)	1,907	2,875	3,127	3,921	4,779
Growth Rate (%)	51	51	9	25	22
Cost of Sales ($M)	1,044	1,506	1,721	1,930	2,316
Gross Margin (%)	45	48	45	51	52
Net Income ($M)	248	453	391	650	819
Net ROS (%)	13	16	13	17	17
Total Employees	19,200	20,800	21,700	23,900	24,600
Sales/Employee ($)	99,323	138,221	144,101	164,059	194,268
Total Equity ($M)	1,276	2,080	2,549	3,592	4,418
Return on Equity (%)	19	22	15	18	19
R&D Expenses ($M)	260	318	365	517	618
Percent of Sales	14	11	12	13	13
Capital Expenses ($M)	302	477	422	680	948
Percent of Sales	16	17	13	17	20
Total Assets ($M)	2,499	3,550	3,994	5,376	6,292

Source: Dataquest (October 1992)

eroded significantly and Intel is expected to see a drop in gross margins for 1992.

Intel has seen its most dramatic changes in productivity, as indicated by the sales per employee ratio climbing from $99,000 in 1987 to more than $194,000 in 1991. Intel has been investing in the tools that are critical to enabling high productivity, primarily those used in design and development. These tools reduce the time to complete design tasks and thus reduce work hours per design and time to market. Intel also runs on a highly disciplined structure where planning is an essential element, decision-making is done quickly, and people are encouraged to take risks to move ahead.

Comparison to Industry Conditions

In comparison to other large semiconductor companies, Intel has exhibited nothing short of stellar performance from a financial operating standpoint. Intel revenue grew 250 percent from 1987 to 1991 (see Table 4). In comparison, AMD's revenue grew 23 percent, TI's 17 percent, Motorola's 168 percent, and National's 71 percent.

Intel's profitability and productivity ratios also stand out, again stemming from higher-than-average gross margins, which led the industry at 52 percent. Intel led the industry in 1991 in return on sales (net income) and return on equity. However, its most dramatic lead is in sales per employee, which reached an all-time high in 1991 of $194,000, nearly twice that of the competition.

Table 4
Comparative Industry Financial Conditions

	Company				
	Intel	AMD	TI	Motorola	National
1987-1991 Revenue Growth (%)	250	23	17	168	71
Gross Profit Margin* (%)	52	46	17	36	24
Return on Sales* (%)	17	12	-6	4	-9
Return on Equity* (%)	19	19	-21	10	-23
Sales/Employee* ($K)	194	109	108	111	57
Sum of 1989-1991 R&D Expense ($M)	1,500	620	1,600	2,893	703
Sum of 1989-1991 Capital Expense ($M)	2,050	609	2,276	3,701	570
Total Revenue* ($M)	4,779	1,227	6,784	11,341	1,702
Semiconductor Revenue* (%)	84	100	40	34	94

*1991 calendar year.
Source: Dataquest (October 1992)

Intel has been investing heavily in R&D and capital equipment, positioning itself as a world-class semiconductor manufacturer. When investment expenses accumulated over the last three years are compared, Intel is in the middle in total R&D expenses and capital expenses. However, for the semiconductor business segment, if it is assumed that these expenses are allocated as a percentage of revenue, Intel is probably the leading U.S. semiconductor investor in both categories.

Semiconductor Business Analysis

This section will focus on analyzing the position, opportunities, and threats for Intel's $4.0 billion semiconductor business segments. After providing an overview of the semiconductor market, our discussion will divide into three major areas: the 80x86 microprocessor, other microcomponents, and memories.

Semiconductor Market Outlook

The worldwide semiconductor market represented a $60 billion business in 1991 and is forecast to grow 58 percent over the next five years, reaching about $95 billion by 1996 (see Table 5 and Figure 6). The market can be divided into six product-type segments: MOS microcomponents, MOS memory, MOS logic, analog, bipolar digital, and discrete/optoelectronic. The first five of these segments comprise the integrated circuit (IC) subset; the first three comprise the MOS digital subset. All segments except bipolar digital are projected to grow over the next five years, with the strongest growth coming in MOS microcomponents and MOS memory, the two areas Intel competes in.

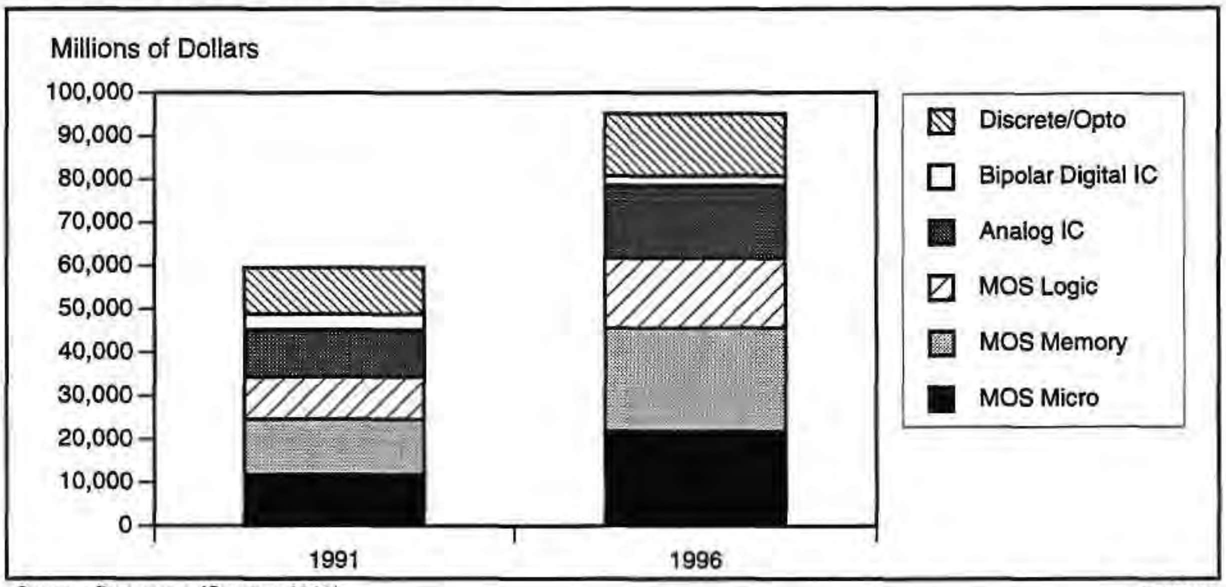
MOS microcomponents represent the brainpower behind most electronic devices performing data processing, numerical calculations,

Table 5
1991 Worldwide Revenue, Top 10 Vendors in Total Semiconductors

Rank	Vendor	Revenue ($M)	Share (%)
1	NEC	4,774	8.00
2	Toshiba	4,579	7.67
3	*Intel*	*4,019*	*6.73*
4	Motorola	3,802	6.37
5	Hitachi	3,765	6.31
6	Texas Instruments	2,738	4.59
7	Fujitsu	2,705	4.53
8	Mitsubishi	2,303	3.86
9	Matsushita	2,037	3.41
10	Philips	2,022	3.39
	Total Worldwide Revenue	59,694	100.00

Source: Dataquest (October 1992)

Figure 6
Semiconductor Market Overview



Source: Dataquest (October 1992)

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Table 6
1991 Worldwide Revenue, Top 5 Vendors in MOS Microcomponents

Rank	Vendor	Revenue ($M)	Share (%)
1	*Intel*	*3,578*	*30.15*
2	Motorola	1,171	9.87
3	NEC	1,149	9.68
4	Hitachi	583	4.91
5	Mitsubishi	543	4.58
	Total Worldwide Revenue	11,867	100.00

Source: Dataquest (October 1992)

and I/O control functions. Intel holds the dominant position in the MOS microcomponents segment, turning in $3.6 billion of the total $11.8 billion potential, or a 30 percent market share (see Table 6). The only two competitors close to Intel are Motorola and NEC, each with a 10 percent share and each less than one-third Intel's size in microcomponents.

Microcomponents comprises three related subsegments: microprocessors, microcontrollers, and microperipherals. Intel is the kingpin of microprocessors, taking $2.5 billion or nearly two-thirds of this $3.9 billion market (see Table 7). More than 95 percent of this revenue results from the 80x86 family of microprocessors, and nearly 95 percent of this 80x86 revenue comes from the 32-bit 386/486 generation of processors. Microprocessors will be the growth leader in MOS microcomponents and will be Intel's market to lose over the next five years.

Intel is also the leader in MOS microperipherals with a 20 percent market share—$650 million of this $3.2 billion segment (see Table 8). Its largest contributor is the math coprocessor, which accounts for some $300 million in revenue completely tied to the 80x86 market growth, as are most of Intel's microperipheral sales. The math coprocessor portion of this market will go away over the next few years but in turn will lead to further growth in the microprocessor market as the function is absorbed inside the CPU.

Ranking fourth in MOS microcontroller revenue, Intel finds itself catching up in the race for microcontrollers (see Table 9). Because the largest portion of microcontroller shipments are consumed in Japan, it is not surprising that NEC is the leading vendor, followed by several other Japanese vendors. However, second-ranked Motorola is actually Intel's top competitor and will give it a tough fight.

Table 7
1991 Worldwide Revenue, Top 5 Vendors in MOS Microprocessors

Rank	Vendor	Revenue ($M)	Share (%)
1	*Intel*	*2,504*	*64.32*
2	Motorola	363	9.32
3	AMD	327	8.40
4	National	81	2.08
5	Hitachi	76	1.95
	Total Worldwide Revenue	3,893	100.00

Source: Dataquest (October 1992)

Table 8
1991 Worldwide Revenue, Top 5 Vendors in MOS Microperipherals

Rank	Vendor	Revenue ($M)	Share (%)
1	*Intel*	*650*	*20.19*
2	Western Digital	209	6.49
3	Motorola	194	6.03
4	Texas Instruments	194	6.03
5	NEC	192	5.96
	Total Worldwide Revenue	3,219	100.00

Source: Dataquest (October 1992)

Table 9
1991 Worldwide Revenue, Top 5 Vendors in MOS Microcontrollers

Rank	Vendor	Revenue ($M)	Share (%)
1	NEC	860	19.43
2	Motorola	574	12.97
3	Mitsubishi	463	10.46
4	*Intel*	*424*	*9.58*
5	Hitachi	364	8.22
	Total Worldwide Revenue	4,427	100.00

Source: Dataquest (October 1992)

Table 10
1991 Worldwide Revenue, Top 5 Vendors in MOS Nonvolatile Memories

Rank	Vendor	Revenue ($M)	Share (%)
1	*Intel*	*311*	*10.13*
2	Sharp	306	9.96
3	NEC	258	8.40
4	AMD	237	7.72
5	Toshiba	226	7.36
	Total Worldwide Revenue	3,071	100.00

Source: Dataquest (October 1992)

MOS memory provides exactly what its name suggests, data retention capability for digital systems, and can be divided between volatile and nonvolatile types. Intel does not hold a significant share of the overall MOS memory market. However, it is the leader in nonvolatile memories (see Table 10), a $3.1 billion segment of this market. Volatile memories are the bulk (more than 75 percent) of the market, which is further divided between DRAMs and SRAMs. Intel invented the commercial DRAM and developed technology all the way to the 1Mb level before deciding to exit the market in 1985 because of its commodity nature, low margins, and the high capital investment required. Intel does produce some SRAMs, primarily for military use and use with its high-end microprocessors, though these are not of financial consequence to the company.

Intel's 80x86 Microprocessor Business

Intel has had four generations of upward-compatible microprocessors since the 80x86 family was first introduced (see Table 11). The original 8086 introduced by Intel in 1978 had 29,000 transistors (then state-of-the-art), ran at under 5 MHz, had a die size of 51,000 square mils, and initially sold for nearly $200 (now a

Table 11
Intel 80x86 Product Line

Microprocessor	Introduction Date	Word Width (int-ext)	Transistor Count (K)	Performance Range (mips)	Price Range ($ per 1,000)
8086	1978	16-16	29	<1	5-6
8088	1979	16-8	29	<1	3-5
80286	1982	16-16	130	1-2	7-9
80386SX	1988	32-16	275	2-4	49-79
80386DX	1985	32-32	275	6-11	99-119
80386SL	1990	32-16	855	4-5	48-96
80486SX	1991	32-32	1,185	13-20	99-119
80486DX	1989	32-32	1,200	20-40	367-536
80486DX2	1991	32-32	1,200	40-54	487-650
P5 ("586")*	1992	32-64	3,100	80-100	900-1,400

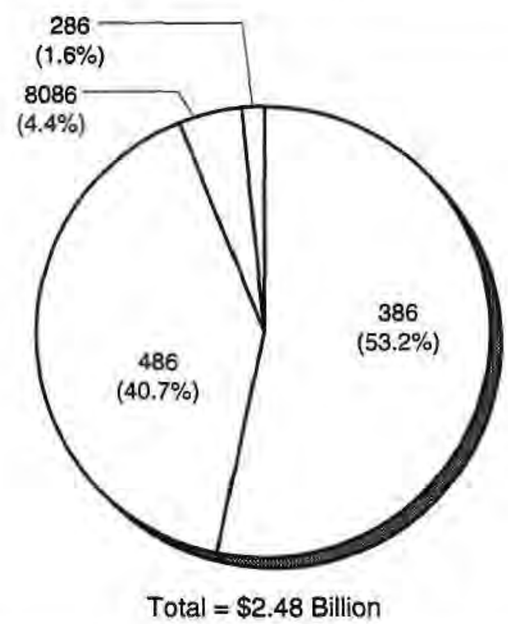
*Estimated parameters
Source: Dataquest (October 1992)

$6 part). Now the 80486 has 1.2 million transistors, runs up to 50 MHz, has a die size of 261,000 square mils, and initially sold for nearly $800. What these parts have in common is the power of compatibility with more than 10,000 software applications, with chips and systems cloned by anyone that can make them. This power has driven 80x86 microprocessor volumes to more than 50 million units per year, with increasing ASPs that have made the cloning of this golden goose a very hot target.

Intel makes nearly 95 percent of its 80x86 revenue from its proprietary 386/486 products (see Figure 7). The 80x86 market was originally opened through second-source licensing agreements, pushed by IBM as a result of its selecting the 8088 for its PC. The scene changed after growing critical mass in the market, using the early 8088 and 80286 processors, both of which were widely second-sourced. Intel introduced the 32-bit generation of 80x86 processors with the intent to grow its business around a family of single-sourced, upward-compatible processors that would eventually reach workstation performance.

As of 1991, Intel had only about 50 percent of the 80x86 unit volume (see Figure 8) but took an estimated 85 percent of the total revenue. A rapid decline is beginning for the 16-bit 80x86 processors (8086/88 and 286 generations), except the integrated versions

Figure 7
Intel 80x86 Revenue Breakdown



Source: Dataquest (October 1992)

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such as the 80186 and Chips and Technologies' PC-Chip, which will continue to grow in embedded and hand-held devices. These processors were the lifeblood of the 1980s' PC, which is now dominated by the 386/486 generation. However, these proprietary products face competition from two angles: direct 386/486 clones and the various members of the RISC camp.

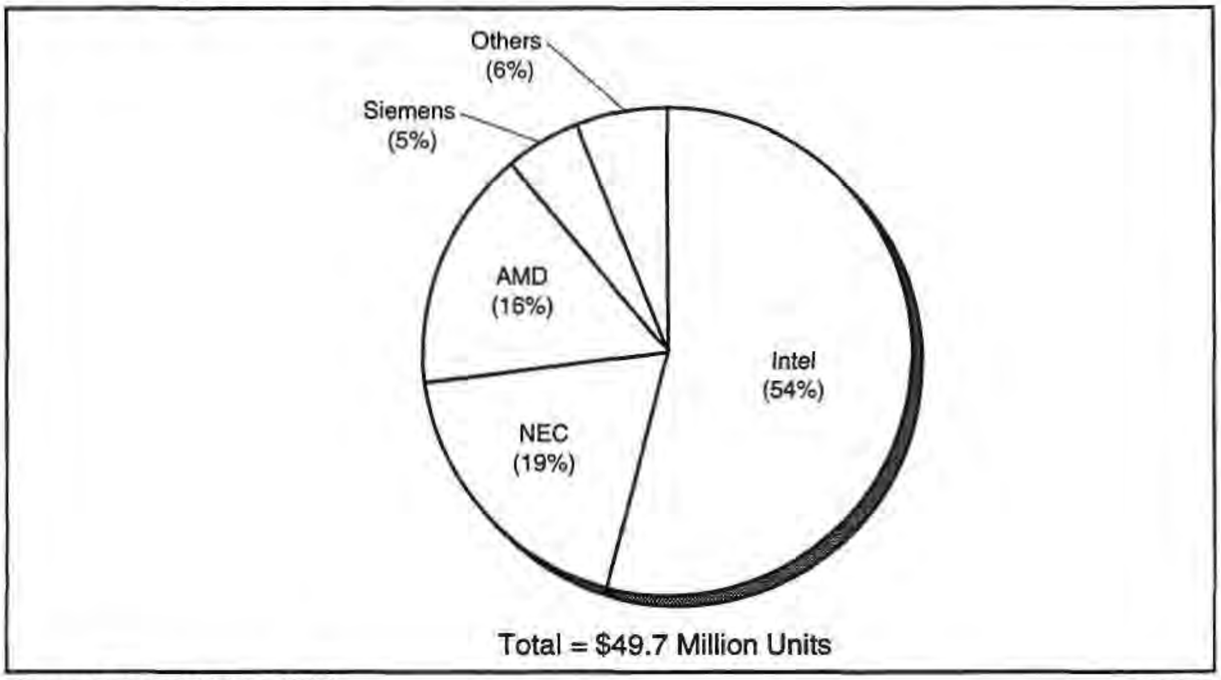
From the RISC front, there is only one viable long-term competitor to the 80x86 family, the PowerPC from the IBM-Motorola-Apple alliance. It has a large pull component from joint systems marketing by Apple and IBM, excellent design expertise from IBM and Motorola, plenty of manufacturing muscle from Motorola, and planned strong mainstream operating systems development from the roots of the Macintosh. The primary problem with the other RISC camps, including MIPS, SPARC, PA-RISC, and ALPHA, is lack of critical mass from system vendor support, lack of mainstream operating systems, or both.

As for the 386/486 clones, until last year Intel had 100 percent of the market, but after AMD's successful entry in 1991, the scene has changed. The following sections discuss competitive positions.

AMD

AMD entered the market in the second quarter of 1991 with exact copies (including microcode) of the 386DX and 386SX versions. Its

Figure 8
80x86 Microprocessor Market Share



Source: Dataquest (October 1992)

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strategy has been to use its "licensed rights" to Intel's intellectual property to reverse-engineer fully compatible clones of Intel's products, including microcode, and offer higher-speed grades at the same price Intel offers the standard speed grades. This strategy paid off initially as AMD attained about 15 percent of the 386 market by the end of 1991 and about 35 percent by the end of the second quarter of 1992. Keeping the momentum going, in January 1992 the company preannounced plans for 486 clones to be sampled in the third quarter and shipped in the fourth quarter. However, these plans were severely impacted in June 1992 when AMD lost a court battle over intellectual property rights (the 287 microcode case). It will suffer a significant setback because it must now forward-engineer its 486 clones, which will result in AMD moving them out to mid-1993 for shipments and taking away its "exact replica" advantage over other clones. AMD is expected to provide additional focus during 1993 on versions of 386 and 486 products for the portable market.

Cyrix

Cyrix entered the market in the second quarter of 1992 with a proprietary design representing a cross between the 486SX (instruction-set, cache) and 386SX and DX versions. Its strategy has been to forward-engineer its designs with 486 instruction-set compatibility and attack the installed base of 386 designs and units, offering OEMs a pin-compatible option to upgrade their 386 system designs to 486s, and offering corporate end users the option to upgrade their installed 386s to 486s. Furthermore, Cyrix intends to do the same thing for the 486 installed base as it starts releasing upscaled versions of its product line in the coming months. Having recently won a court battle contesting its rights to use SGS-Thomson as its foundry, Cyrix is successfully growing its sales and will probably ship some 400,000 units by the end of this year, representing a growing threat to Intel.

C&T

C&T entered the market in the fourth quarter of 1991 with a combination of exact clones and proprietary enhancements to the 386, as well as a single-chip PC based on an enhanced 8086 core. Having suffered severe technical problems in addition to poor financial health, C&T has announced its departure from the 386/486 clone race to pursue only integrated versions of the x86 family for handheld and portable devices. In its current condition, it does not pose a real threat to Intel.

Texas Instruments

TI announced that it will enter the market in the fourth quarter of 1992 using the Cyrix design with intentions of following up with more highly integrated versions using its wide array of technologies. Based on its manufacturing capabilities and widespread sales channels, TI presents a potential long-term threat to Intel. However, its limited microprocessor design expertise mitigates some of this threat.

Nexgen

Nexgen has preannounced plans for years to enter the market and now aims at a P5-like product, expected to be announced during the first quarter of 1993. Nexgen has an historical credibility problem to overcome in the industry and must align itself with an appropriate foundry for its parts.

UMC

UMC is working on a clone of the 486SX, expected to be introduced in the first quarter of 1993, having acquired design house Meridian Technology during 1991. With limited manufacturing muscle, a relatively low technology base, and limited sales channels (except in Asia-Pacific), UMC may have a difficult time sustaining its growth in this ultimately competitive arena.

Other companies rumored to be working on 386/486 clone products include VM Technology, a Japanese company reportedly with funding from Fujitsu; Seiko-Epson, which is working on a version of the 486 primarily for captive use; and IIT, a competitor in the math coprocessor arena working on a 486-type product with ultrahigh floating point performance.

Intel's 80x86 road map for the future calls for a dual focus on both desktops and portables, delivered in concert with its central strategy. It has long believed that its ultimate marketing edge is to drive up available transistor count through process and design technology and use that transistor count to do the following:

- Create leading-edge performance (desktop focus). This direction will result in the introduction of the P5 during the first quarter of 1993, a 100-mips class microprocessor with workstation-level floating point performance. Following this at 18- to 24-month intervals will be the P6 and P7, offering additional increases in performance level and multiprocessor support.
- Create leading-edge integration (portable focus). This direction will result in the 486SL, a 486 equivalent to the 386SL providing the ideal match for color notebooks. Following this will be the 386SC (single chip) class of devices, now being jointly developed with VLSI Technology.
- Continually decrease manufacturing costs. This direction will result in continued shrinkage of existing 486 and SL lines of products, reducing the die sizes and thus costs, enabling Intel to offer high-end (relative to competition) performance and integration at mainstream prices.
- Continually increase barriers to entry. This direction will result in limiting the available foundry capacity to the industry because of the level of design and process technology required to be performance- or cost-competitive, creating a strategic weakness for fabless vendors.

To maintain momentum in the marketplace, Intel uses a two-pronged marketing strategy as a countermeasure to the insurgence of competition. First, extensive litigation is used to slow existing competitors, discourage potential new competitors, and create anxiety within the market over using potentially illegal competitive products. Second, Intel is driving the PC market transition into its second-wave products (486 and SL versions) where end users gain better performance/features, competition is limited, and barriers to entry are much higher. Intel also intends to increase its brand preference through aggressive advertising of the "Intel Inside" concept and its "overdrive processor" upgrade programs.

Intel's Other Microcomponents

Beyond the 80x86 product line, Intel has two other families of microprocessors, the i960 embedded microprocessor and the i860 microprocessor. Together, these two families represented a combined total of about $25 million in business for Intel in 1991, or 1 percent of 80x86 revenue. The i960 is beginning to pick up momentum and is winning designs in many embedded areas including communication, X terminals, and laser printers. Having shipped about 250,000 units in 1991, Intel claims it is on track to ship close to 1 million units this year, a fourfold increase. Based on evidence at hand, we expect the i960 family to reach respectable business levels in two to three years. On the other hand, the i860 family is expected to remain a niche part for supercomputers and very high end graphic subsystems and to not provide a substantial revenue contribution for the foreseeable future.

Most of Intel's microperipheral products are designed to be fully compatible with one of its microprocessors. As mentioned earlier, Intel's line of 80x86-compatible math coprocessors has accounted for nearly 50 percent of the microperipheral revenue. With an estimated 1991 market size of more than $350 million, 80x86 math coprocessors are poised to head downward fast as the coprocessor function becomes integrated into the microprocessor, as it has in the 486 generation of devices. Intel has maintained the lion's share of this market, taking more than 75 percent of the market, leaving the remainder to Cyrix, IIT, and others. Having planned this evolution of coprocessor integration, Intel has now switched its strategy to overdrive processors (microprocessors for field upgrades) and will supplant this microperipheral revenue loss with gains in microprocessor revenue.

Among Intel's other microperipherals, PC chip sets—specifically high-performance versions—have been a focal point. After the AT bus became mature and performance needs exceeded its capacity, the industry spawned the EISA (Compaq-driven) and MCA (IBM-created) busses. Intel was the first to create compatible chip sets for these busses and remains the dominant vendor for each type. Unfortunately, the ISA bus remains the dominant standard and the others have not risen to great proportions. Thus PC chip sets represent a small contribution to the overall revenue (estimated at $100 million) and are expected to remain that way for the near future.

Intel is the third largest producer of ethernet controller chips, producing high-performance versions for workstations, X terminals, network routers/bridges, and high-end PCs, yielding some $25 million in revenue. Fax/modem chip sets, cache controllers, and its DVI line of multimedia controllers are examples of other minor revenue-producing microperipheral chips for Intel. Intel is expected to grow market share in each of these other areas as they become more central to its overall strategies.

Microcontrollers will present Intel with its toughest challenge to maintain or grow market share. Currently ranked fourth, Intel will have to place a greater emphasis on these components to pose a threat to Motorola or the Japanese vendors. Its focus has been on the proprietary MCS-96 family of 16-bit microcontrollers, where it currently dominates, attempting to change the industry momentum from 8-bit to 16-bit products. Though expected to continue success in the 16-bit segment, Motorola and other vendors will be attempting to shift focus to 32-bit parts as a counter to Intel's strategy.

Intel's Memory Business

Intel's bent toward innovation has also paid off in memories, yielding it substantial revenue (more than $300 million in 1991) from its leadership in the nonvolatile market (which it invented) and from royalties on DRAM and SRAM products (well over $60 million since 1990). There also is potential exploitation of its flash products. Though Intel is now primarily a microcomponents company, its inventions in the memory area include the following:

- The first DRAM (a 1Kb part in 1970)
- The first EPROM (a 1Kb part in 1971)
- The first high-speed MOS technology SRAM

Ironically, Intel does not plan to pursue market share using any of its own original inventions in the memory business, but it will place its emphasis on flash memories, a device first conceived by Toshiba.

Intel announced in 1990 that it would discontinue pursuit of EPROM developments to pursue the development of flash technology. Intel leads the industry in flash technology and holds an 85 percent market share in this subsegment of the nonvolatile market. In April 1992, Intel introduced the highest-density flash device, an 8Mb part, aggressively priced at $29 in low quantities. Intel also just entered an agreement to provide Sharp with rights to Intel's flash technology in exchange for Sharp building a $700 million facility for the production of Intel and Sharp flash memory products. This move may afford Intel a competitive manufacturing cost structure it has lacked in the past.

Intel's vision for flash includes being able to overcome problems with endurance (cycles), write speed, and programming voltage to produce the ideal memory that is nonvolatile, reads as fast as DRAM, writes quickly enough to keep up with an input write buffer, and is scalable in density beyond that of any other technology. This means that the bulk of portable products could replace DRAM and magnetic storage with one type of solid-state memory product. Intel's arguments carry enough weight that Microsoft has produced a FlashFile system for its operating systems that supports the Intel 8Mb flash memories. Based on current momentum, Intel should gain market share in memories over the next five years, providing a positive contribution to its overall growth.

Dataquest Perspective

Intel's Strengths

Strategically Balanced Product Mix

Intel has gained leadership positions in all forms of computational systems and has structured its participation toward maximum leverage at each level. At the center is the PC, where the 80x86 family reigns supreme and Intel uses its microprocessor design and manufacturing expertise on top of compatibility to offer a range of industry-leading products with high revenue and attractive margins. At the low end are the hand-held devices where Intel will use its intellectual property and alliances with VLSI technology (integrated 386 cores) and Sharp (flash memories) to proliferate large volumes with reasonable royalties. At the high end are supercomputer systems where Intel develops and markets the complete system (including microprocessors) to gain high sales and margins in a low-volume business. In addition, Intel gains the technological synergy from participating in all areas, enabling it to push supercomputing advances into the desktop or take desktop performance into a hand-held device.

Strong Momentum in the PC Market

Intel is the leader in microprocessors for PCs and can drive the transition toward microprocessors that result in higher performance, higher ASPs, and higher barriers to entry. This transition includes support by all the top PC manufacturers, which includes very close relationships with IBM, which remains a steadfast customer and joint-developer of Intel's 80x86 processors; Compaq, which is a joint developer/tester at the systems-level that dropped the MIPS/ACE initiative to focus on Intel's P5; NCR, which works directly with Intel on innovative directions in servers and pen-based systems; Digital, which entered into an agreement for Intel to manufacture its systems; and all major Japanese vendors including Toshiba, NEC, and Epson, which have remained 100 percent Intel houses.

Leader in 80x86 Microprocessor Products

Intel maintains the leading position in performance, integration, and product breadth. With planned R&D investment of $800 million per year, 75 percent of which ($600 million) will directly apply to the 80x86 product line, Intel will most likely maintain this lead. Adding to this, Intel's joint development programs with IBM and VLSI technology for highly integrated processors will also strengthen its position. Furthermore, Intel's relentless pursuit of intellectual property protection using the legal system presents an additional financial drain to many smaller would-be cloners.

Strong Process and Manufacturing Capabilities

Intel was yielding 1-million-transistor processors (486) two years before the competition and began producing a 2.5-million-transistor chip (i860XP) more than one year ahead of any others. As competition begins to form by pairing innovative fabless design companies with large semiconductor manufacturers, Intel will have the cost advantage of vertical integration. We believe that Intel has a significant advantage in manufacturing technology for logic products, which will give it an edge for the next several years.

Leader in Flash Memory Products

Intel's focus on flash technology, its partnership with Sharp, and its captive ExCA marketing program for portable PCs and hand-helds will keep it ahead of the market for some time.

Leader in Supercomputer Performance

Intel's move into the supercomputer business strengthens its ability to design leading-edge microprocessors, especially as the move into an era of multiprocessor systems begins.

Intel's Weaknesses

Strategic Shift Upcoming in the PC Market

The first PCs came from IBM. Then vendors produced IBM-compatible PCs—clones of the complete system design. Then Intel drove the transition to PCs that were 80x86-compatible, clones of the instruction-set architecture, starting with the Compaq 386. Now Microsoft is driving the transition to PCs that are Windows-compatible, clones of the operating system environment, starting with the MIPS/ACE environment. As we enter the mid-1990s, this paradigm will be in full swing with users purchasing Windows NT systems or PowerOpen systems on various microprocessor-based systems. Though the 80x86 family has the most operating system support of any microprocessor, the loss of instruction-set compatibility as a requirement will level the playing field and enable competition to grow where a monopoly once was.

Lack of PC Systems Profitability

The same power that created demand for more than 100 million installed 80x86-compatible PCs has resulted in lack of differentiation, weak prices, and thus low profits for nearly all vendors in the PC industry. Though stuck for now in the mode of moving low-margin undifferentiated PCs, many of these vendors must change to remain financially viable for the long term. This means either using a differentiated approach with a non-Intel 386/486 product, or moving to a RISC architecture with an upscale pricing structure.

Growing 80x86 Competition

As the lure of high profits draws more competitors into the 386/486 clone game, Intel's product monopolies become shorter and harder to defend. In the past, Intel's product positioning left holes in its product line, such as 25-MHz 386SXs. Existing and future holes are prime targets for competition looking for differentiation among the compatibility. Furthermore, the period over which Intel can monopolize the market will shrink and increase pressure on time-to-market of next-generation products.

Weak Products in PC Microperipherals

Outside of math coprocessors, Intel has had problems developing a strong line of support chips. This includes failures in PC core-logic chip sets (it was reselling ISA chip sets from VLSI Technology), graphics controllers (82786 and various VGA controllers), and its early DVI chip sets.

Summary and Outlook

Intel's future depends on leveraging its strengths in the semiconductor business segments, particularly the 80x86 microcomputer chip sets. It was clearly evident during 1991 that the future for the 80x86 class of processors will be a competitive arena filled with Intel, AMD, and others. Intel intends to migrate desktop computers to the increasingly fast 486s (and soon to be P5s) and portables to the increasingly integrated SL line of 386s (and soon to be 486s). Dataquest believes that Intel has the power to make this happen by 1993, which will impose increasingly high barriers to competition. However, as Intel repositions its products to maintain market share, it will begin to lower its gross margins and thus some of its revenue growth will come at the expense of profits.

Using the projected growth of the microcomponent and memory segments and assuming Intel's market share remains constant over the next five years, its semiconductor revenue should grow 85 percent or from $4.0 billion to $7.4 billion. Based on the current environment, this is a likely scenario because we believe that Intel will maintain market share in microcomponents while slightly growing its share in memories over the next five years. Assuming an equivalent growth rate for its nonsemiconductor businesses, Intel could see a $10 billion business by the end of 1997.

(This profile is a reprint from a Vendor Profile written by Ken Lowe for Dataquest's Microcomponents Worldwide service. This service analyzes in detail the market size, trends, and future of this semiconductor market.)

Dataquest Vendor Profile

Semiconductor Procurement *Worldwide*

August 31, 1992

Linear Technology Corporation

Corporate Statistics

Corporate Headquarters	Milpitas, California
President and CEO	Robert H. Swanson Jr.
Vice President and Chief Operating Officer	Clive B. Davies
Fiscal 1992 Revenue	$120 million
Total Assets	$159.8 million
Stockholders Equity	$123.5 million
Number of Employees Worldwide	814
Revenue per Employee	$147,400
Number of Offices Worldwide	13
Number of U.S. Offices	6
Fiscal Year	July to June
Year Founded	1981

Corporate Overview

Linear Technology Corporation designs, manufactures, and markets high-performance analog ICs targeted for computer, industrial, telecommunications, and military applications. The company was founded in 1981 on a business plan that called for revenue to reach $99 million and profits of $13 million toward the end of the decade. The incredibly prescient result was fiscal year 1991 revenue of $94 million and profits of $17 million. A more recent result is revenue of $120 million for fiscal year ending June 28, 1992—and income of $25 million.

The backdrop question to this company profile is whether Linear Technology, which remains relatively small in the face of giant worldwide analog IC suppliers such as SGS-Thomson, Toshiba, and National Semiconductor, can sustain the kind of growth and success during the 1990s that it achieved during the 1980s. Framing the question more ominously, will this $100 million supplier lose the battle to billion-dollar-plus competitors and disappear later this decade? The perspective of Professor Carver Mead of the California Institute of Technology should be kept in mind. He believes that analog technology will be to this decade and the next what digital technology meant to the industry during the 1970s and 1980s.

For more information on Linear Technology Corporation or the semiconductor procurement industry, call Ronald Bohn at (408) 437-8542.

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Organization

Key corporate officers at Linear Technology include the following executives:

- Robert H. Swanson, Jr., president and chief executive officer
- Clive B. Davies, Ph.D., vice president and chief operating officer
- Robert C. Dobkin, vice president, engineering
- Thomas D. Recine, vice president, marketing
- Sean Hurley, vice president, operations
- Paul Coghlan, vice president, finance, chief financial officer
- Paul Chantalat, vice president, quality, reliability, service
- Tim Cox, vice president, North American sales
- Hans Zapf, vice president, international sales

In terms of management stability, which is a critical element to most companies' future prospects but especially so to a relatively young supplier such as this, Robert Swanson and Robert Dobkin were two of the original five founders of the company. The employee base increased to 814 employees as of June 1992 versus 729 as of June 1991. The strong engineering teams (design, test, and process) and manufacturing teams have also remained quite stable.

Business and Economic Conditions

This section provides the world economic background against which Linear Technology will operate during 1992 and 1993. As the semiconductor industry has matured, the marketplace—including the analog segment—has moved more into synchronization with general economic trends vis-a-vis the somewhat countercyclical pattern during the 1970s and early 1980s. For example, demand for commodity-type linear ICs such as operational amplifiers and voltage regulators now conforms largely to general economic cycles. Even so, more specialized analog parts such as mixed-signal ICs and high-performance operational amplifiers—which exemplify some of Linear Technology's key product technologies—typically outpace general rates of growth.

Linear Technology has pursued a global sales strategy. Dataquest estimates that Linear Technology's worldwide analog revenue as of calendar year 1991 derived from four regions: North America—58 percent; Europe—20 percent; Japan—12 percent; and Rest of World/Asia—10 percent. The strategy calls for continuing expansion (for example, offices) of global sales support.

The worldwide economy continues to show mixed results as of the second half of 1992. The Dun & Bradstreet Corporation forecasts an improving outlook for Linear Technology's key geographic markets. For example, the U.S., Canadian, and U.K. economies are expected to recover from the recession in 1992, although in quite modest fashion.

Real gross domestic product (GDP) is expected to expand 2.1, 1.6, and 0.5 percent, respectively, in 1992. Expansion should increase to 2.5, 4.0, and 2.2 percent, respectively, in 1993.

Another example is as follows: 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. The respective economies are expected to reaccelerate to 2.8 percent and 3.3 percent growth in 1993.

Application Markets Strategy

Overall, worldwide electronic systems production is expected to expand 3.1 percent in 1992, slightly faster than the 2.4 percent rate of growth in 1991. For Linear Technology—which has performed well under global recessionary conditions—this outlook should mean market momentum. Worldwide expansion is expected to accelerate further in 1993 to 7.6 percent as the worldwide economic climate improves.

The emerging host of battery-powered applications represents a key market opportunity for Linear Technology. From an application-market perspective that focuses on Linear Technology's target markets, the forecast makes the following series of assumptions.

The Computer Market—Poised for Recovery?

Data processing production—which marks an estimated 25 percent of Linear Technology's business as of calendar year 1991—should make a moderate 2.6 percent recovery in 1992, after a depressing 2.2 percent decline in 1991. Key system applications in this marketplace for Linear Technology include desktop PCs, laptop PCs, disk drives, modems, monitors, plotters, and printers, along with an increased emphasis on switching power supplies.

In North America, recovery in the computer and other markets will continue into 1993 as economic conditions continue to improve and stabilize. In Europe—which is Linear Technology's second largest market—local content regulations are spurring the placement of production facilities, helping explain a boost of growth expected for 1993. Nevertheless, the specter of trade friction pervades that region.

The Japanese economy, including the computer segment—which is Linear Technology's third largest marketplace—will remain hemmed in for the remainder of 1992, as business and households adjust downward their spending plans in response to the lackluster business climate. However, Japan should be back on the path of normal growth during 1993 and beyond, and growth in Japan should resume a more sustainable pace once facilities are in place. Production prospects in the Asia/Pacific region, a growth market for Linear Technology, remain upbeat because this region has become the choice for mass manufacturing of established technologies such as PCs.

A Challenge—The Industrial Market Downturn

There are no free lunches or stress-free paths to success, even for bright stars such as Linear Technology. A major challenge is that production of industrial equipment has borne the brunt of the recent downturn in business conditions, especially in North America. For Linear Technology, industrial applications account for more than 30 percent of IC revenue for 1991. Leading applications for Linear Technology's products in this segment include industrial process control systems such as for flow metering or energy management. Instrumentation systems such as medical scanners (EKG and CAT) and test equipment are other key industrial segments.

Europe and Asia/Pacific have been somewhat insulated from the recent cyclical downturn in the industrial electronics sector, owing to foreign investment spurred by local production factors and cost of production advantages, respectively. In North America and Japan, though, these application markets are forecast to rebound in 1993 with the expected relaxation of budget constraints.

A Bright Spot—Telecommunication

By contrast, communications production ranks as one of the most stable-growing of the application markets for IC suppliers such as Linear Technology. The reason is the heterogeneous composition of personal wireless communication, premise voice and data products, and large-scale, long-life investment in public telecommunications infrastructure.

Linear Technology should be positioned well in this market not only for the 1992 to 1993 period but also for the long-term horizon. The company garners an estimated 19 percent of its analog IC revenue from telecom applications, which range from cellular phones through modems and fax machines to PBX systems. This segment of the electronics markets will decelerate slightly in 1992 to 6.1 percent from 7.3 percent in 1991. However, investment in networking the existing stock of data processing equipment should drive communications hardware growth through 1996.

Evolving Markets: Military and Automotive

Military and civil aerospace electronics production—which account for just less than 15 percent of the company's business—was hit hard by Washington, D.C. budget cuts in 1991 and the global output of these systems declined to 5.5 percent worldwide. Few positive opportunities remain for all but the most specialized niche players participating in simulation systems, dedicated military computer systems, and civil-space projects. Linear Technology has targeted a range of military applications over the past decade including communication, displays, radar systems, sonar systems, and surveillance equipment. Civil aerospace electronics production will remain the most bright spot in this application market, fueled by replacement of aging jet airliners and upgrades of the worldwide air traffic control system.

The automotive sector—primarily engine and transmission control systems—accounts for an estimated 10 percent of Linear Technology's analog IC sales as of 1991. Transportation electronics production growth is expected to accelerate from 4.8 percent growth in 1991 to 6.0 percent in 1992, and to 10.2 percent in 1993. Production was hurt by the recession, but growth prospects are relatively positive because of increased household spending, combined with increasing share of electronic systems' added value to new vehicles.

A Snapshot of Application Market Prospects

In aggregate, Linear Technology faces some short-term challenges in the worldwide industrial marketplaces and the Japan region. However, the company should be well-positioned for continuing expansion in the telecommunications and automotive segments. The company is well-positioned for Europe and is positioning itself for an advance in Asia/Pacific. For 1993, Linear Technology should benefit from recovery in the global computer marketplace and industrial markets such as North America and Japan.

In the early start-up years, the military segment was one of Linear Technology's most important markets. The company has carefully positioned itself for decreasing reliance on this revenue stream. The automotive market in part should displace military sales at Linear Technology during this decade.

Succinct Financial Analysis—Impressive Results

For the global network of Semiconductor Procurement service clients who are using or evaluating the use of Linear Technology's products, financial performance over the past several years clearly weighs heavily in the decision-making process. Since 1981, Linear Technology has consistently achieved record quarterly revenue and profits—along with associated record annual financial results. The most recent five-year result is as follows: For fiscal years 1988 through 1992, Linear Technology's worldwide analog IC revenue more than doubled—from $51 million for 1988 to $120 million for 1992—while income excluding extraordinary credits more than tripled from $7 million to $25 million.

Consolidated Financial Statements

Table 1 provides Linear Technology's balance sheet for fiscal years 1988 through 1992 (unaudited for 1992). Table 2 provides Linear Technology's consolidated statement of income for the same period (unaudited for 1992).

The Fundamental Financial Question

The critical question remains, as stated at the outset. Can Linear Technology sustain the performance shown in the financial statements?

Product Strategy

Analog ICs—which include linear ICs and mixed-signal circuits—constitute the company's sole product division. Table 3 depicts the company's estimated product segmentation for calendar year 1991. The

Table 1
Linear Technology Corporation Balance Sheet (in Thousands, except Share Amounts)

Fiscal Year Ending	6/30/92*	6/30/91	7/1/90	7/2/89	7/3/88
Cash	27,757	17,479	25,059	46,468	40,322
Marketable Securities	67,521	51,746	28,379	NA	NA
Receivables	19,719	14,094	14,619	11,887	9,395
Inventories	7,921	7,543	5,882	5,690	4,647
Raw Materials	1,214	1,273	789	771	652
Work in Progress	4,652	4,453	3,449	3,734	2,711
Finished Goods	2,055	1,817	1,644	1,185	1,284
Prepaid Income Taxes and Other Current Assets	11,330	9,628	6,485	5,755	2,984
Total Current Assets	134,248	100,490	80,42	469,800	57,348
Prop., Plant, and Equip.	50,454	40,613	32,464	27,37	21,241
Accumulated Dep.	(24,903)	(20,361)	(16,534)	(12,535)	(9,217)
Net Prop. and Equip.	25,551	20,252	15,930	14,842	12,024
Total Assets	159,799	120,742	96,354	84,642	69,372
Annual Liabilities ($K)					
Fiscal Year Ending	6/30/92	6/30/91	7/1/90	7/2/89	7/3/88
Accounts Payable	3,542	4,199	2,255	2,216	2,000
Current Portions of Long-Term Debt and Capital Lease Obligation	4,713	1,731	1,997	2,186	NA
Accrued Expenses	10,863	7,654	3,492	6,365	3,908
Income Taxes	7,558	4,963	3,694	2,887	3,792
Other Current Liabilities	6,838	5,171	7,162	3,271	2,518
Total Current Liabilities	33,514	23,718	18,600	16,925	14,436
Deferred Charges/Inc.	1,028	903	815	538	NA
Long-Term Debt	1,726	6,439	8,170	9,003	NA
Total Liabilities	36,268	31,060	27,585	26,466	21,112
Common Stock Net	62,352	50,683	46,186	45,281	44,379
Retained Earnings	61,179	38,999	22,583	13,130	4,228
Other Liabilities	NA	NA	NA	(234)	(346)
Shareholder Equity	123,531	89,682	68,769	58,176	48,260
Total Liabilities and Net Worth	159,799	120,742	96,354	84,642	69,372

*Unaudited for 1992
NA = Not applicable
Source: Linear Technology, Dataquest (August 1992)

Table 2
Linear Technology Corporation Income Statement (in Thousands of Dollars)

Fiscal Year Ending	6/30/92*	6/30/91	7/1/90	7/2/89	7/3/88
Net Sales	119,440	94,152	75,620	64,722	51,325
Cost of Sales	49,505	41,778	36,048	31,216	24,765
Gross Profit	69,935	52,374	39,572	33,506	26,560
Expenses					
Research and Development	12,344	10,219	7,763	6,088	4,779
Selling General and Administrative	21,996	19,096	16,619	14,948	11,465
Operating Income	35,595	23,059	15,190	12,470	10,316
Interest Income	3,931	4,419	3,762	3,615	2,362
Interest Expense	(1,038)	1,256	1,460	1,490	1,352
Income before Income Taxes	38,488	26,222	17,492	14,595	11,326
Provision for Income Taxes	13,471	9,283	6,191	5,693	4,416
Net Income	25,017	16,939	11,301	8,902	8,916

*Unaudited for 1992
Source: Linear Technology, Dataquest (August 1992)

fast-growing mixed-signal technology represents slightly more than 20 percent of the company's analog market revenue.

The information in Table 3 reveals that amplifiers and voltage regulators are the company's two largest analog product markets, followed by special-function analog, voltage reference, and interface circuits. Linear Technology ranks 19th for 1991 among worldwide suppliers of linear ICs. Dataquest estimates that Linear Technology's worldwide analog IC revenue broke the $100 million revenue barrier during calendar year 1991.

Product Strengths and Weaknesses

This section steps through a critical examination of Linear Technology's market strengths and weaknesses and related threats and opportunities. The predominant competitive threat derives from the much broader product lines and the greater technical service and support capabilities of competitors such as Analog Devices, Motorola, National Semiconductor, and Texas Instruments.

Linear Technology has consistently and profitably managed this "giant competitor" risk since the start-up days by targeting specialized analog requirements that the giants tend to overlook. The full product portfolio includes high-performance operational amplifiers, voltage references, voltage regulators, switching regulators, and voltage converters, comparators, filters, instrumentation amplifiers, data conversion circuits, interface circuits, analog switches, and special analog function circuits.

Some of the opportunities have already been described, such as medium-term prospects in the global industrial, computer, and telecommunications markets. However, Linear Technology's real

Table 3
Linear Technology Corporation
Calendar Year 1991 Estimated Revenue, by Product Type

	Company Revenue (%)	Worldwide Ranking
Amplifiers	22	11
Voltage Regulator	22	6
Voltage Reference	13	1
Comparator	5	10
Special Function	16	11
Automotive	2	15
Data Converter	5	22
Telecom	3	40
Interface	12	7
Total Revenue ($M)	105	19

Source: Dataquest (August 1992)

opportunity continues to rest in a relentless search for systems' unsatisfied analog needs.

Key Points on Strategic Alliances and R&D

In assessing Linear Technology's competitive strengths and weaknesses, two key points should be noted. First, Linear Technology has no strategic alliances in effect. This reflects current market strength that serves as a wild card option should long-term market conditions change unexpectedly. An alliance with TI terminated in April 1991. Nor is the company currently embroiled in any major patent or related legal actions.

The second point is that Linear Technology typically spends an estimated 10 percent of revenue on research and development (R&D) efforts, which take place at facilities in Milpitas, California and Singapore. This level of R&D spending likely will be maintained over the long term in order for the company to maintain its edge in serving the specialized niches of the analog marketplace.

Under the aegis of industry legend Bob Dobkin, analog engineering expertise propels the R&D effort. Linear Technology had more than 50 analog engineers at the headquarters facility during fiscal year 1991.

Operational Amplifiers

As shown in Table 3, Linear Technology ranks 11th among worldwide suppliers of operational amplifiers. Top-ranked suppliers include Analog Devices and National Semiconductor—which have shares of slightly more than 10 percent—as well as Harris and Texas Instruments, with shares of just less than 10 percent.

Linear Technology does not compete against industry titans such as National Semiconductor and TI in the commodity op amp business. Rather, it focuses on circuits that Linear Technology claims offer lowest noise or else universal precision. Voltage levels range from 5V to 15V as well as the emerging 3V devices targeted for battery applications.

The refrain in the analog product/market evaluations that follow will sound similar because Linear Technology's competitive strategy basically holds across the product board—to bypass industry giants in order to profitably serve high-performance segments.

Voltage Regulators

Table 3 reveals that the company ranks sixth worldwide in the voltage regulator marketplace. The top-ranked companies are National Semiconductor and Motorola, each with a share of 15 percent or more. TI ranks third with a 7 percent stake.

Linear Technology's competitive line includes low dropout linear regulators and switch mode regulators, a growing segment that targets switch mode power supplies. The product line includes high-speed pulse width modulator controllers.

Special Function

The information in Table 3 shows that Linear Technology ranks 11th among suppliers of special-analog function ICs. SGS-Thomson holds more than one-third of the market share. Hitachi has garnered a 9 percent stake of the market; Philips and National Semiconductor follow with 5 percent shares, with TI just behind.

This segment allows for potentially lucrative returns—independent of market share—if a supplier such as Linear Technology can serve systems demanding specialized analog requirements. In segments such as this, analog engineering expertise combines with considerable customer hand-holding in order to precisely "tweak" circuits in line with systems' specialized needs.

Voltage Reference

As shown in Table 3, Linear Technology ranks as the world's leading supplier in the small-voltage reference segment. Other leading suppliers in this somewhat fragmented market include Sanyo, Analog Devices, Matsushita, Mitsubishi, GEC Plessey, and TI.

Linear Technology's approach is to achieve what it views as the industry benchmark-setters on parameters such as lowest long term drift.

Interface

Table 3 depicts Linear Technology's seventh-place ranking worldwide in the interface circuit market. TI commands nearly one-third of the market. National Semiconductor holds 17 percent of the market, followed by Toshiba and Motorola.

Data Converter

The information in Table 3 shows that Linear Technology ranks 22nd among suppliers of data converters. Analog Devices remains the market kingpin by far with almost one-third of market share. Brooktree—which is noted for its video DACs—ranks second, with National Semiconductor and Burr-Brown next.

Although Linear Technology offers some impressive and presumably reasonably profitable 8-bit, 10-bit, and 12-bit converters, the supplier has not made the level of penetration that was originally expected. Linear Technology commands a respectable 5 percent share of this attractive market, but not only does Analog Devices remain the market leader by far, but also a host of small suppliers such as Brooktree and Burr-Brown command more market attention than does Linear Technology.

Automotive

As shown in Table 3, Linear Technology ranks 15th among suppliers of analog automotive ICs. SGS-Thomson holds nearly 30 percent of this segment and is trailed by Motorola, National Semiconductor, Allegro MicroSystems, and TI.

Linear Technology faces fierce competition in this market. The company holds less than 1 percent market share. The customer base prefers larger suppliers. However, the automotive industry has been undergoing a restructuring process that opens a window of opportunity for Linear Technology in terms of system design-ins or perhaps strategic alliances. We should also note that when all of Linear Technology's analog IC revenue is aggregated, the automotive segment represents nearly 10 percent of the company's business—a good foundation for future penetration of this specialized segment.

Comparator

Table 3 depicts Linear Technology's 10th-place ranking worldwide in the comparator market. National Semiconductor commands nearly 20 percent of this market, followed by TI, NEC, Motorola, and Philips. Linear Technology's ever-familiar-sounding product line of comparators are high-performance devices that offer ultrahigh-speed or micropower capability.

Design Center Locations

As noted, the company has two design centers. The domestic North American facility is located in Milpitas, California.

A newer center was opened in Singapore during the second half of 1991.

Manufacturing Facilities

Linear Technology has two fabs in Milpitas, California (see Table 4).

The facility in Singapore performs metal-can assembly, test, marking, and other design functions. The expanding scope of operation will include direct shipping to customers. Singapore will become the Asian headquarters with construction of a 50,000-square-foot high-tech facility scheduled to start by the fourth quarter of 1992.

The first Milpitas fab was constructed in 1981 and supports an estimated $150 million of product sales. The new Milpitas fab can support an estimated $100 million of product sales—setting the stage for Linear Technology's move during this decade toward the goal of being a quarter-billion-dollar business.

Process Technology

Linear Technology emphasizes the versatility of its fab processing capability. The company offers 20 different process flows, which represent a variety of bipolar and linear CMOS processes. These competitive processes—which in effect are required for survival in the analog marketplace—include p-well silicon gate CMOS, n-well silicon gate CMOS, high-power bipolar, low-noise bipolar, high-speed bipolar, complementary bipolar, and high-voltage CMOS. These processes are clearly geared to serving high-speed, precision applications. Regarding military/aerospace applications, the company has earned JAN S level certification.

Table 4
Linear Technology Manufacturing Overview

	Operation Begin	Clean Room (Sq. Ft. Gross)*	Process Technology	Combined Wafer Start Capacity**	Wafer Diameter
Fab I	1982	18,000	CMOS M2, BiCMOS M2, Bipolar	15,000	4 Inches
Fab II	1992	*			

*Combined square footage for both Fab 1 and Fab 2
**Estimated maximum theoretical capacity per four-week month
Source: Dataquest (August 1992)

Dataquest Perspective

To answer the lead question in this profile, although it is unlikely that Linear Technology—or any company—can maintain such stellar financial performance throughout the 1990s, Dataquest believes that the supplier will continue to outpace the IC market. Dataquest certainly does not foresee the company stumbling and disappearing later this decade.

Carver Mead expects that complete analog solutions will be a driving force to market success during the 1990s—and Linear Technology's core of analog design expertise puts the company in position for global success. Linear Technology will flow with the market into low-voltage battery applications. One application focus likely will be power supplies for portable systems. Linear Technology will aim at producing complete 3V analog solutions. The company clearly faces a stiff challenge from competitors such as Analog Devices in the data converter marketplace and industry giants such as SGS-Thomson in the automotive arena.

Regardless, Linear Technology will continue to evolve with the market—in fact, lead the evolution to some extent—into the high-performance analog systems of the 1990s and beyond.

Dataquest's blunt assessment is as follows: as long as the core management and analog engineering teams remain relatively intact, Linear Technology should thrive during this decade. Five years ago, some Silicon Valley reporters and investment analysts queried the author of this report regarding major management/engineering defections from the company—and its impending demise. Dataquest did not see that scenario then—and we do not see it today.

Dataquest

Dataquest Perspective

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Product Analysis

IC Pricing Pressure Mounts as Recession Persists

Global economies are in recession at the start of 1992, and downward pressure is mounting on IC pricing in North America. The results of Dataquest's recent North American bookings price survey reveal that users should expect competitive pricing for memory ICs and ASICs. Intel Corporation's pricing strategy has taken a turn and the company is adjusting to new 1992 market realities.

(Note: The pricing analysis in this article correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement service (SPS) clients on December 20, 1991. The survey information was collected by Dataquest's Research Operations team. For SPS clients that use the SPS online service, the pricing correlates with the quarterly and long-range price tables dated December 1991 in the SPS online service. The price tables will be available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: First Quarter 1992." For additional product coverage and more detailed product specifications, refer to those sources.)

Microprocessor Trends

The fourth quarter of each year marks a key period of business decision making, while the first quarter marks the implementation of new strategies. We noted in October that "Intel's strategic response in the next several months to market competitive forces could well determine whether or not Intel remains long-term king of the worldwide microprocessor market" and that all signals would "appear to augur a turning point in Intel's aversion to low-ball competition."

A Turning Point for the Intel MPU Price Strategy?

The competitive reality of 1992 and beyond—meaning, multiple sources/pricing competition for the 80386 family—apparently has prompted Intel to compete more aggressively on price. Dataquest learned at press time that Intel plans to cut 80386/80386SX pricing at the start of second quarter 1992—with 80486 price cuts expected to follow. Intel had issued no press release or price sheet at press time.

Intel's pricing strategy and tactics appear to be changing. The assumptions behind Dataquest's forecast on Intel MPUs—and recent changes in these assumptions—shed light for users regarding the supplier's direction should Intel cut pricing during the second quarter of 1992. Based on current reports, Intel will slash by nearly half 80386/80386SX devices' pricing during the second quarter of 1992.

Intel MPU Price Forecast Assumptions

First Assumption: Synchronization with Intel's MPU Plans

The first assumption behind the Intel MPU price forecasts—that Intel will most favorably support users that coordinate system life cycles in line with Intel's migration schedule—appears to be bending under the heavy weight of market forces. Intel wants to pursue this strategy over the long term. However, for 1992 Intel must respond to continuing market demand for low-cost 386/386SX machines by lowering 80386/80386SX pricing. The life cycle for 80386/80386SX-based PCs is extending into 1992 and 1993—longer than Intel originally expected. Intel still intends during 1992 and 1993 to migrate users to the higher-priced 80486 family and away from the lower-priced 80386 family. Intel will not easily cede the 80386 market to competitors such as Advanced Micro Devices Inc. (AMD) or Chips & Technologies Inc. (C&T).

Second Assumption: 1992 Means Multisourcing Plus the FTC Investigation

Intel now operates in a new competitive environment that threatens to reshape the company during 1992 and over the long term. Both the complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) markets mean a trend toward multiple sources for users of MPUs—a break with the sole-sourced Intel/Motorola world of the not too distant past. Barring a major legal reversal, the 80386 marketplace has become a multisourced arena for Intel.

Even if Intel maintains its patent-based monopoly, the ongoing investigation by the U.S. Federal Trade Commission (FTC) could force—or perhaps already has forced—Intel to change its way of doing business and treating customers, especially in North America. As Dataquest has noted before, the FTC investigation—even more so than other widely publicized legal cases—might be the wild card that alters Intel's long-term product/pricing strategy.

Third Assumption: Intel's Resistance to Pricing Competition

Last quarter, we noted that another key assumption behind Dataquest's 80486 price forecast—Intel's intention to be relatively impervious to external pricing competition—seemed likely to change given year-end 1991 competitive realities. Dataquest anticipates that Intel over the long term will ignore to the best of its ability competitors' pricing for similar products. Even so, competitive multisourced pricing likely will become the predominant trend in the MPU business of the 1990s.

Intel's short-term strategy, however, calls for response to competitors' pricing. Dataquest's current forecast expects drops in 80486 pricing during 1992 that will set the stage for user migration to the 80586 device. A key point is that pricing for the 80486/80486SX device could take a step function downward by midyear 1992 if competitive pressure does not abate.

Fourth Assumption: No Intel Pricing Wars

Dataquest continues to assume that Intel will avoid a pricing war with AMD, C&T, or any other 80386/80486 market competitor. The price slashing for the 80386/80386SX devices—if they hold—to some extent is old news for major buyers (that were paying the lower prices during 1991) or else long overdue for smaller customers that had anticipated such pricing since the first half of last year. For example, AMD does not want a pricing war at this time because a pricing war could threaten its recent string of profitable quarterly results.

Dataquest Perspective

The first quarter of each year marks a time of implementation of new plans. The recession continues. Under these market conditions, IC pricing pressure mounts.

Users now can start to anticipate a turning point in the 80386/80486 pricing strategy. At press time, the spectre of a demand slowdown during 1992 and the evolution of a multisourced marketplace apparently has motivated Intel to fundamentally change its product pricing strategy—at least for 1992.

By Ronald Bohn

(Excerpted from SPWW-SVC-DP-9201, January 20, 1992)

Does Intel Face a Turning Point as IC Pricing Pressure Builds?

With 1991 nearing an end, market factors signal continued downward pressure on IC prices in North America. The results of Dataquest's third-quarter 1991 North American bookings price survey reveal strong signs of price pressure in the microprocessor (MPU) segment. For example, Motorola offers a host of lower-priced, 32-bit MPUs—an appropriate response to current market conditions. A major issue to be addressed in this article is whether users can expect Intel to undergo a turning point in the 80386/80486 pricing strategy during the rest of 1991—and when?

The price analysis presented in Table 1 correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement service clients on September 6, 1991. The survey information was collected by Dataquest's Research Operations interviewing team. For Semiconductor Procurement clients that use the online service, prices presented here correlate with quarterly and long-range price tables dated September 1991 in the Semiconductor Procurement online service. Price tables are available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: Fourth Quarter 1991." For additional product coverage and more detailed product specifications, please refer to these sources.

Microprocessor Trends

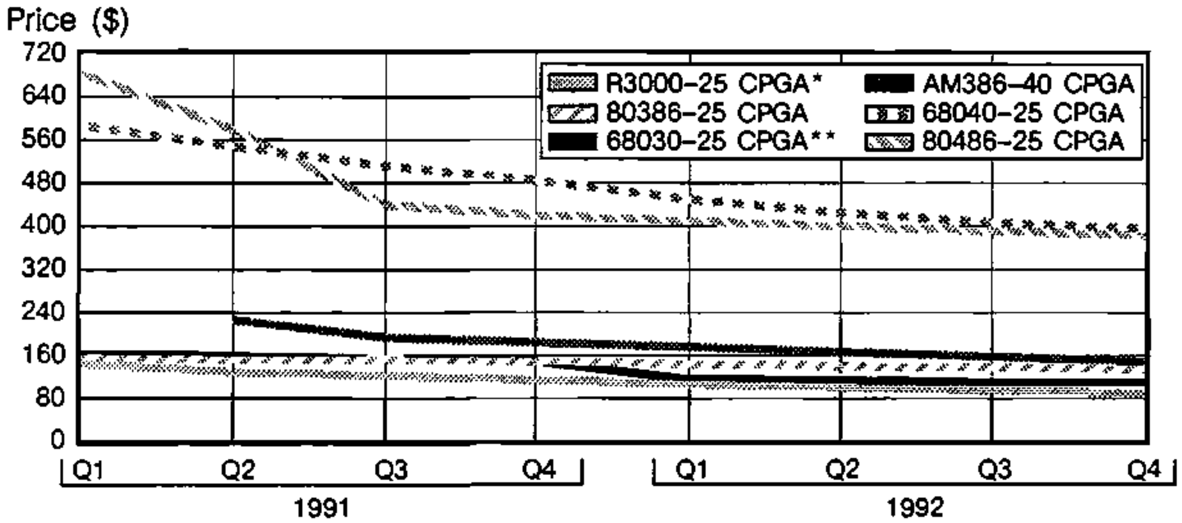
The fourth quarter of each year marks a key period of business decision making. Users are making critical evaluations of their system migration plans for 1992 and beyond, including the microprocessor choice. Advanced Micro Devices (AMD) and Chips & Technologies (C&T) attack Intel Corporation on the low end and midrange of the performance scale. Suppliers of reduced-instruction-set computing (RISC) processors mount a high-end attack with Motorola Incorporated everywhere. Figure 1 shows the North American bookings price forecast for key 32-bit MPUs. It shows a competitive arena pitting AMD, Intel, Motorola, and suppliers of RISC chips against one another. Intel's strategic response in the next several months to market competitive forces could well determine whether

Table 1
Estimated Semiconductor Pricing and Lead-Time Trends (North American Bookings, Volume Orders)

	1991 Pricing Trend (Dollars)			
Part	Estimated Q3 Price Range	Forecast for Q4	Estimated Q4 Price Range	Lead Times
80286-16 MHz PLCC	11.80 to 14.55	11.50	10.04 to 13.25	1 to 10 weeks
80486-33 MHz CPGA	410.00 to 445.00	425.00	405.00 to 427.00	6 to 8 weeks
68EC020-16 MHz PQFP	NA	25.00	25.00	4 to 8 weeks
1Mb × 1 DRAM 80ns, DIP/SOJ	4.00 to 4.49	4.18	3.60 to 4.40	1 to 8 weeks
4Mb × 1 DRAM 80ns, SOJ 300 mil	15.50 to 16.50	14.75	14.00 to 15.45	1 to 12 weeks

NA = Not available
Source: Dataquest (October 1991)

Figure 1
Microprocessor Price Trends



Note: This information coordinates with Dataquest's quarterly forecast for 1991–1992 dated September 1991.
* Price for this device excludes FPU, memory management, and related accessory ICs.
** 68030-25: CQFP for 1992.

Source: Dataquest (October 1991)

or not Intel remains long-term king of the worldwide microprocessor market. A key issue: Will users soon see a genuine turning point in Intel's 80386/80486 price strategy toward more aggressive pricing?

The Competitive Arena

Slow system sales in North America and Europe (with the exception of workstations) in the face of an expanding supplier base mean increased competitive pressure on MPU suppliers during the second half of 1991. Despite legal and marketing uncertainty, AMD and C&T plan to take share from Intel's once-exclusive 80386 domain and also the 80486 business.

AMD's first line of attack, as shown in Figure 1, offers a faster 386 device (i.e., 40 MHz) at competitive pricing. So far, the market has not budged much from the Intel 80386 brand name, partly because AMD is still building its supply of parts. AMD is likely to continue to ramp supply of the 40-MHz AM386 and then wage an all-out price war as 1991 ends, lowering the AM386 price profile shown on Figure 1. The market impact of C&T, if any, should start to manifest itself at that time.

Sluggish demand combined with increased supplier competition would *appear* to augur a turning point in Intel's aversion to low-ball price competition. An analysis of the assumptions behind Dataquest's forecast on Intel MPUs, however, shows that such a turning point is not likely to occur *except* for large-order buyers of lower-performance devices. In other words, Intel will focus on the sale of 32-bit MPUs that sell at $200 or more and place less emphasis on 32-bit devices that sell for well under $200.

Another Look at the Assumptions behind the 80486 Price Forecast

For the multiple set of assumptions that guide Dataquest's 1991 to 1995 price forecast for Intel MPUs, see the article entitled "Users' Long-Range Price Outlook—80X86s versus AMX86s versus 680X0s versus RISC Processors" later in this issue and the Semiconductor Procurement *Dataquest Perspective*, Volume 1, Number 9, July 22, 1991, article entitled "System Price Cuts Augur a Midyear 1991 Downward Shift in IC Prices."

A Two-Tier Pricing Strategy?

At this time, Dataquest's Semiconductor Procurement analysts are monitoring client reports and other sources to determine if an additional assumption should be made—that Intel is moving to a *two-tier* price structure as a response to competitive forces. One tier would be the familiar Intel price-resistant strategy but limited to high-performance MPUs (80486 family and above). The new second tier would be a more aggressive price strategy for the lower half of the Intel MPU product portfolio, the 80386 family. A quick preview of our perspective: Despite mounting competitive pressure on the the lower half of the Intel MPU product portfolio, only a few major buyers can expect a sharp price break for maturing products.

A Consistent First Assumption—Be Synchronized with Intel's MPU Plans

A fundamental assumption lies behind the Intel MPU price forecasts. Intel will most favorably support users that coordinate system life cycles in line with Intel's migration schedule. As will be discussed, despite current competitive factors, Intel is likely to adhere to this prong of its product/pricing strategy. For example, the midyear 1991 easing of the price for 80486 ICs, along with the recent introduction of low-power 80486 parts, signal Intel's objective to migrate users to the higher-priced 80486 family and away from the lower-priced 80386 family.

Intel's Shifting Rules of the Game—Or an FTC Wild Card?

Dataquest continues to assume that Intel—still the holder of monopoly power through its MPU patent portfolio—will time the "shift" of users to high-end MPUs like the 80486 in line with Intel's profit objectives and not necessarily in conformity with users' strategic plans. The current investigation by the U.S. Federal Trade Commission makes Intel alert to North American users' concerns over fairness (e.g., periods of allocation). The FTC investigation could become a "wild card" that upsets Intel's long-term pricing strategy. Otherwise, we expect Intel's pricing strategy to be based on a series of carefully timed, if not abrupt, shifts of Intel users to ultimately higher-priced devices.

For example, looking to the fourth quarter of 1991, Intel just announced a series of 32-bit MPUs aimed at manufacturers of portable PCs. One objective: to move some users from the 20-MHz 80386SL device, which sells for $135 (1,000 units) to a 25-MHz version that sells for $189 (same volume). Users of the 20-MHz device should prepare to migrate to the higher-speed part or else eventually risk decreased supplier support. The concomitant introduction of low-power 80486/80486SX devices is a sign of Intel's goal to migrate users *now* to the higher-priced 80486 arena and away from the lower-priced 80386/80386SX market. According to the SP quarterly price survey, Intel's 16-MHz 80386SX and 20-MHz 80386SX devices (1,000-5,000 unit volume) should sell during the fourth quarter of 1991 for $56.35 and $84.90, respectively. The 25-MHz 80386 device should sell for $153.50 during the fourth quarter (same volume). By contrast, the new Intel devices are priced higher. Prices for the low-power versions of the following ICs (1,000 units) are as follows: 16-MHz 80486SX—$235; 20-MHz 80486SX—$266; 25-MHz 80486—$471. Users should note the $200 price point.

Competitor's Options?

AMD, C&T, and other competitors must soon make a key strategic decision: to focus on the 80386 marketplace or to leapfrog aggressively to the 80486 segment. Recent trends indicate that the PC life cycles are lengthening vis-à-vis original expectations, which means a longer-term opportunity in the 80386/80386SX business. Intel's competitors face two risks: first, they lag Intel, and by focusing on the 80386 segment now and next year these companies will continue to lag Intel—especially as the company makes proper use of its marketing and legal clout to preserve its monopoly position. However, if they make a strategic jump to the 80486 arena and system life cycles become extended, they face the risk of a deadly, premature battle against Intel.

Assumption: Intel's Imperviousness to Price Competition

As noted last quarter, a third assumption behind Dataquest's 80486 price forecast, that Intel intends to be relatively impervious to external price competition vis-à-vis prior MPUs such as the 80286/80386SX, seems subject to change given second half 1991 competitive realities (AMD, C&T). Nevertheless, a main point of the discussion above on Intel's fourth-quarter shift to new parts is that unlike competitors such as Motorola, Intel continues to emphasize higher-priced/higher-performance 32-bit MPUs.

Dataquest firmly believes that over the long term, Intel will ignore to the best of its ability competitors' prices for similar type products. Intel can remain immune to monopoly charges of "predatory pricing," a no-no under antitrust laws. To paraphrase Lord Keynes, however, we are all dead in the long run—so how will Intel respond to competitors' prices in the short run?

As indicated last quarter, users are seeing a somewhat sharp drop in prices for 25-MHz 80486 and 33-MHz 80486 MPUs. As noted, Intel's objective of migrating users with the lower-priced 80386 family to the much higher-priced 80486 family, in part, accounts for this price scenario. The rate of price declines since the parts introduction during the fourth quarter of 1989 is still in line with historic cost learning curve expectations.

Market forces such as flat demand and increased competition could mean continued sharp drops in 80486DX prices during 1992. Nevertheless, for 1992 Intel prefers to shift users to even higher-priced devices as opposed to slashing prices for 25-MHz and 33-MHz 80486 ICs. Although no firm price estimate is available yet, Intel plans to achieve volume-level production of the 50-MHz 80486 device during fourth quarter 1991. An objective is to draw users away from 25-MHz 80486 or 33-MHz 80486 MPUs, which could fall below the $400 price level by year-end 1991 (1,000-5,000 units) and toward the much higher priced 50-MHz part. A related objective is to set the stage for a late 1992/early 1993 user migration to the 80586 device. For users, the likely reality is that Intel will not fundamentally alter its price strategy for high-performance MPUs such as the 50-MHz 80486 or the 80586 successor. Intel assumes timely market acceptance for these parts and will not shift the price curve downward barring a genuine competitive threat.

RISC ICs could prove such a threat. Dataquest's 80486 price forecast does not currently assume that Intel will aggressively compete on price against multisourced RISC ICs. Sun's SPARC architecture means market success for Sun. If the ACE Consortium can jumpstart the number of design wins for the just-announced R4000 64-bit device, Intel would eventually—willingly or not—adopt a more aggressive pricing strategy for the 50-MHz 80486/80586 products. Intel's high-end CISC MPU strategy will not change otherwise.

Assumption: No Intel Price Wars

Dataquest continues to assume that Intel will avoid a pricing war with AMD, C&T, or any other 80386/80486 market competitor. For example, the 40-MHz AM386 part had some effect over the first half of 1991 on Intel's pricing for the 80386/80486 families, although the AMD part more dramatically influenced the evolution of Intel's product portfolio (e.g., 80486SX, 80487) and especially the timing of new product introductions. The crying question in many users' minds is: What must happen for Intel to shift to a more aggressive pricing strategy—if only at the low end of the performance scale—and when?

At this time, Intel still refuses to be drawn into outright pricing battles. For example, in Asia the Intel 80386/80486 brand name continues to carry great clout with users. The 40-MHz AM386 is being evaluated by prospective major users in Asia, Europe, and North America, but the device has not yet had an impact on Intel's general pricing strategy. Dataquest has received reports, however, that for some large orders in different world regions Intel recently granted unusually sharp volume discounts on pricing. To date, this price scenario remains the *exception* and not the rule—especially for users who buy in volumes of 1,000 to 5,000 units.

AMD is gearing—in terms of volume supply—for an AM386/80386 price war. AMD has the potential to effect a change in Intel's strategy. The timing: the first half of next year, which gives Intel time to pull wild cards from the Intel deck of product/marketing/legal strategies so as to avoid such a price war.

Despite intense competition, users should not expect Intel to drastically slash fourth quarter 1991 pricing of the 16-MHz 80386SX device from the $50 to $55 level—or of the 20-MHz version from the $80 to $85 level. Nor should users expect pricing for the 25-MHz 80386 IC to crash from the $150 to $160 range to anything approaching $100.

Intel will make a fierce competitive response to the AMDs and C&Ts of the world. The marketing and legal fronts will be the first lines of attack. A shift of fab capacity to other devices such as the 80386SL-25 or the 80486 family, which offer higher selling prices, would be another response. But a price war in which Intel bleeds red—as in financial loss—would be the last resort.

Dataquest Perspective

The fourth quarter of each year marks a period of change—if not turbulence. The fourth quarter of 1991, a recessionary year for several world regions, will be no exception. Systems manufacturers look for a business upturn that has not yet materialized for many companies. Under these conditions, most IC suppliers confront bruising competition.

To answer the key question asked at the outset: Users should not yet expect Intel to undergo a sharp turning point in the 80386/80486 pricing strategy. To do so would go diametrically against the Intel corporate grain—and wreck a pricing structure that returns to Intel one of the highest profit margins in the industry. Intel's profit record over the past several years should allow the company several quarters of less than impressive results—from the Intel perspective—before management would consider such a fundamental change of strategy.

By Ronald Bohn

(Excerpted from Vol. 1, No. 14, October 14, 1991)

Users' Long-Range Price Outlook—80X86s versus Amx86s versus 680X0s versus RISC Processors

Executive Summary

In the midst of war, system houses continue to plan for long-term IC price trends. As shown in Table 1, this article provides semiconductor users with a strategic perspective on Dataquest's microprocessor (MPU) price forecast through 1995. The long-range forecast is based in part on the results of Dataquest's most recent price survey. This article assesses the critical "whys" behind the forecast—Dataquest's assumptions on suppliers' strategies, marketing trends, and legal issues—so users can adapt to the shifting market. As reflected in Table 1 and by the title of this newsletter, users can plan for competitive MPU pricing over the long term.

Overview

This newsletter focuses on three price estimates—the 1991 price, the fourth quarter 1992 price, and the 1995 price—for select microcomponent devices in order to assess long-term price trends. Emphasis is placed on highlighting the assumptions on which Dataquest bases the long-range forecast to provide users with deeper insight into Dataquest's SUIS pricing outlook for 1993 and beyond.

The pricing analysis presented here correlates with the quarterly and long-range price tables mailed to SUIS clients on December 20, 1990. For SUIS clients that use the SUIS online service, the quarterly pricing information presented here correlates with the quarterly and long-range price tables dated December 1990 in the SUIS online service. The price analysis in this newsletter also correlates with the *Source: Dataquest* report entitled "Semiconductor Price Outlook: First Quarter 1991" dated January 1991. For additional product coverage and more detailed product specifications, please refer to those sources.

Microprocessor Pricing Issues

Table 1 shows that users of high-speed 16- and 32-bit MPUs can expect continued price competition over the long term among major suppliers of CISC and RISC ICs. The following issues should heavily influence these price trends from now until 1995: the evolution of Intel's 80X86 and Motorola's 680X0 families of CISC products; the possible wild-card role of AMD's 80386-type device (AMX86s); and the impact of RISC devices on the CISC market.

Will the 80286-80386SX Battle Ever End?

Table 1 shows that the North American bookings price for the 12-MHz 80286 device (PDIP) in 15,000-piece orders should be $8.47 for 1991. Dataquest forecasts a price of $7.15 for the fourth quarter of 1992.

A key assumption behind this forecast is that the supplier base will remain competitive over

Table 1
Semiconductor Price and Lead Time Trends
(North American Bookings, Volume Orders)

	Long-Range Price Trend (Dollars)			
Part	1991 Price Forecast	Q4 1992 Price Forecast	1995 Price Forecast	Key Assumptions behind Long-Term Forecast
80286-12 PDIP	8.47	7.82	7.15	Supplier base will remain competitive.
80386SX-20 CPGA	89.85	79.82	77.10	Intel's war to kill the 80286 will shift to ICs such as the 80386SL.
80386-25 CPGA	155.93	146.00	143.00	Users must coordinate system life cycles with Intel's MPU product path—or else suffer negative consequences.
80486-25 CPGA	530.75	416.00	394.00	Intel will change the rules of the MPU game.
68020-25 CPGA	94.00	85.00	80.60	The ceramic package makes the difference.
68030-25 CPGA	161.00	140.00	130.00	As users move to the 68040, Motorola has less incentive to lower 25-MHz 68030 prices.
68040-25 CPGA	538.85	400.90	365.00	The 68040 will have a long and healthy life cycle.
SPARC-25	88.74	66.55	53.66	Suppliers of RISC processors will battle on price.

Source: Dataquest (February 1991)

the long term. Two suppliers—AMD and Siemens—have been and are expected to be strongly supportive of users of the 80286. Both suppliers experienced a surge in new orders from Eastern Europe during 1990, which should extend the product's life cycle well into the 1990s, especially in that world region.

To answer the question of will the 80286-80386SX battle ever end, AMD and Siemens will continue the battle, although one of the companies may eventually be forced from this market. For example, Dataquest projects a price of $7.15 for this device for 1995. Pricing at this low level means a narrow profit margin and signals a future contraction of the supplier base.

Intel's 80386SX: Flat—or Rising—Prices after 1992

Table 1 shows that the North American bookings price for 20-MHz 80386SX devices in a ceramic pin-grid array (CPGA) package in orders of 1,000 to 5,000 pieces should be $89.85 for 1991. Dataquest forecasts a price of $79.82 for the fourth quarter of 1992. Users should anticipate stable prices thereafter.

A key assumption behind the price forecast for both 20-MHz 80386 IC and 12-MHz 80286 devices is that Intel will continue its campaign to kill the 80286 but will shift the fight from the 80386SX to other products such as the 80386SL. For example, Dataquest expects Intel to attack the portable and laptop PC markets—key applications for suppliers of the 80286—with innovative and ultimately price-competitive newer ICs such as the 80386SL. While maintaining pricing pressure on the 80286, Intel will halt pricing declines for 80386SX products over the long term.

Table 1 shows that Dataquest expects a price of $77.10 for the 20-MHz 80386SX during 1995. Dataquest forecasts a flat price profile for this device ($77.10) during the 1993 through 1995 period.

Why? Because of a second assumption behind the 20-MHz 80386SX forecast: Intel will strongly and favorably support users that coordinate system life cycles with Intel's MPU production migration schedules. In essence, users that migrate to higher-speed and higher-priced devices (or to entirely new replacement devices) in line with Intel's migration path can expect to experience fewer spot shortages and fewer rising price scenarios. The forecast says, in effect, that Intel wants users to migrate from the 20-MHz 80386SX during the second half of 1992, if not sooner. Users that do not can expect stable prices at best and run the risk of long-term price increases, which occurred to *some* users of the 16-MHz 80386 IC during 1990.

The 25-MHz 80386: Users Should Migrate as Price Stabilizes

Table 1 reveals that the North American bookings price for the 25-MHz 80386 IC (CPGA) in orders of 1,000 to 5,000 pieces should be $155.93 for 1991. Users can expect relatively stable prices after 1991. For example, during the fourth quarter of 1992, Dataquest forecasts a price of $146 and a price of $143 for 1995.

The critical assumption behind the 25-MHz 80386 price forecast was stated in regard to the 20-MHz 80386SX forecast: Intel will most favorably support users that coordinate system life cycles with Intel's product migration schedules. Intel's commitment to the 25-MHz 80386 has started to decrease. During the second half of 1991 and over the long term, users that shift from the 25-MHz 80386 MPU to higher-performance devices such as the 33-MHz 80386 or the 80486 can expect sharper declines in price for these higher-priced ICs—and also reduce the risk of untimely spot shortages or extended lead times.

The 25-MHz 80486: A Change in Intel's Rules of the Game?

In the DRAM business, many of the prior rules of the game regarding such things as process technology and fab funding changed with the move from 1Mb DRAMs to the 4Mb density. Likewise, a basic assumption behind the price forecast for the 80486 is that Intel will set new rules as users move to the 80486 and later to its likely successor, the 80586.

Why? A new element has been added to the equation—these MPUs (unlike in prior generations) incorporate on-board microperipheral functions such as floating-point and memory management, which can be maintained or dropped from the MPU depending on individual customers' needs. Over the long term, Intel's product/pricing strategy will no longer be based on a simple and straightforward premium charge for a higher-speed version of a device (e.g., the 25-MHz 80386 versus the 33-MHz 80386). Instead, by varying the MPU's architectural mix or other features such as power management, Intel will be able, in effect, to tailor future microcomponents to users' micromarket needs regarding product price/performance trade-offs. For example, during 1991 Intel might introduce a lower-performance version of the 80486 (e.g., with no floating-point capability) in order to accelerate the move by users away from the 25-MHz 80386.

A second and related assumption is behind the 80486 long-range price forecast. Intel plans to become more impervious to external pricing pressure than had been the case with the 80286 and 80386SX devices and, to a lesser extent, the 80386. Users of Intel devices will be able to sacrifice (or gain) product performance in exchange for a somewhat lower (or higher) price, but Intel will ignore, to the best of its ability, *competitors'* pricing for similar-type products. This strategy dovetails with Intel's aim of obscuring clear and simple speed-based price structures for a family of devices.

As shown in Table 1, Dataquest forecasts that the North American bookings price for the 25-MHz 80486 IC (CPGA) in orders of 1,000 to 5,000 pieces will be $530.75 for 1991. Learning-curve cost savings should bring the price for the fourth quarter of 1992 to the $416 level.

Under the assumptions outlined above, pricing will grudgingly move down to $394 for 1995. After 1992, users of the 80486 are likely to migrate to the 80586 device, a RISC product, or special versions of the 80486.

A Wild-Card Role for AMD's 80386-Type Device?

Many clients have asked Dataquest what long-term effect will AMD's entry into the 80386-type product segment have on Intel product pricing *if* such entry results in market acceptance. To date, Dataquest assumes that there will be little market effect from AMD's 386-type offering on Intel's 80386—and even less on the 80486 and successors. This assumption, in turn, is tied to two other assumptions.

First, Dataquest fully expects Intel to use, with some success, every legal and marketing attack possible to delay or disconcert users from using this IC in systems. Dataquest foresees no impact from AMD's 80386-type part on the market until the middle of 1991 at the very earliest. More likely, Intel will be able to use the courts of law in conjunction with an aggressive marketing campaign to stifle the initial effect, if any, of the new AMD chip until the end of 1991. Second, as already indicated, Dataquest assumes that Intel will fiercely and successfully resist being drawn into any more pricing battles with AMD. *If* AMD's 80386-type device survives the anticipated legal and marketing onslaught and proves a winner in the marketplace, Intel would accelerate the shift of users from the 80386 family to the 80486 family or to RISC processors.

SUIS analysts recognize that other members of the industry—including some Dataquest analysts—believe that AMD's device will have a sharper market impact. That difference, in perspective, is a major rationale for this article—to explain the assumptions behind the forecast so users can better understand and use the pricing information.

Motorola Microprocessors

As of early 1991, the major news concerns the ramp up by Motorola—or the reduction in users' backlogged demand—for the 68040 IC. The 68020 and the 68030 devices remain Motorola's workhorse products.

25-MHz 68020 Devices: The Ceramic Package Makes the Difference

Table 1 shows that the North American bookings price for 25-MHz 68020 devices (CPGA) in 1,000- to 5,000-piece orders should be $94 for 1991. Dataquest expects a price of $85 throughout 1992. Users can expect a relatively flat price profile for the 1992-through-1995 period.

The key assumption behind the forecast is that Motorola will continue to target high-end PC and workstation applications with the 25-MHz 68020 processor, which uses a CPGA, and will target lower-performance PC applications with the 16-MHz 68020 IC, which uses a plastic quad flat pack (PQFP) package. Under this assumption, after 1991, Motorola will be limited by the ceramic package cost constraint from making sharp reductions in the manufacturing cost and market price for the 25-MHz 68020 device (CPGA). Dataquest expects the price of $85 for 1992 to edge down slowly to just under $81 for 1995.

25-MHz 68030: A Steady—If Not Spectacular—Decline in Pricing

Table 1 shows that the North American bookings price for the 25-MHz 68030 device (CPGA) in 1,000- to 5,000-piece orders should be $161 for 1991. Dataquest expects a price of $140 for the fourth quarter of 1992. Pricing should continue to steadily but not dramatically decline over the long term. Dataquest expects pricing to decline to $130 for 1995.

Two assumptions exist behind this outlook. First, during 1991 and 1992 Motorola must migrate users to the 68040 device, which reduces Motorola's incentive for cutting the price of the 25-MHz 68030 IC for the next two years.

By contrast, Motorola will be able to lower pricing more sharply for the higher-priced 33-MHz 68030 MPU during 1991 and 1992; this 33-MHz part generates a lower sales volume and a wider profit margin than does the 25-MHz 68030, which means more room for price decreases. Motorola has used this device to satisfy *some* users that endured a delay in delivery of the 68040, and an ease in pricing for this MPU may appease long-term customers.

The second assumption behind the 25-MHz 68030 forecast signals a steady if not spectacular decline in pricing after 1992. Although the ceramic package remains an important cost element of the 25-MHz 68030 MPU (CPGA), the forecast assumes that Motorola will be *less constrained* from lowering the manufacturing cost and market price of this part over the long term than will be the case with the lower-priced 25-MHz 68020 IC (CPGA).

The 25-MHz 68040: Competitive Long-Term Pricing

Table 1 shows that the North American bookings price for 25-MHz 68040 devices (CPGA) in 1,000- to 5,000-piece orders should be $539 for 1991. Dataquest expects a price of $401 for the fourth quarter of 1992. Prices should continue to decline steadily over the long term. Dataquest expects prices to decline to $365 for 1995.

The main assumption behind this outlook is that despite Motorola's inability to attain its original goal of a ramp during the second half of 1990, we do foresee a healthy long-term life cycle for the 68040. Many users are likely to migrate to the 68040 device, and over the long term, Motorola should be able to reduce manufacturing costs and market price as reflected in our long-term outlook. Once Motorola recovers the high cost of developing and bringing this product to market (which should occur at about the end of 1992), Motorola could be even *more* aggressive on 68040 pricing—in response to market competition from RISC and other CISC chips—resulting in somewhat lower prices than currently projected.

The 25-MHz SPARC: A Multisourced RISC Processor

Table 1 shows that the North American bookings price for the 25-MHz SPARC device in 1,000- to 5,000-piece orders should be $88.74 for 1991. Users can anticipate a price of $66.55 for the fourth quarter of 1992. Prices should continue to decline steadily over the long term. Dataquest expects prices to decrease to $53.66 for 1995.

The key assumption behind this forecast is that suppliers of RISC processors will battle on price with each other *and* suppliers of CISC processors over the long term in order to win and keep system design-ins. The RISC arena will be more of a multisourced world than will the CISC 32-bit MPU segment. For example, as of early 1991, users can turn to about 10 suppliers for supply of the 25-MHz SPARC IC. This supplier base could narrow over time, but users will still enjoy multiple sources of supply.

The reality of multisourced RISC ICs will keep pricing pressure on all MPU suppliers during the next five years. Suppliers of CISC 32-bit processors may elect to avoid pricing battles, but the long-term threat of RISC IC alternatives should moderate sole-source suppliers' pricing power vis-à-vis the trend of the late 1980s.

Dataquest Conclusions And Recommendations

Table 1 shows Dataquest's pricing outlook for critical MPUs and the assumptions on which the forecast is based. A key assumption is that Intel is changing the rules of the game for users of its processors. Another critical assumption is that the availability of RISC devices from multiple sources will lessen the pricing power of sole-source suppliers. A controversial assumption is that as of early 1991, the SUIS forecast does not foresee great market impact from AMD's 80386-type IC on Intel's product pricing strategy.

Under current conditions, Dataquest makes the following recommendations:

- Users of the 80286 IC can plan for a competitive, although more narrow, supplier base over the long term.
- Users of Intel's MPUs—the 80386, 80386SX, and 80486—must coordinate long-range system life cycles with the Intel MPU migration path or else face unfavorable prices and extended delivery schedules.
- As shown already through the 80386SL and 80486 devices, users must plan for a change in Intel's rules of the game: the IC price/performance trade-offs of the last decade will be replaced by the architectural/price/performance trade-offs of the next decade.
- RISC ICs translate into more favorable prices for many users.

By Ronald Bohn

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Clarifying Intel Microprocessor Migration Plans

System Segment Targets

As the chart illustrates, Intel Corporation clearly will continue to target and position the i386 products in specific system market segments. Intel divides the market into four segments that correspond to specific system price ranges. This information is important to system OEMs because it allows them to better plan their product development and support strategies. The high-end segment, with a system price of about $8,000, was addressed by the 486-33 and 486-25 in 1990 and is expected to migrate to the 486-50 in 1991. The performance midrange segment, at approximately $5,000, is a 386-33 market moving to 486-33 in 1991. The volume midrange segment, at about $3,000, is 386-25 and 386-20 going to 486-25 and 386-33 in 1991. The entry-level segment costs approximately $1,000 and currently is served by the 286 and the 386SX. Intel intends to target the 386-25 and 386-20 as well as the 386SX at this segment. (The designations 386 and 486 are registered trademarks of Intel Corporation.)

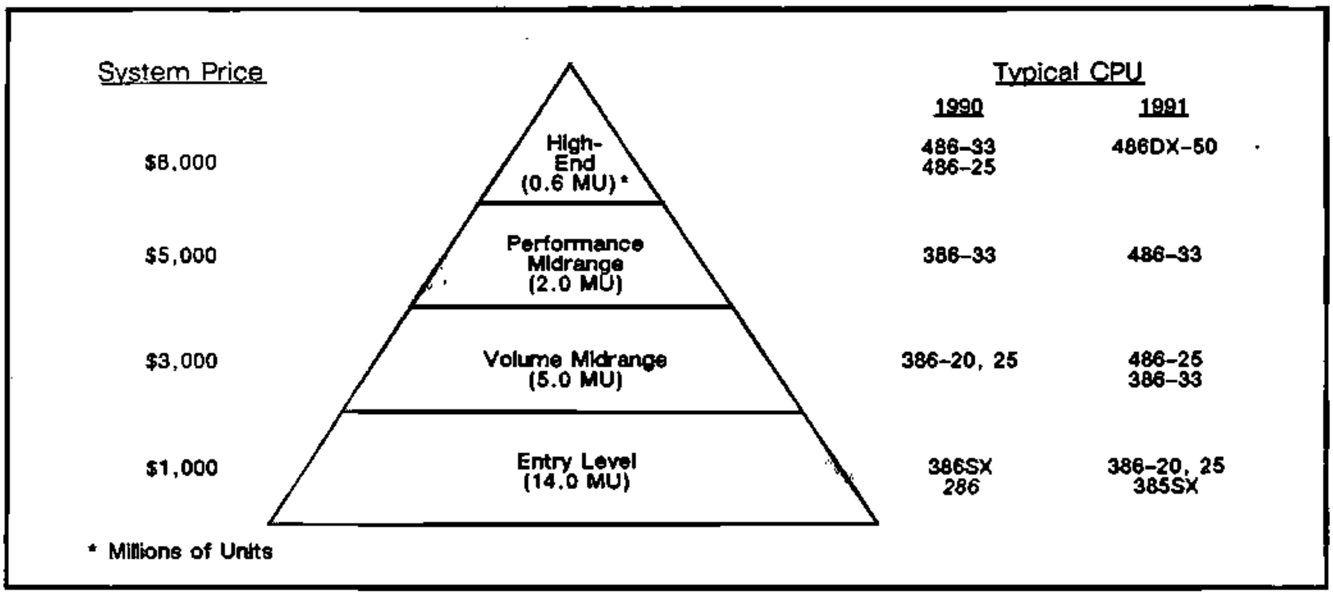
System vendors have voiced concern recently about the rapid proliferation of new microprocessor products and speed grades, which in turn led to a proliferation of system products. Such proliferation has caused an increased burden for the system vendor, in terms of new product development and support, and has helped to blur the lines of product differentiation. When asked why Intel continues with this proliferation, David House, general manager of Intel's Microprocessor Components Group), answered that he would be glad to slow the pace of development and spend fewer R&D dollars if he could only convince Intel's competitors to do the same.

In fact, it is clear from the chart and from other remarks made at this meeting that Intel understands this issue and is attempting to better control product segmentation. Intel intends to continue driving the technology at a rapid pace but will not necessarily proliferate products through speed upgrades. New products will be based on architectural and manufacturing process improvements. Horizontal versions that address specific application or form factor issues, such as the 386SL, also will be forthcoming.

Obsolescence And The Anticlone Strategy

Mr. House admitted that the 386DX shipments had peaked in 1990, the product is being "squeezed at both ends" by the 486 and the 386SX, and it will be phased out. The 386DX-16

Figure 1
1991 PC Market Segmentation
(Approximate 1991 Volumes)



Source: Intel

is not going to be supported, therefore, and it is not likely that there will be a 40-MHz version of the part. Intel's goal is to establish the image of performance and desirability for the 486 product. This goal probably will mean substantial price reductions for the 486, particularly the 486-25, during 1991. We can see also from Figure 1 that there will not be a 40-MHz version of the 486. The company intends to go directly from a 33-MHz to a 50-MHz version.

As for the 286, apparently it falls off the chart in 1991. However, it is not clear from the figure either when or if Intel plans to discontinue support of the 286. What is clear is that the company does intend to continue emphasizing the 386 family (which includes the 486 and, presumably, the 586) and promoting the move toward 32-bit computing. No matter how strongly some protest, the 286 is in the waning years of its product life cycle. The product may get a temporary reprieve as a result of its use in notebook PCs and possibly from a boost in sales to Eastern Bloc countries, but this reprieve will be short-lived.

A more interesting issue than the fate of the 286 is the potential for 386 clones. Advanced Micro Devices is expected to release a 386 clone, and others may follow. Intel's campaign to kill off the 286 already is giving way to a similar effort to obsolete the 386DX, as evidenced by remarks at the analysts meeting that the 386DX will be phased out. Intel hopes that the rapid introduction of new generations of microprocessors, along with horizontal versions such as the 386SX and 386SL, will keep pursuers lagging far behind.

By Ronald Bohn

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Semiconductor Users Still Eye the Risks of Sole-Sourced CISC 32-Bit MPUs

Summary

As discussed in prior newsletters, systems manufacturers continue to confront tough decisions about which 32-bit complex-instruction-set computing (CISC) or reduced-instruction-set computing (RISC) microprocessor(s) to use and from which manufacturer. The broad strategic decision of whether to use single- or multisourced ICs will challenge systems manufacturers throughout the 1990s. Currently, although users reported to Dataquest a rising interest in future use of RISC MPUs, systems manufacturers remain largely committed to 32-bit CISC devices. Table 1 shows that using single-sourced 32-bit CISC MPUs carries a special set of risk/benefit trade-offs—as illustrated by the recent stunning legal ruling on the 68030 microprocessor.

Overview

This article is based on the information presented in Table 1, with focus on the risks associated with the use of single-sourced ICs—specifically, CISC 32-bit MPUs—and recommendations to users for reducing risk exposure. Table 1 centers on two critical user issues: competitive component/system pricing and global availability of single-sourced ICs. Dataquest will provide a user perspective on the emerging RISC technology in a future newsletter.

Strategic IC Pricing Risks

As shown in Table 1, users typically pay higher prices for single-sourced ICs such as CISC 32-bit MPUs than for components that are available from multiple sources. In addition, all component buyers, whether of single- or multisourced ICs, confront other pricing/availability risks: inconsistent IC pricing, supply, and quality among the different world regions.

Higher IC ASPs

Although the use of sole-sourced ICs in systems typically means higher IC pricing vis-à-vis multisourced devices, the use of these higher-priced components *can* translate into enhanced system performance and profitability. Users of sole-sourced ICs must realize, however, that the long-term pricing trend for these higher-priced devices is likely to be different than the historical pattern.

IC Life Cycle Pricing

Historically, semiconductor users have grown accustomed to rapid attrition in IC pricing during the early (or forward) stages of the IC life cycle, especially for multisourced devices such as standard logic or memory products. This pattern of semiconductor pricing is called life cycle or forward pricing.

Users of sole-sourced 32-bit CISC devices should expect a somewhat different pricing

Table 1
A User View of Single-Sourced CISC 32-Bit Microprocessors

Prospective Benefits for Users	Possible Risks for Users
Enhanced system value and competitiveness by use of proprietary technology	Higher IC ASPs (versus second-sourced 32-bit MPUs)
Protection against shortages through long-term contracts	Inconsistent world regional IC supply, quality, and pricing
More accurate production forecasts per close user/supplier relationships	Periodic allocations to users in times of product scarcity
Clear system/technology road map	Inability to meet system production and life cycle plans
Improved supply/pricing of ICs used along with the 32-bit MPU	Legal uncertainty associated with patent enforcement and other claims

Source: Dataquest (May 1990)

structure. The huge expense (e.g., R&D, fab construction, legal protection) of producing these complex chips motivates suppliers of 32-bit MPUs to resist stiff price declines during the early years of the IC's life cycle. Pricing for these devices typically declines between 5 and 9 percent per quarter during the growth stage. By contrast, pricing for multisourced devices often declines at a quarterly rate of between 10 and 30 percent during the forward stages.

Depending on the CISC 32-bit MPU supplier, product pricing *for major buyers* should either stabilize or continue to decline moderately during the later years of the life cycle. When pricing stabilizes, a higher-speed product typically costs no more than a lower-speed version for long-term customers (i.e., 16-MHz and 20-MHz price parity).

World Regional Supply Risks

Inconsistent IC pricing among different world regions relates directly to global supply/demand trends. For systems manufacturers that develop coordinated international procurement/manufacturing/marketing plans, management of world regional IC supply/pricing trends should become a central concern. Over the long term, some *suppliers* might be able to sell ICs at uniform prices worldwide, but that remains a future goal.

For users of CISC 32-bit MPUs, global pricing management requires, at a minimum, that users monitor suppliers' worldwide manufacturing capabilities, preferably taking an active role in shaping the global fab plans of the sole-sourced supplier. This strategy can help reduce the likelihood of another risk associated with use of single-sourced products: periodic allocations to users in times of product scarcity, as is now occurring for users of Intel's 80386/80386SX devices. Depending on supply/demand trends, a product can be on allocation in one or more world regions but be more readily available in other areas.

The 32-Bit CISC MPU Global Fab Networks of Intel and Motorola

Table 2 weighs the global manufacturing strengths of Intel and Motorola regarding production of 32-bit CISC devices. These components include Intel's 80386, 80386SX, and 80486 products and Motorola's 68020, 68030, and 68040 devices.

Manufacturing by World Region

Table 2 reveals that Motorola and Intel are well positioned to serve long-term North American demand. Motorola's United Kingdom fab puts suppliers in a good position to supply European users. Intel currently supplies European users of 80386 partly with products from the Israel fab. The approach of 1992 could mean expanded capacity for that region.

Table 2 also shows that users in Japan and Rest of World (ROW) know firsthand of the challenges involved in globally sourcing single-sourced ICs. Motorola's alliance and joint-fab arrangement with Toshiba should enable Motorola to serve the Japan market effectively over the long term.

Table 2
32-Bit CISC MPU Worldwide Manufacturing Capability—Intel and Motorola (as of May 1990)

	Motorola 32-Bit CISC MPUs[1]	Regional Total	Intel 32-Bit CISC MPUs[1]	Regional Total
		Number of Fabs by World Region		
North America	2	4	3	7
Europe	1	3	1[3]	1[3]
Japan	1[2]	1[2]	0	0
ROW	0	0	0	0
Total number	4	8	4	8
		Square Feet of Clean Room by World Region		
North America	76,900	91,800	72,000	182,000
Europe	34,000	94,600	24,000[3]	24,000[3]
Japan	0	23,800[2]	0	0
ROW	0	0	0	0
Total	110,900	210,200	96,000	206,000

[1]Intel and Motorola fabs largely dedicated to 32-bit CISC MPUs
[2]Joint Motorola/Toshiba facility
[3]Israel
Source: Dataquest (May 1990)

The Risk of Allocation

Nevertheless, unexpectedly strong market demand can overwhelm the ability of the formidable single-source suppliers to meet all user needs, as is now occurring with Intel's 80386/80386SX products. SUIS clients that forged long-term contracts with Intel for these products report little interruption of supply, unlike buyers that operate on the spot markets.

At the time of this writing, Dataquest had been informed that the supply/demand imbalance is not expected to improve in North America and Europe until the second or third quarter of 1990. The imbalance in Japan and ROW also should not improve until the third or fourth quarter of this year.

Legal Risks

Users of 32-bit CISC MPUs must be ready to confront another risk: potential legal uncertainty surrounding the validity of sole suppliers' patents and other intellectual property. For example, an invalid patent ultimately vitiates the benefits presented as rationales for using sole-source devices. As shown in Table 1, these benefits include enhanced system value through use of proprietary MPU technology and clear long-term system/technology road maps.

68030 Litigation

The stunning decision in the Hitachi/Motorola case concerning microprocessor (and microcontroller) patent infringement claims shocked users of the 68030 microprocessor. Regarding the CISC 32-bit MPU arena, the case could have severe and unanticipated consequences for Motorola and users of this device.

Setback for Users?

Users continue to receive shipments of 68030 products from Motorola during the second quarter of 1990. In late June 1990, barring a prior settlement, Hitachi and Motorola will return to court. A major issue is whether or not Motorola should be allowed to continue shipments during the lengthy appellate process. If not (again, barring a settlement), users will experience major disruption of 1990 system production plans and long-term uncertainty regarding their systems life cycles and technology road maps.

A Fairly Speedy Settlement?

Dataquest believes that both Hitachi and Motorola have good reasons for seeking a resolution to their litigation. In Motorola's case, the threat of injunction hangs over a product that Dataquest believes garnered revenue in the $120 million to $150 million range in 1989. As noted, of greater long-term significance is the fact that stopping the flow of 68030s represents a serious hardship to Motorola's customers. Succinctly, major users are dependent on the 68030 as the sole-source heart of significant portions of their systems sales.

Hitachi also is motivated to come to terms. Although U.S. sales of its H8 product may not be as monetarily significant as the 68030, sales of the H8 in Japan would be jeopardized if the final destination of domestic equipment was the United States. As has been demonstrated by Intel and Texas Instruments, invoking the powers of the International Trade Commission (ITC) in defense of one's intellectual property can empower customs to seize imports of equipment containing an offending product. Consequently, many of Hitachi's customers also probably want a hasty resolution of the issue.

Given the stakes involved for both Hitachi and Motorola, Dataquest anticipates a fairly speedy settlement and an end to the jitters felt by 68030 customers. The settlement may cost Motorola the millions of dollars it might have hoped to gain from Hitachi when it first pressed its lawsuit more than one year ago. Nevertheless, the current bottom line is that users of the sole-sourced 68030 remain waiting for a legal resolution that could occur as soon as tomorrow or not for several years.

A User Eye on Unresolved Legal Issues

Dataquest strongly recommends that users carefully monitor legal developments associated with *all* sole-sourced ICs—not only the 68030 MPU, but also 80386/80386SX products and application-specific ICs (ASICs).

Regarding the 68030 litigation, the resolution of the following issues could have a forceful impact on users' 1990 production schedules and long-term technology road maps:

- If Hitachi and Motorola do not settle the litigation, how long will users have to wait before the case is resolved?
- Would a cross-license deal, as part of a settlement, imply access to selected technologies or outright second-sourcing of the 68030?
- Is Hitachi at all interested in producing the 68030?
- If the 68030 were to be second-sourced to Hitachi, how would this affect Motorola's agreement with Toshiba, with which it has a DRAM/microprocessor joint venture?
- Will pricing for 68030 products be higher than originally expected (e.g., pass-on of Motorola's royalty payments), unaffected, or lower (i.e., Hitachi as second source)?

More Legal Shocks for Users of Sole-Sourced 32-Bit MPUs?

Dataquest will be tracking the 68030 case with an eye on these issues. As noted in previous newsletters, the recent events surrounding the 68030 product augur future shocks for supply-base managers at systems companies that use single-sourced CISC 32-bit MPUs. For example, users of 80386 devices must monitor the arbitration case between AMD and Intel over 80286 products. AMD claims a right to produce *80386* devices. Should AMD win that argument—as stunning as the scenario seems—AMD might emerge as a supplier of 80386 products. The unresolved issues surrounding the 68030 litigation could become for users—with some modification—the unresolved issues surrounding *the 80386 case.*

Dataquest Conclusions and Recommendations

Dataquest believes that users of sole-sourced ICs such as CISC 32-bit microprocessors confront a challenging set of risks in terms of pricing, worldwide supply, and legal claims. Use of these proprietary processors can mean enhanced system value and competitiveness, provided that the risks are minimized. Generally, risks can be minimized through close user/supplier relations that include the mutual sharing of sensitive forecast information.

Specifically, Dataquest also makes the following recommendations:

- To manage pricing risks (higher prices; no life cycle pricing), users must actively monitor suppliers' R&D/capital equipment plans to make certain that these plans coordinate with users' long-term *worldwide* system production goals and technology road maps.
- To manage global supply risks, users must track their single-sourced suppliers' worldwide network of fabs *as well as* world regional demand patterns in order to gauge the periodic likelihood of limited allocation *on a world regional basis.*
- To manage legal risks, users must monitor any legal developments surrounding any single-sourced IC and require from suppliers information on any such products currently involved or likely to be involved in a legal dispute.

By Ronald Bohn

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About Dataquest's Worldwide Semiconductor Procurement Service

Dataquest's Semiconductor Procurement information service, formerly Semiconductor User Information Service, is a comprehensive market research service covering the world's major semiconductor markets. Dataquest provides semiconductor users with indispensable information needed to make solid, intelligent, and quick procurement and design-in decisions. Through the service, Dataquest's analysts become an extension of your purchasing and component engineering teams by delivering concise information and analysis on the issues that affect your strategic and tactical business plans.

The service is available on an annual subscription basis and provides you with authoritative industry pricing projections, worldwide market forecasts, objective market share estimates, and a forward-looking assessment of the forces affecting semiconductor procurement. The service also delivers Dataquest analysis of key industry trends, leading manufacturers' strategies and product offerings, and enabling and competing technologies.

Product Coverage

The following represents some of the areas that are covered by the Semiconductor Procurement information service.

Price/Lead-Time Trends

Quarterly price/lead-time forecasts for over 200 devices

Semimonthly snapshot of booking prices of 25 critical products in the United States, Europe, Japan, Taiwan, Hong Kong, and Korea

Product/Technology Trends

Major Product Families: ASICs, Memories, Microcomponents, Standard Logic

Product/Technology Life Cycles

Market Size/Shipments

Product Specification Trends

Semiconductor Product Cost Analysis

Packaging Trends

Quality Issues

Monthly Procurement Pulse

Average Monthly Semiconductor Orders

Average Semiconductor Lead Times

Actual versus Target Inventory Levels—All OEMs

Actual versus Target Inventory Levels—Computer OEMs

Monthly Market Watch

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European DRAM Market Update—Welcome to the 4Mb

Introduction

Dataquest published its long-term outlook for the European DRAM market in March 1991. This article focuses on the short-term issues that will affect the market up to the end of 1992. Our forecast is quarterly, and, where appropriate, updates are made to our March analysis. Special attention is given to the 4Mb DRAM as this product is approaching volume production and DRAM buyers are now considering their options.

Summary

The European DRAM market is in a state of transformation. Our quarterly forecast shows that the European DRAM market will grow in value by 10.9 percent in 1991, assuming a unit growth of 6.6 percent and an average selling price (ASP) growth of 4.0 percent. This is a promising recovery from 1990, which saw a 26.1 percent market decline caused by an ASP decline of 33.8 percent and a unit growth of 11.6 percent.

Three key changes have occurred in the market since we prepared our long-range European MOS Memory Consumption Forecast booklet. These are as follows:

- Total DRAM sales to the European market for 1990 have been finalized at $1,216 million. This is $76 million greater than the preliminary market size given in the booklet and is believed to include direct shipments of 1Mb devices from Japan.
- Poor first quarter results by major end users of DRAM have led us to revise the expected unit demand for the 1Mb in 1991.

- Market prices for the 1Mb increased substantially at the beginning of the second quarter of 1991. This development is believed to be related to the DRAM reference price agreement between Japanese companies and the European Commission, and it is discussed in detail later.

In summary, key assumptions for 1991 are:

- The 64K is experiencing a sharp decline in demand.
- The 256K shows general slowdown in production, leading to higher prices.
- The 1Mb shows slowdown in Japanese production, leading to higher prices.
- The 4Mb is ramping up in Japanese production, leading to price erosion.
- The 4Mb has reached price-per-bit parity with the 1Mb.
- The European PC market is growing at approximately 10.0 percent.
- No shortages are expected in 1Mb or 4Mb DRAMs.
- DRAM market growth is at 10.9 percent.
- DRAM market growth in 1992 will be at 34.9 percent.

Product Analysis

Price Trends

Japanese companies continue to be a major influence in the European market despite the fact that only two out of the top five suppliers to the European DRAM market in 1990 were Japanese. Those two are Toshiba and NEC, ranked second and fifth, respectively. In fact, the market share results belie the fact that in 1990 Japanese companies collectively served an estimated 47.1 percent of the European DRAM market. At the 4Mb density, this dominance is greatest, and currently stands at around 85.0 percent. Obviously then, any forces affecting the DRAM activities of Japanese companies will affect the marketplace.

In January 1990, the European Commission entered into an agreement with Japanese DRAM manufacturers; it set minimum European price guidelines for Japanese DRAM products based on cost of manufacture.

Dataquest believes that 1Mb and 4Mb DRAM reference prices (RPs) applied to Japanese-sourced DRAMs increased in the first quarter of 1991, followed by further growth in the second quarter. The cause was rising manufacturing costs, which are used to determine RPs. Japanese companies have been reducing production of 1Mb DRAMs, which has augmented unit costs, and hence the 1Mb RP.

The 4Mb DRAM RP increases are less easy to understand, but are believed to be caused by the late inclusion of some previously overlooked manufacturing costs by Japanese companies. The RP agreement allows for the correction of previously underestimated costs by adding the shortfall to current cost estimates. The scale of the rise in RP varies depending on the currency used, but the fact remains that these increases have been followed closely by growth in market prices.

Dataquest believes that Japanese companies do not always lose their business to non-Japanese competitors as a result of increases in reference prices. Some Japanese suppliers are believed to offer package deals, which maintain conformance to DRAM reference price levels, but include other products at discount. In this way, competitiveness can be maintained against suppliers not bound by DRAM reference prices. The net effect is that Japanese companies hold on to their DRAM customers, and the market ASPs reflect RP levels.

We found it necessary to integrate RP trend assumptions into our forecast, linked to how Japanese DRAM production capacity is utilized and affects the 1Mb and 4Mb:

- 1Mb RPs are expected to continue to rise throughout the forecast period.
- 1Mb market ASPs will follow a similar trend, but will be below 1Mb RPs. RPs will have progressively less effect on market ASPs as Japanese suppliers withdraw from this density.
- 4Mb RPs are expected to decline from the third quarter of 1991 to the end of the forecast period.
- 4Mb market ASPs will closely follow 4Mb RP trends as Japanese suppliers are expected to maintain leadership in this market throughout the forecast period.

- RP trends will show short-term deviations as a result of exchange rate fluctuations, DRAM production changes, and errors and corrections in cost projection.

Product Diversification

The DRAM market of the past was driven by technology, and users needed to design their systems around the product. The DRAM market of today is driven by application. The number of user options available for DRAM has increased with each generation, and currently exceeds 400 at the 4Mb density from some vendors. These options cover speed, configuration, package type, refresh mode, write mode, read mode, power consumption, and special modes. This excludes permutations possible from DRAM module configurations. It is now vitally important to understand what the customer wants in order to ensure that the correct balance of options is made available to the market.

Trends by Product

Dataquest has surveyed major European users of DRAM in order to produce a demand-driven quarterly forecast that has been balanced against production estimates from suppliers.

64K DRAM

From the beginning of 1991, this part has experienced a sharp decline in demand. Users have finally chosen to move up to the 256K part, which is only 10 percent more expensive. The 64K and 256K DRAM ASPs are expected to converge and follow a similar upward trend through to the end of 1992. Dataquest believes that the timing of this move was inevitable. The number of suppliers of the 64K is dwindling, and as each one of them withdraws, the volume of supply will be reduced significantly.

Most vendors can effectively support three generations of DRAM, and so the imminent takeoff of the 4Mb market puts the 64K on borrowed time. Typical applications for the 64K include TV teletext buffers, satellite receiver memory, and small system memory upgrades. Even if some of these applications do not require the capacity of a 256K, the lower cost-per-bit and benefit of a more secure supply will prevail. The short-term outlook for the 64K market is therefore rapid decline.

256K DRAM

Demand for the 256K part has been in steady decline since mid-1989 when the price-per-bit of the 1Mb reached parity with it. Current supply of this part in Europe is mainly from non-Japanese vendors such as Samsung, Texas Instruments, and Siemens, and many of these plan to phase out the product by the close of 1991. Major European users of the 256K include telecommunications and computer manufacturers, with key applications being digital exchanges and PCs, respectively. These end users are finding that shortages of the part have led to higher prices.

Leading package options, in order of preference, are dual in-line package (DIP), plastic leaded chip carrier (PLCC), and zigzag in-line package (ZIP). The 1Mb, in 64K×16 and 256K×4 configurations, is a convenient replacement for the 256K in 64K×4 and 256K×1 configurations. The outlook for the 256K market is for continued decline in units coupled with increasing prices. Notices of withdrawal from the 256K market are expected to be announced by vendors throughout the year.

1Mb DRAM

This product has now reached maturity and is expected to peak in unit shipments in the third quarter of this year. Unit demand is expected to decline in the second half of 1991, and coupled with price erosion, will lead to a sharp drop in revenue. After the second quarter of 1992, 1Mb revenue will fall below that of the 4Mb. Key European applications of the 1Mb include most PCs, workstations, memory expansion modules, laser printers, and telecommunications equipment. Leading package options, in order of preference, are small outline J-leaded (SOJ), DIP, ZIP, and thin small-outline package (TSOP) type 2. Configuration options, also in order of preference, are 1Mb×1, 256K×4, and 64K×16. Access speeds vary from 120ns to 53ns, with most demand in the region of 80ns, though the trend is toward 70ns.

Japanese suppliers began cutting back on 1Mb production in the third quarter of 1990 as there was a slump in worldwide demand. This led to increases in 1Mb reference prices from the first quarter of 1991, which took the 1Mb user base by surprise. Many non-Japanese vendors have ramped up production in order to take up the excess business. This has led to Samsung becoming the world's largest producer of 1Mb DRAMs. However, this concerted effort has not prevented the 1Mb from becoming booked out or prices from rising in Europe.

The 1Mb price rise meant that the 4Mb part achieved price-per-bit parity with the 1Mb. We expect non-Japanese suppliers to reduce 1Mb prices again to delay users migrating to the 4Mb. However, there are complications to this effort, as the European Commission is investigating a number of South Korean DRAM suppliers accused of dumping DRAMs in Europe. Dataquest is of the opinion that 1Mb DRAM market prices in Europe will begin to diverge from reference price trends in the medium term.

Welcome to the 4Mb

This part is now at parity on price-per-bit with the 1Mb DRAM. Second-generation devices are becoming available, with package outlines and speeds that are attractive as replacements for the 1Mb. This article pays special attention to the future development of this market.

The growth of the 4Mb market through 1990 was dogged by continued price erosion of the 1Mb DRAM. This kept the price-per-bit of the 4Mb above that of the 1Mb for longer than would normally be expected. Added to this, 4Mb suppliers shot themselves in the foot by promising that the 4Mb would eventually have the same outline as the 1Mb. This would be achieved by releasing a second-generation 4Mb using 0.8μm design rules to replace the initial first-generation 1.0μm offering. This is believed to have given users cause for concern: the first-generation 4Mb in 350-mil SOJ might not last long before being made obsolete by its 300-mil SOJ successor. A wait-and-see attitude thus developed.

The growth of the 4Mb market is now finally under way. Our key 4Mb market assumptions are as follows in configuration options:

- 4Mbx1—Bit-wide organized versions of the 4Mb are required in large systems such as mainframe, mini-computers, and large dedicated systems. These users were some of the early adopters of the 4Mb. This organization currently accounts for 50 percent of the European market. It will represent a smaller share in the future, as strong growth in other applications is expected to demand wider organized 4Mb.
- 1Mbx4—Nibble-wide organized versions of the 4Mb are in demand for 80386/80486- and 68030/68040-based systems for main and expanded memory. This organization has remained popular from the earliest days of the 4Mb, although it lost some ground to the 4Mbx1 over the last two years. The outlook is for increased share of the 4Mb market, as OEMs of the above systems collectively move to the 4Mb from the 1Mb. Memory modules are also an important application for the 1Mbx4. As an example, a 1Mbx9-configured single in-line memory module (SIMM) can have its power consumption reduced by 67 percent and its height reduced by 18 percent when using two 4Mb (1Mbx4) DRAMs and one 1Mb (1Mbx1) DRAM instead of nine 1Mb (1Mbx1) DRAMs on the board.
- 512Kx8—Byte-wide organized versions of the 4Mb are required in a number of portable systems such as notebook computers and in high-resolution output devices such as laser printers. Memory modules are also an important application for the 512Kx8. As an example, the 512Kx36-configured SIMM can have its power consumption reduced by 50 percent by using four 4Mb (512Kx8) DRAMs and eight 256K (256Kx1) DRAMs instead of sixteen 1Mb (256Kx4) DRAMs and eight 256K (256Kx1) DRAMs. Samples of this part are now becoming available from leading suppliers, with other vendors following by the end of 1991. Versions of the 512Kx9 configuration will be released simultaneously for users requiring a parity check facility on-chip. The outlook for this configuration is expected to be a relatively minor share in the medium term.
- 256Kx16—Word-organized versions of the 4Mb are already in demand from users currently employing the 1Mb in a 256Kx4 configuration. This covers a wide range of equipment, including systems based on 80386 and 68030 microprocessors. High-resolution displays also require this configuration. Samples of this part will become available from major vendors this quarter and from other vendors over the next

12 months. Some vendors have brought forward their release dates in response to strong interest from users. The 256K×18 versions will be released simultaneously for parity checking. The outlook for this part is for a significant share in the medium term.

The 4Mb has a number of packaging options. All dimensions in the following list are based on 4Mb×1 and 1Mb×4 configurations. For 512K×8/9 and 256K×16/18 configurations, add 50 mil and 100 mil, respectively, to give a rough guide. Packaging options for the 4Mb are as follows:

- SOJ—This surface mount package is available in 350 mil from most 4Mb vendors. Second-generation 300-mil versions are now becoming available from leading vendors. This part is suitable for use on motherboards and modules in most systems. The SOJ is estimated to account for 85 percent of all European shipments today. This share is forecast to decline as other packages increase in popularity.
- ZIP—This through-hole package is available in 400 mil from most vendors. Second-generation 300-mil versions are now being test-marketed in through-hole and surface-mount versions. This part is suitable for motherboard mounting in large systems where small footprint and heat dissipation are major issues.
- TSOP type 1—This surface-mount package is now available in 315 mil from leading vendors. Second-generation versions featuring smaller outlines will be available in the second quarter of this year. This part is suitable for high-density mounting on motherboards, modules, and, most importantly, memory cards. The availablity of reverse-pinout versions allows for maximum mounting density when required. However, the fine pin pitch (0.5mm) of this device makes it difficult to mount, and is expected to be used only in applications where minimum board space is a critical consideration. The future for this package is mainly dependent on the market for memory cards, which is expected to take off strongly in the medium term. Development of memory cards is particularly advanced in Japan.
- TSOP type 2—This surface-mount package is available in 450 mil from most vendors. Second-generation 300-mil versions are now also becoming available from leading vendors. The main benefit of this part is that it has the same height as TSOP type 1 and the same footprint as the second-generation SOJ. However, it is easier to mount than TSOP type 1 because the pin pitch (1.27mm) is greater. Applications will be a cross between those for SOJ and TSOP type 1. The outlook for this part is for significant market share in the medium term.
- Others—This category includes DIP and tape-automated bonding (TAB). DIP is a through-hole part and is believed to be available from only one manufacturer to date. It is suitable for small-volume custom equipment where small outline is not a concern and assembly facilities are primitive. The outlook for this part is as a niche option. TAB is a low-profile surface-mount part and is expected to be used in portable applications such as memory cards and notebook computers. The outlook for this part is mainly dependent on the market for memory cards, which is expected to take off in the medium term, as discussed earlier.
- Modules—This category includes padded SIMMs and pinned single in-line packages (SIPs). Modules currently account for a high proportion of 4Mb DRAM shipments and stood at an estimated 70 percent of all 4Mb shipments in the first quarter of 1991. Modules are suitable for memory expansion and dense motherboard assemblies. They are expected to continue to account for a major part of the market, although TSOP and second-generation ZIP will steal some of this business.

16Mb DRAM

Samples of this product are available now from leading suppliers. It is available in 400-mil SOJ, ZIP, and TSOP type 2. Access speeds range from 60ns to 100ns, with the most popular at 70ns, and a trend is expected toward 60ns. Current configurations are 16Mb×1 and 4Mb×4, with plans for 2Mb×8 and 1Mb×16 by the end of 1992. Internal voltages range between manufacturers but are understood to be 3.3V or 4.0V, as opposed to 5.0V standard for preceding generations. External voltages are 5.0V in all versions, but users may find the internal voltage better to work with, especially if the 16Mb is for use in portable equipment. The outlook for the 16Mb market is for general prototyping demand beginning in the first half of 1992.

Dataquest Perspectve

The European DRAM market is now in recovery following weak unit growth and rapid price erosion in 1990. The end of the Gulf war has released a wave of pending orders, reflected in the very high DRAM book-to-bill ratios of leading suppliers in recent months. Some of these orders are likely to have been prompted by the news that DRAM reference prices were to increase again in the second quarter of this year. Orders of this nature tend to be soft. Dataquest believes that these are a minority, and the majority of recent orders are firm. However, the second half of 1991 is expected to be weak in terms of new orders, leading to a mild growth of 10.9 percent in total revenue. The year 1992 should see a stronger market, with 34.9 percent growth in revenue.

The availability and pricing of the 4Mb now makes it an attractive proposition in Europe. Users are looking hard at their options and are generally believed to be ready to take up the successor to the 1Mb. The 4Mb supplier needs to be ready to supply the options its customer wants. This is a task to be undertaken with forethought, especially for those suppliers with the responsibility of investing in European fabrication facilities. The 4Mb market has no clear leader yet, though Hitachi and Toshiba are clearly ahead of the rest of the competition. Ultimately, the successful players of the 4Mb market will be determined by the customer base that will place orders with those suppliers offering the right product mix. Diversification will be the name of the game.

By Byron Harding

(Reprinted from Vol. 1, No. 6, June 11, 1991)

Japanese DRAM Market Update—Will 4Mb DRAMs Have a Short Life?

Introduction

When plummeting 64Kb and 256Kb DRAM prices in the 1985 semiconductor recession caused major chipmakers to restrain capital investment, only Toshiba continued aggressive investment in 1Mb DRAMs; later, it dominated the market. Now Dataquest sees more competition in the 4Mb DRAM market. Hitachi has a slight lead, closely followed by Toshiba, NEC, Mitsubishi Electric, and Fujitsu. Slow growth of 4Mb demand appears to help narrow the difference. Empirical evidence shows that chipmakers that dominated the DRAM market invariably enjoyed a significant growth in semiconductor revenue, and in order to recover their gigantic investment, 4Mb chipmakers are engaged in a serious race for survival.

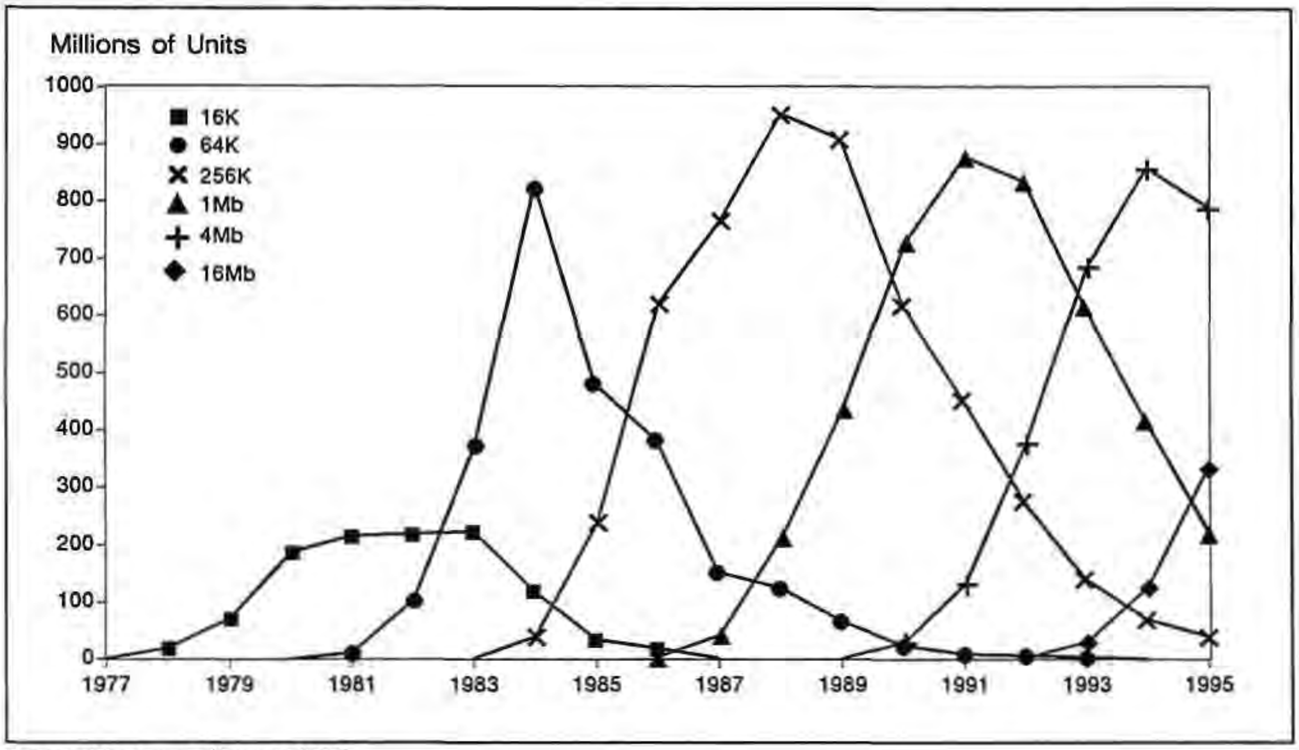
This year is supposed to be the year for 4Mb DRAMs. However, with volume production of 16Mb DRAMs scheduled in 1992 and as development of 64Mb DRAMs is accelerated, some say that 4Mb DRAMs may have a short life. If so, it would certainly be a life-and-death matter for DRAM suppliers that are behind in 16Mb development. A short life for 4Mb DRAMs would cause some companies to withdraw from the DRAM business. This article examines the potential life of 4Mb DRAMs.

The 4Mb DRAM Life Cycle

Since the birth of 16Kb DRAMs in 1977, the semiconductor industry has introduced a new generation to the market every three years. Although this technological tradition is expected to continue up to the 64Mb DRAM generation, the pace of volume production growth has slowed steadily from one generation to the next (see Figure 1). In particular, the initial growth of 4Mb production has obviously lost the momentum seen in past generations.

Dataquest looks at the peak of DRAM production in each generation. Assuming that a new generation of DRAMs is introduced every three years and production peaks every four years, the life cycle becomes longer for later generations. If applied to 4Mb DRAMs, production will reach a peak level between 1994 and 1995, at which time more than two generations will be in the market. Dataquest believes that this situation is likely because DRAMs, the demand for which has previously been governed by computer market growth (e.g., PC booms in 1984 and 1988) will find a wide range of applications including facsimiles, telephones, automobiles, VCRs, and TVs; therefore, consumption of DRAMs with smaller storage capacity will continue in the foreseeable future. Coexistence of several

Figure 1
DRAM Life Cycle
(Millions of Units)



Source: Dataquest (August 1991)

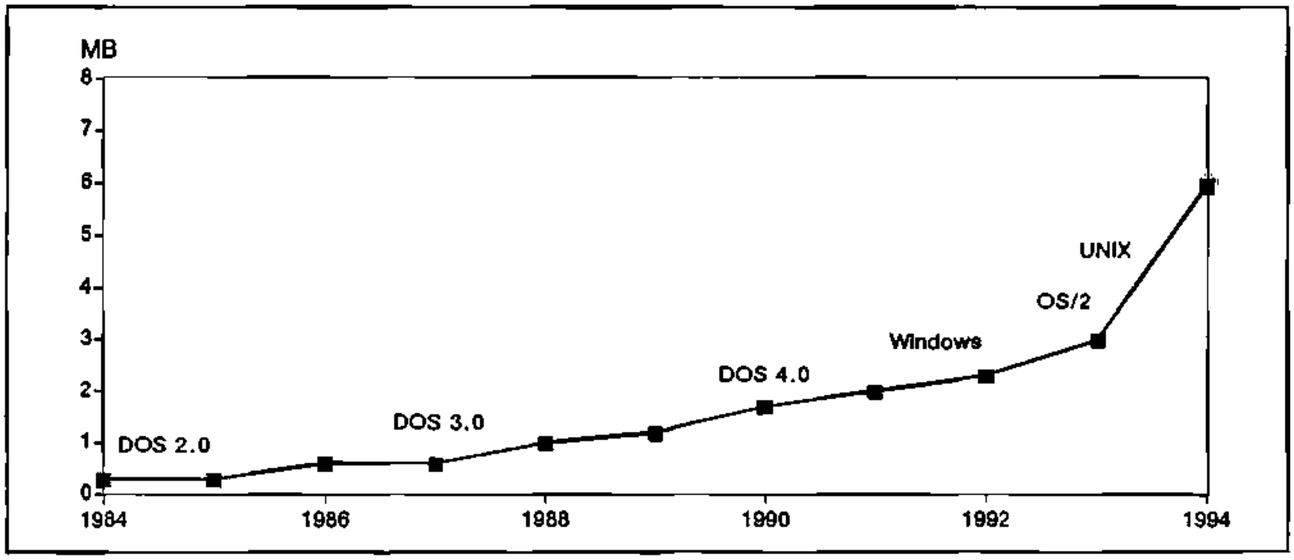
generations is already seen in non-DRAM memories, and DRAMs are not likely to be an exception to such a trend.

PC Evolution and DRAM Consumption

The PC market absorbs one-half of DRAM supply. Based on shipment data, peak production exceeded that of the previous generation up to 256Kb DRAMs, but was down in 1Mb DRAMs (see Figure 1). A probable cause is that the increase in DRAM storage capacity has outpaced that of PC memory capacity, leading to a slowdown in DRAM consumption. PCs use main memories with 1 or 2MB (see Figure 2), which can be satisfied by much cheaper 1Mb DRAMs. Nevertheless, with main memory capacity expected to increase with wider use of Windows and other factors, the shift to 4Mb is likely to be accelerated. This is further evident in several types of laptops recently introduced to the market.

Another factor to consider in increasing memory capacity is the constant increase in data volume handled by large general-purpose computers and PC-application programs. Because the maximum capacity of PC main memories is largely governed by the operating system and CPU architecture, the relationship between the average capacity of PC main memories and OS has been examined by the industry in general. In 1983, the wide use of DOS 2.0 boosted the average memory capacity to 512KB, consuming a large amount of 64Kb DRAMs. Then in 1985, emergence of DOS 3.0 pushed main memory capacity up to 640KB and spurred consumption of 256Kb DRAMs. Today, the average memory capacity is 1.5MB, using 1Mb DRAMs. However, current OS will limit the increase in the main memory capacity, driven by the upgrading of OS versions and improvement of application software from 2MB to 3MB until 1993. Although OS/2, which is capable of handling a 16MB address space, is expected to drive a significant increase in main memory capacity, it will take more than three years before the new OS becomes widely used. Until then, Dataquest believes that 4Mb DRAMs will be the

Figure 2
PC Main Memory
(Megabytes)



Source: Dataquest (August 1991)

mainstream device, and the shift to 16Mb will take place after 1994.

Improvement of CPU performance is also an important factor in determining the direction of DRAM consumption. Currently, 32-bit CPUs are at the leading edge and will be the mainstay of PCs for upcoming years, ending the CPU evolution from 4- to 8- to 16- to 32-bit devices. This evolution will affect DRAM consumption, which has been growing with CPU performance improvement. Dataquest therefore concludes that current needs are satisfied by 4Mb DRAMs, and consumption is not likely to grow significantly in the next few years.

Diversification of 4Mb DRAMs

DRAM makers have to provide many types of DRAMs including different packaging, different speed, and different organizations because of diversified applications.

Although the computer main memory capacity will continue to increase in the future, it does not necessarily mean that all systems require such large memory. Dataquest expects consumption of x4, x8, and x16/18 types of DRAMs to grow rapidly; if 4Mbx1 versions are used for the main memory of a 16-bit PC, 16 units of 4Mbx1 DRAM are required and 32 units in case of a 32-bit CPU-based PC. A 16-bit PC using a 1Mbx4 DRAM would require 4 units of 1Mbx4 DRAM. A 16-bit PC using a 256Kbx8 DRAM would require 2 units of 256Kbx8 DRAM. These wide-bit DRAMs minimize the need for replacement with 16Mb DRAMs in order to save space.

16Mb DRAMs and 4Mb Shrink Versions

The 16Mb DRAM will be initially marketed as x1 and x4 versions in a 475-mil package. Dataquest believes that the market will not be ready to accept these products because the high price and large package are likely to discourage users from replacing 4Mb DRAMs just because of quadrupled storage capacity. The industry has experienced this phenomenon with the 350-mil SOJ package of 4Mb DRAMs; the full-fledged 16Mb DRAM market will likely have to wait until the second-generation version of 400-mil SOJ is introduced.

With the current cycle of introducing x1 commodity products with higher integration every three years, the available memory capacity may exceed the growth of per-bit demand for DRAMs by system products, leading to production decrease. This problem cannot be avoided if DRAMs continue to rely on being used in computers. Thus, the industry must explore other uses for DRAMs or reduce production costs to improve profitability.

One solution is to manufacture 4Mb shrink versions by using 16Mb DRAM technology;

chipmakers plan to introduce this shrink-version device as their third-generation version. By using a 0.5-micron process, the chip size can be made one-half the size of the first-generation versions, reducing the price significantly and using smaller packaging. Many chipmakers anticipate that, by operating the 16Mb DRAM production line for 4Mb shrink versions, they can offer favorable foreign market values (FMVs) once 16Mb production begins to dominate the market. This intention is clearly reflected in aggressive investment by leading DRAM chipmakers on 16Mb facilities. In this sense, 4Mb DRAMs play a key role in surviving the next-generation DRAM market.

DRAM Price Trends

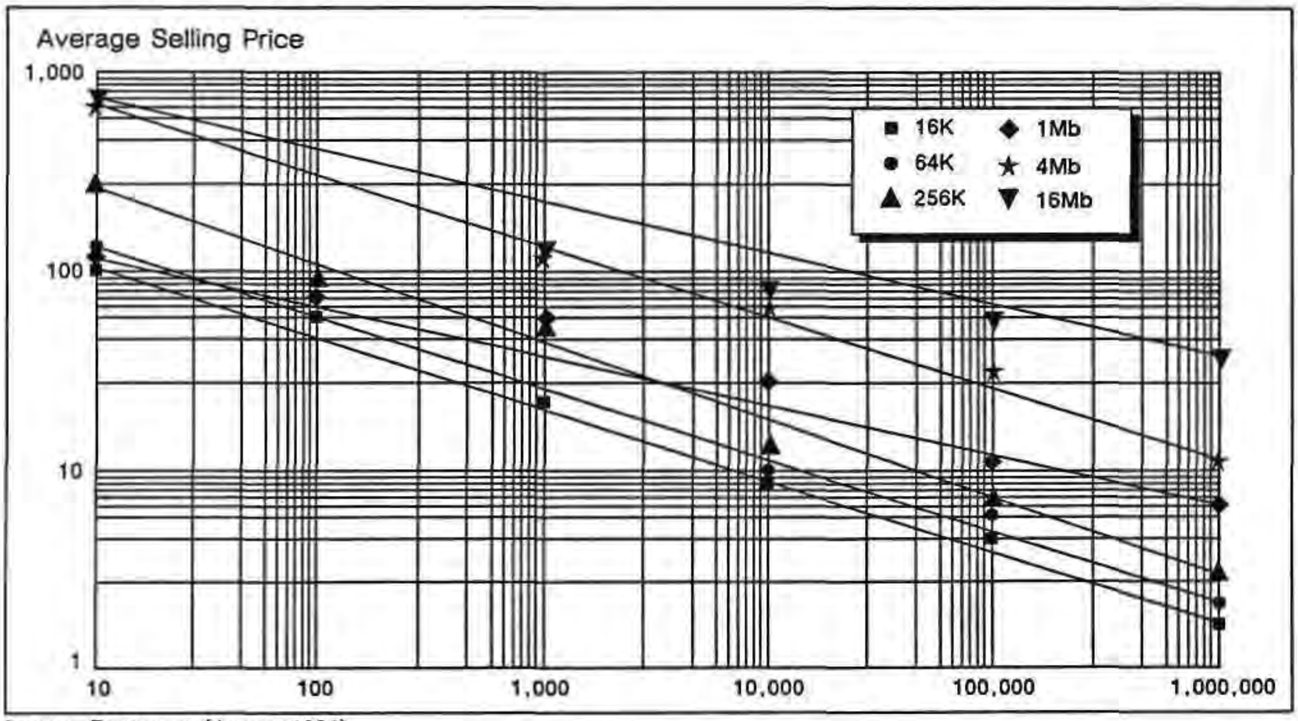
DRAM price trends, from market introduction to total shipments of 1 billion units, are examined for each generation. Although prices declined in a similar pattern from the 16Kb to the 256Kb generation, the rate of price decline became moderate for the 1Mb and 16Mb generations (see Figure 3). Prices for the 1Mb DRAM remained at a high level in 1989 and declined relatively late. However, our analysis suggests that 16Mb prices are likely to follow a similar pattern.

Now that the pace of increase in memory capacity of memory ICs has exceeded that of memory capacity of system products, users will shift their focus of interest from space-saving merit to price advantage. As long as 16Mb prices are high, the life of 4Mb DRAMs will be prolonged accordingly.

Dataquest believes that 16Mb prices will not fall as much as users expect and thus will not follow the learning curves experienced in 256Kb and older products for the following reasons:

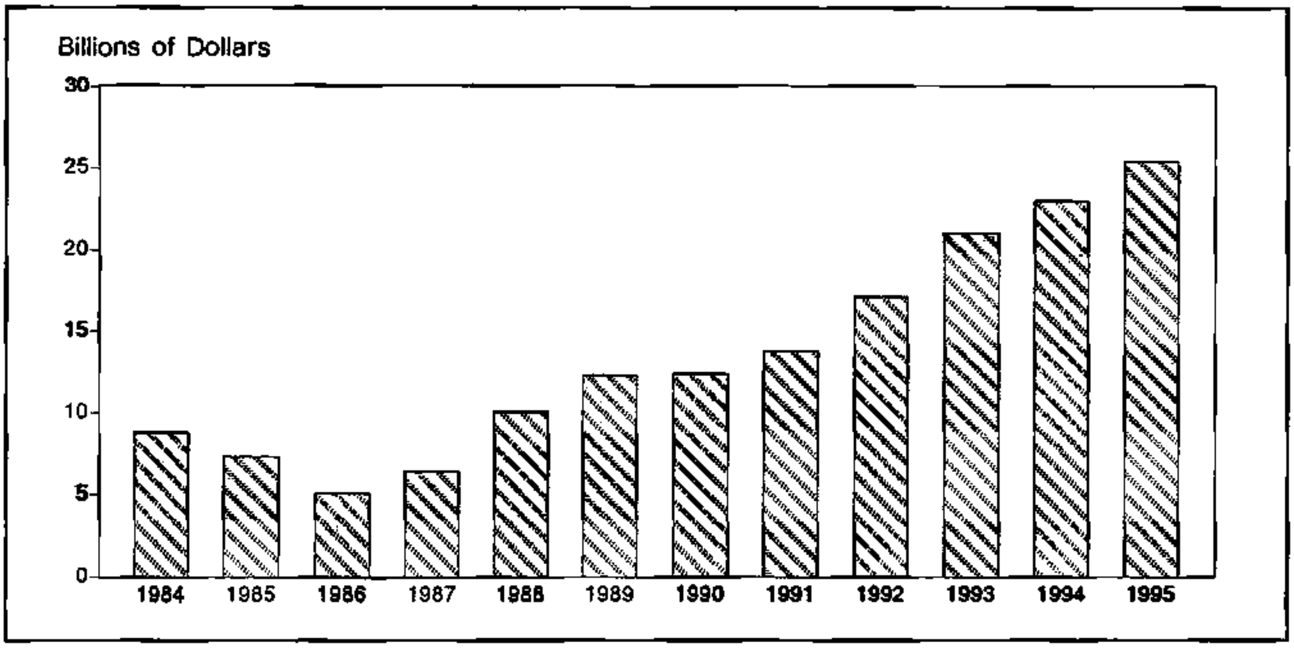
- The increase in the number of processes will increase the influence of particles and contamination on slowing the pace of yield improvement.
- DRAM makers are delaying the shift to wafer processing from 6 to 8 inches.
- Increases in development costs will create a diverse product mix.

Figure 3
Price Learning-Curve Comparison



Source: Dataquest (August 1991)

Figure 4
Worldwide Capital Spending
(Billions of Dollars)



Source: Dataquest (August 1991)

- The increase in product line will make it difficult to achieve cost reduction through volume production of a small product line.
- Value-added products including low voltage, low power consumption, and high speed will increase.
- Capital spending will continue to increase (see Figure 4).

All of these factors will work to fend off the shift from 4Mb to 16Mb devices.

Dataquest Perspective

From an analysis of the factors affecting 4Mb DRAM consumption, Dataquest draws the following conclusions:

- In terms of life cycles, 4Mb, 16Mb, and later generations are expected to have a longer product life.
- 4Mb prices will decline at a faster pace than 16Mb prices.
- Increasing applications will keep products in the market longer, where a few generations of products will coincide.
- 4Mb DRAMs will dominate the PC market, with main memory capacity up to 6Mb.
- Increasing use of Windows and OS/2 will boost main memory capacity, serving as momentum for the shift to 4Mb DRAMs.
- Various technological hurdles must be cleared before volume production of 16Mb DRAMs begins.
- 4Mb shrink versions will be used for early recovery of investment on 16Mb production facilities while acting as a spearhead for exploring the 16Mb market.

Dataquest believes that these findings indicate a long life for 4Mb DRAMs.

By Akira Minamikawa

(Reprinted from Vol. 1, No. 10, August 12, 1991)

Advice for DRAM Users: Staying Alive in a Competitive, DRAM-Hungry World

Executive Summary

Dataquest estimates that worldwide production of DRAMs totaled 1.4 billion units during 1990, a 1 percent decline from the 1989 level. For users, life is never easy in this DRAM-hungry world, as shown by erratic first-half 1991 trends in the 1Mb DRAM segment. Based on Dataquest's final 1990 DRAM market share ranking, this article evaluates the life cycle stage for DRAMs in 64K through 16Mb densities and assesses the supply/supplier base for these critical products now and in the year 2000.

Overview—DRAM Cost Containment

This article provides DRAM users with practical and strategic information for choosing which devices to use and from which supplier or suppliers. (The articles replace the "DRAM Product Trends" section of the *Industry Trends* binder of the former Semiconductor User Information Service.) Like the other 1991 *Dataquest Perspective* articles in this product trends series, this one contains three sections. The first develops a guide to cost-effective, long-term procurement of DRAMs through the use of product life cycle analysis. The second section on the top-ranked suppliers of DRAMs looks at market positions, technology strengths, and future product strategies of the leading suppliers. The third section combines analyses of DRAM life cycles and the supplier base. The sections blend a discussion of key industry issues affecting DRAM users today and over the long term.

A key element to our strategy for DRAM demand management is for users to match system life cycles with DRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans against DRAM life cycles for the purposes of managing DRAM costs *and* planning for DRAM changeovers in those cases where system/DRAM life cycles do not match.

DRAM Product Life Cycles

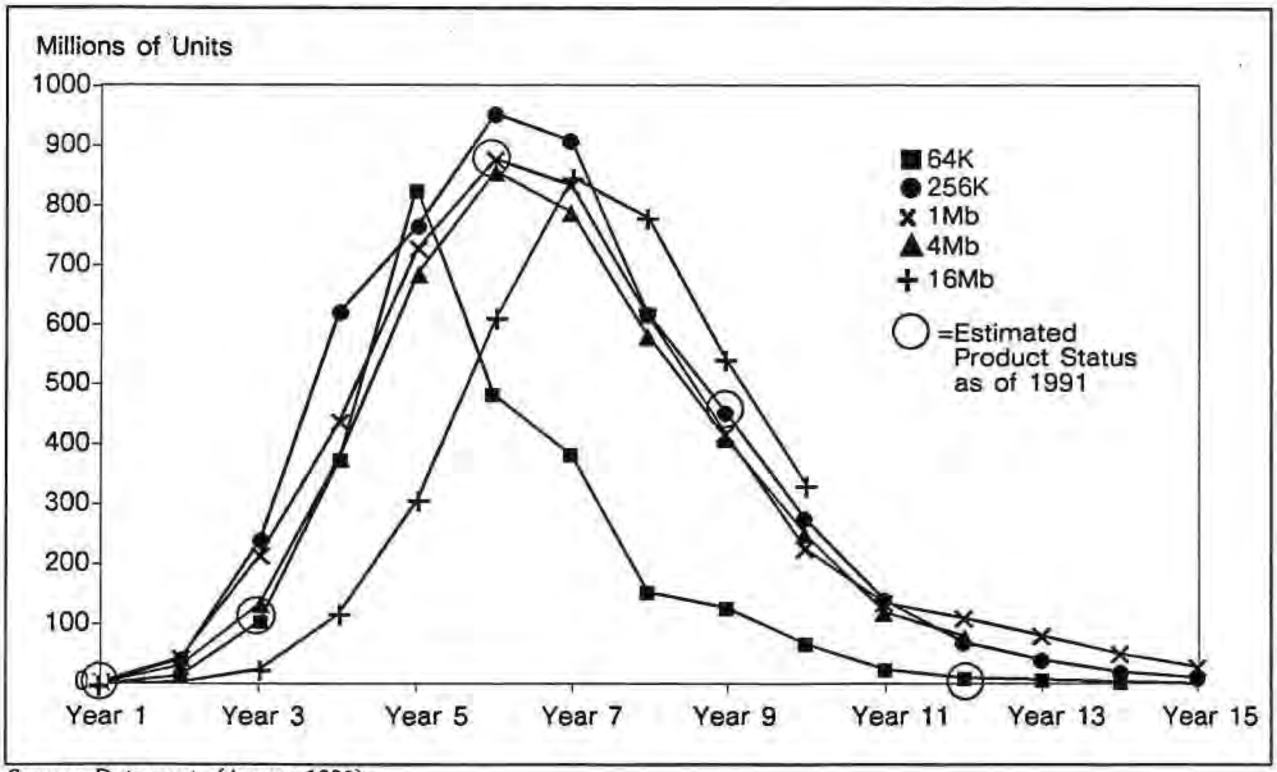
This section uses information on DRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over time. This section also states the basis for other analyses based on DRAM life cycle curves.

Typical Life Cycles for DRAM Products

Figure 1 shows a series of curves that map the product life cycle of DRAMs in densities of 64K to 16Mb. This figure is based on Dataquest's historical DRAM unit shipments and forecast information.

Figure 1 reveals that DRAMs typically experience a life cycle of 15 years or more, excluding the R&D phase. The figure

Figure 1
DRAM Product Life Cycles by Density as of August 1991



Source: Dataquest (August 1991)

illustrates that the DRAM cycle reaches the critical peak stage of unit/supply during its fifth or sixth year.

Factors That Affect DRAM Life Cycle Behavior

The trend is toward longer life cycles for megabit-density DRAMs versus that of the prior generations of lower-density parts. (Factors that affect DRAM life cycle behavior are described in the Semiconductor Procurement *Dataquest Perspective* Volume 1, No. 10, article entitled "Will 4Mb DRAMs Have A Short Life?")

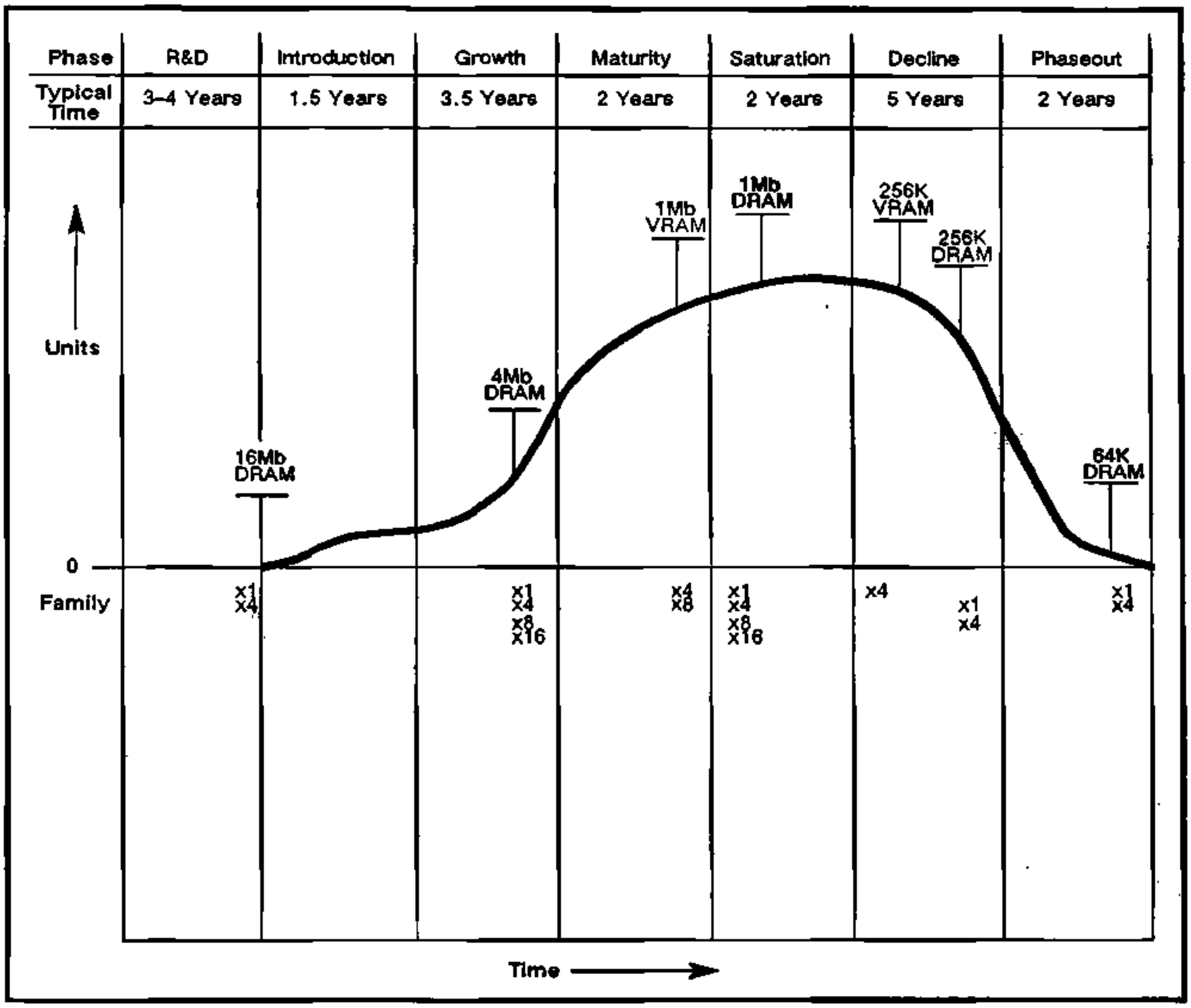
DRAM and DRAM Life Cycles by Configuration Over Time

Figure 2 depicts the life cycles for DRAMs and video RAMs (VRAMs) on the basis of organization. The figure breaks each stage into specific time intervals.

DRAM Life Cycle Stages

Figure 2 shows that the DRAM R&D stage occurs over a three- to four-year period. The DRAM introduction and growth stages extend for five years. The maturity and saturation stages total another five years. The decline/phaseout

Figure 2
1991 DRAM Product Life Cycles by Configuration as of August 1991



Source: Dataquest (August 1991)

period typically persists for as long as seven years.

Figure 2 reveals that 64K DRAMs have already been phased out by most suppliers. The 256K DRAM continues to move through its decline stage and is now causing heartburn for some users. The 1Mb DRAM life cycle, which should peak during the 1991 to 1992 timeframe, should extend past 1995. Figures 1 and 2 show—as does the cited article on the 4Mb DRAM—that Dataquest expects a long life, extending to the year 2000, for 4Mb DRAMs. Dataquest's worldwide network of DRAM analyst will continue to monitor the factors that could affect megabit-density DRAM life cycles. As shown in Figure 2, the 16Mb DRAM is nearing the introductory stage of a cycle that will extend well beyond the year 2000.

DRAM Product Configurations

The ×1 design and the ×4 have been the mainstream DRAM organizations. Two DRAM product trends will intensify in the 4Mb segment: a design trend toward wide-word DRAM configurations (e.g., ×8/×9, ×16/18); and a trend toward increased supply/demand for single in-line memory modules (SIMMs) and single in-line packages (SIPs). SIMM life cycles are virtually the same as those of the underlying DRAM devices. By contrast, the VRAM life cycle lags behind the stages of the equivalent-density DRAM by one year (e.g., 1Mb VRAM versus 1Mb DRAM). For the newly emerging wide-word configurations, the life cycle may be somewhat less consistent than for the DRAMs organized in ×1 or ×4 designs.

DRAM Trends in Europe

For a discussion of DRAM product trends in Europe, see the article entitled "European DRAM Market Update—Welcome to the 4Mb."

Supplier Analysis

This section analyzes the product and market strategies of leading DRAM suppliers. It covers each company's DRAM market ranking, product/technology positioning, strategic direction, and related issues.

Current or prospective users of megabit-density DRAMs must be aware that the highly competitive early stages of the DRAM product life cycles—an intense R&D period followed by a short introductory phase—often mean a sharp competitive advantage for early entrants, which are able to enjoy premium pricing through the introduction and growth phases. The extended maturity phase eventually tips the competitive balance to low-cost producers. This reality serves as the background on analysis of the 1Mb and 4Mb DRAM supplier base.

Table 1 shows the 1990 worldwide ranking of DRAM suppliers as measured in dollarized units. The table presents each company's ranking in terms of units for densities from 64K through 4Mb. It also shows which suppliers have sampled 16Mb DRAMs as of July 1991.

As noted, early leadership for the next-generation product often signals future DRAM market leadership. Dataquest restates what we said previously: For users looking ahead, Dataquest expects the 1992 to 1993 total ranking to be strongly influenced by 4Mb DRAM ranking.

Toshiba

As shown in Table 1, which is based on 1990 worldwide dollarized units, first-ranked Toshiba holds first-place ranking in 1Mb DRAMs and second in the 4Mb product area. The industry giant held the number one spot in the 4Mb segment during 1989; however, during 1990 Toshiba adjusted to a 4Mb DRAM market shift from a 350-mil-wide device—the 4Mb part with which it started—to the now industry-standard 300-mil part. Toshiba should remain a leader in the DRAM market for the foreseeable future.

As shown by Toshiba's huge state-of-the-art DRAM fab network, this vertically integrated supplier positions itself at the leading edge of DRAM technology. In the 1991 to 1992 time frame, the company will emphasize the 4Mb DRAM density and de-emphasize 256K DRAMs and 1Mb DRAMs. The product portfolio includes high-speed DRAMs (60ns or faster), wide-word configurations (e.g., ×8, ×9, ×16, ×18), and SIMMs. As of midyear 1991, 16Mb DRAM samples are available. Toshiba is a leading supplier of 1Mb VRAMs (e.g., 256K×4, 128K×8) and should be a major player in the 4Mb VRAM segment as that market emerges.

Table 1
Top Worldwide DRAM Suppliers[1]

Supplier	1990 Total Ranking[2]	64K	256K	Ranking by Density[3] 1Mb	4Mb	16Mb[4]
Toshiba	1		12	1	2	S
Samsung	2	1	1	2	6	S
NEC	3		2	3	3	S
Hitachi	4		12	6	1	S
Fujitsu	5		9	4	4	S
Texas Instruments	6	2	4	5	10	S
Oki	7	3	3	9	7	S
Mitsubishi	8		8	8	5	S
Micron	9	4	7	10		
Motorola	10		18	7	11	
NMB	11		5	12	12	S
Siemens	12		16	11	8	
Matsushita	13	5	14	12	8	S
Hyundai	14		6	15		
Intel	15		16	14		
Vitelic	16		10	18		
Goldstar	17		11	18		
Sharp	18		15	17		
Sanyo	19		19	16		
Total (Million of Units)		24	617	728	30.3	0

[1]In terms of "dollarized units," which represent the sum of all units sold by a company weighted by each DRAM density's 1990 worldwide ASP
[2]Includes VRAMs
[3]In units
[4]Samples as of July 1991
Source: Dataquest (August 1991)

Samsung

Second-ranked Samsung of the Republic of Korea continues an impressive advance in the global DRAM marketplace, moving one notch higher in the ranking during 1990 versus its third-place ranking for 1989. Table 1 reveals that Samsung ranks first in the older 64K and 256K segments, which is no surprise, but somewhat surprisingly ranks second in the maturing but still mainstream 1Mb segment. A key factor is that the company has used its vertically integrated structure to emerge as a low-cost DRAM producer.

Samsung strives to position itself as a DRAM technology leader. As shown by its sixth-place ranking in the 4Mb segment, Samsung still lags leaders such as Hitachi and Toshiba. A strategic factor—the goal of maintaining a reputation for DRAM product quality—partially accounts for the sixth-place ranking. The sound strategy caused Samsung to be conservative in terms of bringing the complex 4Mb DRAM device to market during 1990.

Users can continue to look to Samsung for 1Mb DRAMs during 1991 and 1992. The product portfolio includes SIMMs (e.g., 1Mb×8, 1Mb×9), and some users of 64K DRAMs and 256K DRAMs can forge long-term supply arrangements with this supplier. Users can expect a competitive 4Mb DRAM product line from Samsung including wide-word configurations (e.g., ×8, ×9, ×16, ×18) and SIMMs. Table 1 shows that 16Mb DRAM samples have been available as of midyear 1991.

In order to protect its long-term position in the worldwide DRAM arena, Samsung must avoid trade friction, which will be challenging. For example, this supplier, along with other Korean companies, is being investigated for alleged dumping in Europe.

NEC

NEC, ranked third overall, holds third-place ranking in the 1Mb DRAM and 4Mb DRAM segments and second ranking in the declining 256K arena, as shown in Table 1. Users can expect NEC to de-emphasize 256K and 1Mb DRAMs during the 1991 to 1992 period.

In line with prior history, NEC continues to act from a DRAM technology "catch-up position" in a learning-curve-dominated segment of the semiconductor business. The vertically integrated company has in the past successfully executed this somewhat risky strategy by supporting superior manufacturing planning with "deep-pockets" financial strength. An early leader in the 4Mb market, NEC should remain a top worldwide DRAM supplier.

NEC's strategy for 1991 and beyond focuses on success at DRAM densities of 4Mb and greater. Users of 4Mb DRAMs can look to NEC for a competitive product portfolio: high-speed 4Mb DRAMs, wide-word configurations (e.g., ×8, ×9, ×16, ×18), and SIMMs. NEC should make an orderly migration from 1Mb VRAMs such as the 256K×4 device to 4Mb VRAMs in line with market demand trends. Samples of 16Mb DRAMs from Hitachi are available now.

Hitachi

Hitachi ranks fourth among DRAM suppliers—the same ranking as in 1989—but ranks *first* at the critical 4Mb level (see Table 1). As with other leading Japan-based suppliers, users can expect Hitachi to de-emphasize 256K and 1Mb DRAMs during 1991 and 1992. Users can look to Hitachi for 256K VRAMs (e.g., 64K×4), 1Mb VRAMs (e.g., 256K×4, 128K×8), and SIMMs (e.g., 1Mb×8, 1Mb×9). The supplier will make an orderly move to the 4Mb VRAM when demand grows.

As a former top player in the DRAM business, Hitachi's strategy calls for an aggressive effort to win the 4Mb market battle and the concomitant market stature. Along with DRAM design know-how, manufacturing prowess, and marketing skill, users can expect Hitachi to display the device speed and packaging technology expertise that previously enabled the company to achieve effective DRAM product differentiation.

Hitachi's competitive 4Mb DRAM product portfolio offers wide-word configurations (e.g., ×8, ×9, ×16, ×18), SIMMs, and high-speed DRAMs. Samples of 16Mb DRAMs reflect Hitachi's future strategic direction.

Fujitsu

Table 1 shows that Fujitsu held the same ranking in 1990 as in 1989—fifth place. As a vertically integrated supplier, a high percentage of captive DRAM demand shields Fujitsu somewhat from DRAM merchant market volatility. Users can look to Fujitsu for VRAMs (e.g., 64K×4) and SIMMs (e.g., 1Mb×8, 1Mb×9, 256K×36). This company will place less emphasis on 256K and 1Mb DRAMs during 1991 and 1992.

As indicated by its fourth-place ranking, to some extent Fujitsu is playing catch-up in the 4Mb segment. In terms of technology, the supplier emphasizes the thin small-outline package (TSOP) for the 4Mb and 16Mb devices in line with the market trend toward higher pin-count packages.

Although not the 4Mb DRAM technology leader, users can look to Fujitsu as a dependable and competitive supplier of 4Mb DRAMs during 1991 and 1992. The product portfolio will be familiar and competitive: SIMMs, wide-word configurations (e.g., ×8, ×9, ×16, ×18), and high-speed choices.

Texas Instruments

Sixth-ranked Texas Instruments (TI) continues to hold the same ranking as in 1989. Table 1 reveals that this company ranks second in the 64K segment, fourth at the 256K density, fifth in the 1Mb arena, and tenth in the critical 4Mb business. It pursues the same strategic direction during the second half of 1991 as other leading DRAM suppliers—to emphasize 4Mb DRAM production and de-emphasize lower-density devices.

The company is leaving the 64K business. Current TI customers that use 256K devices should be able to forge special supply arrangements. TI will be de-emphasizing the 1Mb device during the 1991 to 1992 period; however, the pace of the trend will depend on events in the 4Mb arena. If the market moves quickly to the 4Mb product, the 1Mb part will be more quickly de-emphasized. If the 4Mb trend stalls—as has already occurred at times—TI will likely shift some support to users of the 1Mb device.

The supplier offers a competitive 4Mb DRAM product portfolio that includes wide-word configurations (e.g., ×8, ×9, ×16, ×18) and SIMMs. As the market shifts over time to 4Mb VRAMs, TI will migrate from the current line of 256K VRAMs (e.g., 64K×4 devices) and 1Mb VRAMs such as the 256K×4 part. Currently, 16Mb samples are available.

To maintain its long-term stake in the competitive megabit-density DRAM market, TI's strategy calls for the forging of alliances and other arrangements for sharing the risks and benefits of participation in this worldwide business. One example is an alliance among TI, Hewlett-Packard, Canon, and the government of Singapore for production/consumption of DRAMs in Singapore. Another example is a prior venture between TI and the Italian government on a megabit-density DRAM fab in Italy. At the time this article was written, the TI-Acer fab in Taiwan had just started 4Mb DRAM production.

A second prong of TI's DRAM strategy calls for aggressive protection of its DRAM/IC patent portfolio via litigation or negotiation toward the goal of collecting royalty payments.

Oki

Oki has consistently ranked seventh or eighth among worldwide DRAM suppliers since 1988. Table 1 reveals that seventh-ranked Oki ranks third in the 64K and 256K segments, ninth at the 1Mb density, and seventh in the emerging 4Mb arena.

In addition to 4Mb DRAMs, Oki's strategy emphasizes SIMMs, with a trend toward SIMMs based on the 4Mb device. Users can expect Oki to de-emphasize 64K DRAMs and 256K DRAMs. The 1Mb device will also be de-emphasized, except for some use in SIMMs. For example, Oki's 1Mb SIMM product portfolio includes modules organized as follows: 1Mb×8, 1Mb×9, 1Mb×32, and 1Mb×36 as well as 2Mb versions (e.g., 2Mb×36). The trend is toward expanding use of 4Mb DRAMs in these SIMMs. For example, in prior years the 1Mb×8 SIMM used eight 1Mb×1 DRAMs. Increasingly, Oki and other SIMM suppliers base this module on two 1Mb×4 DRAMs and one 1Mb×1 DRAM.

Users can expect Oki to be a leader in the migration of the market to 4Mb SIMMs (e.g., ×8, ×9, ×32, ×36, and evolving organizations). Oki also offers 16Mb DRAM samples.

Mitsubishi

Table 1 shows that Mitsubishi, ranked eighth overall, ranks eighth in the 256K and 1Mb segments but fifth in the critical 4Mb arena. This supplier's overall DRAM ranking has declined somewhat in recent years, which might be deceptive.

Dataquest restates what we stated in the *DRAM Product Trends* service section dated August 1990: "The competitive advantage of Mitsubishi's process and packaging technology expertise is likely to grow more significant as the industry moves to the 16Mb and 64Mb densities." Success in the 4Mb DRAM business can serve as a long-term indicator of long-term survival—and the Mitsubishi strategy to some extent already signals 4Mb success.

Mitsubishi's typical but competitive 4Mb DRAM product portfolio includes high-speed DRAM and wide-word configurations (e.g., ×8, ×9, ×16, ×18). Currently, 16Mb DRAM samples are available.

Micron

As shown in Table 1, ninth-ranked Micron ranks fourth in the 64K DRAM segment, seventh in the 256K density, and tenth in the 1Mb market. The company broke into the top 10 tier of DRAM suppliers in 1990.

One prong of Micron's strategy calls for cost-oriented competitive ability, meaning that the product portfolio is weighted toward mature DRAM devices with densities of 1Mb and below. For these mature devices, the market typically favors low-cost producers such as Micron. Users of 256K DRAMs, 1Mb DRAMs including 64K×16 configuration, VRAMs (e.g., 256K×4, 128K×8), and SIMMs (e.g., 1Mb×8, 1Mb×9, 256K×9, 256K×36) can look to Micron during the 1991 to 1992 period. Users of 64K DRAMs should be able to forge special long-term supply arrangements with Micron.

As indicated by the 4Mb DRAM ranking, Micron is not a DRAM technology leader like Hitachi or Toshiba. Even so, a second prong of the company's strategy—to serve specialty applications—is leadership in a sense. For example, in addition to mainstream 1Mb devices, users can look to Micron for 64K×16 DRAMs, 256K×4 VRAMs, and 128K×8 VRAMs. Users can also expect Micron to become an increasing force in the 4Mb DRAM segment as the product nears the maturity stage of the life cycle.

Motorola

Tenth-ranked Motorola slipped one notch during 1990 from its ninth-place position in 1989. As shown in Table 1, Motorola ranks seventh in the 1Mb segment and eleventh in the 4Mb market. Motorola departed the mainstream 256K arena. SIMMs such as the 1Mb×8, 1Mb×9, 256K×9, and 256K×36 modules represent a key aspect of the product portfolio.

Motorola has used an alliance with Toshiba as part of its DRAM strategy. The agreement started for product densities of 4Mb and below and eventually also applied to densities of 16Mb and above. The industry giant will emphasize 4Mb DRAMs but can remain responsive to market demand for 1Mb products.

NMB

Eleventh-ranked NMB positions itself as the leading supplier of high-speed DRAM devices that operate at speeds of 60ns and faster, which conforms nicely with the DRAM market trend. Table 1 shows that NMB ranks fifth in the 256K DRAM arena and twelfth in the 1Mb and 4Mb segments.

NMB relies heavily on a shifting set of strategic alliances for design technology and foundry service. The list of its alliance partners over time has included Alliance Semiconductor, Intel, Inmos (now owned by SGS-Thomson), Ramtron, and Vitelic.

Siemens

Twelfth-ranked Siemens slipped from the top 10 tier of DRAM suppliers during 1990. Table 1 shows that Siemens ranks eleventh in the 1Mb DRAM segment and eighth in the critical 4Mb business—an augur of future challenge.

A major strategic response for Siemens was the IBM alliance on 16Mb DRAMs that was announced in July 1991. This alliance augments a prior agreement between Siemens and IBM on 64Mb DRAMs. Even so, the 1991 to 1992 period will be critical in terms of Siemens' ability to grow its share of the European market for 1Mb/4Mb DRAMs and penetrate the North American marketplace.

Supply Base Analysis

This section uses information on DRAM life cycles and suppliers to present a density-by-density evaluation of the supply base for these devices in the medium to long term. Figures 3 through 6 show the 1990 total market size in unit shipments and the shares of the leading suppliers of each density. This information correlates with information presented in Table 1.

Supply Base for 64K DRAMs

The 64K DRAM device is being phased out. Figure 3 shows that production of 64K DRAMs during 1990 totaled 24 million units—less than half of the 1989 volume.

Dataquest recommends that users migrate from this device in system designs lacking a long-term procurement arrangement. Figure 3 shows that the leading suppliers are Samsung and TI; however, TI likely will limit support, if any, to long-term customers.

Supply Base for 256K DRAMs

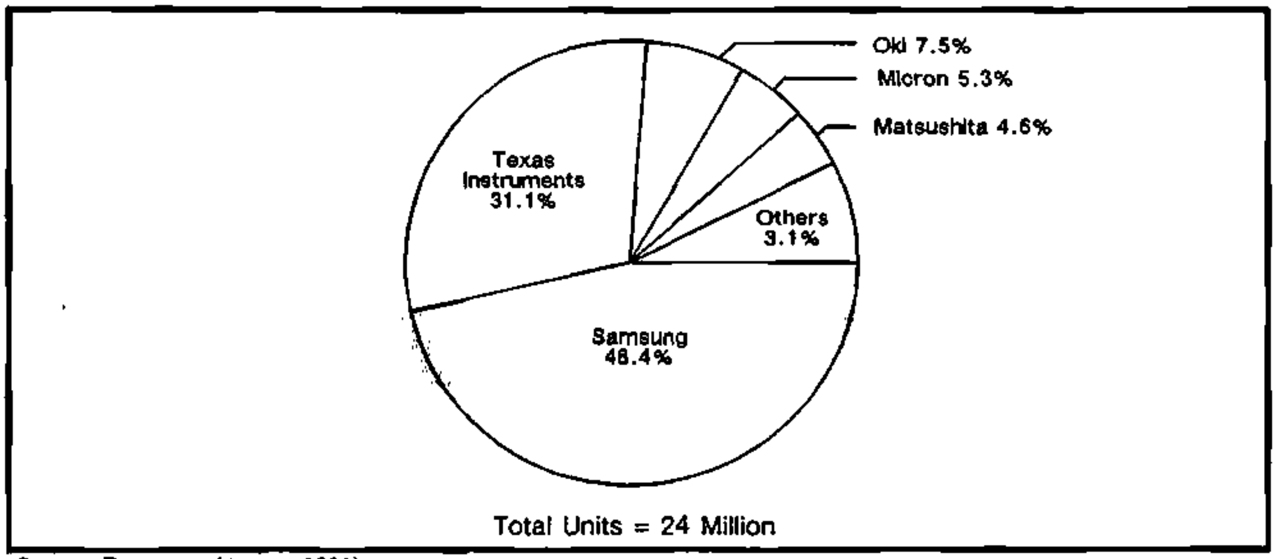
Figure 4 lists the top-ranked 256K DRAM suppliers based on 1990 unit shipments.

Figure 4 shows that leading suppliers in descending order are Samsung, NEC, Oki, TI, NMB, Hyundai, Micron, Mitsubishi, Fujitsu, Vitelic, and Goldstar. Table 1 shows the full spectrum of suppliers.

Periodic Spot Shortages

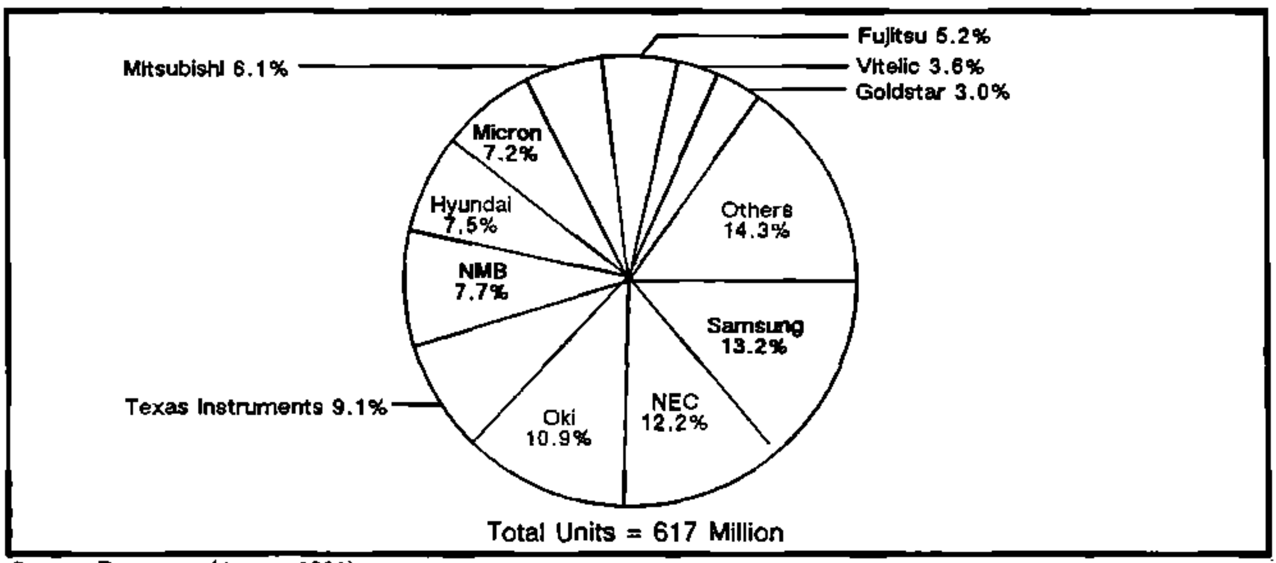
Figures 1 and 2 show that the 256K DRAM product is moving through its decline stage.

Figure 3
64K DRAM Supplier Base



Source: Dataquest (August 1991)

Figure 4
256K DRAM Supplier Base



Source: Dataquest (August 1991)

Worldwide production of 256K DRAMs for 1991 is expected to total 450 million units—that number may seem impressive, but in fact it is just half of the peak volumes of 1988 to 1989. Annual supply should exceed 100 million units through the year 1993; however, users should expect periods of spot shortage as suppliers make production cutbacks during the 1991 to 1993 time frame. For example, at the time this article was written, planned cutbacks in production of 256K DRAMs by some suppliers signaled a supply crunch for late 1991 or early 1992.

Dataquest Recommendation

To minimize supply line disruption, users should be prepared to forge long-term supply arrangements with current suppliers or qualify new suppliers. The other alternative is to migrate to megabit-density DRAMs.

Suppliers likely to remain committed to the 256K segment include the following Korean companies, which increased market share during 1990: Goldstar, Hyundai, and Samsung. Micron has maintained its share of the 256K market and is likely to consider special supply agreements for some users. The life cycle for high-speed DRAMs lags general DRAM life cycles, so NMB should remain supportive to users of high-speed 256K DRAMs.

Supply Base for 1Mb DRAMs

Figure 5 presents the top-ranked 1Mb DRAM suppliers based on 1990 unit shipments. Figure 5 shows that the top-ranked suppliers in descending order are Toshiba, Samsung, NEC, Fujitsu, Texas Instruments, Hitachi, Motorola, Mitsubishi, Oki, Micron, Siemens, Matsushita, and NMB. Global production of 1Mb DRAMs totaled 728 million units in 1990.

An Adequate Supply of 1Mb DRAMs?

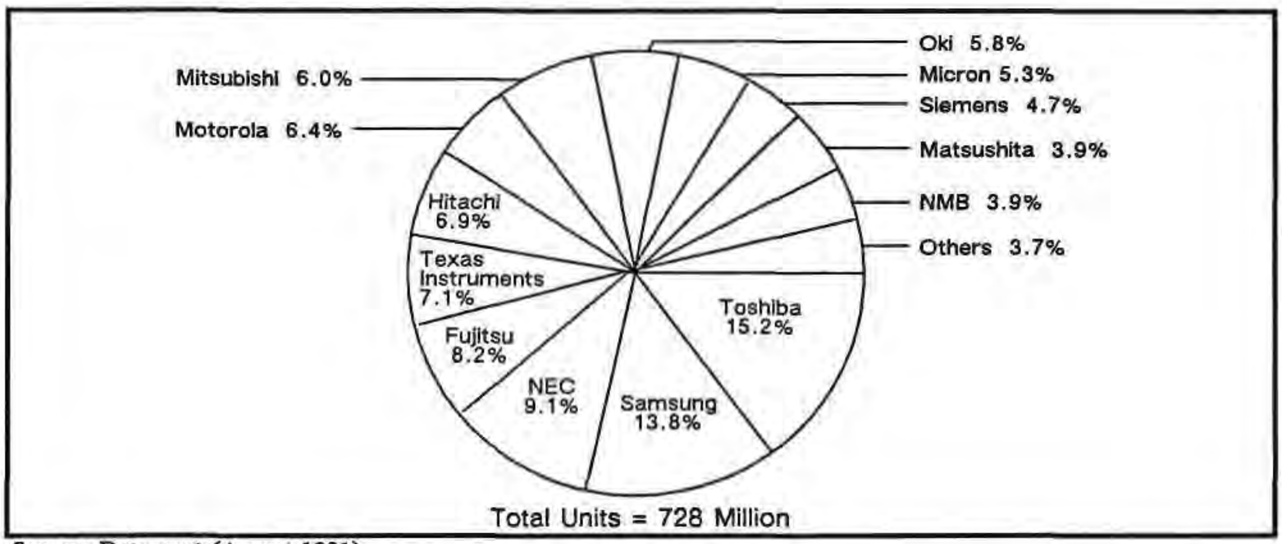
Users can expect the 1Mb DRAM to reach the peak stage—or saturation stage—of its life cycle during the 1991 to 1992 period with output exceeding 800 million units each year. Supply should decrease thereafter as the device moves along the decline stage of the curve, but it should still exceed 200 million units for the year 1995. Users can expect an adequate supply of 1Mb products during the 1990s, but only to the extent that users accurately forecast and "spec" product demand *and* also align themselves with an appropriate set of suppliers.

For example, under guidance from Japan's Ministry of International Trade and Industry (MITI), some Japan-based suppliers have shifted and will continue shifting capacity to 4Mb DRAMs. Other suppliers vacillate but will continue to support users of 1Mb DRAMs as warranted by market demand and price trends. Another set of suppliers fully intend to increase their share of the 1Mb DRAM marketplace during the 1991 to 1992 time frame.

User Alternatives to 1Mb DRAMs

The first alternative for users is to redesign systems and migrate to 4Mb DRAM, as many users are doing. For systems where redesign

Figure 5
1Mb DRAM Supplier Base



Source: Dataquest (August 1991)

might be feasible although not urgent, the use of SIMMs provides a hedge alternative, especially with the 4Mb DRAM market still somewhat unsettled.

Some older system applications remain profitable, such that any system redesign might not be a feasible alternative. The following recommendation is targeted for users that expect to continue using 1Mb DRAMs.

Dataquest Recommendation to Users of 1Mb DRAMs
To establish a dependable supply of 1Mb DRAMs at competitive prices, users should forge annual purchase contracts and special supply commitments. Otherwise, users must be prepared to buy on the 1MB DRAM spot market, which is likely to be highly volatile and erratic.

Users must *now* reevaluate the 1Mb DRAM supplier base, deciding whether to keep or drop current suppliers and requalify new suppliers. In order to target 1Mb DRAM suppliers, look for suppliers that have recently increased or decreased market share. For example, the following suppliers increased market share by more than 2 percent in 1990: Fujitsu, Micron, Motorola, NEC, and Samsung. The Japan-based suppliers are likely to de-emphasize 1Mb output. Micron, Motorola, and Samsung are likely to continue emphasis on the 1Mb device during 1991 and 1992. Some suppliers also are likely to remain committed to serving demand for the 1Mb part—these supplers are Goldstar, Hyundai, Intel, Matsushita, NMB, and Sanyo. These companies increased market share, albeit by less than 2 percent, during 1990.

By contrast, the following suppliers lost more than 2 percent of market share during 1990: Hitachi, Mitsubishi, Oki, and Toshiba. Their emphasis will be on the 4Mb DRAM device. Sharp, Siemens, and Texas Instruments lost ground during 1990, but by less than 2 percent of market share. Siemens and Texas Instruments are increasing their roles in the 4Mb DRAM market but are watching 1Mb DRAM supply/demand trends.

Supply Base for 4Mb DRAMs

Figure 6 lists the top-ranked 4Mb DRAM suppliers in terms of 1990 unit share.

In descending order, the leading suppliers of 4Mb DRAMs are Hitachi, Toshiba, NEC, Fujitsu, Mitsubishi, Samsung, and Oki. Siemens, Matsushita, Texas Instruments, Motorola, and NMB hold less than 1 percent of 1990 market share. Other suppliers such as Micron are joining the fray. Although the 4Mb DRAM race is just ramping up, Hitachi and Toshiba have positioned themselves early for long-term success.

As shown in Figure 6, global 4Mb DRAM production totaled 30 million units in 1990. The life cycle curves in Figures 1 and 2 show that the 4Mb DRAM device is now moving through the growth stage of the life cycle. Supply should exceed 100 million units during 1991. The peak maturity stage of the life cycle should be reached during the 1994 to 1995 time frame, when annual output should exceed 800 million units. The 4Mb DRAM life cycle should extend to the end of this decade.

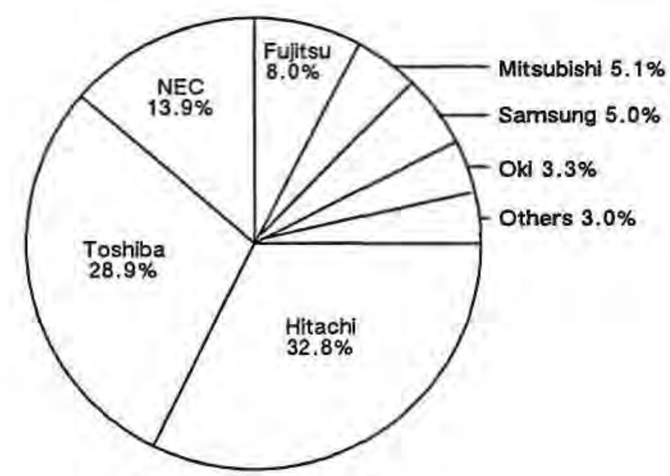
Dataquest Recommendation to Current and Prospective Users of 4Mb DRAMs
Dataquest strongly advises users to carefully and *continuously* monitor the 4Mb DRAM supplier base during 1991 and 1992 for signs of early market exit by any suppliers that may conclude they cannot win the 4Mb DRAM market battle—and might migrate more quickly to 16Mb DRAMs or rethink their DRAM strategies.

In addition to supplier selection, a major challenge for users will be the choice and designation of product specification. As noted, the 4Mb DRAM product line will include wide-word DRAMs (e.g., ×8, ×9, ×16, ×18) and a profusion of SIMMs and VRAMs. The 4Mb DRAM packages will include less familiar versions such as zigzag-in-line package (ZIP), thin small-outline package (TSOP) in two types, and tape-automated bonding (TAB).

Supply Base for 16Mb DRAMs

The life cycle curves in Figures 1 and 2 show that the 16Mb DRAM product is now moving from the R&D stage toward the introductory stage of its cycle. Table 1 shows which suppliers offer 16Mb DRAM samples as of mid-August 1991 and which suppliers have 16Mb samples on the way. As shown in Figure 1, the product life cycle of this part should extend beyond the year 2005.

Figure 6
4Mb DRAM Supplier Base



Source: Dataquest (August 1991)

Dataquest Perspective

DRAM cost management represents the stiffest challenge for many of Dataquest's SPS clients. This article lays out a strategy based on system/ DRAM life cycle analysis, coupled with a evaluation of the supplier base at each density of DRAM, for cost-effective management of DRAM demand now and through the year 2000. A key element of the strategy invites users to assess system migration paths against Dataquest's DRAM life cycle forecasts.

DRAM users face a host of risks that can be reduced to two extremes. The first and most immediate risk is the all-too-familiar scenario of DRAM spot shortages and erratic prices, which may affect *some* users of 256K DRAM as this product moves through the decline stage of its life cycle during the second half of 1991 and in 1992.

A second risk entails a long-term mismatch between a system's specific DRAM requirements in the face of a shifting global supplier base. Regarding megabit-density DRAM, the latter risk will not manifest its results for several years; however, this threat can be managed today through careful DRAM life cycle and supplier base evaluation.

Dataquest Recommendations

Life will remain challenging in our DRAM-hungry world. However, users should be able to minimize, if not avoid, the impact of periodic DRAM supply constraints.

A strategic recommendation is that purchasing managers, component engineers, and system designers use the DRAM supplier base/life cycle assessment to coordinate system and DRAM life cycles during this decade. SPS analysts can provide support toward this goal through the inquiry service.

As noted, users of 256K DRAMs should expect periodic spot shortages during the 1991 to 1993 time frame, perhaps as soon as by late 1991 or early 1992. Users can either forge supply relationships with suppliers such as Goldstar, Hyundai, Micron, and Samsung or migrate to higher-density DRAMs.

Many users are migrating now from 1Mb DRAMs. Dataquest recommends that users in general be prepared to make the migration during the 1992 to 1994 time frame in line with declining supply of this device. For users of 1Mb DRAMs that have no alternative but continue to use 1Mb DRAMs in the long term—through 1993 and beyond—Dataquest advises that the following suppliers be targeted for special long-term supply arrangements: Micron, Motorola, and Samsung. NMB should be targeted for higher-speed DRAMs. A less visible set of suppliers—Goldstar, Hyundai, Intel, Matsushita, Sanyo, and Sharp—also can be targeted.

Hitachi and Toshiba have taken the early but often critical lead in the 4Mb DRAM, with NEC again playing catch-up. Dataquest strongly recommends that users monitor the 4Mb DRAM supplier base via the *On-Line Dataquest Monday* service or by inquiry for clarification of any reports of either new market entrants or early market exits.

By Ronald Bohn

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Manufacturing Capacity and Cost Will Govern Long-Range DRAM Price Trends

Sluggish demand during early 1992 should mean competitive memory pricing during the first half of 1992 for most North American and European buyers. For the long-term outlook, Table 1 provides a summary of Dataquest's Semiconductor Procurement service forecast of North American bookings pricing for select DRAMs and SRAMs through the year 1995. Tables 2 and 3 outline the assumptions that govern the long-range price forecasts. Dataquest views capacity and cost as the critical factors that should shape long-term DRAM price trends.

Long-Range DRAM Price Trends

Table 2 lists the key assumptions that guide Dataquest's 1992 to 1996 North American DRAM bookings price forecast. The table includes a ranking on the significance of each assumption from the perspective of Dataquest's worldwide network of DRAM analysts in London, San Jose, Seoul, and Tokyo. The assumptions and conclusions in this article pertain most directly to the North American bookings price forecast. However, key differences in regional perspective will be noted.

DRAM Cost Reductions

As shown in Table 2, Dataquest analysts view continued DRAM cost reductions as a critical factor associated with long-range DRAM pricing trends, not only in North America but also in rest of world (ROW), Asia, and Europe (that is, 4Mb DRAMs). Users can expect the average DRAM price-per-bit to decrease by an estimated 20 percent per year during this decade. For example, Table 1 shows that the low end of the 1Mb DRAM price range in North America should decline to a level approaching $3 by the end of 1993. Some additional 1Mb DRAM technology improvements are possible (for example, another die shrink).

Table 1
Long-Range Memory Pricing Trends* (North American Bookings, Volume Order)

Part	Price Range Expected for Q1 1992 ($)	Price Range Expected for Q4 1993 ($)	1995 Price Forecast ($)
1Mbx1 DRAM 80ns, SOJ	3.50 to 4.09	3.00 and 3.85	3.80
4Mbx1 DRAM 80ns, SOJ	13.50 to 14.55	7.50 to 11.00	7.90
8Kx8 SRAM PDIP, 25ns	3.04 to 3.35	2.75 to 3.30	3.00
64Kx4 SRAM PDIP, 25ns	8.75 to 7.20	6.60 to 6.50	5.41
128Kx8 SRAM PDIP, 25ns	48.40 to 52.06	21.00 to 29.25	12.26

*These prices correlate with the SPS forecast dated December 1991.
Source: Dataquest (February 1992)

Table 2
Key Assumptions for the Long-Range North American DRAM Price Forecast (In Order of Ranking by Dataquest DRAM Analysts)

Dataquest Ranking	Assumption
1	Users can expect continued DRAM cost reductions because of suppliers' manufacturing technology improvements.
2	DRAM capacity should adequately meet long-term demand.
3	Non-Japanese Asian suppliers will increase DRAM market share.
4	The legal jurisdiction of intellectual property law will expand across the globe *and* be more aggressively enforced at the local level.

Source: Dataquest (February 1992)

Additional 4Mb DRAM technology improvements are virtually certain. For example, the low end of 4Mb DRAM pricing in North America could decline to $5.50 or lower by the 1995 to 1996 time frame. Dataquest's cost model says DRAM pricing in North America could fall to these low levels over the long term, although some other market factors to be discussed should keep the market price somewhat above these levels.

Adequate DRAM Capacity

Dataquest believes that worldwide DRAM capacity should be adequate to meet anticipated long-term demand (see Table 2). This assumption ranks second—just behind the cost model assumption—in terms of its significance to Dataquest's global network of DRAM analysts regarding long-range DRAM price trends. For analysts in North America and Japan, this assumption marks the key factor that should influence long-range DRAM price trends. The capacity assumption indicates competitive long-term DRAM pricing trends.

The blunt issue for DRAM users and suppliers is: Will long-term DRAM capacity more likely be insufficient or excessive for meeting demand? For suppliers who have been in the DRAM business since the early 1980s, the history of the 1985 to 1986 period says that the risk of overcapacity far outweighs the risk of undercapacity. Furthermore, the capital markets in Japan and North America during the 1990s likely will provide more limited funding for DRAM fab construction versus the less prudent pattern of the 1980s.

A related critical point on the 0.8-micron fabs required to produce 4Mb DRAMs is that suppliers—especially Japan-based companies—have cut year-end 1992 capacity goals by 20 percent versus their plans of less than two years ago. In addition, the risk of periodic regional spot shortages remains ever present in the volatile DRAM marketplace. For example, the market transition to next-generation DRAMs—as suppliers shift capacity between prior-generation DRAMs to the next-generation device or to slow SRAMs in periods of slower DRAM demand—often occurs in an uneven fashion, which can result in DRAM spot shortages. As indicated earlier, Japan's Ministry of International Trade and Industry (MITI) projects that 4Mb production will increase by 13.5 percent between the second half of 1991 and the first half of 1992, with worldwide 4Mb DRAM demand forecast to grow by 75 percent during this period. The spectre always lurks of short-term DRAM allocation.

Nevertheless, to date rather telling Dataquest analysis shows that adequate DRAM capacity exists to meet demand and should continue to do so. For example, excluding demand from IBM, worldwide demand for 4Mb DRAM during 1992 could theoretically be met by just one dozen 0.8-micron fabs that produce 20,000 6-inch wafers per month. The scenario for future years is similar. The example is extreme—by choice—to make this point: Dataquest assumes that long-range DRAM capacity will be adequate to meet demand.

Readers should note that Dataquest analysts are currently comparing the DRAM fab capacity outlook against DRAM demand forecasts. The results of that assessment will be published in a Semiconductor Procurement *Dataquest Perspective* article during the second quarter of 1992.

Non-Japanese Asia Suppliers Will Increase DRAM Market Share

The assumption ranked third is as follows: Following the path broken by Korea-based supplier Samsung, suppliers from the Asian "Tiger" nations will increase global DRAM market share with concomitant downward effect on pricing. Dataquest views two Korean suppliers—Goldstar and Hyundai—as two key wild cards in the long-range DRAM pricing equation. For example, Goldstar, a huge vertically integrated supplier, has become quite adept at successfully adapting its business practices—despite rising trade friction—in overseas markets such as North America. This supplier has formed a key alliance with Hitachi of Japan on DRAMs that continues to expand—with a time lag—as new generations of DRAMs are introduced.

Hyundai, another vertically integrated giant, along with Goldstar could become one of the world's future low-cost DRAM producers. Hyundai's management in alliance with the Korean government and financial community continually ponders the company's future role in the IC business, which remains subject to change (that is, potential withdrawal). Long-term success in other global business enterprises such as automobile, ship, and steel manufacturing could enable this Korean supplier to grow into a giant of the DRAM business.

In terms of the DRAM supplier base, Dataquest also views other suppliers such as IBM, Matsushita, Oki, and Siemens as prospective DRAM wild cards. For example, for users in North America and especially Europe, the IBM/Siemens alliance on DRAMs carries an enormous long-term potential effect on the DRAM market outlook. Even so, from Dataquest's perspective, the rise of DRAM suppliers in Korea, Singapore, and other Asian countries should have the strongest impact—being downward—on DRAM pricing for the next half-decade.

International Expansion of Intellectual Property Law

Dataquest analysts rank the global expansion of intellectual property law and more aggressive local enforcement as the fourth most significant factor affecting the long-range DRAM price scenario. North American manufacturers such as Texas Instruments—joined by other regional suppliers such as SGS-Thomson of Europe via its Mostek-based patents—will drive more vigorous global respect for patent and related intellectual property laws. An additional cost element, royalties of several percent, must be factored into the long-range DRAM pricing equation—especially for regions such as Europe and ROW/Asia.

For example, Wang's lawsuits against alleged nonlicensed sellers and users of the Wang patent on the "30-pin x9" single in-line memory modules (SIMMs) have thrown a global spotlight on the potential impact on DRAM pricing. Wang currently is settling with unauthorized users and suppliers for an estimated 4 percent royalty charge. Legal uncertainty often translates into market uncertainty. Hitachi's recent agreement with TI on the Kilby patent and the intellectual property agreement between the People's Republic of China and the United States highlight the trend.

Other Key Assumptions

Other assumptions that did not make Table 2 should be significant to users and suppliers in Europe, Japan, and Asia.

Alliances

The evolving global network of DRAM alliances should have some long-term impact on North American pricing trends. However, market players in Europe and Japan should expect a stronger degree of alliance-related pricing effects. For example, as noted before the IBM/Siemens alliance on DRAMs carries an enormous long-term potential effect on the Europe DRAM price scenario. For a detailed look at worldwide DRAM technology alliances, see "Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest," in the Semiconductor Procurement *Dataquest Perspective*, Vol. 1, No. 17.

Increased Trade Friction

Dataquest analysts in Europe and ROW/Asia expect global trade friction to increase although the effects on pricing should vary by world region. For example, Europe's Reference Pricing system in part has caused 4Mb DRAM pricing during early 1992 to be higher vis-á-vis other world regions. The European pricing reality will continue until Japan-based suppliers complete new European fabs. By contrast, Japan/United States trade friction likely will have little impact on DRAM pricing because of intense North American user disdain with the now-terminated foreign market value system. Asian suppliers—whether from Korea, Japan, or other countries—continue to walk a very closely monitored line between competitive pricing practices and allegations of dumping in regions such as Europe.

Long-Range SRAM Price Trends

Table 3 contains the assumptions that guide Dataquest's 1992 to 1996 North American SRAM bookings price forecast.

Non-Japanese Asian Suppliers Will Increase Slow SRAM Market Share

The key assumption for the long-range North American slow SRAM bookings price forecast, which assumes that non-Japanese Asian suppliers will increase market share and keep pricing competitive, parallels the third-ranked assumption on DRAM price trends. As identified over the years by Dataquest, the reason relates to the manufacturing trade-off that can be made between slow SRAMs and DRAMs. Most suppliers of slow SRAMs are vertically integrated suppliers from Japan or Korea. These companies can produce either DRAMs or slow SRAMs from the same manufacturing line, allowing for a time lag of several quarters to make the switch. In times of stronger demand, suppliers focus on the potentially more lucrative DRAM device. During periods of slow DRAM demand or aggressive pricing, the slow SRAM serves as a product alternative (or fab filler).

As vertically integrated Korean suppliers such as Samsung and still unproven Hyundai flex their DRAM manufacturing strength, their impact on global slow SRAM pricing trends should also increase. To date, these suppliers have focused on establishing their brand name at the 64K density, now positioning Korea as the world's low-cost 64K slow SRAM source. Samsung, perhaps joined by Hyundai and/or Goldstar, will make a long-term migration to higher density devices and ultimately shape North American pricing trends.

Fast SRAM Assumptions: Commoditization, Price Compression, Supplier Shifts

Tabe 3 lists the three critical assumptions that guide Dataquest's long-term outlook on fast SRAM pricing trends in North America. First, the market trend is toward commoditization, although some micromarket opportunities should remain available. Second, for the global network of fast SRAM suppliers and users the commoditization trend connects directly to the next assumption: commoditization should cause long-term compression—or lowering—of fast SRAM pricing. During the 1980s, the fast SRAM business was in part a series of micromarkets such that the limited number of suppliers in each niche could command wide profit margins.

Table 3
Key Assumptions for the Long-Range North American SRAM Price Forecast

Ranking	Assumption
Slow SRAMs	
1	Low-cost suppliers from ROW/Asia will compete against Japan-based suppliers for slow SRAM market share.
Fast SRAMs	
1	The trend in the fast SRAM market is toward commoditization although some micromarket opportunities should remain available.
2	The trend to commoditize should cause some compression of fast SRAM pricing, meaning fast SRAM cost-reductions will drive pricing trends a la DRAMs and slow SRAMs.
3	The global fast SRAM supplier base will continue to shift and not contract dramatically.

Source: Dataquest (April 1992)

Dataquest assumes that future fast SRAM cost reductions will govern pricing trends a la the DRAM/slow SRAMs scenario. This trend should result in more competitive pricing for users, more narrow margins for suppliers, and perhaps ultimately a more narrow supplier base. For users in North America and Europe, the prospect of more competitive pricing, however, will require—as indicated in the third assumption—more active management of a shifting global fast SRAM supplier base.

The Future Scenario

The pricing forecasts for three fast SRAMs in Table 1 illustrate the interplay between the assumptions on the market forces that guide Dataquest's North American price outlook.

64K Fast SRAM

Because of unimpressive growth prospects, the supplier base for some fast 64K SRAMs (for example, 64Kx1 SRAM 25ns, 16Kx4 SRAM 35ns, and 8Kx8 SRAM 45ns) will decline. Suppliers will shift to more vibrant market segments such as 8Kx8 SRAM 25ns or 16Kx4 SRAM 25ns or else migrate to higher-density devices, although in a few cases suppliers from other regions (for example, Taiwan) will enter maturing segments such as the 8Kx8 SRAM 45ns arena in order to establish market presence and reputation. Suppliers from around the globe aim to meet North American and European demand for 8Kx8 SRAM 25ns and 16Kx4 SRAM 25ns.

In addition, new entrants will target these vibrant segments. A main point is that users can expect continuing shifts in the fast SRAM supplier base—and more competitive long-term pricing trends. For example, over the long term North American users can expect less familiar suppliers from North America such as AT&T and Taiwan (for example, ISSI, UMC, and Winbond) to have considerable effect on pricing for devices such as 8Kx8 SRAM 25ns. Demand from PC clone manufacturers in part explains the trend.

Before this year, Japan's MITI informally established $3 as the lowest price to be charged by Japan-based suppliers for 64K fast SRAMs. As shown in Table 1, for North American users recent shifts in the supplier base for 8Kx8 SRAM 25ns mean that the low end of the price range for this device should fall below $3—and already approaches $2 in Taiwan. Users in Europe should expect only low-cost suppliers to survive over the long term.

256K Fast SRAM

For North American and European users of 256K fast SRAMs, the influence of Japan's MITI on the pricing strategy of familiar Japan-based suppliers such as Fujitsu and Hitachi should decrease somewhat—meaning more competitive long-term pricing. Non-Japanese suppliers such as Cypress, IDT, Motorola, and Micron aim to increase market share within defined product segments although the targeted segments, as noted, should shift in response to evolving application/demand trends. In addition, other Japan-based suppliers such as Sharp and Sony clearly aim to increase share in North America and Europe. In Europe, SGS-Thomson (including Inmos) remains a force although Matra-MHS continues to expand.

The long-term upshot for users is that compressed pricing will be linked—most simply—to the cost of manufacturing. For example, Table 1 shows the outlook on pricing for 64Kx4 SRAM 25ns. The low end of the price range is currently at $7.25 in North America. For year-end 1993, Dataquest projects a price level of $6.50 in North America, dropping under $5.50 for 1995. North American and European users should view this forecast as conservative, given the intense level of supplier competition in the growing 256K fast SRAM marketplace.

1Mb Fast SRAM

The three assumptions that guide the 64K/256K fast SRAM price forecast for North America apply in general to the 1Mb fast SRAM forecast shown in Table 1—with a caveat. The caveat: Through informal advisories to leading edge Japan-based suppliers, Japan's MITI should exert influence on the rate of price declines in regions such as North America and Europe, essentially applying the brakes against a rapid tumble in pricing during the forward (or earlier) stages of the product life cycle. As noted, North American users can look forward to increased pricing competition from non-Japanese suppliers (for example, Motorola). However, vertically integrated suppliers from Japan will continue to wield market power in this segment of the fast SRAM business—with an agenda that calls for a steady and manageable long-term decline in pricing.

Dataquest Perspective

At press time, Dataquest's Research Operations team (field interviewing) had just begun the February-March 1992 survey of North American users and suppliers of ICs including DRAMs and SRAMs. This report identifies the assumptions and assesses the market factors that guide the long-range North American DRAM and SRAM price forecasts. In effect, this article lays out the thinking that will guide the long-range forecasts to be generated during March 1992. Users can compare these assumptions with their long-range views and modify Dataquest forecasts or their in-house forecasts for strategic planning purposes.

These assumptions are not set in stone. Dataquest's worldwide network of memory analysts identify them now in order to allow our thinking to change during 1992 and beyond, in line with changing memory market realities. A key DRAM pricing assumption—that DRAM capacity should adequately meet long-term demand—undergoes scrutiny now to test its validity.

For now, users in North America can expect an ample supply of 1Mb and 4Mb DRAMs, which will be carefully managed and monitored by the global supplier base. DRAM and SRAM pricing should be competitive, although not predatory, now and over the long term. In maturing product areas such as 64K slow SRAMs and 256K DRAMs today—and 1Mb DRAMs and 64K fast SRAMs in the next year or two—users must carefully manage the selection of the supplier base.

By Ronald Bohn

(Reprinted from SPWW-SVC-DP-9201, February 17, 1992)

About Dataquest's Worldwide Semiconductor Procurement Service

Dataquest's Semiconductor Procurement information service, formerly Semiconductor User Information Service, is a comprehensive market research service covering the world's major semiconductor markets. Dataquest provides semiconductor users with indispensable information needed to make solid, intelligent, and quick procurement and design-in decisions. Through the service, Dataquest's analysts become an extension of your purchasing and component engineering teams by delivering concise information and analysis on the issues that affect your strategic and tactical business plans.

The service is available on an annual subscription basis and provides you with authoritative industry pricing projections, worldwide market forecasts, objective market share estimates, and a forward-looking assessment of the forces affecting semiconductor procurement. The service also delivers Dataquest analysis of key industry trends, leading manufacturers' strategies and product offerings, and enabling and competing technologies.

Product Coverage

The following represents some of the areas that are covered by the Semiconductor Procurement information service.

Price/Lead-Time Trends

Quarterly price/lead-time forecasts for over 200 devices

Semimonthly snapshot of booking prices of 25 critical products in the United States, Europe, Japan, Taiwan, Hong Kong, and Korea

Product/Technology Trends

Major Product Families: ASICs, Memories, Microcomponents, Standard Logic

Product/Technology Life Cycles

Market Size/Shipments

Product Specification Trends

Semiconductor Product Cost Analysis

Packaging Trends

Quality Issues

Monthly Procurement Pulse

Average Monthly Semiconductor Orders

Average Semiconductor Lead Times

Actual versus Target Inventory Levels—All OEMs

Actual versus Target Inventory Levels—Computer OEMs

Monthly Market Watch

Semiconductor Book-to-Bill Ratio

Semiconductor Inventory Level

U.S. Weighted Semiconductor Price Indicator

DOC Computer Demand

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9212 December 26, 1992

In This Issue...

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Korea
74AC244	0.43	0.43	0.37	0.29	0.37
Lead Time: (Weeks)	4	5	4		6
4F244	0.22	0.26	0.21	0.26	0.26
Lead Time: (Weeks)	4	6	4		6
7805-TO92		0.14	0.14		0.11
IMSG171D-35 MHz		3.62	3.05		4.20
Lead Time: (Weeks)		5	8		12
DRAM 1Mbx1-8	3.23	2.98	3.50	3.45	2.80
DRAM 256Kx16-8	13.50	11.44	12.80	13.25	10.70
DRAM 3 CHIP MOD	30.25	25.77	26.80	28.50	24.00
DRAM 4Mbx1-6	11.75	10.31			9.90
DRAM 4Mbx1-8	11.00	9.66	10.60	11.50	9.90
DRAM 4Mbx4-70	95.00	100.67	92.00	125.00	
DRAM 512Kx9-8	13.25	10.47	13.50		
EPROM 2Mb 170n	6.25	6.20	5.00		4.10
FLASH 1Mb	8.35	7.26	7.45	6.50	
FLASH 2Mb	13.78	13.69	15.90		
SRAM 128Kx8-70	10.16	10.07	7.50		7.60
SRAM 32Kx8-70	3.70	3.14	3.00	3.23	2.90
SRAM 64Kx4-25	5.25	5.23	4.50	4.75	4.30
VRAM 128Kx8-8	6.83	6.60	7.00		6.95
Lead Time: (Weeks)	8	6	8		6
68040-25	382.50	450.99	370.00		
80386DX-40	46.50	92.61	85.00	60.50	73.00
80386SX-20	49.50	37.85	38.00	47.00	32.00
80486DX-33	325.00	322.14	350.00	345.00	340.00
R3000-25	91.70	96.64	80.00		
Lead Time: (Weeks)	4	7	4		

*Prices in U.S. dollars
Source: Dataquest (December 1992)

Market Analysis

December Procurement Pulse: DRAM Storm Passes, Leaves Inventory Increase in Its Wake

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rates Expected to Bounce Back

Bookings of semiconductors are expected to increase an aggregated 28 percent over last month's rate, based on our semiconductor bookings index (see Figure 1). This is primarily being caused by concern over potential shortages after the passing of the first DRAM spot market shock wave caused by the U.S. Department of Commerce's (DOC) dumping determination against Korean DRAM suppliers. The overall system six-month sales outlook slipped again, coming in at 6.25 percent, down from last month's 6.6 percent forecast. Although one month does not a trend make, the computer subset's six-month forecast has noticeably dropped from last month's 6.2 percent to a current 2.5 percent outlook. This may be the first sign of a slowdown in computer demand that has remained steady for the past 18 months. Overall semiconductor prices again fell less than a half percent (0.4 percent), again highlighting

Figure 1
Averaged Monthly Semiconductor Orders

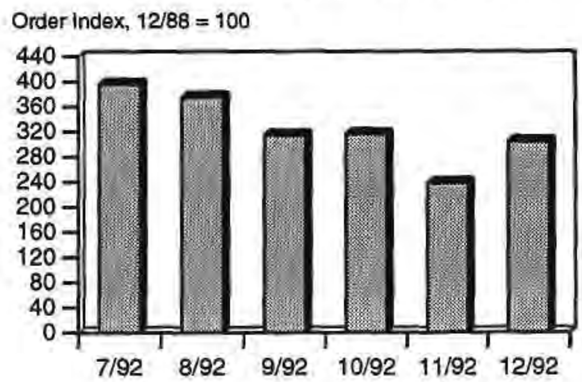


Figure 2
Averaged Semiconductor Lead Times

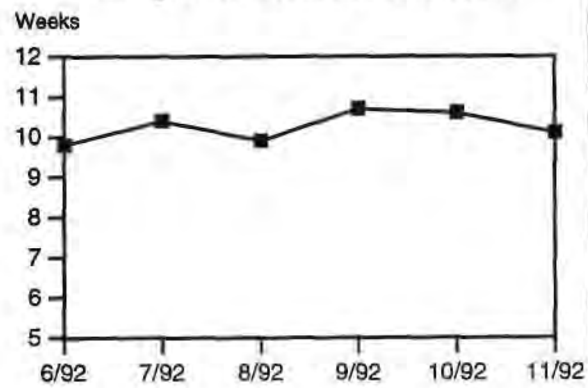


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

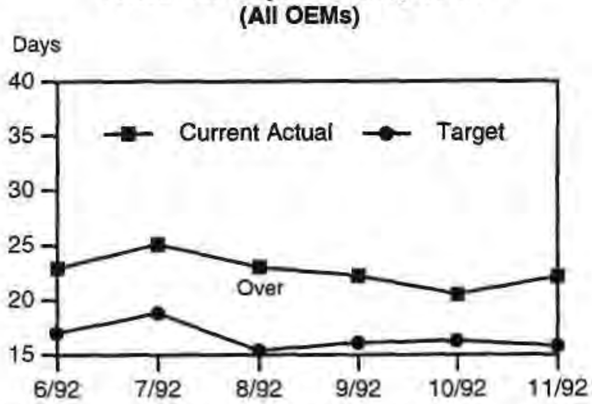
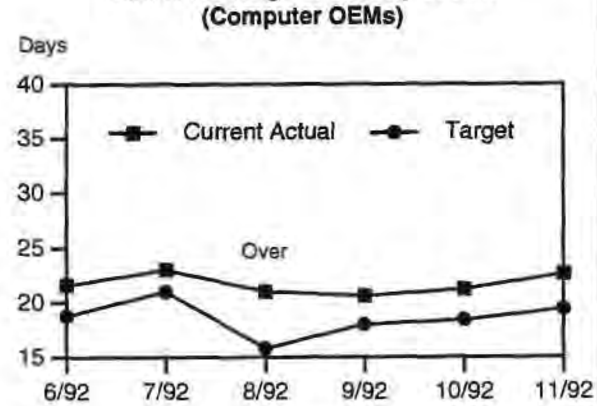


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (December 1992)

G2000304

the balancing act being played out as suppliers stay cautious in pricing negotiations. This is primarily because of the pending final DOC dumping determination due in March 1993 and the recent legal ruling prohibiting AMD from using Intel microcode in its AM486 device. The effect will be to keep memory (particularly DRAM) and high-end microprocessor prices stable for the next 3 to 6 months. Legalities aside, there remain two product areas (SOIC logic and Flash memory) that are on allocation because of capacity constraints and are not expected to improve for at least 3 to 6 months. Highlighting the SMT problem is that all but one of our respondents are having problems sourcing surface mount packages, either logic, memory, linear, or discrete devices.

Semiconductor Lead Times Under Control

As shown in Figure 2, lead times remain in the manageable range of 10.1 weeks, down from last month's 10.6-week average. Although prices in general are firming, delivery schedules remain relatively on-time because of good communications levels between users and suppliers. The SMT situation continues to keep overall lead time levels steady, yet other packaged devices are readily available in at or under 8 weeks (DIP logic, SOJ DRAM, some QFP microprocessors). Lead times for contract orders remain the most stable, offsetting the volatile spot market swings in lead times for affected DRAM, DRAM SIMM, SOIC logic, and Flash memory parts. Lead times as long as 32 weeks have been quoted recently for spot buys of some SOIC logic parts. Adequate capacity remains for most devices and incremental additions recently have been announced by some major Japanese memory suppliers that should alleviate some supply bottlenecks in the upcoming months. It is expected that the current strong demand for low-cost/high-performance PCs will continue for most of next year, with corresponding levels of demand for the devices that make up those systems (that is, DRAM SIMMs, x386 MPUs, and SMT logic, among others).

Semiconductor Inventories Rise Slightly

Possibly as an indirect result of the unstable DRAM market and allocation status of Flash memory and SMT logic, actual inventory levels rose back to levels comparable with September (see Figures 3 and 4). Overall targeted and actual inventory levels for November were 15.8 and 22.1 days, compared with October like levels of 16.3 and 20.5 days. The computer subset's semiconductor target/actual inventory status went from October's 18.4 and 21.4 days to a respective targeted 19.4- and actual 22.6-day level. Even with the increase in inventory levels, a 22- to 23-day inventory pad combined with average lead times of 10 weeks still adds up to excellent inventory control in any market. Many suppliers and procurement managers are noting that there are fewer supply problems (pricing and delivery) with parts forecast on a monthly basis over those bought via opportunistic (spot, or brokered) means. As mentioned last month, maintaining consistent and predictable delivery schedules in times of allocation does wonders for the inventory control function.

Dataquest Perspective

Overall demand in the electronics market (low-cost PCs, in particular) continues to keep pressure on semiconductor suppliers and the recent exogenous variables of DOC dumping determinations and x486 court decisions have highlighted the delicate balance in place between suppliers and users. Although the spot market still is reverberating over DRAM price shocks and now 80486 price inflexibility, contract buyers are now receiving payoffs of consistent deliveries at reasonable prices, compared with others that relied primarily on the spot market. It appears that some semiconductor suppliers are listening to their customers and watching the overall demand level and have announced plans to expand existing memory capacities that should come online by the third quarter of 1993. As long as forecasters can count on continued demand for their end product, so should they continue to consistently inform their suppliers of credible short- and longer-term semiconductor needs in order to ensure deliveries in this climate of uncertainty.

By Mark Giudici

Semiconductor Distribution versus Contract Manufacturing: What Is at Issue?

Full-service semiconductor distributors are facing new challenges from nontraditional competitors, the most visible being large-contract manufacturers. Contract manufacturers provide the customer assembly capabilities as well as the purchasing power of a large company, often passing the economies of scale purchasing savings on to their customers. Distributors that have traditionally provided discrete semiconductors and kitting services are responding to the competition by offering "turnkey" subassembly operations, offering contract manufacturer-style services with the added benefit of component warranty support and discrete semiconductor return privileges. These services are being made in the current climate of outsourcing nonessential manufacturing operations to subcontractors/turnkey assemblers to lower total costs of sale. This article reviews how semiconductor distribution and contract manufacturing are evolving, and what the implications are for semiconductor users often charged with reducing the supplier base.

Distribution Evolution

The traditional U.S. semiconductor distributor has been defined as selling small volumes of semiconductors to medium-size and small electronics companies that could not economically acquire them directly from the manufacturer. In addition to often carrying the smaller company's inventory of supplied semiconductors, distributors also "kit" or prepackage subassembly components for ease of manufacture to their customers. All services provided by a franchised distributor carry the warranty by the manufacturer of the specific semiconductor being sold. For these services, distributor semiconductor prices are often 15 to 25 percent higher than large volume manufacturer direct prices.

As the trend to outsource has accelerated, and contract manufacturing has grown, many distributors have responded by providing "turnkey operations" to their traditional customer base as well as to those companies investigating outsourcing. Turnkey operations, in essence, provide a customer subassembly manufacturing along with the traditional distribution services of inventory control and warranty support once a final board design is released. On a like note, some smaller distributors offer referral services to aligned contract manufacturers.

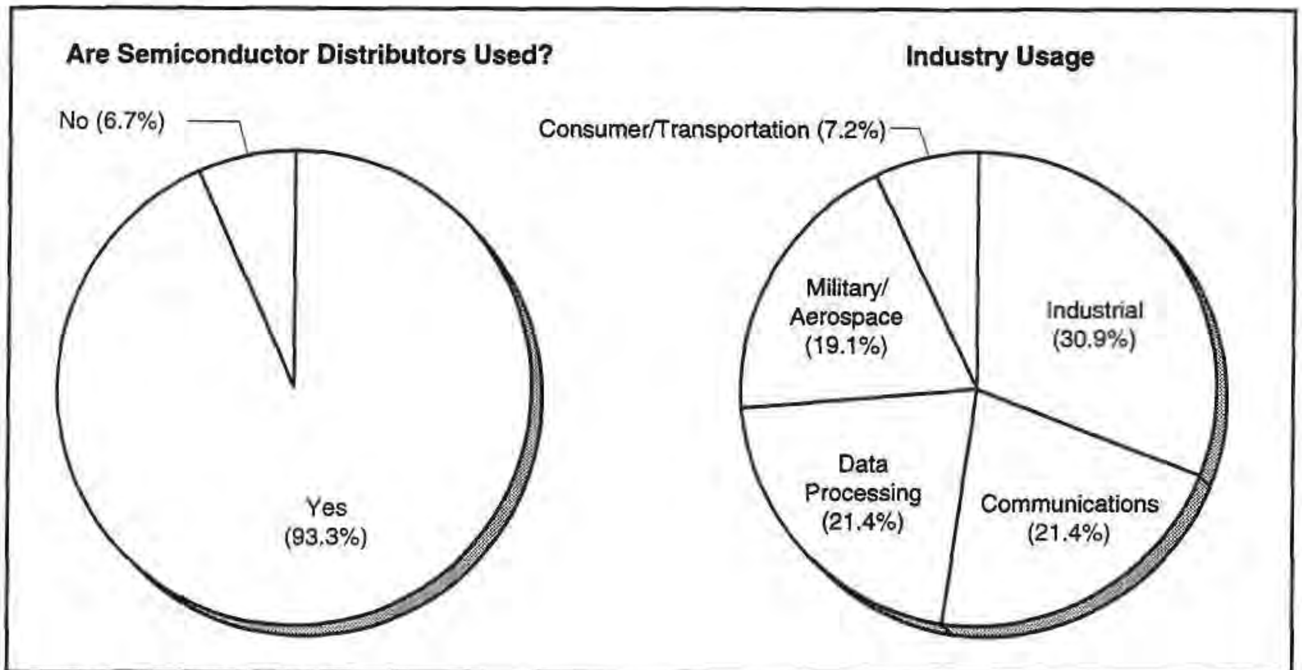
On the basis of our recent survey of the top 200 U.S. electronic company procurement managers, the majority of companies polled do use semiconductor distributors (see Figure 1). The outsource trend has changed the typical distribution customer base from small to midsize companies requiring high levels of service relative to delivery volume toward a broad range of customers that include some of the largest electronic companies as well as the traditional smaller clients needing larger volumes of product and high levels of service. The main reasons customers procure semiconductors from distributors are because the distributor can demonstrably provide better service and provide lower inventory and transportation/logistics costs than that available through any other means (internal or external).

Contract Manufacturing Revolution

Up until the past few years, the perception of contract manufacturing (CM) by many was that these companies performed high-volume, unsophisticated "board stuffing" services for large companies that had maximized internal capacity levels. Using data from the previously mentioned study of the top 200 procurement managers, Figure 2 highlights that close to two-thirds of the respondents now use CMs and have on average used them for 9.6 years. What once was seen as an ancillary manufacturing option has, in many cases, become the predominant method of production for many companies. The current definition of a contract manufacturer generally comes down to a company that manufactures or assembles a subassembly or finished product for another company and covers the breadth of services shown in Figure 3. The level of assembly and manufacturing involvement varies with each customer, with some companies requiring the most basic surface mount assembly. Others utilize the design and procurement services offered by some large CMs. The size of the typical CM customer also has shifted to include smaller companies that do not want the burden of high overhead costs of plant and associated head count.

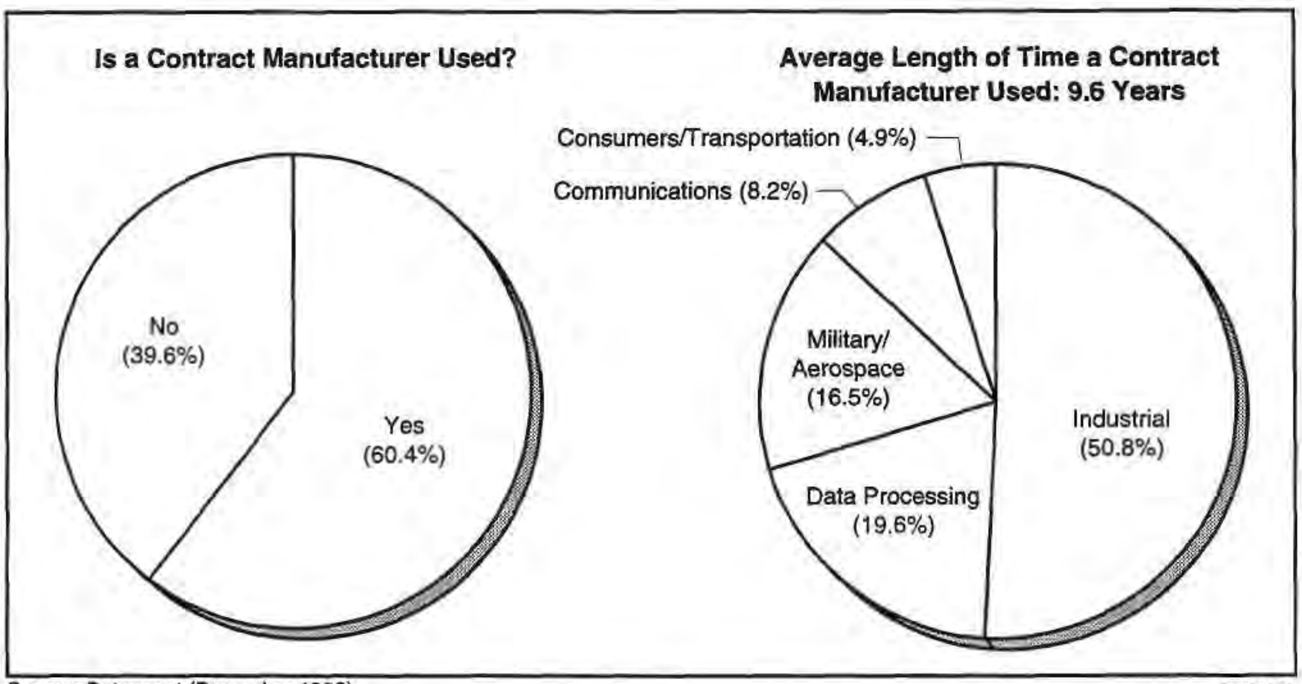
The consensus definition of a CM precludes design and final product manufacture. Yet some CMs theoretically could take a product "concept," design it, assemble it, combine the subassemblies (that is, manufacturing), and provide the "original equipment manufacturer" (OEM) with a marketable good. Outsourcing some or the majority of traditional manufacturing operations has become more and more a fact of corporate survival in the current economic climate of cost reductions.

Figure 1
Distribution Usage



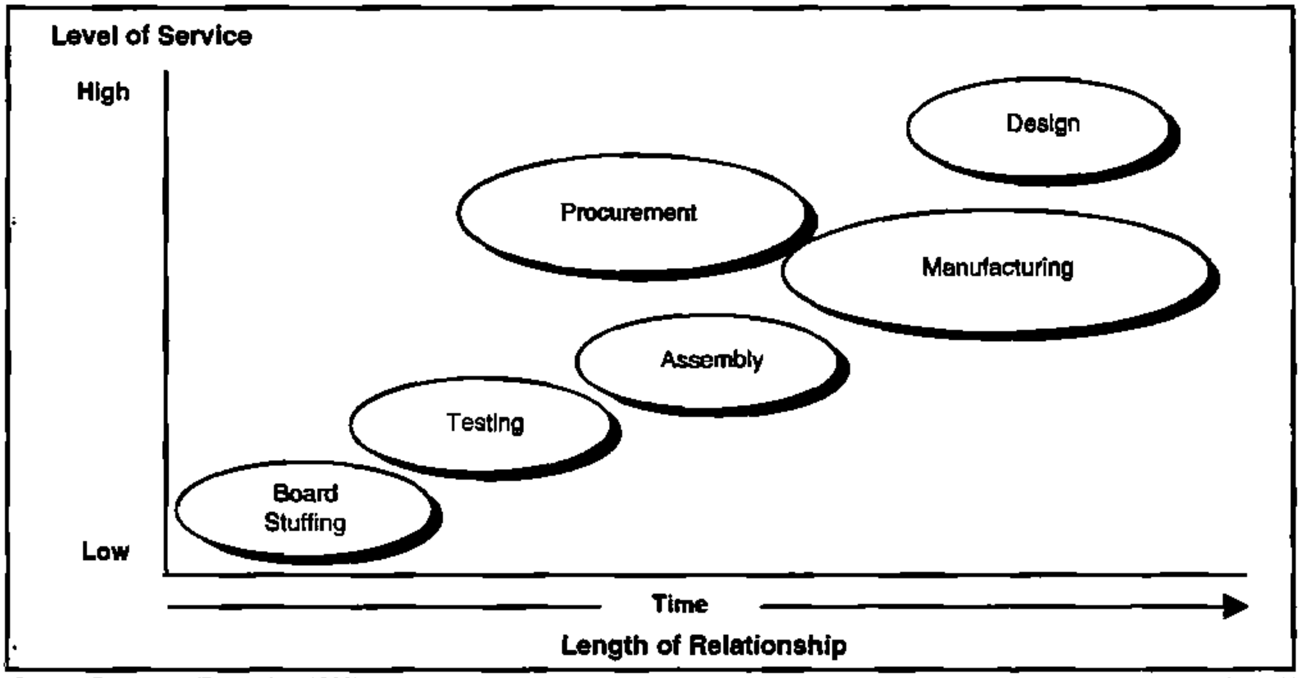
Source: Dataquest (December 1992)
G2001982

Figure 2
Contract Manufacturer Usage



Source: Dataquest (December 1992)
G2001983

Figure 3
Contract Manufacturer Migration Path



Source: Dataquest (December 1992)
G2001984

So What Is at Issue?

The current situation has two historical noncompetitors perceived to be tramping on each other's turf. This in turn has left all participants in the affected procurement equation—semiconductor suppliers, distributors, CMs, and procurement managers—in an evolving market that is not yet well defined. Distributors see their market growth shrinking as customers downsize and need assembly capability. Contract manufacturers increasingly are required to provide top-quality subassemblies, regardless of customer size or product volume. Semiconductor suppliers sometimes have difficulty in defining whether a CM is a customer or quasidistributor, much to the consternation of distributors.

Off-loaded assembly often also includes the off-loading of purchasing of the assembled components. This sometimes leaves the procurement function in question because benchmarking of products, quality, services, and the like can come to include the outsourcing of procurement where there is no value added to the organization. Many companies now actively reviewing not just total product cost, but total costs of sale (including all operations), are finding that world-class levels of performance at all levels (including procurement) are required to remain competitive. The procurement of semiconductors that are fairly generic or commoditized often are first outsourced, leaving proprietary devices that require technical familiarity and close manufacturing support with shifting volumes or prices to in-house procurement.

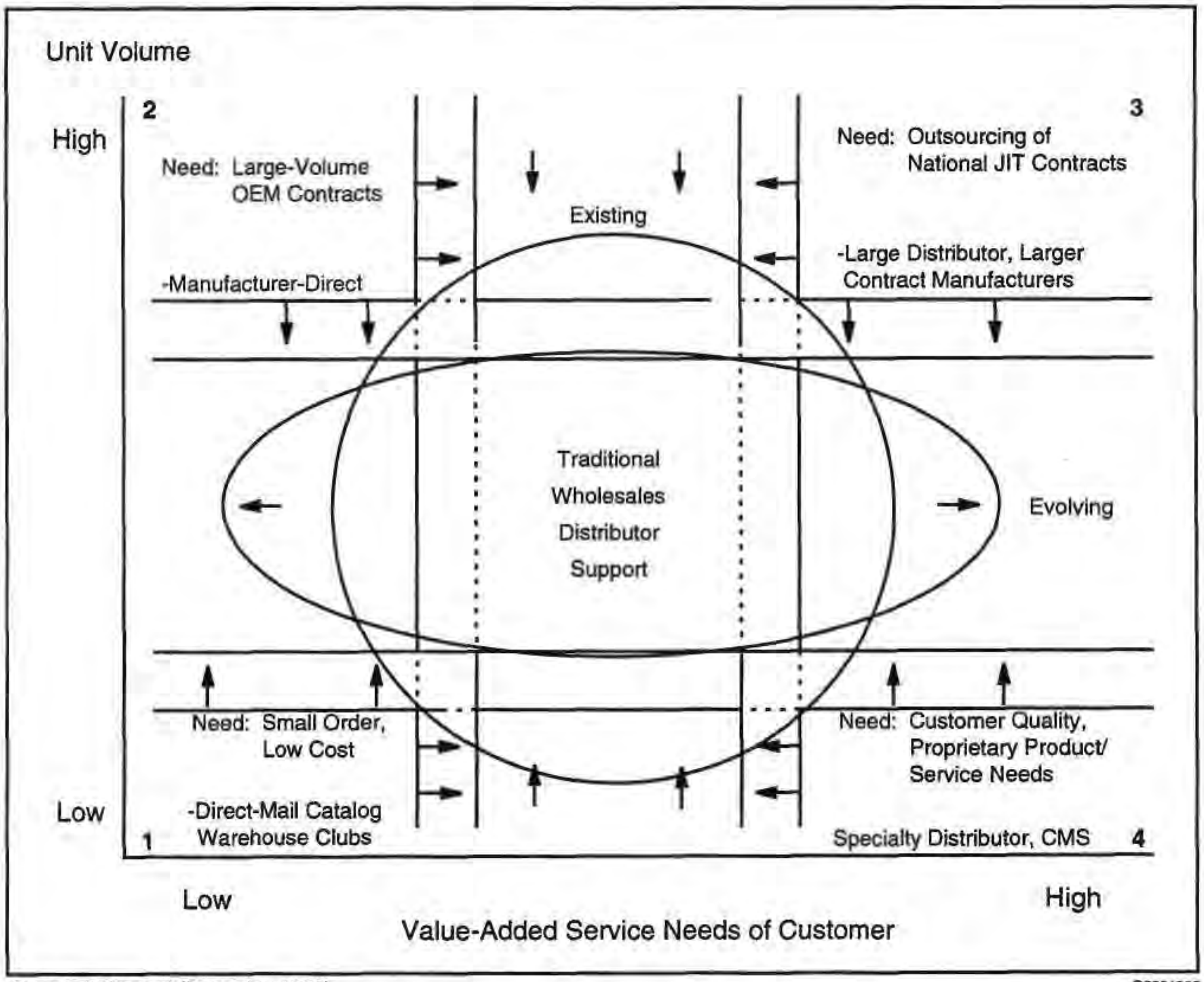
Figure 4 shows a user-supplier matrix that helps explain the changing situation in sourcing and assembling semiconductors and printed circuit boards. Traditional broad-line distributors are seen losing ground to large-volume CMs, specialty catalog houses, and specialty distributors, but are maintaining presence with midsize companies that need higher levels of service and for companies not used to high levels of service and lower total cost. Quadrants 2 and 4 require increased in-house purchasing focus, while quadrants 1 and 3 require less attention from purchasing departments. What was once a clearly defined, concentric distribution market is changing into an ellipsoid where services (inventory, delivery flexibility, and accuracy, among others) more than ever determine distributor market gains.

Dataquest Perspective: Semiconductor Procurement in Flux

Much of what is written about contract manufacturing extols the virtues of the industry and downplays many of the changes and repercussions that occur to customers. The downsizing trend that often results in using contract manufacturers often shifts some purchasing duties over to the CM. Yet there are instances where CMs cannot procure certain semiconductors and still need their customers to purchase them, often at the insistence of sole-source semiconductor suppliers. (This practice may be used by semiconductor companies to protect their overall pricing position for the affected parts.) This effectively reduces some of the cost savings of a CM because some purchasing functions are kept in-house.

Another issue with companies using CMs is the breadth of support offered. Often a CM is chosen based on the highest-volume products that need assembly. This leaves the remaining downsized procurement group with difficulty in supporting needs for new designs because the economy of scale has been farmed out and the CM may not be equipped to handle "exotic" (that is, two-sided SMT with high-pin count packages, among others) boards. Unless

Figure 4
Evolving Semiconductor Sourcing Environment



Source: Dataquest (December 1992)

G2001985

quick-turn specialty CMs are available, or users are willing to hold inventory for their CM, new design work at system companies may be held up because of a lack of logistical and technical support on the CM assembly floor. Depending on the level of service provided, sometimes the actual cost definition of a CM is unclear. This leaves cost accountants deciding whether a CM is a material, labor, or overhead (or mixed) cost.

So, apart from quantifiable price and quality cost parameters, the overall total costs (including hassle factors) often cannot be measured if a cost savings analysis is performed. What is needed prior to any decision regarding contract manufacturing or turnkey distribution is to ensure that the corporate cultures are as identical as possible prior to looking at price or quality savings. Without congruence in operating procedures, many of the tangible savings gained will be spent on correcting logistic problems and communications lapses, among others. In this way an outsource decision will result in greater efficiencies, and not another layer of bureaucracy to work around.

By Mark Giudici

What Price "Benchmarking"?

Executive Summary

Since the late 1980s, "benchmarking" has become a favorite corporate buzzword in North America. For Dataquest's SPS analysts, the strongest client demand to date has been for *tactical* IC "price benchmarks," in effect a search for the lowest—or "best"—worldwide price for critical devices such as 4Mb DRAMs or 80486 MPUs. As an aftermath of the recession—which is still in effect in world regions such as Japan as well as parts of the United States and Europe—SPS anticipates increased client demand during the post-1992 period for information on how to benchmark the procurement process. For this reason, this issue of *Dataquest Perspective* contains two articles on benchmarking. This article focuses on *strategic* benchmarking issues and sets the stage for a procurement benchmarking guide to be issued during mid-1993. The article entitled "Dataquest's North American Memory IC Price Benchmarks" provides *tactical* pricing benchmarks for users of these ICs.

To Benchmark or Not?

This report likely will be viewed as controversial because the aim is to confront unpleasant issues such as the gloomy future that awaits the procurement organizations at some system manufacturers. Dataquest does *not* foresee benchmarking—either generically or specifically related to the procurement process—as a universal panacea for post-recession survival. Instead, benchmarking may enable *some* OEM procurement organizations to survive and prosper from the restructuring process that the market faces during the 1990s.

As the article title indicates, several realities must be stated at the outset of this report, as follows:

- In the best case, successful benchmarking carries a stiff price—including potentially severe organizational change *and* individual personal stress.
- Benchmarking may *not* be most effectively applicable to any given procurement process—perhaps the effort should be focused elsewhere in an OEM's product manufacturing process.
- In an extreme case, the results of benchmarking effort may show that some OEMs should completely reconfigure their processes *or* resort to contract manufacturing.

Even so, for most SPS clients the greatest risk—market nonsurvival—is associated with failure, refusal, or inability to effectively benchmark organizational processes such as procurement.

What Is Benchmarking?

Although some SPS clients, especially North America-based system manufacturers, have been benchmarking their operations and processes for the last 5 to 10 years, for other SPS clients benchmarking remains a relatively new technique.

In general, the global trend toward process benchmarking has been applied more often by electronics manufacturers than by manufacturers in other industries or by service companies. For example, Xerox has been the single most leading proponent of benchmarking since the late 1970s. In Japan, although the word is not used, benchmarking is a firmly ingrained part of the strategic planning process. Furthermore, to date benchmarking has been applied more so by electronics manufacturers in North America and Japan than by Europe-based companies. SPS client surveys reveal, however, strong demand by Europe-based manufacturers for insight on procurement benchmarking.

Dictionary Definition

Webster's Seventh New Collegiate Dictionary has two definitions for "bench mark." The first definition pertains to the word's original use in topographical surveys. The second definition—which is most apropos to process benchmarking—is a "a point of reference from which measurements of any sort may be made."

Operative Definition

There are several similar operative 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." More recent definitions emphasize the search for "best practices," also known as worldwide best-in-class practices.

Three Types of Benchmarking

In terms of nomenclature, Xerox generically refers to its benchmarking process as "competitive benchmarking," although in practice there are three types of benchmarking: internal, competitive, and best practices. Xerox has extensive experience with each type. "Internal" benchmarking can be exemplified by Xerox's benchmarking evaluation of the manufacturing processes in Xerox plants in North America vis-a-vis Xerox plants in Europe and Japan. A different example of internal benchmarking would be a comparison of the different ways different divisions of the same company handle the same function or process, for example, employee training in the financial department versus training in the manufacturing division.

Competitive Benchmarking

Competitive benchmarking is exemplified by the product tear-downs that Xerox has performed over the years on direct competitors' systems regarding components, technology, and cost. Xerox's competitors, in turn, have applied the same competitive tear-down process to Xerox's products.

Corporate procurement and financial organizations have focused on cost containment during the 1991 to 1992 recession. Consequently, the thrust of SPS pricing inquiries for the past 12 to 18 months has been toward competitive IC price benchmarks, including high-volume discounts. During the second half of 1992 the focus also shifted from regional best pricing, for example, the "best" 4Mb DRAM price in Europe, to worldwide best pricing, being the "best" 4Mb DRAM among regional markets such as Europe, North America, Japan, and Singapore.

"Best" pricing is a problematic term. One problem associated with it is quantifying the inherent trade-off between the price paid for a component and the slew of differing delivery/quality/credit payment terms. Another problem is that relentless focus on the immediate issue of competitive component pricing can divert attention from a search for better procurement practices *from another industry* that may translate into a far more significant long-term competitive advantage. The issue of "best price" will recur not only in today's benchmarking articles but also as a market issue throughout 1993 and thereafter.

Best Practice Benchmarking

Best practice benchmarking is exemplified by Xerox's discovery through market research during the early 1980s that L. L. Bean—a relatively small U.S.-based supplier *not* involved in the electronics industry—operated a world-class warehousing operation. Xerox benchmarked its warehousing function against Bean's "best practice" operation and used the results to make dramatic improvements in Xerox's function.

Most informed practitioners of benchmarking recommend "best practice" benchmarking over competitive benchmarking for, among other reasons, a factor noted earlier—outdoing a direct competitor in terms of any procurement measurement such as material cost may mean that an organization is only perpetuating an inherently inefficient process.

Two Key Points for Successful Benchmarking

As we assess the basic steps of the benchmark process, two key points must be stressed. First, benchmarking will fail unless the program has upper-level management support, including integration into the strategic planning process. In addition, benchmarking of the procurement or purchasing process—in the absence of top-level managerial oversight—can rupture key user-supplier strategic relationships over secondary issues such as raw price or delivery performance.

For many SPS clients, however, a lack of upper-level management support is *not* the issue. Rather, for our clients, upper-level management has mandated a benchmarking of the procurement process or at least of material pricing. For SPS clients, corporate financial analysts typically serve as key players in the benchmarking evaluation. Inquiries from and discussions with SPS clients do not indicate the level of integration, if any, between the OEM strategic plans and benchmark goals.

Second, support for benchmarking from line managers and corporate management will increase if the program aims for quantifiable bottom-line results, for example, cost savings. As noted, SPS benchmarking inquiries during 1992 reflected intense demand by our clients for worldwide "best"—or lowest—pricing benchmarks, which lends itself to measurable financial impact.

Basic Steps to Benchmarking

A perusal of the literature on benchmarking shows that the following steps—or a similar version—are basic in the benchmarking process. The number of steps varies according to different perspectives, but generally total fewer than 10.

- Determine which function or process to benchmark
- Determine the outputs of the benchmarking assessment
- Identify the best-in-class company, best competitor, or best internal process
- Measure internal performance
- Measure the performance of benchmark companies
- Determine current and future competitive "gaps" in quantitative and qualitative terms
- Specify function/process improvement goals and programs

For those that have successfully gone this far, Xerox recommends then monitoring or recalibrating.

A Closer Look at Each Step

As noted, this report marks a first step toward production of a procurement benchmarking guide during mid-1993. Based on the author's discussion with clients and industry sources—both within and without the electronics industry—plus associated literature searches, the next sections take a deeper look at the benchmarking process and its potential application to the electronics procurement process. The assessment includes situations where procurement benchmarking would be of limited or no applicability.

The next sections aim to identify the strategic and practical issues associated with procurement benchmarking. The objective is *not* to provide SPS's final statement on procurement benchmarking or the steps associated with the process. Rather, the goal is to set the stage for next year's guide on procurement benchmarking.

Which Process to Benchmark

Although benchmarking can be applied to any process or function, a key question is whether benchmarking *should* be applied to the procurement process. The fundamental question to be addressed is the *potential* gain from a world-class improvement in the procurement process. As stated earlier, preferably the gain should be measurable in quantifiable terms, especially monetary terms.

Practitioners of benchmarking use somewhat different terminology, but most recommend that benchmarking be applied *only* to the company's so-called "critical success factors." For example, if "time to market" is a key success factor for an OEM, procurement benchmarking may not be a valuable effort—unless procurement has been a bottleneck against achieving time-to-market goals.

By contrast, if competitive system pricing is the single most critical success factor, benchmarking the procurement/purchasing process could be fully justified.

The function or process to benchmarked also should be narrow in scope—not broadly defined. For example, if the electronics procurement process is a critical factor in the efficiency of the operation, several key points in the process (such as supplier evaluation) should be benchmarked, not the entire purchasing process.

Benchmarking Outputs

In order to effectively benchmark a function or process, there must be a core set of desired outputs. The "outputs" serve a dual purpose—to measure the performance of the process being evaluated *and* to serve as a guide for future improvement.

The outputs of the benchmarking assessment should include not only quantifiable measurements, which become somewhat obvious for SPS clients interested in worldwide "best" pricing, but also qualitative descriptions of less obvious best practices.

For example, regarding equipment procurement, Japan-based Hitachi recently announced a project to reduce by 20 percent within two years—a precise output—the expenses involved in constructing IC fabs. Hitachi in the past had focused on yield improvements and high production volume as strategic goals. Although Hitachi has not denominated the project as a benchmarking program per se, it plans to achieve the 20 percent goal by reviewing equipment design and processes toward an ultimate goal of reducing the number of steps in the IC production process—clear hallmarks of benchmarking.

Identify the Best

The best-in-class company, best competitor, or best internal function depending on which type of process or function the organization seeks to benchmark, should be identified. Benchmarking associations, literature searches, and Dataquest/The Dun & Bradstreet Corporation can provide much of this information.

Measure Your Performance

Measurement of an OEM's performance may be readily available, depending on the organization's financial/operational reporting system—or may require the tracking of a new set of statistics.

Internal performance measurement typically requires "process mapping." Most organizations have documented their manufacturing or procurement process. However, benchmarking often requires a review and update of the process flow. The key step of process mapping provides the basis for the eventual goal of process improvement. In extreme cases, the entire process must be reconfigured.

Measure the Best Performance

Measuring the performance of the so-called best companies for the purpose of benchmarking represents a challenging but achievable goal. Clearly, the challenge is greatest—if not impossible—regarding direct competitor benchmarking. Ironically, because of less competitive threat, electronics OEMs often can more easily benchmark against the worldwide "best in class" performer(s)—which are probably from another industry—and learn superior practices as a result.

This step most often requires a visit to the benchmarking "partners" identified earlier that have agreed to serve as a partner. Not all will. This step can be achieved in some cases without a formal visit, for example, by telephone interview. The total number of benchmark partners usually ranges from at least two or three to no more than a dozen, typically four to six.

Measure Competitive Gaps

This step requires an assessment—qualitative as well quantitative—of the current gap between the OEM's internal performance level and the best-in-class performance level. Then, the trend in future competitive gaps must be estimated in quantitative and qualitative terms.

Set Improvement Goals

The competitive gap information sets the stage for the next step in the benchmarking process—to establish quantified improvement goals and programs.

At this stage, the goal is to improve one's process to the performance levels of the best in class or to adopt an entirely new set of practices.

Implement a Strategic Plan

The next step—which underscores the initial key requirement of upper-level management/line-operation support—is implementation of a strategic plan for process improvement. Why? Capital expenditure and human resource reallocation are typically required at this step.

Should the Procurement Process Be Benchmarked?

An OEM must carefully determine whether it is worthwhile to benchmark the procurement process. For example, some studies indicate that system-product design in effect "fixes" from about 40 percent to as much as 80 percent of finished product cost. Using this information as a guideline, two basic scenarios exist regarding the potential benefit to an OEM of an improved procurement process, as follows:

- Significant benefit likely would result for manufacturers where 55 to 60 percent of product cost remains variable after product design, being the 40 percent case mentioned earlier. In the electronics industry, this scenario most likely would apply to systems with a large content of commodity-type memory and logic ICs. Narrow system profit margins would be a business hallmark for OEMs in this arena.
- Less dramatic benefit from procurement benchmarking likely would result for manufacturers where just 20 to 25 percent of product cost remains variable after product design—the 80 percent case. In this scenario, other critical success factors such as time-to-market might outweigh material cost as a strategic business consideration.

The first scenario indicates that the OEM purchasing process—at least the key steps—*should* be benchmarked. Benchmarking of the purchasing process should be most beneficial for OEMs in markets where narrow system profit-margins are the competitive norm. Knowledge of competitive price benchmarks should be part of the measurement, although benchmarking practitioners would recommend the focus be on best-in-class practices. The OEM's financial division should be part of the benchmarking program, along with manufacturing, purchasing, and component engineering.

By contrast, the second scenario indicates that more likely the OEM's *product design* process—and less so the purchasing function—should be benchmarked. Because of the large role played by component technology in final product cost, related areas suitable for benchmarking under this scenario include OEM management of supplier/technology partnerships and/or the component technology selection process. For electronics OEMs where time-to-market with leading-edge technology governs business strategy, benchmarking practitioners recommend that organizational participants in the benchmarking operation include corporate *and* product marketing, along with design engineering, component engineering, and/or purchasing and manufacturing.

SPS recognizes that in a broad sense "product design" and "supplier partnering" often fall under the rubric of "purchasing" at some OEMs. But the main point remains the same—for OEMs in which product design sets a large portion of the final product cost, benchmarking the procurement process/component pricing likely will miss the mark in terms of ultimate bottom-line benefit.

How can benchmarking be applied to the procurement or purchasing process? Let us assume that an OEM has decided that the strategic significance of the procurement function warrants benchmarking. Although we cannot fully answer the question in this report, we can illustrate the type of issues that should be addressed in different benchmarking evaluations. The "success factors" or critical functions within any procurement process that should be benchmarked will vary on an OEM-to-OEM basis, depending on the results of *each* OEM's process mapping.

Note that some of the following issues could also be used to benchmark an OEM's product design process.

- Component demand forecasting
  - Do the worldwide "best" procurement groups—whether in electronics or other industries—*consistently* provide suppliers with component demand forecasts?
  - If yes, how often, and to what detail? What "accuracy rate"?
- Cycle time
  - In the "best" procurement groups, what is the time interval between receipt of critical components and shipment of the systems in which the components are used?
  - What is the inventory turns rate?
  - What is the time to market between new system design and new product introduction?

- What practices permit "best" class procurement processes to achieve these rates?

- Human resources
  - What are the education and experience levels of the members of worldwide best-in-class or best-competitor procurement organizations?
  - What blend of skills do the members of the "best" procurement organizations reflect—whether individually or on a team level—regarding materials management? Marketing? Negotiating? Technology?

- Just-in-time (JIT)
  - Do the worldwide "best" procurement groups use JIT—and if so, what kind of JIT system?
  - How do the "best" procurement groups manage any trade-off between pricing and delivery terms mandated by the JIT system?

- Organizational linkage
  - What linkage do the "best" OEM procurement organizations have with the organization's design engineering group?
  - What linkage, if any, do the "best" procurement organizations have with the marketing groups? The financial group?

- Pricing
  - How do the "best" procurement groups buy—on a contract basis, the spot market, on both contract/spot bases, or via supplier alliance?
  - How often do the so-called "best" procurement groups negotiate component pricing?
  - Do the "best" procurement groups monitor on an ongoing basis whether material pricing is the market "best"? If so, how?

- For a second time, how do the "best" procurement groups manage any trade-off between materials pricing and delivery terms such as lead time? (Please see the article entitled "Dataquest's North American Memory IC Price Benchmarks" elsewhere in this edition for fuller treatment of the pricing issue.)

- Supplier evaluation
  - What kind of relationships do "best" procurement groups maintain with suppliers—close relationships/alliances or arm's-length/merchant market relations?
  - How do the "best" procurement groups evaluate supplier base performance regarding delivery, reliability, and technology?
  - What process do the "best" procurement groups use to manage any shift—and the *timing* of any shift—from one set of suppliers to a new supplier set?
  - How do the "best" procurement groups measure *their* performance in managing suppliers?

- Technology
  - How do the "best" procurement groups manage *their* system/component technology evolution?
  - How do the "best" procurement groups manage their *supplier's* technology evolution?

Dataquest Perspective

Dataquest expects an increased emphasis by clients on process benchmarking during 1993. The relentless increase in global competition jump-started the quality benchmarking phenomenon in North America during the late 1970s. The global competitiveness trend will not abate soon—nor will the move toward benchmarking. What will these trends mean for users of ICs?

The entire supply base management network will remain under long-term pressure. A blunt reality hovers over the traditional SPS client base—the threat from the trend toward contract manufacturing. Another reality is that benchmarking may require some OEMs to completely reconfigure critical processes such as procurement.

For users whose companies manufacture commodity-like products such as PCs, the 1993 trend will still be toward benchmarking as a competitive tool—for cost-containment. Narrow system price margins mean continued pressure on purchasers to achieve the "best worldwide price" for components—with all eyes of the company and the market including competitors and security analysts monitoring the effect of material cost on profit margins. With competitive survival immediately at stake, the benchmark effort likely will not be on the more highly recommended search for "best practices" but, rather bluntly, on lowest cost.

At another extreme, for users whose companies' strategic focus is on leading-edge system products, benchmarking as applied to the procurement function *must* concentrate on the best practices search—independent of the industry or geographic source of the practice. For these manufacturers, benchmarking should be on functions such as the product design process, cycle time, or user-supplier alliances—with traditional purchasing issues such as materials cost a secondary or tertiary issue.

We recognize that there is a gray area. For example, many procurement organizations procure material for production of both commodity-type and leading-edge systems. There is no easy single answer on the application of benchmarking techniques to the procurement process. As indicated, this article is SPS's first step toward the production during 1993 of a procurement benchmarking guide—which will include guidance as to situations in which benchmarking is *not* useful—as well as how to effectively evaluate your process.

By Ronald Bohn

Product Analysis

Dataquest's North American Memory IC Price Benchmarks

This article presents memory IC pricing—garnered from Dataquest SPS's November 1992 North American bookings price survey—that can serve as pricing benchmarks. The aim is to provide SPS clients with information including survey minima and large volume discounts for benchmarking performance in buying memory ICs. The article elsewhere in this edition entitled "What Price 'Benchmarking'?" focused on strategic procurement benchmarking. This article focuses on tactical pricing issues—including the problematic search for so-called "best" pricing.

How SPS Clients Benchmark Themselves Against Dataquest Price Information

As a backdrop, some SPS clients use SPS's worldwide online or North American quarterly pricing information to benchmark their purchasing performance. Clients benchmark their purchase price against SPS pricing in the following ways:

- Against the SPS published price for the specified contract volumes
- Against quarterly rates of price change
- Against the low end of the quarterly price range for the specified contract volumes
- Against the low end of the price range for *very large* contract volumes

In the first case, SPS clients aim to ensure that the price they pay for an IC is not much greater than, if not less than, the price published in the SPS quarterly forecast or online service. Some clients also use SPS forecasts to benchmark *past* buying performance.

SPS carefully specifies each device in terms of quality, speed, configuration, package, and volume, among other specifications. For example, Dataquest SPS's quarterly price forecast states the following: "Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines."

In the second case shown earlier, some SPS clients monitor the quarterly changes in pricing, if any, that Dataquest forecasts for consistency with the price trends that our clients expect. In this case, the published price is not the main concern, but rather any quarterly *changes* in pricing. For example, Dataquest may estimate the current quarterly price for a specified device as being $2.00 and declining to $1.90 for the next quarter, a 5 percent decrease. Regardless of whether the buyer/client currently pays $2.25, $2.00, or $1.95 for the specified part, the client uses the forecast of a 5 percent decline as a market benchmark.

In the third and fourth cases, some SPS clients benchmark their buying performance either against the low end of the quarterly price range at the specified contract volume or else against the low end of the price range for *very large* contract volumes.

North American Memory IC Price Benchmarks

For example, based on the results of the recent North American pricing survey, Tables 1 through 5 present the survey average, the maxima and minima prices, and the estimated high-volume discount (in percent) for these memory ICs—DRAM, SRAM, flash memory, EPROM, and ROM. The tables cover the period from the fourth quarter of 1992 through the second quarter of 1993.

How to Use the Information in Tables 1 through 5

The memory ICs in Tables 1 through 5 are precisely specified regarding speed, configuration, package, volume, and related factors. As noted, some SPS clients use the survey *minima* price, that is, the low end of the quarterly price range as a benchmark for the so-called "best" or "competitive best" price available in North America at the given volume. Procurement organizations that pay a price at or below this benchmark price in most cases rank among the most competitive buying groups in the electronics industry.

For volumes greater than those specified in SPS quarterly price forecasts, the volume discount information shown in the tables provides a gauge of the potential discount, if any, for very large volume orders.

In terms of using this volume discount information, prior discussion with SPS analysts is recommended via our inquiry service. For example, in most cases one *cannot* simply take the survey minima and apply the highest volume discount in order to establish a "best" price benchmark. For example, in some cases there may be *no* volume discount available from the survey minima.

The Problems with a "Best Price" Benchmark

The article entitled "What Price 'Benchmarking'?" states that benchmarking the "best price" is problematic, although SPS is fully cognizant that competitive pressures require our clients to do so. A key factor is that "best" price typically means the lowest market price, so "best" pricing/"competitive best" pricing tends to completely ignore the typical trade-off between IC price paid and factors such as product quality, lead time, and assured delivery.

As part of the Micron/DRAM dumping investigation, for example, the U.S. International Trade Commission identified a host of factors that to some degree could affect DRAM pricing in the United States, including the following:

- Availability
- Credit terms
- High credit terms
- End-product compatibility
- Delivery time
- Delivery terms
- Failure rates
- Lowest failure rates
- Price
- Lowest price
- Market-average price
- Highest price
- Product quality
- Reliability
- Service/technical support

Even this schema ignores special user-supplier relations such as joint ventures/alliances regarding fab funding.

We need not detail the potential interplay of these factors on pricing to make this main point—the search by IC users and their corporate management for "best" or "competitive best" pricing must explicitly take into account *some* key variable factors in the price equation. Factors such as quality and delivery time can be assumed to be simple givens. Otherwise, the price benchmarking effort devolves into its logical lowest common denominator—an unrealistic across-the-board search for low-ball pricing.

Dataquest Perspective

Some practitioners of benchmarking might be aghast of this report's focus on competitive memory IC price benchmarks. The "preferred" or most frequently recommended type of benchmarking is the search for "best practices"—regardless of industry. The focus

Table 1
Estimated DRAM Price Benchmarks—North American Bookings (Contract Volume of 100,000-200,000; Dollars)*

Part	1992 Q4	1993 Q1	1993 Q2	1 Million Volume Discount (%)
256Kx1 DRAM 80ns DIP				
Minimum	1.40	1.40	1.40	
Maximum	1.50	1.60	1.60	
Average	1.45	1.48	1.47	2-10
64Kx4 VRAM 120ns ZIP				
Minimum	2.60	2.60	2.60	
Maximum	2.70	2.70	2.65	
Average	2.65	2.65	2.63	0-2
1Mbx1 DRAM 80ns (DIP/SOJ)				
Minimum	3.00	3.10	3.20	
Maximum	3.20	3.20	3.20	
Average	3.06	3.17	3.20	2-8
64Kx16 DRAM 80ns SOJ				
Minimum	4.10	4.10	4.10	
Maximum	4.10	4.10	4.10	
Average	4.10	4.10	4.10	2-9
256Kx4 VRAM 100ns ZIP				
Minimum	6.60	6.18	5.95	
Maximum	7.60	7.60	7.60	
Average	6.93	6.62	6.50	0-5
128Kx8 VRAM 100ns SOJ				
Minimum	6.75	6.50	NA	
Maximum	7.00	6.60	NA	
Average	6.88	6.55	NA	0-5
4Mbx1 DRAM 80ns SOJ				
Minimum	9.95	9.95	9.25	
Maximum	10.65	11.00	10.20	
Average	10.21	10.30	9.73	0-5
1Mbx4 DRAM 60ns SOJ				
Minimum	10.00	9.99	9.25	
Maximum	10.50	11.00	9.25	
Average	10.23	10.50	9.25	0-4
512Kx8 DRAM 70ns				
Minimum	12.36	11.23	10.56	
Maximum	12.36	11.30	10.56	
Average	12.36	11.27	10.56	2-8

(Continued)

Table 1 (Continued)
Estimated DRAM Price Benchmarks—North American Bookings (Contract Volume of 100,000-200,000; Dollars)*

Part	1992 Q4	1993 Q1	1993 Q2	1 Million Volume Discount (%)
256Kx16 DRAM 70ns SOJ				
Minimum	11.80	11.35	10.50	
Maximum	14.40	14.50	14.50	
Average	13.40	13.04	13.13	2-6
1Mbx8 SIMM 100ns (2-piece)				
Minimum	24.00	22.00	20.90	
Maximum	24.00	22.00	20.90	
Average	24.00	22.00	20.90	2-8
1Mbx9 SIMM 80ns (3-piece)				
Minimum	26.00	25.00	23.77	
Maximum	34.00	25.35	23.77	
Average	28.13	25.18	23.77	0-8
256Kx9 SIMM 100ns				
Minimum	12.50	12.50	12.50	
Maximum	13.25	13.25	13.25	
Average	12.88	12.88	12.88	0-4
256Kx36 SIMM 80ns				
Minimum	29.68	32.68	31.11	
Maximum	38.00	32.78	32.78	
Average	33.84	32.73	31.95	0-5
512Kx36 SIMM 80ns (24-piece)				
Minimum	54.69	62.68	62.68	
Maximum	72.00	70.60	63.00	
Average	66.03	66.76	62.84	0-8
4Mbx9 SIMM 80ns (9-piece)				
Minimum	90.50	90.50	NA	
Maximum	90.50	90.50	NA	
Average	90.50	90.50	NA	0-5
1Mbx36 SIMM 80ns (9-piece)				
Minimum	93.00	93.00	NA	
Maximum	93.00	93.00	NA	
Average	93.00	93.00	NA	0-5
4Mbx4 DRAM 70ns SOJ 400 mil				
Minimum	95.00	74.00	58.00	
Maximum	110.00	90.00	58.00	
Average	102.50	82.00	58.00	2-6

NA = Not available
*Contract volume = at least 100,000 per order except VRAMs
Source: Dataquest (December 1992)

Table 2
Estimated Static RAM Price Benchmarks—North American Bookings (Volume: Slow SRAM/50,000 per Year; Fast SRAM/ 20,000 per Year; Package: PDIP; Dollars)

Part	1992 Q4	1993 Q1	1993 Q2	50,000 Volume Discount (%)*
4Kx4 25ns				
Minimum	1.91	2.05	2.05	
Maximum	2.18	2.10	2.10	
Average	2.11	2.07	2.07	5-10
2Kx8 25ns				
Minimum	1.91	2.05	2.00	
Maximum	2.15	2.05	2.00	
Average	2.07	2.05	2.00	5-10
64Kx1 25ns				
Minimum	2.20	2.20	2.20	
Maximum	2.50	2.50	2.40	
Average	2.33	2.33	2.27	0-15
16Kx4 25ns				
Minimum	2.10	2.00	2.00	
Maximum	2.50	2.50	2.25	
Average	2.26	2.17	2.06	0-15
8Kx8 25ns				
Minimum	2.00	2.00	1.90	
Maximum	2.15	2.15	2.00	
Average	2.10	2.03	1.97	0-10
16Kx4 35ns				
Minimum	2.10	2.00	2.00	
Maximum	2.50	2.50	2.00	
Average	2.26	2.15	2.00	0-15
8Kx8 45ns				
Minimum	1.70	1.70	1.90	
Maximum	2.15	2.00	2.00	
Average	1.95	1.90	1.95	0-15
8Kx8 100-120ns				
Minimum	1.60	1.60	NA	
Maximum	1.75	1.75	NA	
Average	1.69	1.68	NA	0
64Kx4 10ns				
Minimum	14.25	20.00	18.75	
Maximum	22.00	20.00	18.75	
Average	20.05	20.00	18.75	5-12

(Continued)

Table 2 (Continued)
Estimated Static RAM Price Benchmarks—North American Bookings (Volume: Slow SRAM/50,000 per Year; Fast SRAM/20,000 per Year; Package: PDIP; Dollars)

Part	1992 Q4	1993 Q1	1993 Q2	50,000 Volume Discount (%)*
64Kx4 25ns				
Minimum	4.75	4.65	4.45	
Maximum	5.75	6.00	4.65	
Average	5.26	5.23	4.58	5-15
32Kx8 12ns				
Minimum	10.50	9.25	8.15	
Maximum	14.80	13.61	12.00	
Average	12.74	11.62	10.05	0-10
32Kx8 35ns				
Minimum	4.35	4.11	0.98	
Maximum	5.50	5.10	4.74	
Average	5.21	4.80	3.44	0-15
32Kx8 100ns SOJ				
Minimum	3.43	3.25	3.60	
Maximum	4.00	4.00	3.60	
Average	3.70	3.63	3.60	0-12
256Kx4 20ns				
Minimum	22.00	23.00	22.00	
Maximum	35.00	29.00	26.80	
Average	28.32	26.21	23.93	0-10
128Kx8 20ns				
Minimum	18.00	16.25	12.50	
Maximum	30.94	27.87	26.12	
Average	26.58	23.04	20.21	5-15
128Kx8 25ns				
Minimum	23.50	20.00	19.42	
Maximum	23.50	21.75	19.42	
Average	23.50	20.88	19.42	5-22
128Kx8 100ns SOJ				
Minimum	9.06	9.00	8.90	
Maximum	11.25	11.25	8.90	
Average	9.95	9.59	8.90	0-5

*100,000 volume discount for slow SRAM
NA = Not available
Source: Dataquest (December 1992)

Table 3
Estimated Flash Memory Price Benchmarks—North American Bookings (12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1992 Q4	1993 Q1	1993 Q2	100,000 Volume Discount
32Kx8, PDIP/PLCC				
Minimum	4.94	4.75	4.56	
Maximum	5.00	4.95	4.75	
Average	4.95	4.79	4.63	0-5
64Kx8, PDIP/PLCC				
Minimum	5.60	5.60	5.35	
Maximum	6.00	5.75	5.75	
Average	5.92	5.64	5.45	0-5
128Kx8, PDIP/PLCC				
Minimum	6.65	6.75	6.50	
Maximum	7.00	8.00	7.50	
Average	6.92	7.04	6.73	5-10
128Kx8, TSOP				
Minimum	7.70	7.40	7.20	
Maximum	9.00	8.75	8.55	
Average	8.13	8.08	7.80	0-10
256Kx8, TSOP				
Minimum	13.00	12.55	12.15	
Maximum	14.60	13.80	13.35	
Average	13.45	13.03	12.57	0-10

Source: Dataquest (December 1992)

here on electronics industry component price benchmarks would be criticized by some as merely perpetuating an ineffective industry practice.

Nevertheless, SPS remains committed to serving our clients' short-term practical needs while also addressing long-term strategic trends. For the latter assessment, see the aforementioned "What Price 'Benchmarking'?"

The information in Tables 1 to 5 of this report should serve as a practical guide for users of memory ICs interested in benchmarking their purchasing performance regarding price paid. We immediately bring attention, however, to the many elements that shape that final price. Whether the lowest price is the "best price" remains an open issue, although current recessionary market conditions say that lowest equals best.

For example, the recent shift in the DRAM marketplace from the buyers market of the past 12 to 18 months to more of a sellers market—especially on the spot market—drives the point home. For the past year, some SPS clients have been frustrated in their effort to achieve the best worldwide 4Mb DRAM price. Some of these clients had long-established relations with suppliers, and their price, either at a typical contract volume or higher volumes, tended to be undercut by spot-market pricing reports, whether real or not. A former SPS client who buys only on the spot market boasted about always paying a "better" price than the SPS published price—and rejected our advice regarding the value of close user-supplier relations.

The point is that quantifying the "value" of established user-supplier relations is a somewhat ephemeral exercise. But at a time such as now, when the DRAM marketplace seems to be

Table 4
Estimated EPROM Price Trends—North American Bookings (Volume: 50,000 per Year; Package: Windowed CERDIP; Speed: 150ns and Above; Dollars)

Part	1992 Q4	1993 Q1	1993 Q2	100,000 Volume Discount (%)
16Kx8 EPROM				
Minimum	1.25	1.32	1.60	
Maximum	1.75	1.80	1.80	
Average	1.65	1.61	1.72	0-5
32Kx8 EPROM				
Minimum	1.40	1.45	1.45	
Maximum	1.75	1.80	1.80	
Average	1.59	1.60	1.62	0-5
64Kx8 EPROM				
Minimum	2.00	2.10	2.20	
Maximum	3.00	2.75	2.40	
Average	2.37	2.33	2.28	0-5
128Kx8 EPROM				
Minimum	3.00	2.75	2.80	
Maximum	3.25	3.25	3.25	
Average	3.05	2.96	3.05	0-10
256Kx8 EPROM				
Minimum	6.10	6.00	5.90	
Maximum	6.50	6.25	6.20	
Average	6.18	6.09	6.07	0-5
128Kx16 EPROM				
Minimum	6.22	6.09	5.99	
Maximum	6.75	6.30	6.30	
Average	6.35	6.14	6.15	0-5
512Kx8 EPROM				
Minimum	10.25	10.00	9.70	
Maximum	10.70	10.80	10.70	
Average	10.59	10.24	10.08	0-5
256Kx16 EPROM				
Minimum	14.00	11.00	10.67	
Maximum	14.00	14.00	12.00	
Average	14.00	12.38	11.34	0-5

Source: Dataquest (December 1992)

Table 5
Estimated ROM Price Trends—North American Bookings (Speed/Package: ≤1Mb Density—150ns and Above; 28-Pin PDIP ≥2Mb Density—200ns and Above; 32-Pin PDIP) (Volume: 50,000 per Year, Dollars)

Part	1992 Q4	1993 Q1	1993 Q2	100,000 Volume Discount (%)
32Kx8 ROM				
Minimum	1.50	1.40	1.35	
Maximum	1.50	1.40	1.35	
Average	1.50	1.40	1.35	0-2
64Kx8 ROM				
Minimum	1.75	1.70	1.65	
Maximum	1.75	1.70	1.65	
Average	1.75	1.70	1.65	0-2
128Kx8 ROM				
Minimum	1.80	1.70	1.75	
Maximum	1.85	1.80	1.75	
Average	1.81	1.78	1.75	0-2
64Kx16 ROM				
Minimum	1.80	1.80	1.80	
Maximum	1.80	1.80	1.80	
Average	1.80	1.80	1.80	0-2
256Kx8 ROM				
Minimum	2.55	2.50	2.50	
Maximum	2.55	2.50	2.50	
Average	2.55	2.50	2.50	0-4
512Kx8 ROM				
Minimum	3.30	3.25	3.20	
Maximum	4.20	4.20	3.25	
Average	3.51	3.44	3.23	0-4
256Kx16 ROM				
Minimum	3.30	3.25	3.20	
Maximum	4.20	4.20	3.50	
Average	3.60	3.57	3.35	0-4
1Mbx8 ROM				
Minimum	5.10	5.00	4.90	
Maximum	5.80	5.75	5.70	
Average	5.54	5.48	5.37	0-4
1Mbx16 ROM				
Minimum	10.00	9.80	9.60	
Maximum	10.75	10.50	9.75	
Average	10.33	10.05	9.68	0-4
2Mbx8 ROM				
Minimum	10.00	9.80	9.60	
Maximum	10.75	10.50	9.95	
Average	10.45	10.12	9.78	0-4

Source: Dataquest (December 1992)

moving toward a tighter supply-demand scenario, the value of these relations is obvious—if not quantifiable.

By Ronald Bohn

Dataquest Looks at the DRAM Price Learning Curve

Executive Summary

A recurring question at Dataquest concerns our research methodology. For SIS Memory and SPS analysts, a key inquiry becomes the methodology behind our DRAM price forecast. As noted in prior articles, the SPS forecast is based on quarterly survey results along with the analytical judgment of SIS and SPS analysts. Dataquest strives to utilize—using clients' phraseology—an "analytically rigorous" forecasting model. This article reports on the combined effort to date involving a team of Dataquest analysts—Terrance Birkholz and Ade Olorunsola of Dataquest's Research Operations, SIS DRAM analyst Lane Mason, and SPS pricing analysts Mark Giudici and Ronald Bohn—to estimate the historic DRAM price learning curve.

What Happens to Those Who Ignore History?

Santayana said those who ignore history are condemned to repeat it. To avoid that scenario, Dataquest recently developed a model that we believe accurately represents the historic DRAM price learning curve. Dataquest does *not* plan henceforth to blindly use this model to spill out a DRAM price forecast—and ignore analysts' experience and judgment in the process—but rather as a tool for strengthening the DRAM price forecast process.

First, we describe the definition and assumptions regarding learning curve theory. Next, we describe the preliminary results of our research. Finally, and most importantly, we describe the implications of the research and Dataquest's plans.

The Learning Curve—Definition, Assumptions, Model

A learning curve—which derives from the airframe industry—may be defined in its basic form as a line that expresses the relationship between the variable cost of production and the *cumulative* volume of production.

The learning curve theory is based on the following three assumptions:

- The variable cost required to produce a unit of a product, here a DRAM bit, will be less each time the productive task is undertaken.
- The variable cost will decrease at a decreasing rate.
- The reduction in variable cost will follow a specific and predictable path, for example, an exponential function.

Dataquest's model uses ordinary least squares (OLS) regression analysis. The model makes a logarithmic plot of the functional relationship between cumulative DRAM bits shipped as a predictor of DRAM price per bit. Dataquest's quarterly DRAM shipment/pricing data utilized in the model covers the period from 1974 through 1991—more than 70 quarters.

The Results

Figure 1 provides the results in graphic form. The regression statistics show that the model "fits" the data reasonably well. For example, the adjust coefficient of determination is 0.96. Clients interested in the data behind this figure or the full set of regression statistics should contact SPS via the inquiry service.

A key statistic from this analysis, of course, is the learning-curve factor—72 percent.

Under learning curve theory, this statistic in turn says that for every doubling of cumulative DRAM bits shipped, DRAM price-per-bit declines by 28 percent (that is, 1.0 to 0.72).

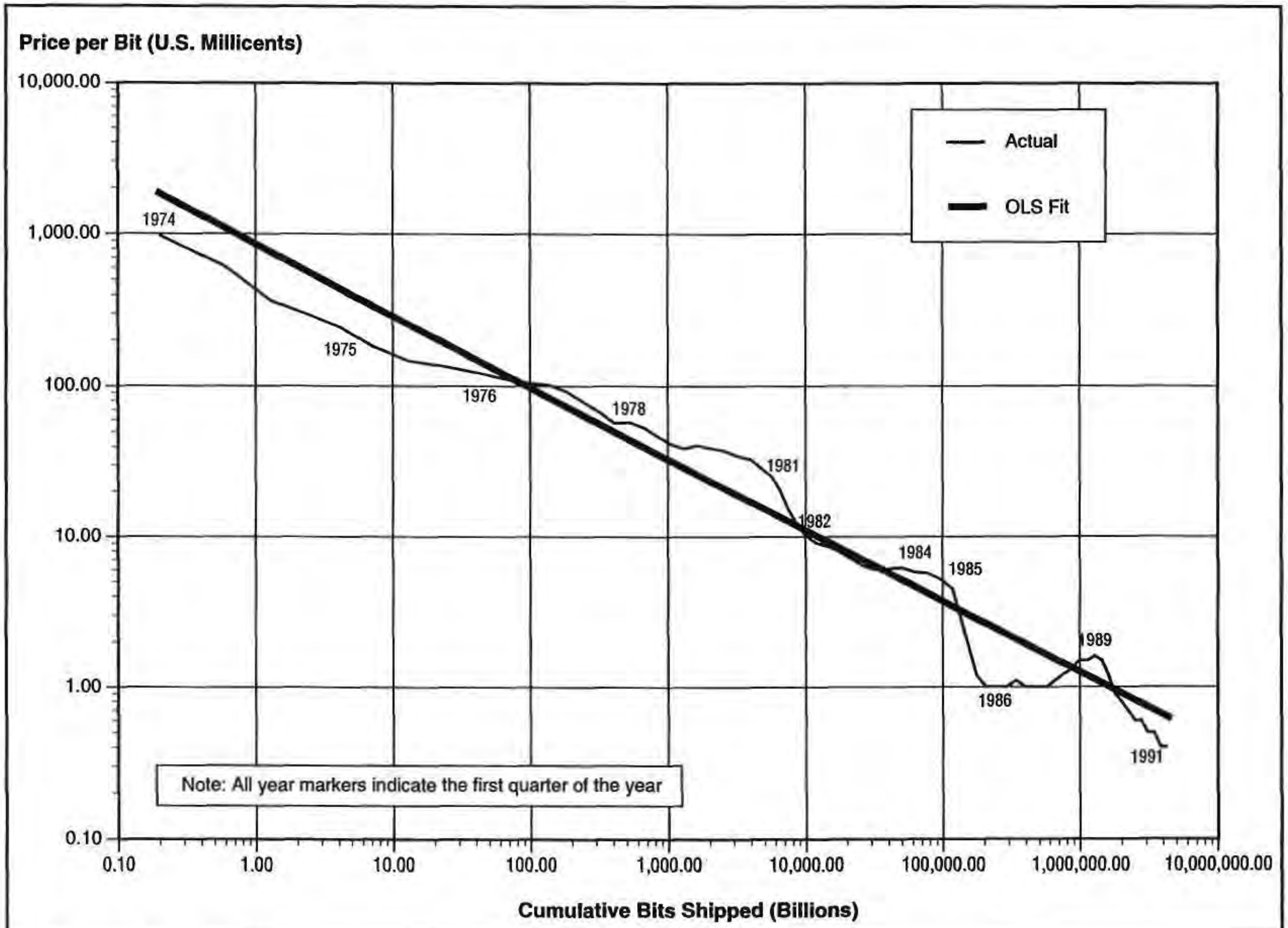
Note in the figure recent deviations of actual DRAM price-per-bit from the OLS line. These occur during the 1986, 1989, and 1991 periods. During 1986 actual DRAM pricing fell below the line—a reflection of Japan's aggressive pricing strategy at that time. By contrast, for 1989 actual DRAM pricing move above the OLS line—an aftermath of the fair market value system established under the United States-Japan Trade Arrangement. For 1991, actual DRAM price per bit again moved under the OLS line—a reflection of the brutal pricing conditions in the DRAM since the latter half of 1990.

Implications

Dataquest analysts see two implications from this research.

First, for 1991—and quite likely most of 1992—actual DRAM pricing has been below the level to be expected, according to Dataquest's DRAM price learning curve. The implication is that there will be less intense DRAM pricing competition during the 1993 to 1994 period vis-a-vis the 1990 to 1992 time frame. What are the current market signals? Mr. Mason reports that

Figure 1
Worldwide DRAM (All Densities): Logarithmic Learning Curve



Source: Dataquest (December 1992)

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the 4Mb DRAM supply-demand equation has already started to tighten somewhat—a critical factor overshadowed by more lurid spot-market conditions associated with the Micron case decision—and that supply-demand should remain relatively tight into 1994.

Second, without dwelling *too* much on history, Dataquest can use the DRAM price learning curve to more rigorously anticipate market turning points—inflection points—which most models cannot forecast. Dataquest—and our clients can join us in this exercise—will initially focus on the market conditions associated with some of the key periods shown on Figure 1, for example, pre-1980s, 1984 to 1986, and 1989 to 1991. Then we can qualitatively and/or quantitatively identify major DRAM/semiconductor market shifts that we expect in the post-1992 period. The ultimate goal is to estimate the effect of likely future changes in DRAM market conditions on the proximity of quarterly DRAM price per bit to learning curve line.

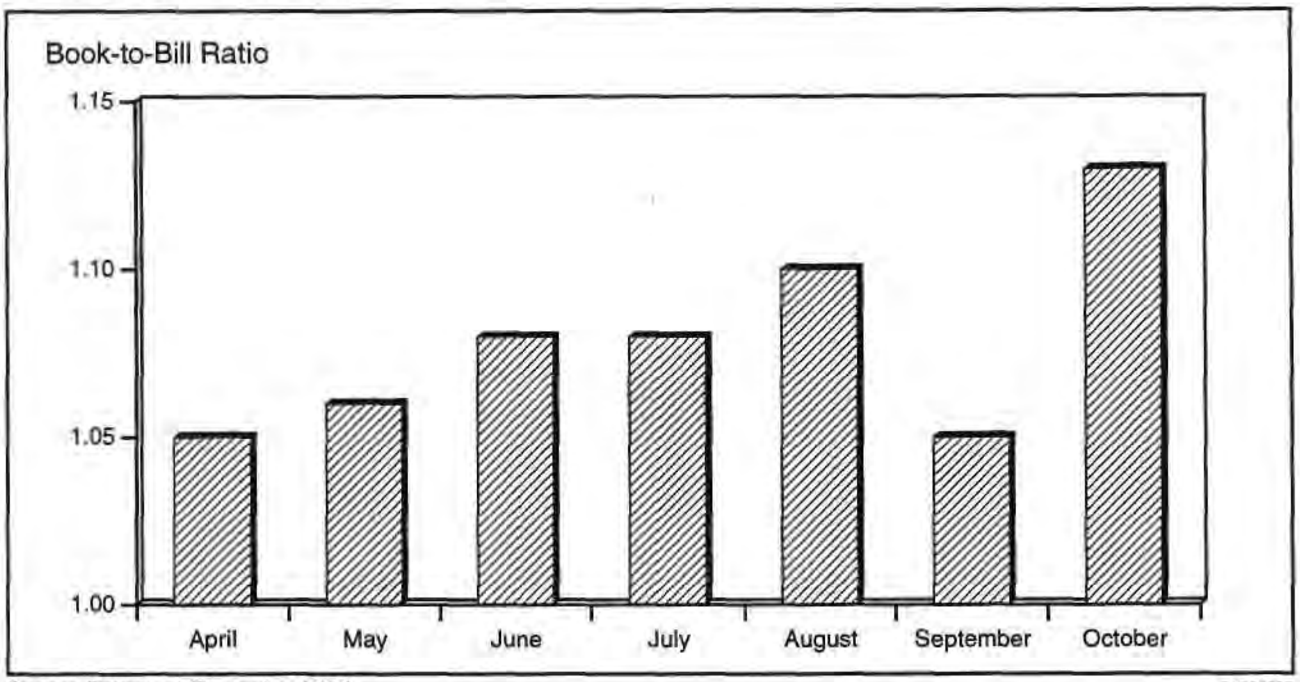
By Terrance Birkholz
Lane Mason
Ade Olorunsola
Mark Giudici
Ronald Bohn

News and Views

Procurement Supplement

Figure 1 shows the U.S. semiconductor distribution book-to-bill ratio since April 1992. The overall book-to-bill ratio trend is generally picking up momentum. With lead times stretching out, this pickup in distributor bookings is likely to continue.

Figure 1
U.S. Semiconductor Distribution Book-to-Bill Ratio



Source: Dataquest (December 1992)
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Inquiries of the Month

Semiconductor Procurement Inquiry Highlights

Q1 What is the availability status of the 8Mb flash memory now and into the near future, and what alternative product solutions are there for high-density programmable memory?

A Much of the current availability problems in the 8Mb flash supply stem from the inability of one Intel foundry—NMB of Japan—to bring the flash process up to production levels (the second delay). Current estimates of NMB 8Mb flash production are for July 1993.

What Are the Options?

Because the 8Mb flash from Intel is a sole-sourced proprietary device, users of this part are stuck with long lead times, limited shipments, and little recourse aside from expensive redesign work.

As far as the best available alternative flash configurations/manufacturers, the most readily available devices are densities of 1Mb and below. Regarding compatibility with Intel's flash technology, AMD offers devices in densities of 256K to 1Mb. If Intel-compatibility is not an issue, Atmel is a source for 3V and 5V flash devices in densities of 1Mb or less. Catalyst Semiconductor also offers densities of 1Mb and less. Toshiba has a 256K flash device. Mitsubishi has just started shipping these densities of flash memory, and Hitachi should start in several months. Texas Instruments forecasts first-quarter 1993 market entry.

In terms of ease of technology, Dataquest recommends the following alternatives to flash memory:

- EEPROMs: First choice. Available suppliers include Atmel, Catalyst, Microchip, SGS-Thomson or Xicor.
- EPROM: Next choice, but less preferable. Suppliers include, of course, AMD and Intel, plus Fujitsu, SGS-Thomson, Microchip, and Texas Instruments, among others.
- ROM: Least recommended choice. Sharp—Intel's alliance partner—is the leading worldwide ROM supplier. Other suppliers include Hitachi, Mitsubishi, and Toshiba.

Contrary to some reports, users should *not* pay twice the price for flash memory because of allocation of devices. For example, pricing for devices in PDIP/PLCC should firm up somewhat—perhaps 5 percent to 10 percent in North America for *nonmajor* customers. Some major users in North America still report flat or even slightly declining pricing moving into 1993, although the second-quarter 1993 outlook remains quite uncertain. By contrast, users of flash memories in TSOP should expect to pay a minimum 10 percent to 20 or 25 percent premium for these parts because of package constraint.

Current Status

The response to this situation from users ranges from calm—because they are just moving into lower-density flash memory—to anger, especially regarding the 8Mb part. These North American users are actively talking to as many current/suppliers of flash memory and EPROM as possible. No common solutions have emerged. Some major buyers here have not qualified the EEPROM suppliers (except SGS-Thomson and then more so for EPROM), so this market alternative has not yet attracted attention. With the market for flash memory quickly growing, aggregate demand is expected to soon exceed supply levels, with resulting longer lead times and firmer pricing for most of the flash product offerings. Links should be made now with flash suppliers for steady delivery commitments for the upcoming year.

Q2 What are the introduction dates and prices, highest volume shipment levels, and current prices for the 80286, 80386, and 80486?

A See Table 1.

Table 1
Historical Data for the 80286, 80386, and 80486

Product	Introduction Year	Highest Volume/Year	Introduction Price ($)	Current Price ($)
80286	1983	13,000,000 units/1990	150.00	7.50
80386DX	1985	4,500,000 units/1991*	300.00	70.00
80386SX	1988	9,900,000 units/1991*	164.00	48.00
80486DX	1989	1,900,000 units/1991*	1,000.00	325.00
80486SX	1991	600,000 units/1991*	260.00	96.00

*1991 is the latest shipment data available.
Source: Dataquest (December 1992)

For More Information . . .

On the topics in this issue .... Mark Giudici, Director (408) 437-8258
About upcoming Dataquest conferences .... (408) 437-8245
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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9211 November 23, 1992

In This Issue...

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Korea
74AC244	0.43	0.41	0.37	0.26	0.36
Lead Time: (Weeks)	8	5	4	-	5
4F244	0.22	0.26	0.21	0.22	0.22
Lead Time: (Weeks)	6	5	4	-	5
7805-TO92	-	0.14	0.14	-	0.15
IMSG171D-35-MHz	-	3.51	3.05	-	-
Lead Time: (Weeks)	-	5	8	-	-
DRAM 1Mbx1-8	3.05	2.97	3.30	3.00	2.65
DRAM 256Kx16-8	12.95	11.08	12.76	11.20	-
DRAM 3 CHIP MOD	26.50	24.98	26.50	27.50	23.00
DRAM 4Mbx1-6	11.75	9.99	-	11.00	10.00
DRAM 4Mbx1-8	10.75	9.37	10.30	10.30	9.60
DRAM 4Mbx4-70	100.50	97.57	92.00	130.00	-
DRAM 512Kx9-8	13.38	10.15	13.26	-	-
EPROM 2Mb 170n	6.25	6.01	4.30	-	0.46
FLASH 1Mb	7.08	7.03	5.85	6.50	-
FLASH 2Mb	13.18	13.27	13.50	-	-
SRAM 128Kx8-70	11.03	9.76	8.00	10.50	7.70
SRAM 32Kx8-70	3.35	3.04	3.00	3.15	3.00
SRAM 64Kx4-25	5.38	5.46	4.50	4.00	4.20
VRAM 128Kx8-8	7.10	6.40	6.95	10.50	-
Lead Time: (Weeks)	8	6	4	-	-
68040-25	385.00	468.35	370.00	-	-
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	-	-
Lead Time: (Weeks)	4	7	4	-	-

*Prices in U.S. dollars
Source: Dataquest (November 1992)

Market Analysis

November Procurement Pulse: DRAM Disturbance Disrupts Semiconductor Order Outlook

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rates Expected to Slip

The booking rate for semiconductors is expected to decline by about 25 percent because uncertain memory supplies have caused some buyers to slow spot market bookings at relatively high prices (see Figure 1). This correlates with the relatively static equipment order rate outlook for systems, compared with last month. The overall sample six-month growth forecast declined slightly to 6.6 percent, down from last month's 6.8 percent outlook, while the computer subset slipped to a 6.2 percent outlook, compared with the 7.0 percent forecast last month. Although the semiconductor future looks relatively soft, system sales stabilized, moving from last month's 6.1 percent increase to the current 6.4 percent level of sales growth. Overall semiconductor prices fell less than 1 percent (0.3 percent), reflecting the concern with the recent U.S. Department of Commerce (DOC) Korean DRAM dumping determination, combined with the continued short supply of SOIC standard logic. The SMT logic situation appears to be unfolding into

Figure 1
Averaged Monthly Semiconductor Orders

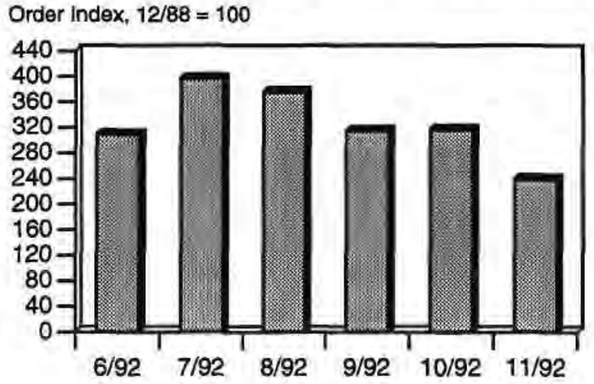


Figure 2
Averaged Semiconductor Lead Times

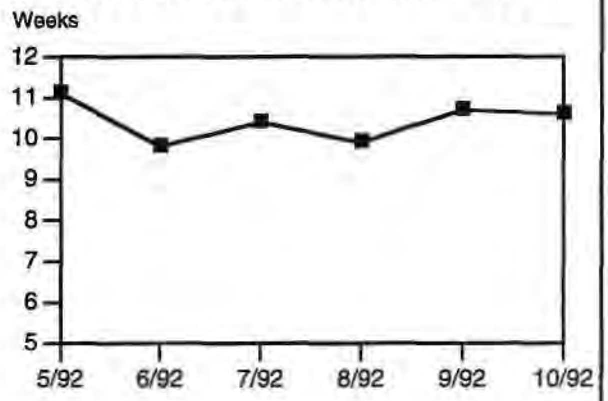


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

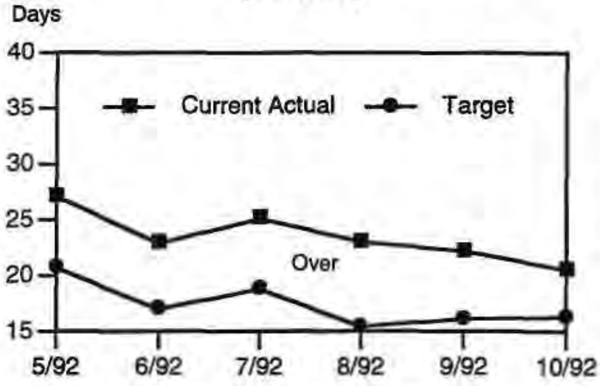
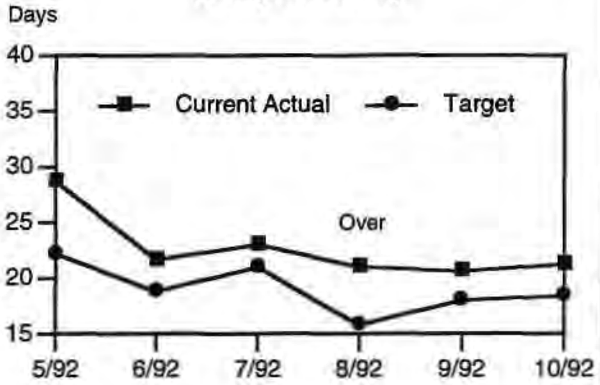


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (November 1992)

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a long-term problem because suppliers are hesitant to add back-end test and handling capacity without absolute order guarantees. This and the relatively long time for additional capacity qualification (6 to 9 months) make it appear now that the easing of supply for these packages has been pushed out from the late fourth-quarter 1992 time frame to a best-case third-quarter 1993 window. Although additional SOIC capacity planned to come online this quarter has not been fully utilized, unexpected increases in demand have continued to outstrip supply. As mentioned in earlier reports, other SMT devices (TSOP memory and SOIC linear) are also seeing higher-than-expected demand levels.

Semiconductor Lead Times Stabilize

The average semiconductor lead time stabilized at 10.6 weeks, compared with last month's 10.7-week average (see Figure 2). The continued ready availability of microprocessors, DIP logic, and memory continues to hold the average lead time down, while SMT devices (logic, memory, and linear) are tending to pull it upward. As mentioned earlier, the SOIC logic situation is taking a lengthened allocation turn, with lead times heard to stretch as long as 36 weeks for some new customers scrambling for parts. There are rumblings that incremental price hikes for these parts may begin soon. Contract memory lead times (key word is contract) remain relatively stable, despite the stiff penalties levied against the Korean DRAM suppliers. The spot market is another story. Lead times and prices both have shot up for all DRAMs (especially SIMMs). DRAM spot market volatility is not unknown, but for the recent past it has been notably absent, given the market dynamics over the last 18 months. Dataquest continues to see adequate supplies of DRAM meeting overall demand levels for the next 3 to 6 months as suppliers balance internal capacity product mix with demand levels. Once the reshuffling of existing capacity is fully used, the resulting capacity crunch will extend overall lead times. Given a 9- to 12-month lead time for additional capacity to go from ground-break to production-level shipments, the third quarter of 1993 would be the earliest that any additional capacity started now would be able to meet demand growth. As we have mentioned before, Dataquest has not seen any appreciable capacity expansion begin beyond that planned two-plus years ago.

Semiconductor Inventories Continue to Be Scrutinized

Cost control (often read inventory control) remains closely monitored and, per this month's respondents, well under wraps (see Figures 3 and 4). This barometer of semiconductor availability also lends credence to the existence of predictable, adequate supplies meeting current demand levels. Overall targeted and actual semiconductor levels for October were 16.3 and 20.5 days, compared with respective 16.1- and 22.2-day levels noted for September. For the computer subset, the latest targeted and actual chip inventory levels increased slightly to targeted and actual levels of 18.4 and 21.2 days, compared with September's target/actual range of 18.0 and 20.6 days. Even though the numbers show slightly increased inventory activity, in reality inventory control is alive and well, anchoring a sense of stability in an otherwise uncertain market. As mentioned many times in the past, continual, persistent, and accurate 6- to 9-month semiconductor forecasts backed with P.O. commitments that are updated quarterly (in some cases monthly) now are taking priority by many suppliers as certain product supplies become stressed. Maintaining predictable delivery schedules will go a long way toward controlling inventory levels in the upcoming months.

Dataquest Perspective

The continued demand pull of the low-cost/high-performance PC market is keeping pressure on both prices and capacity levels of strategic semiconductors. The recent DOC preliminary determination against Korean DRAM suppliers, while not disrupting contract buyers, highlights the level of unease in the memory market in the way the spot market reacted to the news. While existing capacity levels may be shifted to meet specific product needs, the overall size of the capacity pie is not getting bigger. As demand continues to chug along at a reasonable 5 to 7 percent level of growth, plans to meet this long-term trend need to be put in place now. Regional market softness in Japan is delaying capacity addition there at this time, yet worldwide demand is dependent on Japanese semiconductor supply for sustained growth now and into 1993. Opportunities exist for suppliers providing, or planning to provide, SMT logic, linear, and specific memory products to U.S. and

European markets. Disciplined procurement of these parts now continues to require excellent levels of communication that will have paybacks in more predictable delivery/availability schedules.

By Mark Giudici

Semiconductor Capital Spending Forecast: A Secular Change for the Market

Worldwide semiconductor capital spending is expected to decline 9.5 percent in 1992 (see Table 1) largely because of severe cuts in spending by Japanese companies. Dataquest believes that 1992 will mark the bottom of the spending cycle. However, we are only forecasting moderate growth in spending in 1993. Moreover, the five-year worldwide compound annual growth rate for spending through 1996 is estimated to be 6.9 percent. This rate is at an historic low and is caused in the short term by weak global economic conditions and an overhang in production capacity. Over the longer term, the slower growth scenario is attributable to weak growth in the global economy and uncertainty about the emergence of a high-octane semiconductor application.

Worst-Case Scenario for Japanese Semiconductor Capital Spending Unfolds

Our recent survey of Japanese device makers reveals that capital spending on new plant and equipment will drop 24.0 percent in 1992. Sharp cuts in spending can be attributed to several factors, including a large production capacity overhang caused by the boom in spending in the late 1980s, weak domestic and export markets, and mounting trade friction with Western countries.

The vertically integrated Japanese computer makers will make on average the smallest cuts in semiconductor capital spending in 1992. Even so, we expect companies such as Fujitsu, NEC, and Toshiba to cut spending levels 13 to 30 percent (see Table 2). These companies face a weak domestic economic environment and poor returns on their 4Mb DRAM investment. Dataquest estimates that Japanese 4Mb lines are running at 60 to 65 percent capacity utilization.

The slow adoption of the 4Mb DRAM and an anticipated slow ramp up of the 16Mb DRAM have caused the computer makers to turn cautious on capital spending. In addition, Korean DRAM vendors are continuing to win a larger share of the market, thus adding to the competitive pressures in the memory segment.

Weak domestic consumer demand and weak export markets have prompted the large vertically integrated consumer electronic companies to deeply cut their spending on their semiconductor operations. Consumer electronic equipment inventories continue to mount, although companies such as Sony and Matsushita are

Table 1
Worldwide Capital Spending by Region Forecast, Including Merchant and Captive Semiconductor Companies
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	3,851	3,559	3,754	4,344	4,883	5,688	8.1
Percentage Growth	-5.8	-7.6	5.5	15.7	12.4	16.5	
Japan	5,636	4,312	4,601	5,107	5,551	6,634	3.3
Percentage Growth	3.9	-23.5	6.7	11.0	8.7	19.5	
Europe	1,234	1,087	1,011	1,110	1,359	1,808	7.9
Percentage Growth	-18.4	-11.9	-7.0	9.8	22.5	33.0	
Asia/Pacific	2,274	2,808	2,676	2,914	3,138	4,002	12.0
Percentage Growth	52.1	23.5	-4.7	8.9	7.7	27.5	
Worldwide	12,995	11,765	12,042	13,475	14,932	18,131	6.9
Percentage Growth	3.8	-9.5	2.4	11.9	10.8	21.4	

Source: Dataquest (November 1992)

Table 2
1991 and 1992 Calendar Year Semiconductor Capital Spending Estimates (Merchant), Millions of U.S. Dollars, Top 11 Rankings

		1991 Rank	1991	1992 Rank	1992	Percentage Change
1	Intel	1	948.0	1	1,000.0	5.5
2	NEC	3	751.8	2	610.8	-18.8
3	Motorola	5	673.0	3	550.0	-18.3
4	Fujitsu	4	703.0	4	514.7	-26.8
5	Hitachi	7	649.7	5	512.3	-21.1
6	Toshiba	2	788.9	6	492.6	-37.6
7	Mitsubishi	6	664.5	7	472.9	-28.8
8	Sony	9	519.8	8	374.4	-28.0
9	Samsung	8	530.0	9	360.0	-32.1
10	Matsushita	10	462.2	10	352.7	-24.0
11	TI	11	383.0	11	323.0	-16.0

Source: Dataquest (November 1992)

doing a better job at managing the problem than they were at the beginning of the year. However, shrinking profit margins and quarterly losses suggest that capital spending by consumer electronic companies will not snap back in 1993.

Japanese steel companies such as Kawasaki Steel and NKK, which were late entrants to the semiconductor game, are in a more precarious position. In a scramble to diversify beyond the declining steel industry, the largest steel companies in Japan made large investments in the semiconductor business in the late 1980s.

Dataquest believes that the production capacity brought on by the steel companies is currently running at less than 50 percent capacity utilization. Moreover, Japanese steel companies will face serious problems filling those factories if the weak economic environment persists because steel companies do not have a captive market for their devices.

Many Japanese companies announced delays in 200mm line investment plans late in 1991. Japanese companies have not earned a return on their 4Mb investment, and their strategy to achieve this return is to postpone the next round of investment in 16Mb lines. However, because of the severity of capital spending cuts in 1992, we now expect that some of these delayed lines will not be built at all.

Japanese spending on advanced semiconductor lines in the United States and Europe is also expected to decline. Though Japanese companies have completed most of their "green-field" investment in offshore fabs, many capacity additions to these facilities are not expected to proceed anytime soon.

U.S. Spending Pulled Down by Japanese Companies' Cuts

Capital spending in the United States will decline by 7.6 percent in 1992. The largest falloff will be experienced by Japanese companies spending in the United States, from more than $400 million in 1991 to less than $200 million in 1992. This precipitous drop will be attributed to the completion of some major green-field projects by Japanese companies such as Fujitsu and NEC.

Spending by U.S. companies in the United States will be down slightly in 1992. Investment in new microprocessor lines by Intel, Digital Equipment Corporation, and Hewlett-Packard will prevent capital spending from decreasing steeply. Intel is building a new development line in Oregon and is converting its R&D line in Santa Clara, California to 200mm. There also are rumors that Intel has selected Austin, Texas as a site for a new green-field facility, on which construction will begin either at the end of the year or the beginning of 1993. Both Digital and HP are commercializing their RISC microprocessor technology and are investing in fabs to ramp device production.

Other new fab activity not in the MPU area includes National Semiconductor's expansion in Arlington, Texas and AT&T's new line in Orlando, Florida. IBM is also refurbishing buildings 222 and 223 in East Fishkill, New York.

Europe Expected to Decline through 1993

Capital spending in Europe is forecast to decline 11.9 percent in 1992 and sink another 7 percent in 1993. The bleak outlook for spending is based on steep cuts by European companies and cutbacks by Japanese companies that have recently completed a round of investment in new fabs. The situation would be much worse if it were not for the major projects being undertaken by IBM in France and Intel in Ireland.

However, Intel will complete the lion's share of its spending in 1992, leaving only the IBM project as the main driver for spending in 1993. Consequently, we are expecting 1993 to be a down year as well. Dataquest is more optimistic from 1994 and beyond as we expect the European economy to begin benefiting from unification. Even so, the timing on this upturn is still very speculative.

Korean Companies Place Some Big Bets

Dataquest believes that the Asia/Pacific region will be the one bright spot in terms of semiconductor capital spending in 1992. We are forecasting that spending will leap ahead 23.5 percent. The Korean chaebols (conglomerates) will account for the bulk of that spending. Investment in Korean fabs is expected to climb to U.S.$1.8 billion in 1992.

In the short term, with excess worldwide DRAM capacity, the gamble for the Korean companies rests on the strength and timing of the recovery in the U.S. and European economies. If the Western economies have a strong recovery over the next several years, DRAM demand will grow quickly and the Korean companies may exit the recession with more market share than they had prior to the recession. Toshiba pursued a similar strategy in the 1985 recession with the 1Mb DRAM and was very successful. On the other hand, if the Western economies limp out of recession and there is only moderate growth in DRAM demand, then these investments are not expected to pay off financially.

There is a more fundamental problem for the chaebols over the longer term. History has shown that the health of a company's semiconductor operations cannot rest on merchant sales of devices alone. For companies involved in the production of commodity devices, a healthy semiconductor operation is increasingly dependent on captive operations using those devices.

Yet, Korean electronic products are losing their competitive edge. Increases in wages are driving up the prices of Korean electronic products, although their quality still lags behind high-end Japanese and U.S. products. On the low end, developing countries such as China and Thailand, with much lower labor costs, are grabbing market share.

Dataquest believes that Asian/Pacific investment will decline 4.7 percent in 1993 as the three large Korean companies complete the current round of investment in 4Mb and 16Mb lines. However, we expect the Asia/Pacific region to remain the fastest-growing region in terms of capital spending. Much of the growth in capital spending will occur outside of Korea, which now dominates the semiconductor industry in the region. As countries such as China and India develop, we believe that semiconductor production capability will be a key strategy in building their industrial infrastructure.

Dataquest Perspective

Capital spending growth rates are expected to decline from the double-digit compound annual growth rates of the late 1980s to single-digit growth over the next five years. The biggest change in spending levels will happen in Japan as companies adjust to a more restricted capital environment. U.S. spending, on the other hand, will benefit from the region's strong position in the microprocessor market, although we do not expect capital spending levels to achieve the growth rates of the past decade. European spending will remain in a downward spiral through 1993, though we expect unification to kick life back into this market toward the middle of the decade. And finally, the Asia/Pacific region is expected to remain the star performer in terms of spending, although we strongly believe that there will be a rotation away from the current countries that dominate the capital spending roster in this region.

By Rebecca Burr
Mark FitzGerald

Product Analysis

The SRAM Supplier Base—Crowded, Shifting, and Still Vibrant

For many users, SRAMs rank next to DRAMs as their most crucial memory IC supply base concern. For users such as military system manufacturers, fast SRAMs are the most critical memory product. Dataquest estimates that worldwide production of SRAMs totaled 704 million units during 1991 and should expand at a 5.4 percent compound annual growth rate to 915 million units during the 1991 to 1996 period.

Based on Dataquest's final estimate of suppliers' 1991 SRAM market share, this article assesses the product life stage as of November 1992 for fast SRAMs in densities of 16K through 1Mb and slow SRAMs in densities of 64K through 4Mb. It also assesses the evolving supply/supplier base for these critical products today and for the remainder of this decade. In line with prior SRAM supply base reports by Dataquest's Semiconductor Procurement service (SPS), for purposes of this report we use an operating definition of fast SRAMs as SRAMs with access times at or less than 70ns. Slow SRAMs are defined as devices with access times of more than 70ns, including pseudo SRAMs (PSRAM).

As noted in prior articles in this series of IC supply base reports, a key element to the SPS strategy for SRAM demand management is for users to match system life cycles with SRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans against SRAM life cycles for the purpose of managing SRAM costs and planning for SRAM product changes in cases where system and SRAM life cycles do not match.

Modeled in the same fashion as previous Dataquest articles in our series of IC supply base reports, this article is organized in three main sections. The first section develops a guide to cost-effective procurement of SRAMs through the use of product life cycle analysis. The second section focuses on the top-ranked suppliers of SRAMs and looks at market positions, product strategies, and technology strengths of leading suppliers. The third section of this article combines the analyses of SRAM life cycles and the supplier base. This section supports users of SRAMs in assessing which direction to take for SRAM products and suppliers over the long term.

SRAM Product Life Cycles

This section uses information on SRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. This section also lays the basis for other analyses based on SRAM life cycle curves.

Typical Life Cycles for SRAM Products

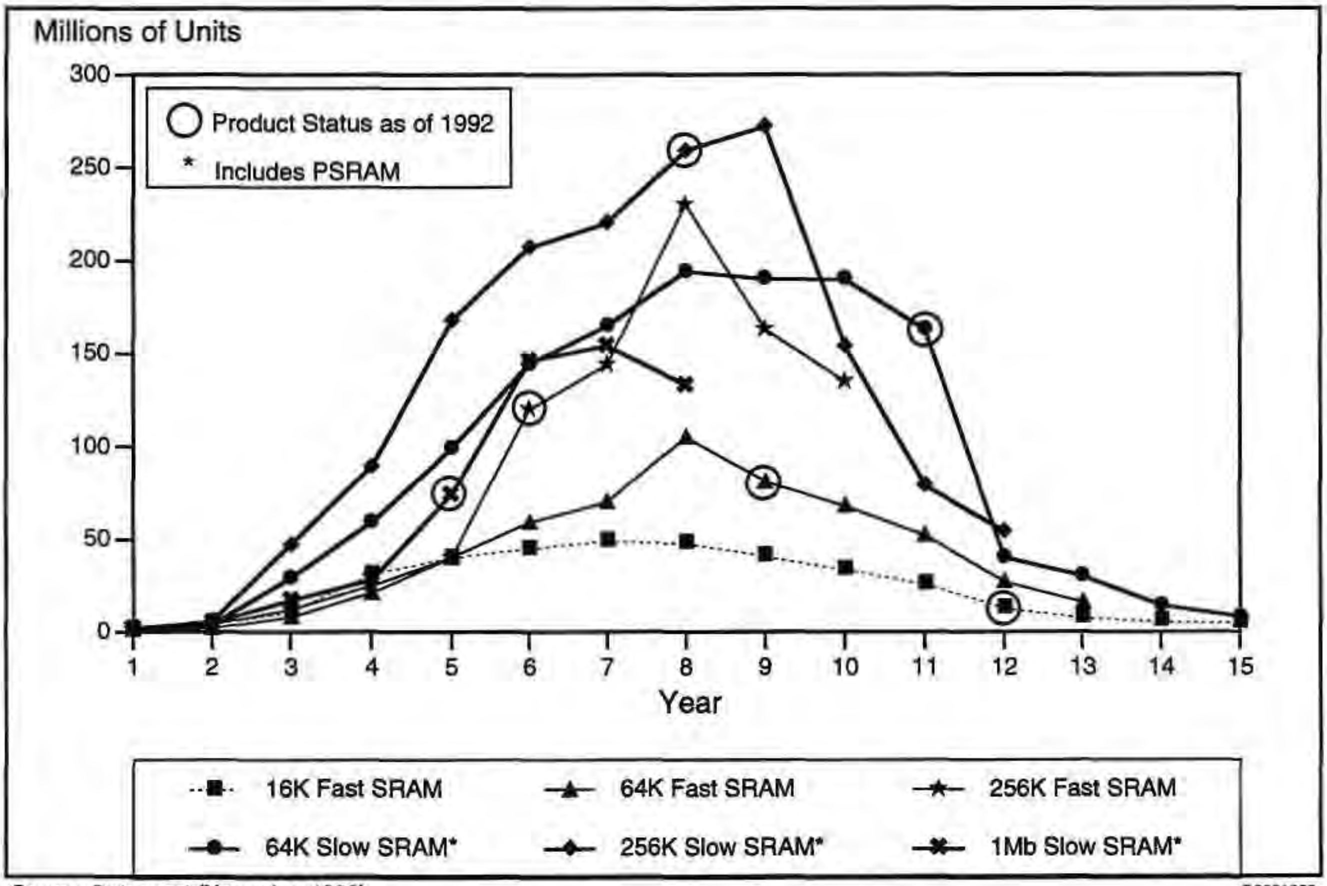
Figure 1 shows a series of curves that depict the life cycles of fast SRAMs with densities of 16K, 64K, 256K, and 1Mb and slow SRAMs with densities of 64K, 256K, and 1Mb. This figure is based on historic and projected unit shipment information.

Figure 1 reveals that SRAMs—excluding the R&D phase—historically experience a life cycle in the range of 12 to 15 years. Users of fast SRAMs can expect a decreasing supply of 64K parts in 1993—fewer than 70 million units versus just more than 80 million units for 1992. An exception is the sub-10ns niche, which continues to expand from less than 1 million units for 1992 to 2.6 million units for 1994. The supply of fast 16K SRAMs also continues to decline and should fall under 15 million units during 1992 as this part moves toward the end of a life cycle that started more than a decade ago.

Supply of 256K fast SRAMs should continue to grow—from 120 million units for 1992 to nearly 150 million units for next year. As stated in last year's report, supply of 1Mb fast SRAMs is expected to start to ramp up during 1993.

Regarding slow SRAMs—which include PSRAMs—Figure 1 shows that the 256K device has started to lose its position as a mainstream part, a trend will become more pronounced during 1993. Supply of 256K slow SRAMs/PSRAMs

Figure 1
SRAM Product Life Cycles, by Density (As of November 1992)



Source: Dataquest (November 1992)

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should decline sharply after 1993, falling from more than 250 million for 1992 to 154 million for 1994. The supply of 1Mb slow SRAMs/PSRAMs began to ramp during 1992 and should hit nearly 75 million units this year and exceed 100 million units for 1993.

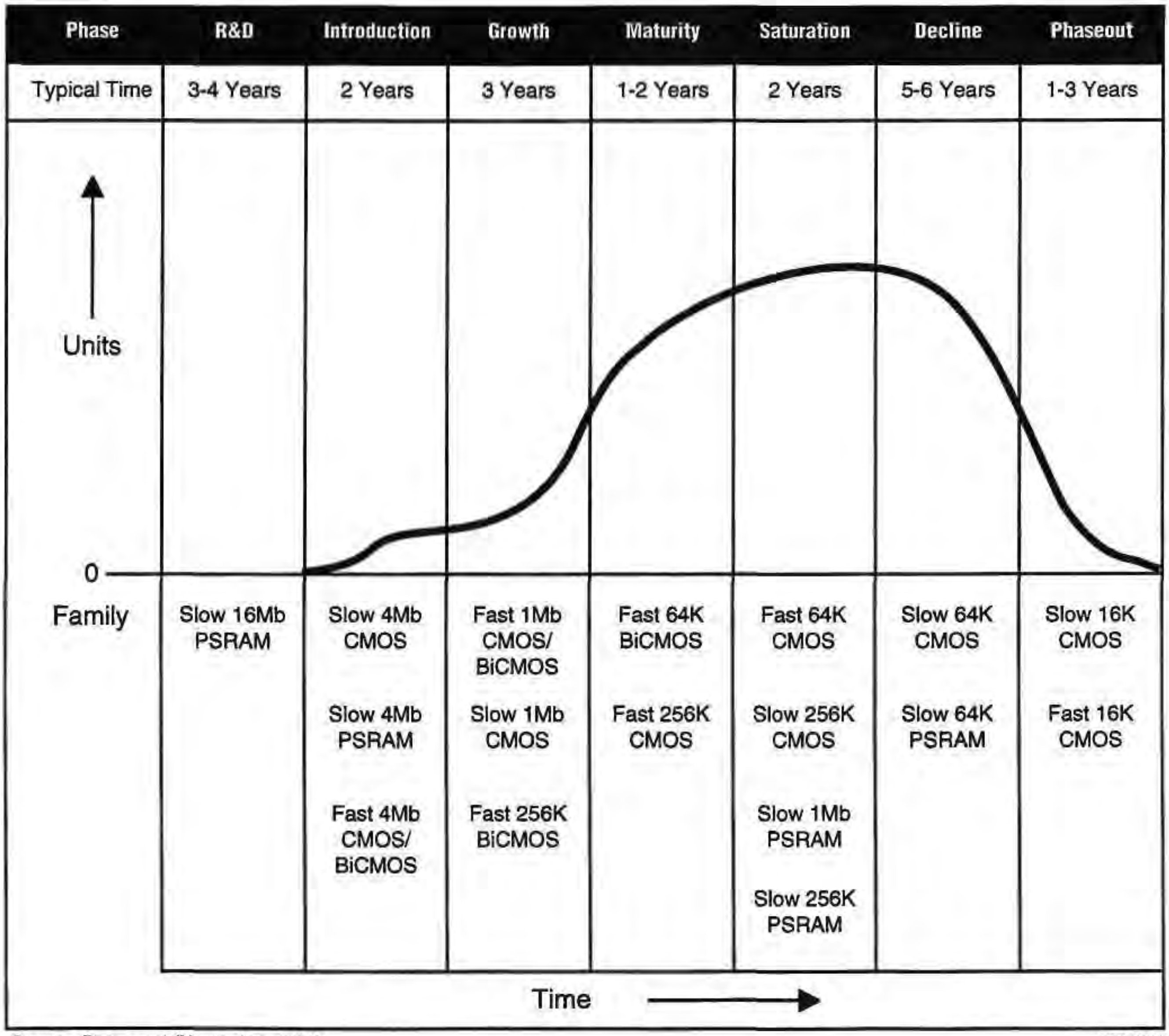
Figure 1 signals that users of 64K slow SRAMs can expect supply cutbacks. Barring an unexpected change in suppliers' strategies for this older market, 64K slow SRAM unit output should drop below 100 million during 1993 and decrease to 30 million units for 1994.

SRAM Life Cycle Stages

Figure 2 depicts SRAM life cycles on the basis of density and technology, breaking each stage of the cycle into specific time intervals. The SRAM R&D stage occurs over a three- to four-year period. The introduction and growth stages extend for five years. The peak maturity-saturation stage totals three years, which is somewhat shorter vis-a-vis other memory ICs.

Dataquest sees some shortening of the decline/phase-out stages of the SRAM life cycle. For example, in prior years Dataquest estimated the length of these stages as being in the range of 6 to 9 years—versus 5 years now. Two reasons account for this change of perspective. First, the decline of the military market should decrease the willingness of suppliers to support military and other specialized demand for extended periods. Second, in earlier generations of fast SRAM (such as 4K and 16K) suppliers periodically prolonged the product life cycle by introducing faster-speed versions of these densities. Now, suppliers such as Motorola aim to introduce the very-fast-speed parts in the *earlier*—and not later—stages of the life cycle.

Figure 2
SRAM Life Cycles, by Stage Over Time



Source: Dataquest (November 1992)

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SRAM Life Cycle Stages, by Density

Figure 2 shows that 16K fast SRAMs and 16K slow SRAMs approach the phase-out state on the part of most suppliers. The 64K slow SRAM is in the decline stage of its curve. For these devices, users should monitor the supply base or else forge longer-term user-supplier relations to protect against procurement disruption.

The 256K slow SRAM stands at the saturation stage of its life cycle. The decline stage for 256K slow SRAMs should start during 1994.

The 64K fast SRAM has moved into the decline stage of the life cycle. The life cycle of CMOS 256K fast SRAMs now moves through the peak maturity/saturation stage, while BiCMOS 256K devices still move through the growth phase.

The life cycle of 1Mb slow SRAMs and 1Mb fast SRAMs—which are in the growth stage—should extend until the end of the 1990s. The life cycle for 4Mb slow SRAMs and 4Mb fast SRAMs—which will continue to be introduced by suppliers—should extend toward the year 2000.

Supplier Analysis

This section analyzes the product and market strategies of the leading SRAM suppliers. This assessment covers market strategy, product positioning, and market ranking.

This assessment reflects recent SRAM supplier base. The supplier base remains poised for more reshuffling over the long term. For example, although Japan-based suppliers predominate in the SRAM business—especially the more lucrative higher-density segments—emerging market factors should result in some re-evaluation and reshuffling in the Japan-based SRAM supplier base over the next several years. Vertically integrated Japan-based suppliers have encountered lower system revenue during 1992, which should undercut *some* Japan-based suppliers' capital resources for sustaining leading-edge market positions. Another factor is that non-Japanese Asian suppliers, being Korea-and Taiwan-based manufacturers, are increasing their role in the market. This scenario applies to both local markets (such as United Microelectronics Corporation (UMC) of Taiwan in fast SRAMs) and worldwide markets (Samsung in slow SRAMs and fast SRAMs). A related factor among North America-based suppliers has been the rise of Motorola in the fast SRAM marketplace and recent slippage by smaller suppliers such as Cypress Semiconductor and Integrated Device Technologies.

Table 1 shows Dataquest's final 1991 worldwide market share ranking of the top suppliers for devices with densities of 16K to 1Mb.

Table 1 continues to show a wide supplier base for fast SRAMs and a more narrow base for slow SRAMs. The supplier base for fast SRAMs remains somewhat more flexible in terms of market entrants/departures vis-a-vis the slow SRAM supplier base. For example, the information in Table 1 contains names such as EDI, Paradigm, and Winbond Electronics Corporation, which might be less familiar to users of SRAMs. Other names such as AT&T, National Semiconductor, and Texas Instruments may be quite familiar to market players, but less so as suppliers of SRAMs.

The profiles of leading SRAM suppliers are presented in descending order of 1991 worldwide SRAM factory revenue, which includes internal captive consumption.

Hitachi

Hitachi ranks first in terms of 1991 worldwide SRAM factory revenue in part because of its structure as a vertically integrated supplier. As measured in 1991 unit shipments, Hitachi ranks first among suppliers of 256K fast and 256K slow SRAMs as well as 1Mb fast and 1Mb slow SRAMs. This major force in the SRAM business also ranks second in the 16K fast, 64K fast, and 64K slow segments, although those markets should be de-emphasized over time by Hitachi.

At Hitachi, internal consumption—for example, mainframes and supercomputers—drives fast SRAM product/process technology including the bipolar and BiCMOS processes. A recent slowdown in returns from systems' businesses—in part because of the worldwide recessionary environment but also because of restructuring of demand toward workstation systems—could undercut the long-term flow of SRAM R&D and capital spending.

Nevertheless, Hitachi should remain at the forefront of SRAM technology regarding product speed and density. In addition, as a leading supplier of DRAMs, Hitachi has DRAM technology development that enables it to advance its leadership role among suppliers of high-density slow SRAMs including PSRAMs.

Fujitsu Ltd.

Fujitsu advanced its market ranking by several notches during 1991 in terms of factory revenue. Even so, the company now confronts challenges similar to other vertically integrated Japan-based manufacturers. For example, internal captive demand requires that Fujitsu maintain the leading edge in fast SRAM technology and manufacture slow SRAMs. However, the systems business remains under restructuring pressure. In addition, the supplier faces increased competition in terms of new product introductions.

Regarding unit shipments, Fujitsu ranks third among suppliers of 64K slow, 256K fast, and 1Mb fast SRAMs and sixth in the 16K fast, 64K fast, and 1Mb slow SRAM segments. The company ranks 11th in the 256K slow SRAM arena.

Table 1
1991 Worldwide Ranking of Top SRAM Suppliers, by Density (Based on Unit Shipments)

	16K		64K		256K		1Mb	
Company	Fast	Slow	Fast	Slow[1]	Fast	Slow[1]	Fast	Slow[1]
AMD	10							
ATT	15		21		20			
Cypress	1		3		7			
Fujitsu	6		6	3	3	11	3	6
Goldstar		2	11			19		
Harris				22				
Hitachi	2	9	2	2	1	1	1	1
Hyundai		4		4		8		
IDT	3		10		10			
Inmos			13		21			
Matra MHS	7		8		13			
Matsushita				18		9		
Micron	8		5		6		4	
Mitsubishi	14		7	15	9	4		5
MOSel		12	20	16	11	13	11	
Motorola	5		4		5		9	
National Semiconductor			22	24	14	22	7	
NEC	15	15	14	8	16	2	6	4
Paradigm					12		8	
Oki		13		17		12		8
Performance	9		12		15			
Philips				13				
ROHM		6		20		20		
Samsung			23	6	22	6		6
Sanyo		1		5		17		
Seiko		10	19	14		7		9
SGS-Thomson[2]	4	7	9	10	17	14		
Sharp	13	3	16	1	8	10	5	7
Sony	10	11	11	9	4	5	2	3
Texas Instruments			17					
Toshiba	12		1	7	2	3	12	2
Vitelic	16		25					
UMC	11	5	18	12	23	16		
Winbond		8	15	19	18	23		

[1]Includes pseudo SRAMs.
[2]Excludes Inmos.
Source: Dataquest (November 1992)

Toshiba Corporation

Toshiba, another vertically integrated Japan-based manufacturer, continues to rank as a leading player in the slow SRAM marketplace and a major factor in the fast SRAM segment. Although Hitachi focuses quite strongly on leading-edge fast SRAM technology, Toshiba's strategy centers somewhat more so on slow SRAMs along with mainstream fast SRAMs. Toshiba ranks second in the 1Mb slow SRAM segment and third in the 256K slow SRAM marketplace. The slow SRAM product portfolio includes PSRAMs. Toshiba ranks first in the 64K fast SRAM segment, second in today's mainstream 256K fast SRAM arena, and twelfth in the now expanding 1Mb fast SRAM business.

NEC Corporation

NEC is another vertically integrated Japan-based supplier. Unlike Hitachi and Fujitsu, NEC's internal captive demand slants *less* toward leading-edge fast SRAMs.

Table 1 shows that NEC ranks second in terms of unit shipments of 256K slow SRAMs and fourth in 1Mb slow SRAM units. Users of slow SRAMs can expect NEC to play a continuing strong role in the slow SRAM business including next-generation 4Mb devices. Regarding fast SRAMs, NEC ranks sixth in the emerging 1Mb business but below the top tier in the lower-density segments.

Sony

Sony—still another vertically integrated Japan-based company—has earned a leadership reputation in terms of SRAM product technology and market strength. Sony ranks among the top five suppliers in terms of 256K fast SRAM and 256K slow SRAM unit shipments and also the 1Mb fast SRAMs and 1Mb slow SRAMs. Sony's strategy aims for leadership in densities of 1Mb and greater and gradual de-emphasis on densities of 256K and below.

For Sony, the fast SRAM is a technology-process driver, and SRAM serves as a critical element to Sony's product portfolio and long-term IC market strategy. Like other vertically integrated Japan-based suppliers, Sony must adjust to the aftermath of the worldwide economic slowdown. However, it continues to do well because of its focus on higher-density SRAMs.

Mitsubishi Electronics Corporation

Mitsubishi maintained its overall ranking as measured in factory revenue in this highly competitive business during 1992. The strategy at Mitsubishi, a vertically integrated Japan-based supplier, calls for a long-term commitment to the SRAM technology. Mitsubishi ranks fourth in terms of unit shipments among suppliers of 256K slow SRAMs and fifth in the 1Mb slow SRAM marketplace. Mitsubishi ranks among the top 10 suppliers of 64K fast and 256K fast SRAMs and is moving into the fast 1Mb arena.

Motorola Incorporated

Motorola continues to advance in the worldwide memory market, boosting its worldwide SRAM ranking in terms of factory revenue by one notch during 1991. Motorola focuses on the high-density fast SRAM segment, which offers higher selling prices and profit margins versus low-density SRAMs and other memory ICs. Motorola's product direction in SRAMs links to its role as a supplier of application-specific memories. Motorola aims to introduce leading-edge product speeds based on its BiCMOS process (such as 256K SRAM 10ns).

Motorola ranks among the top five suppliers of fast SRAMs in densities of 16K fast, 64K, and 256K. Users should expect Motorola—now ranked ninth—to advance in the 1Mb fast SRAM marketplace.

Cypress Semiconductor Corporation

Cypress, a relatively small supplier that focuses on fast SRAMs as a technology-process driver, experienced companywide challenges during 1991. Cypress lost one place regarding SRAM market ranking as measured in factory revenue. Regarding unit sales, Cypress ranks first among suppliers of 16K fast SRAMs and third among 64K fast SRAM suppliers—two segments marked by a host of new competitors. Cypress lags, however, at the critical higher densities where competition is less brutal and pricing/profit margins are higher.

The North America-based supplier faces market pressure in terms of remaining at the leading edge of fast SRAM product technology. Even so, Cypress remains a viable competitor. Management is carefully evaluating the current and future direction of all product technologies including fast SRAMs. Users should expect continued adherence by Cypress to pushing fast SRAM technology including product density, configuration, and speed during 1993—in fact, to accelerate the rate of fast SRAM technical innovation so as to regain market stature and strategic posture.

Sharp

Sharp has garnered great market recognition from other memory products, for example, ROM or the Intel alliance on flash memory. Regardless, vertically integrated Sharp ranked ninth among the top 10 suppliers of SRAM during the 1990 to 1991 period.

Like other Japan-based suppliers, Sharp must balance memory R&D/manufacturing budgets in line with a drop in system revenue. Sharp announced discontinuation of DRAM technology development plans during the second half of 1992, which should be an even stronger commitment to the SRAM business.

Sharp ranks among the top 10 suppliers of 256 fast and 1Mb fast SRAMs, which places it in a good position regarding the mainstream product technology through 1993. Sharp ranks seventh among suppliers of 1Mb slow SRAM, another mainstream product. Sharp sells slow SRAMs through North American suppliers such as EDI and National Semiconductor.

Samsung Electronics Company Ltd.

Samsung, the vertically integrated Korea-based supplier, aims to make an aggressive advance in the global SRAM marketplace. Samsung ranks sixth across-the-board in the slow SRAM business—64K, 256K, and 1Mb densities. Users should expect continued commitment by Samsung to serving slow SRAM demand, *especially* should trade friction impede the company's DRAM effort.

The big news concerns Samsung's plans for the fast SRAM business. Samsung appears to lag the market leaders in the fast SRAM arena. However, during the second quarter of 1992 it introduced a broad range of fast SRAMs in densities of 64K, 256K, and 1Mb. Then, late in the third quarter of 1992, Samsung announced samples of state-of-the-art 1Mb BiCMOS SRAM that operate at a speed of 10ns. Samples of Samsung's 256Kb BiCMOS SRAM 8ns were scheduled for release during the first quarter of 1993—signaling Samsung's intent to compete against suppliers such as Hitachi, Fujitsu, and Motorola.

Supply Base Analysis

This section uses information on SRAM product life cycles and SRAM suppliers to present an evaluation of the supply/supplier base for these devices in the 16K, 64K, 256K, 1Mb, and 4Mb densities during 1993 and over the long term. Product life cycle analysis serves as the basis for a succinct assessment from the users' viewpoint of the anticipated supply base for each SRAM density. Table 1 serves as the basis for the supplier analysis. This assessment aims to provide users with advice for choosing suppliers.

In addition to the information on suppliers in Table 1, users in Europe and North America should note supplier leadership for their respective regions. Regarding Europe, leading SRAM suppliers, in descending order (measured in factory revenue) are as follows: Hitachi, NEC, Toshiba, Matra MHS, Motorola, SGS-Thomson, Mitsubishi, Samsung, Sony, Cypress Semiconductor, Micron Technology, and Hyundai. For North America, the regional ranking also shows Hitachi first, followed by Toshiba, Cypress Semiconductor, Motorola, Micron Technology, Fujitsu, Mitsubishi, NEC, Sony, Integrated Device Technology (IDT), Samsung, and MOSel.

Supply Base for 16K Fast SRAMs

Figures 1 and 2 reveal that 16K fast and 16K slow SRAM are moving toward the phase-out stage of the life cycle. Regarding 16K slow SRAM, the information in Table 1 shows that users should focus on the following suppliers—Sanyo (24 percent share of unit shipments), Goldstar (17 percent), Sharp (13 percent), and Hyundai (12 percent).

Users of fast 16K SRAMs continue to face a tighter supply scenario as this product moves through the latter stage of its life cycle. As recommended last year, supply base managers with systems that use 16K fast SRAMs should plan for system redesigns during the 1993 to 1994 period. As noted, the decline/phase-out stage of the life cycle for fast 16K SRAMs has contracted somewhat during the past year, which could mean procurement challenge for some users (such as military users) during the 1993 to 1994 period.

Users of 16K fast SRAM must monitor suppliers' medium-term strategies for serving demand for these devices. Most suppliers are reevaluating their strategy for this segment. For example, during late 1992 and the first half of 1993 suppliers will signal their intention to remain or withdraw from this market.

Based on 1991 unit shipments, market leaders are as follows, Cypress (19 percent share), Hitachi (15 percent), IDT (15 percent), SGS-Thomson (11 percent), Motorola (10 percent), Fujitsu (10 percent), and Matra MHS (6 percent).

Cypress's product portfolio focuses on devices with the full range of access times, but especially faster than 45ns. IDT's strategy parallels that of Cypress. Based on 1993 unit shipments, Cypress holds 25 percent share of the market for sub-20ns devices, which places it third behind Micron (37 percent) and Performance Semiconductor (26 percent).

Hitachi focuses on devices that operate at a speed of 20ns or slower. Hitachi joins Cypress as coleader based on 1991 unit shipments in the market for 16K SRAMs that operate at 20ns to 44ns. These two suppliers each hold a 22 percent share, followed by IDT and Motorola at 18 percent each.

SGS-Thomson and Fujitsu focus on fast SRAMs that operate at 45ns to 70ns. These suppliers hold 24 percent and 22 percent share, respectively, of 1991 unit shipments. Other leading suppliers include Cypress (13 percent), IDT (11 percent), Matra MHS (11 percent), and Hitachi (9 percent).

Supply Base for 64K SRAMs

Buyers of fast 64K SRAMs now face a somewhat less favorable long-term supply situation vis-a-vis the outlook of one year ago.

Supply Base Outlook for Fast 64K SRAMs

Figure 2 shows that 64K fast SRAMs now stand at the decline stage of the life cycle. Suppliers will focus on devices that operate at speeds of faster than 45ns because these parts command higher pricing. Users should note that the x4 configuration likely will have a somewhat longer life cycle than organizations such as the x1.

First-tier Japan-based suppliers will de-emphasize this density for higher-density devices. Users—depending on their region—should focus on suppliers such as Cypress, Matra MHS, SGS-Thomson/INMOS, IDT, and Performance. Less familiar market suppliers for evaluation include AT&T, Winbond, and UMC.

Cypress' 64K fast SRAM market strength has centered on CMOS devices across the full range of speeds and especially faster than 45ns. Motorola has established a market position in the CMOS segments. Motorola's product portfolio focuses exclusively on devices that operate faster than 45ns. Micron also concentrates exclusively on products with sub-45ns access times. Matra MHS supplies devices that operate faster than 20ns. However, its largest market share rests at slower speeds, for example, 45ns and slower. SGS-Thomson has also centered its position on the 45ns and slower marketplace.

Regarding market share in terms of product speed segmentation, based on 1991 unit shipments, Micron leads the ranking in the sub-20ns segment with 22 percent, closely followed by Motorola (19 percent), Performance Semiconductor (18 percent), Hitachi (16 percent), Cypress (9 percent), Toshiba (8 percent), and IDT (6 percent).

In the 20ns to 44ns segment of the 64K SRAM business, Toshiba (16 percent) ranks first in terms of 1991 unit shipments. North America-based suppliers follow—Cypress (13 percent), Motorola (13 percent), and Micron (12 percent). Other leading suppliers include Japan-based companies Hitachi (9 percent), Fujitsu (7 percent), Mitsubishi (6 percent), and Sony (6 percent)—along with IDT (5 percent). During 1992, UMC, a Taiwan-based supplier, increased pricing competition in this product segment, especially in the Asia/Pacific-Rest of World (ROW) region.

For users of 64K SRAMs that operate at speeds of 45ns to 70ns, the supplier base is more regionally dispersed. For example, Fujitsu joins Matra MHS and SGS-Thomson in the leadership position—each holds 13 percent share of 1991 unit shipments—followed by Hitachi (12 percent) and Inmos (11 percent). Like UMC, Taiwan-based Winbond (5 percent) demonstrated competitive pricing competition in this segment during 1992 in the Asia/Pacific-ROW region.

Supply Base Outlook for Slow 64K SRAMs

The supplier base for slow 64K SRAMs could contract somewhat abruptly during the 1993 to 1994 time frame as this product continues to move through the decline stage of its life cycle. As shown in Table 1, Sharp ranks first in terms of worldwide unit shipments. Other Japan-based suppliers such as Hitachi and Fujitsu have migrated in effect to higher-density slow SRAMs.

In addition to Sharp and Sanyo of Japan—who held 17 percent and 9 percent shares of 1991 worldwide unit shipments—users that need long-term supply of 64K slow SRAM should concentrate on non-Japan-based suppliers. The supplier base includes Korea-based suppliers—Hyundai (9 percent), Samsung (9 percent), and Goldstar (3 percent)—along with Europe-based SGS-Thomson (5 percent) and Taiwan-based UMC (2.4 percent).

Users should note, however, that all suppliers are re-evaluating their longer-term commitment to this segment of the SRAM marketplace.

Supply Base for 256K SRAMs

Users of 256K SRAMs face a favorable long-term supply base. Figure 2 shows that 256K fast SRAMs stand at the late-growth/early-maturity stage of the life cycle. 256K slow SRAMs have moved further along the life cycle curve to the late saturation stage.

Supply Base Outlook for Fast 256K SRAMs

Worldwide unit shipments of 256K fast SRAMs should peak during 1994 at more than 200 million units. By 1995, supply of 256K devices that operate at speeds of 20ns or slower will start to decline. However, the much smaller sub-20ns 256K marketplace should still be growing.

Regarding product speed segmentation, based on 1991 unit shipments, Motorola (56 percent share) has positioned itself in the sub-20ns segment along with Hitachi (29 percent) and Toshiba (12 percent). Historically, Japan-based suppliers lead in leading-edge fast SRAM product markets. The BiCMOS process is a key competitive element in this potentially lucrative high-priced segment.

Leading suppliers of 256K devices that operate at speeds from 20ns to less than 45ns include Fujitsu and Toshiba—each with 18 percent of 1991 unit shipments—followed by Micron Technology (11 percent), Motorola (10 percent), Hitachi (9 percent), Cypress (6 percent), and Sony (6 percent), among others. North America-based suppliers including AT&T, National Semiconductor, Paradigm, and Performance Semiconductor serve demand for these parts.

For 256K devices that operate at speeds from 45ns to 70ns, Japan-based suppliers hold major market shares. Hitachi (30 percent) leads the ranking, followed by Sony (24 percent), Mitsubishi (12 percent), and Sony (8 percent). Table 1 shows that other suppliers include Cypress, EDI, Inmos, MOSel, Matra MHS, NEC, SGS-Thomson, and Winbond.

Supply Base Outlook for Slow 256K SRAMs

Users of 256K slow SRAMs face a generally favorable supply base outlook through 1993. However, the supply should contract somewhat dramatically thereafter. For example, worldwide output of 256K slow SRAM should reach 200 million units for 1993 and be augmented by nearly 70 million units of 256K PSRAM. Some Japan-based suppliers likely will migrate from this marketplace—especially in the second half of 1993—such that output should drop to 100 million units of 256K slow SRAM for 1994.

Based on 1991 unit shipments, NEC (18 percent share) ranks as the leading supplier with a host of Japan-based suppliers following—Mitsubishi (14 percent), Sony (12 percent), and Hitachi (10 percent). For 256K PSRAM, Hitachi and Toshiba lead the market, joined by Sharp.

As in the 64K slow SRAM marketplace, users should view Korea-based suppliers of 256K slow SRAM—Samsung (9 percent) and Hyundai (5 percent)—as suppliers likely to increase their focus on this market during 1993.

Supply Base for 1Mb SRAMs

Figure 2 reveals that slow 1Mb SRAMs continues to move through the growth (or ramp) stage of a life cycle. The fast 1Mb SRAM product has moved into the growth stage of the cycle although suppliers continue to enter the marketplace. The BiCMOS technology competes against the mainstream CMOS technology for high-performance fast SRAM applications.

Supply Base for 1Mb Fast SRAMs

Although the market just started to develop during 1991, in terms of product speed segmentation based on 1991 unit shipments of 1Mb fast SRAMs, Hitachi and Motorola are staking early positions in the leading-edge sub-20ns segment. Leading suppliers of 1Mb SRAMs that operate at speeds from 20ns to less than 45ns include Hitachi, Micron Technology, Sharp, NEC, National Semiconductor, Paradigm, Motorola, EDI, MOSel, and Toshiba.

Regarding 1Mb slow SRAMs that operate at speeds from 45ns to 70ns, Japan-based suppliers hold early market share leadership. In terms of 1991 unit shipments, Hitachi and Sony each held just more than one-third of the marketplace, and Fujitsu just less than a third. Micron also shipped this product during 1992.

Supply Base for 1Mb Slow SRAMs

Japan-based suppliers continue to dominate the 1Mb slow SRAMs business. Hitachi leads with a 29 percent share of 1991 unit shipments, trailed by Sony (19 percent), NEC (15 percent), Toshiba (12 percent), and Mitsubishi (11 percent). As noted earlier, regarding low-density slow SRAMs, users should monitor Korea-based suppliers such as Samsung (10 percent share).

For users of 1Mb PSRAM, Hitachi and Toshiba lead the market, joined by Sharp and Samsung.

4Mb SRAMs

Figure 1 reveals that 4Mb slow SRAMs are moving into the introductory stage of the product life cycle. This pace of the introduction of this next-generation product density has lagged based on original expectations. For example, during 1991 only Hitachi and Toshiba entered the marketplace, each with 4Mb PSRAM. During 1992, the following suppliers also entered the marketplace—Fujitsu, NEC, and Samsung.

Dataquest Perspective

For users, the slow SRAM supplier base has been viewed since the mid-1980s as essentially the DRAM supplier base stripped of non-Japan-based companies. That reality is shifting with the emergence of Korea-based suppliers of slow SRAMs including Goldstar, Hyundai, and Samsung. Japan-based suppliers have been reevaluating their long-term capital plans for the DRAM/slow SRAM markets—a review reinforced by disappointing 1992 high-performance system sales. Korean suppliers—DRAM trade friction aside—should emerge as even more critical to the worldwide users of slow SRAMs.

In the fast SRAM arena, the supplier base remains quite vibrant and competitive—brutally competitive in the 16K and 64K segments—which means continuing pressure for smaller-size suppliers. Motorola's relentless rise to the ranks of leading-edge suppliers such as Hitachi and Fujitsu bodes ill for smaller-size suppliers such as Cypress and IDT. The fast SRAM business still offers some "niche" market opportunities, but in reality the market continues to evolve into a global commodity-type business. The only real niche will be the fastest-speed/highest-density device—where industry giants such as Hitachi and Motorola focus their strategic effort. With the emergence of price-competitive Taiwanese suppliers such as UMC and Winbond, the only small to medium-size suppliers that will succeed—and survive—will be well-managed companies that adhere closely to their new product/technology road map.

By Ronald Bohn

News and Views

Procurement Pop

Table 1 shows 1991 U.S. and Japanese semiconductor manufacturer R&D expenditure as a percentage of revenue.

Table 1
U.S. and Japanese Semiconductor Manufacturer R&D Expenditure As a Percentage of Revenue

Company	1991 Percentage
United States	
Advanced Micro Devices	17.0
Altera	13.0
Analog Devices	17.0
Chips & Technologies	32.0
Cypress Semiconductor	26.0
Harris	12.0
Integrated Device Technology	24.0
International Microelectronic Products	31.0
Intel	15.0
LSI Logic	12.0
Linear Technology	10.0
Micron Technology	8.0
Motorola	10.0
National Semiconductor	12.0
SEEQ Technology	17.0
Texas Instruments	13.0
VLSI Technology	13.0
Xicor	24.0
Japan	
Fujitsu	16.4
Hitachi	18.4
Matsushita	19.5
Mitsubishi	19.0
NEC	14.8
Oki	12.0
Sanyo	13.8
Sharp	17.6
Sony	23.1
Toshiba	15.1

Source: Dataquest (November 1992)

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

Q. What is the latest status regarding the "P-5" product?

A. Intel has named its next-generation "P-5" microprocessor the Pentium. This device will run at 66 MHz and be offered with and without on-board cache RAM.

Pentium chip pricing with cache RAM is about \$1,500; without cache RAM it is less than \$1,000. These noncache-device prices are similar to the introductory price of Intel's 80486DX.

In the meantime, competitor Cyrix has successfully cloned and introduced a true 486DX device; Advanced Micro Devices plans to introduce its version of the 486DX device in December. AMD's announcement follows a recent legal decision in its ongoing 287 microcode case. The Cyrix 486-25 has an internal speed of 50 MHz and is priced at \$249.

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On the topics in this issue .... Mark Giudici, Director (408) 437-8258
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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9210 October 26, 1992

In This Issue...

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File inside the *Dataquest Perspective* binder labeled Semiconductor Procurement

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing*

Device Family	United States	Japan	Europe	Taiwan	Korea
74AC00	0.18	0.17			0.14
74AC138	0.34	0.32			0.21
74AC244	0.44	0.26			0.36
Lead Time: (Weeks)	4	5			5
4F00	0.10	0.11			0.09
4F138	0.16	0.18			0.14
4F244	0.22	0.26			0.22
Lead Time: (Weeks)	4	5			5
7805-TO92	0.16	-			0.15
IMSG171D-35-MHz	5.44	-			-
Lead Time: (Weeks)	-	4			-
DRAM 1Mbx1-8	2.98	3.22			2.65
DRAM 1Mbx9-8	27.50	27.63			-
DRAM 256Kx16-8	12.05	11.89			-
DRAM 4Mbx1-8	10.28	10.46			9.60
DRAM 4Mbx4-70	102.50	113.02			-
DRAM 512Kx9-7	13.25	11.22			-
EPROM 2Mb 170n	-	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			-
Lead Time: (Weeks)	8	6			-
68040-25	385.00	100.46			-
80386DX-40	-	100.46			74.00
80386SX-20	52.00	40.18			32.00
80486DX-33	204.00	326.50			-
R3000-25	93.00	-			-
Lead Time: (Weeks)	8	-			-

*Prices in U.S. dollars
**Data collection was insufficient to warrant a full report. We expect a full report to appear in the November table.
Source: Dataquest (October 1992)

Market Analysis

October Procurement Pulse: Inventories Down, Lead Times Up, and Bookings Are Flat

The Procurement Pulse is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rate Expected to Plateau While Prices Resume Declining Ways

The semiconductor booking outlook of this month's respondents remains flat with last month's forecast (see Figure 1). The static order rate expectations tie in with an average lower six-month overall and computer systems sales outlook, relative to last month. The overall sample six-month forecast fell from last month's 9.1 percent to a current 6.8 percent prognostication, while the computer subset expects six-month sales levels to be 7.0 percent higher, compared with last month's 9.0 percent view. This month's respondents estimated that overall end-equipment sales rose over last month by 6.1 percent, while the computer subset of our sample also saw a rise, albeit a lower 3.7 percent uptick.

Overall semiconductor prices are expected to continue to fall by slightly less than 2 percent (1.8 percent), reflecting continued good availability for most devices, while one respondent noted an overall 2 percent price rise. The surface mount technology (SMT) standard logic supply situation continues, with another strong 73 percent of the respondents noting delivery problems and price increases for these devices. As mentioned in earlier reports, it is expected that this

Figure 1
Averaged Monthly Semiconductor Orders

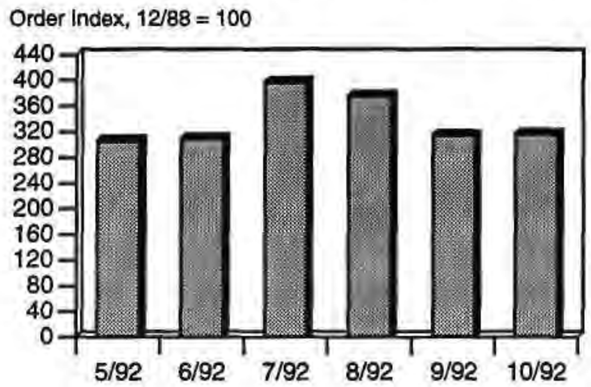


Figure 2
Averaged Semiconductor Lead Times

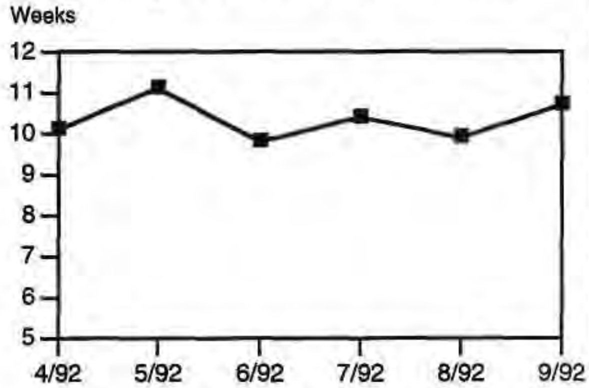


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

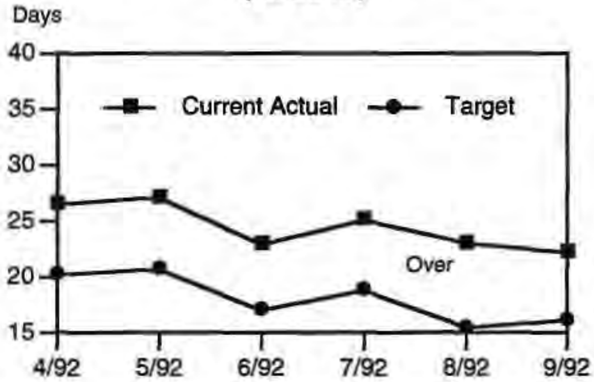
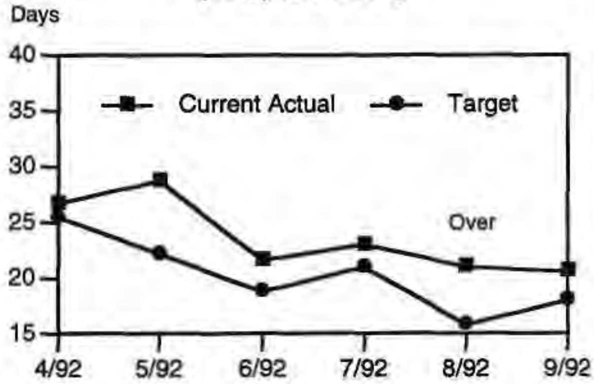


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (October 1992)

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assembly-related problem will resolve itself, as many of the suppliers have already begun to add SMT assembly capacity that should be online within two to three months. Besides standard logic, other SMT products (TSOP SRAMs, SOIC linear devices, and some discrete semiconductors) are firming in price as aggregate demand begins to surpass some suppliers' capacity limits.

Semiconductor Lead Times See-Saw Up Again

The average lead time for semiconductors inched upward this month to 10.7 weeks from last month's 9.9-week average (see Figure 2). This slight increase in the average is attributed to the continuing extended lead times for surface mount logic combined with selected SMT memory parts that in some cases have reached 16 to 24 weeks. Apart from the SMT situation, the majority of products still have manageable lead times in the range of 6 to 9 weeks, with DIP standard logic devices still available in 4 weeks. Evidence from some memory suppliers is that overall lead times may begin to stretch out by the end of the year as a result of continual steady demand slowly filling the capacity pipeline. Dataquest expects current semiconductor capacity (and the resulting steady lead times) to adequately meet demand levels through the next three to six months, barring a draconian verdict in the pending Micron versus Korean memory supplier International Trade Commission/U.S. Department of Commerce (ITC/DOC) case. It is possible for demand to balance overall capacity by mid- to late 1993, especially if—in an unlikely event—the domestic Japanese electronics market turns around.

Semiconductor Inventories Remain Under Control

The continued reduction/maintenance of inventory levels from this month's respondents attests to the focus on inventory control, despite specific device delivery problems. It also highlights that overall semiconductor availability remains predictable and that user-supplier communication has improved. The overall targeted and actual semiconductor levels this month were 16.1 and 22.2 days, compared with last month's respective 15.4- and 23.0-day levels (see Figure 3). The computer subset respondents averaged targeted 18.0- and actual 20.6-day levels, relative to last month's respective 15.8- and 21.0-day target/actual range (see Figure 4).

Although inventory reduction is still a key goal, a comfort zone of slightly more than a month of on-hand inventory appears to be taking shape, and an average target of 3 weeks is now the new accepted goal. As mentioned last month, availability of semiconductors combined with good communication is at the heart of the current low-inventory level situation. To maintain low inventories regardless of availability, regular and persistent communication with suppliers must be adhered to because, as the saying goes, "the squeaking wheel gets the grease."

Dataquest Perspective

The continued strength of the U.S. electronics market is being fueled in part by ever more affordable high-performance (that is, 386 and up) PC offerings and their "necessary" peripherals—laser printers, memory additions, and graphic cards, among others. Continued good overall availability of semiconductor components is allowing the price wars at the system level to descend to the semiconductor level, where competitive pricing has become a way of life. As other areas of the electronics market show increased signs of growth (that is, transportation and telecommunication), additional stress will be placed on existing capacity that will call for increased attention at the forecast/supplier communications level. The pending outcome of the Micron versus Korean memory supplier antidumping case in the extreme could have a serious impact on Samsung, Goldstar, and Hyundai, as well as the users of memory devices from these companies, or it could leave the suppliers unaffected. If the Korean companies are found guilty of dumping DRAMs, preliminary penalties could force users to investigate alternate suppliers or alternate means of acquiring these Korean devices. Stay tuned for the outcome of this important ITC case.

By Mark Giudici

Procurement Issues 1993: Is the Law of Supply and Demand Subject to Appeal?

Mark Giudici and Ronald Bohn of the Semiconductor Procurement Service (SPS) made a joint presentation on 1993 Procurement Issues entitled, "Is the law of supply and demand subject to appeal?" at the Dataquest 1992 Semiconductor Conference held in Monterey, California on October 6. The presentation explored three specific areas of interest: key procurement issues based on a recent client survey; product technology and price trends; and emerging technologies affecting semiconductor procurement. Three main points highlighted in the presentation were as follows:

- Cost control
- Competitive pricing
- Benchmarking

We examined the impact on procurement of the now fragmenting 32-bit microprocessor market and the next-generation "specialty" memory offerings and how they translate into deliverable, cost-effective solutions. The session ended with a discussion revolving around two, new technologies that are and will continue to affect semiconductor users: flash memory and 3V semiconductor devices.

Procurement Issues

SPS conducted a telephone survey of its top 20 U.S. clients to uncover the key issues they expect to face in the upcoming year. The respondent companies represented estimated 1991 electronic sales of $170.4 billion and estimated 1991 semiconductor purchases of $1.7 billion.

The respondents' title and industries represented were as follows:

- Purchasing Manager/Senior Buyer: 50 percent
- Procurement Manager/Component Engineer: 35 percent
- Buyer: 15 percent
- Data Processing/Communication: 50 percent
- Industrial/Consumer: 43 percent
- Military/Transportation: 7 percent

As mentioned, the three main points of the Procurement Issues presentation revolved around cost control, competitive pricing, and benchmarking. The constant focus on cost control over the past two-plus years is expected to continue as electronics companies cope with increasingly competitive markets. A large part of cost control is price and competitive pricing, which will remain a closely scrutinized area, another result of the ongoing system price wars expected to continue through 1993. In line with competitive pricing, the global marketplace is causing many companies to benchmark their total cost variables (quality, price, delivery schedules, and inventory levels, among others) on a regional basis in order for them to remain competitive.

From the actual survey, this year's respondents reported that the top three issues were cost control, lead times, and availability/allocation (see Table 1). In historical perspective, these have not been critical issues. Because cost control encompasses most if not all of the other individual issues, this sampling of procurement managers has become more sophisticated in coordinating efforts to reduce overall cost through lead time reduction, competitive price negotiation, and development of strong supplier relations.

Table 1
Historical Procurement Issues

	1993	1992	1991	1990	1989	1988
Cost Control	1	6	3	3	7	4
Lead Times	2	-	-	-	-	-
Availability/Allocation	3	4	2	4	1	1
Pricing	4	1	1	2	2	2
Developing Supplier Relations	5	10	-	-	-	-
Quality/Reliability	6	2	5	6	4	6
JIT/Inventory Control	7	7	4	5	6	9
Memory Products	8	0	0	0	5	5
On-Time Delivery	9	3	6	1	3	3
Packaging Standards	10	-	-	-	-	-

Source: Dataquest (October 1992)

Although the individual issues remain, the combination of effectively balancing them toward the goal of tangible cost control remains the key concern.

As we did last year, this year we asked respondents to rank the variables that comprise total cost. As seen in Table 2, there has been little change in the priority of total cost parameters. Quality and on-time delivery remain prerequisites for cost control, while overall price, technical support, and customer service continue to be differentiators in the current market. If and when suppliers fill their semiconductor capacities next year, it is estimated that on-time delivery will also become a supplier differentiation.

This year we asked what top technical needs of semiconductor users were not being met by suppliers (see Table 3).

Nearly one-third of the respondents needed more wide-word, specialty memories earlier and in higher volume for testing, evaluation, and production. One-quarter of those with unmet technical needs noted the broad area of ASICs—primarily in choosing a particular ASIC solution in terms of supplier viability, process characterization, and long-term migration paths for the product. On a similar note, one-fifth of the respondents noted a lack of clearly defined standard logic alternatives as systems become increasingly integrated. This involves the ASIC system solution dilemma (need No. 2) because many current, standard logic functions will be integrated into ASIC parts. ASIC suppliers need to have better migration plans for current and prospective customers as mature, standard logic devices lose their technical edge.

Table 2
Ranking of Total Cost Variables

1992	Issue	1991
1	Quality	1
2	On-Time Delivery	2
3	Overall Price	3
4	Technical Support	4
5	Customer Service	4

Source: Dataquest (October 1992)

Table 3
Top Three Unmet Technical Needs

	Need	Percentage
1.	Specialty/Next-Generation Memories	30
2.	ASICs	25
3.	Standard Logic Alternatives	20

Source: Dataquest (October 1992)

Another area of interest was contract manufacturing. As seen in Figure 1, nearly two-thirds (65 percent) of the respondents had used a contract manufacturer (CM). Of this percentage, a CM was in service an average 7.5 years. The trend toward contract manufacturing is not new to this set of respondents; many cited lower total costs, equal or better quality, and on-time delivery as the reasons to go with a contract manufacturer.

Pricing and Technology Trends

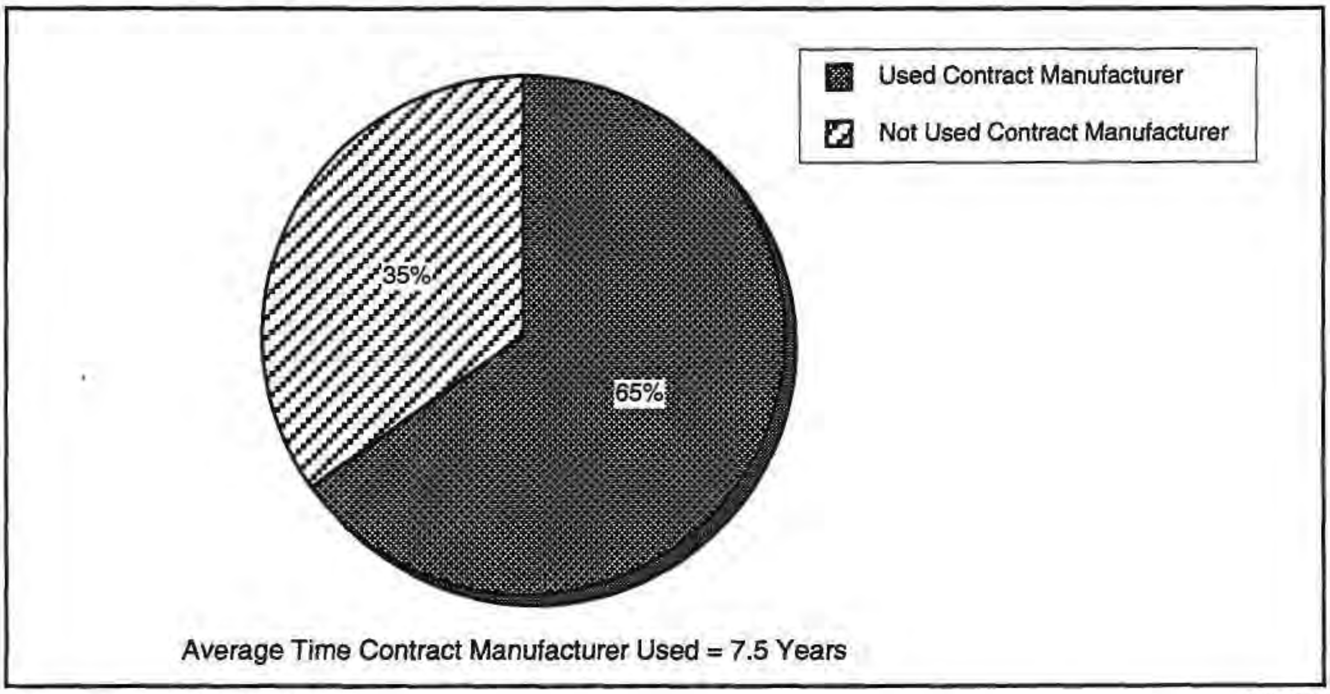
As noted, benchmarking—specifically, price benchmarking, which directly relates to the cost-containment trend—serves as a background to our discussion of microprocessor and memory IC price trends. The title given this article was chosen to highlight the conflict between the economic and legal systems. The interplay and conflict between IC market economics and the law provides a second backdrop to the discussion.

32-Bit MPUs

Intellectual property law has moved to the forefront among issues that have been affecting 80486 price trends during 1992. Two sets of cases affect the supply/demand and pricing trends for the 80486 device. First, there is the 287 microcode cases—which include Intel's stunning victory during June before a federal court jury and Advanced Micro Devices' (AMD) earlier victory in the 386 arbitration case. In effect, the so-called "287 case" really is a "80486 case." AMD has not established a legal right to the 287 microcode and consequently missed the 1992 window of opportunity to enter the 80486 market.

The second set of cases focus on the right, if any, of Intel's cross-licensees to serve as foundries for alternate suppliers of x86 devices. Here we refer to cases that pit Intel against ULSI Systems via Hewlett-Packard; against Cyrix and SGS-Thomson—a case that Cyrix/SGS won in a federal court in Texas during

Figure 1
Contract Manufacturing Usage



Source: Dataquest (October 1992)

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July 1992; and against Chips & Technologies and Texas Instruments. Intel views its position as protecting itself against x86 patent laundering. The other parties claim clean, simple, and lawful foundry activity. The courts have issued conflicting decisions—and the U.S. Supreme Court likely will make the ultimate decision in this set of cases. Any final victory for Intel means a more narrow 80486 supplier base—while any defeats would mean supply base expansion.

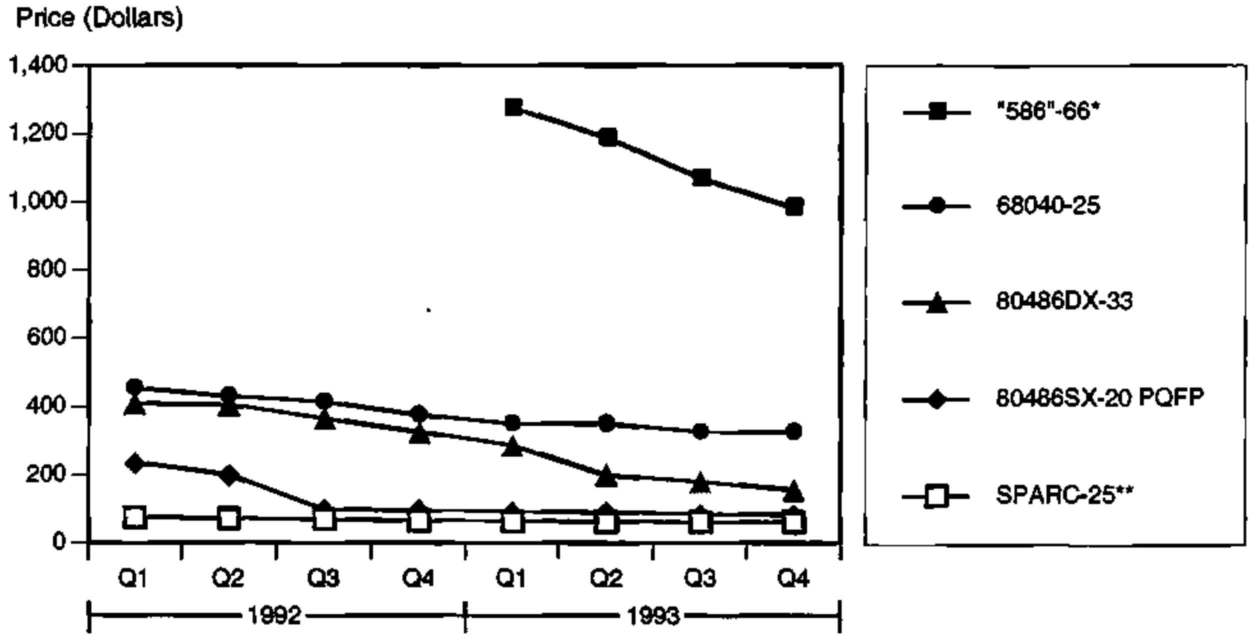
How should this state of the law affect 80486 pricing over the next six months? A hot question associated with Figure 2 is as follows. Will the 33-MHz 80486DX price curve—which should be priced at $325 in North American 1,000-unit orders during the fourth quarter of 1992—take a step function down? Dataquest believes that they will. If so, then when? The 80486SX price curve took a step function down during the second quarter of this year, which undercut Intel 386 competitors such as AMD and Cyrix (see Figure 2).

As of early October 1992, two factors indicate that Intel will slash 80486DX pricing during early 1993—but not much sooner. First, at the top of the curve, we see the "586" (also known as "P5") price curve. Intel could have introduced that part this quarter, but instead chose early 1993. The 80486DX price plunge that we expect should occur in synchronization with the "586" introduction. Second, during 1993, competitors such as AMD should enter the 80486DX market. A lowering of the 80486 price curve for 1993 would hurt Intel's competitors more than Intel. We also learned recently that Intel's 80486DX capacity is nearly fully booked—meaning skyrocketing pricing on the gray market for the 33-MHz 80486DX device—another signal that the likely price break should occur during early 1993 but not sooner. Cyrix and Texas Instruments have a 80486-type device, but that part is basically a 386DX with a 487 coprocessor.

Figure 2 shows pricing for Motorola's 68040 device. Motorola is reporting impressive shipment levels during 1992 for this device as well as the embedded control version. Users should expect a steady long-term downward slide in pricing. Pricing for the 68040 likely will mirror the 80486DX price curve, but with a lag of 6 to 12 months.

A comparison of the 32-bit MPU suppliers' market share table for 1991 versus the 1988 table is highlighted in the expansion of the

Figure 2
32-Bit MPU Price Trends (North American Bookings; Volume: 1,000-5,000 CPGA)



Notes: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated September 1992.
* Includes cache memory on chip; volume of 100-1,000 for the first quarter of 1993; estimated but not by survey.
** Pricing excludes accessory parts such as floating point and memory management.

Source: Dataquest (October 1992) G2002282

32-bit MPU supplier base—especially of RISC processors. This supply base trend should translate into more competitive pricing versus the monopoly environment of several years ago.

In fact, a few years ago this table had just four names or categories: Intel, Motorola, National Semiconductor, and "other." System manufacturers such as Sun and MIPS—through technology licensing programs for their respective SPARC and MIPS architectures—have increased the supplier base with varying degrees of success since the late 1980s.

Today's "other" category might contain the most dramatic information for the next several years, when users can look forward to emergence of RISC suppliers such as the Apple-IBM-Motorola alliance on the Power PC processor; Digital Equipment's 64-bit ALPHA device; HP's Precision Architecture; and new suppliers of the SPARC family including Texas Instruments but also perhaps Motorola. We will examine the RISC versus CISC "thing" later in this article.

Price Benchmarking

Dataquest sees that "benchmarking" in its broadest sense refers to the process by which corporations strive to learn—and then surpass—the performance parameters of the so-called "best-in-world-class" performers regarding any given organizational process or function. Earlier at this conference, Mr. Ko Nishimura, CEO of Solectron Corporation, provided an excellent discussion of how his company's use of benchmarking led to its status as a winner of the Baldridge award—and recent outstanding financial performance.

In a more narrow sense, price benchmarking represents the search by a growing number of SPS clients for the so-called "best price"—translated, the lowest market price with quality as a given—for critical devices such as a standard 4Mbx1 DRAM. Dataquest does not believe that this trend toward price benchmarking will be problem-free. For example, for many companies the broader strategic benchmarking effort often proves to be more of a short-term fad than a long-term trend.

Nevertheless, with cost containment now the No. 1 procurement issue, SPS expects increased client interest in price benchmarking for now and 1993.

Memory ICs

Figure 3 highlights the standard 4Mbx1 DRAM price curve. As a price benchmark, many SPS clients have inquired as to whether the fourth-quarter 1992 North American bookings price for this device will break below the $9 level. Our survey results—and the current market scenario—indicate a "no" answer. The SPS quarterly survey of users and suppliers in this region estimates a fourth-quarter price range from $9.50 to nearly $10.50 for orders of 100,000 to 200,000 units. First-tier Japanese suppliers and most North American suppliers likely will aim for a $10 price—and not much below $9.50 even for half-million volume orders. They likely will remain firm regardless of the decision in the Micron case. Should Micron prevail in the antidumping case against the Korean suppliers, sub-$9 pricing becomes even less likely.

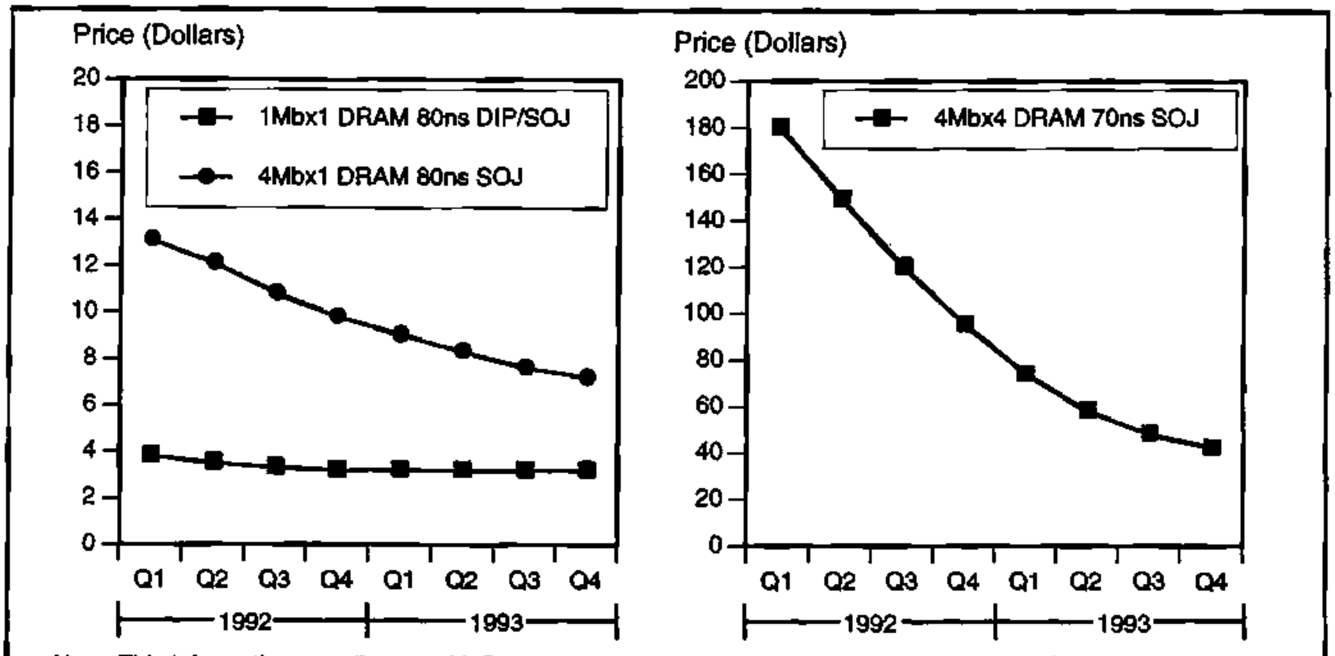
Pricing for standard 1Mbx1 DRAM approaches the trough at the bottom of Figure 3. Fourth-quarter pricing in North America should hover near a best price benchmark of $3 for our specified contract volume—and about $2.85 for the occasional half-million or million-unit orders. We should note that pricing for this device during 1992 has periodically—but not inconsistently—been below the $2.85 level in other world regions such as Europe and Asia.

Two points are stressed regarding the separate 16Mb DRAM price curve. Barring a complete reversal in the 1993 DRAM capacity outlook—which we will look at soon—16Mb DRAM pricing should move down the curve during 1993 as supply/demand ramps up. Second, Dataquest expects the 4:1 crossover to 16Mb DRAM to occur during 1994—not the end of 1993 nor delayed to 1995, but by the middle of 1994.

DRAM Price Forecast Assumptions

Recent imposition by the European Community (EC) of the 10.1 percent antidumping duty on Korean suppliers—and the impending announcement by the U.S. government of the Micron case decision—mandates a review of two key DRAM pricing assumptions. SPS documents the assumptions behind critical price forecasts so that as market conditions change—which may alter some operating

Figure 3
DRAM Price Trends (North American Bookings; Volume: 100,000-200,000)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated September 1992.

Source: Dataquest (October 1992)
G2002283

assumptions—we can adjust our price forecast and assumptions in line with market reality.

The following two assumptions envelop the antidumping cases:

- Non-Japanese Asian suppliers will increase DRAM market share.
- The legal jurisdiction of intellectual property and other laws will expand across the globe and be more aggressively enforced at the local level.

The first assumption postures increased impact from Korean DRAM suppliers such as Samsung, Goldstar, and Hyundai. The next assumption returns us not only to intellectual property law—for example, Wang's claims to the x9 modules and Texas Instrument's royalty campaigns—but also to trade laws such as the U.S. and European antidumping acts. A strong victory for Micron could flatten somewhat the first-half 1993 price curves for standard 4Mb and 16Mb DRAMs. At the time of the conference, we learned that the preliminary result should be available toward late October 1992—an example of how legal decisions can be delayed and delayed again.

Dataquest distinguishes standard DRAM from specialized DRAM. Standard DRAM are organized in the x1 or x4 configuration and packaged in an SOJ, TSOP, or module. Specialized DRAM include VRAMs, the so-called wide-word configurations such as the x8 or x16, and the host of emerging cache-DRAM, R-DRAM, and other niche products. Regarding pricing, the supplier base for specialized DRAM—which is a growth segment—will be somewhat more narrow and more likely to shift over time versus the standard DRAM supply base.

In terms of price benchmarking, this means that users likely will pay higher prices and can expect a flatter price curve for specialized DRAM. For example, pricing for 1Mb VRAMs currently remains over $6.50, while standard 1Mb DRAM moves toward $3. Standard 1Mb DRAM lead times range from 1 to 6 weeks—versus 3 to 20 weeks for 1Mb VRAM. Why? A 1992 surge in VRAM demand caught the entire market off guard. Dataquest expects 1Mb VRAM supply-demand to return to balance during the first quarter or half of 1993. The central point is that users of specialized DRAM should prepare for higher pricing, flatter price curves, and periodic spot shortages.

A Snapshot of Fourth-Quarter 1992 Pricing Trends

A summary of the main fourth-quarter 1992 price trends is that users should expect a competitive pricing environment with exceptions such as SMT standard logic, VRAM, EPROM, and gray-market pricing for the 80486 processors.

For 1993, however, the DRAM capacity outlook might tighten—and with it the entire IC supply-demand equation. The basic point is that for 1991 and 1992 most DRAM suppliers had adequate or more than adequate 4Mb DRAM capacity. Some Japan-based suppliers such as Toshiba publicly declared their intention to sharply cut back on their original plans for DRAM capacity expansion. By the first half of 1993, the trend could be toward tighter DRAM supply and less competitive pricing. Even so, there is a wild card that could serve as counterbalance to the capacity squeeze—IBM. At this time, IBM is evaluating entry to IC merchant markets including the DRAM business.

Emerging Technologies

We now turn to emerging technologies such as flash memory and 3V technology.

Just as DRAM suppliers see a profit cycle ahead, a competitive technology—especially so in portable applications—emerges: flash memory. As Table 4 shows, prior to 1992 flash memory was viewed as a competitor to nonvolatile technologies such as EPROM, and to a much lower extent, DRAM.

Table 4
The History of an Emerging Technology

Year	Technology
1991	Flash memory versus EPROM
1992	Flash memory versus DRAM
Q4/92	Flash memory supply-demand imbalance

Source: Dataquest (October 1992)

Flash technology was always the product of tomorrow—to such an extent that Toshiba, the inventor, in effect ceded market growth responsibility to Intel. During the first quarter of this year, Intel boldly, if not prematurely, announced that henceforth flash memory pricing would be competitive against DRAM on a price-per-bit basis. In effect, Intel wants system designers to benchmark long-term pricing parity between flash memory and DRAM. For 1992, Intel succeeded dramatically in capturing market share of mind. However, the flash memory supplier base has not been able to keep balance with demand. For the rest of this year, lead times are stretching beyond 10 weeks and Intel has apparently put some users on allocation. With standard DRAM pricing quite competitive, the pricing angle fades from the attention of users that now have a somewhat jaundiced but still hungry appetite for flash memory. Despite the current supply-demand imbalance, flash memory represents a key emerging technology for the 3V systems that will proliferate in the worldwide markets during this decade. According to Nick Samaras, an analyst in Dataquest's Semiconductor Applications Markets service, AMD's 3V flash technology likely will be a market winner. Other suppliers such as TI and Hitachi will battle AMD, Intel, and Toshiba for a leadership role.

A Last Look at the RISC/CISC "Thing"

Systems manufacturers care mostly about system performance and software applications. They care much less about this RISC-versus-CISC "thing." Intel's next-generation processor—the "P5" or "586"—aims to drive CISC PC technology upward into RISC workstation applications. The P5 should be a winner.

Even so, as shown at ISSCC 1992, systems manufacturers such as Digital Equipment and the Apple-IBM-Motorola alliance remain decidedly uncomfortable with technology dependence on any single source, including Intel. Everyone will keep an eye out as IBM—the potential wild card in the entire semiconductor business including processors—continues to test the market with its board-level 80486 products. In turn, Intel has aces up its sleeve. During November 1992, the 80486SL device will enable users to place a workstation in their lap. The Intel marketing campaign on the future-generation "686" and "786" processors—or perhaps we should call them the "P6" and "P7"—has already started. Again, IBM could serve as a wild card supplier. Right now, IBM is testing the merchant market waters in the Silicon Valley with a board-level 80486 device.

3V Technology Trends

The current status of 3V semiconductors at press time was that the JEDEC standard JESD8.0 is in the approval process. This standard covers the so-called "unregulated" 3V products for those applications that can utilize a voltage supply range between 2.7V and 5.5V, thus extending battery life. These devices are designed for portable applications where speed is not as important as low power. "Unregulated" refers to the wide range of supply voltages not requiring a voltage regulator. The status of the "regulated" (3.3V ±10 percent, or 2.97V to 3.63V) volt JEDEC standard is also moving along and could be approved within a month.

Many of the current offerings of 3V devices are rescreened parts made under a 5V process. Except for in a few instances, (such as ultralow-temperature -20°C) these devices will meet the needs of most current 3V applications. Where high speed and low power are required, true 3.3V designed parts (set to the pending "regulated standard") often are needed. Current price premiums range from plus 25 to 30 percent for rescreened 5V parts and at least 40 to 50 percent more for 3V designed parts, depending on the supplier. As the number of suppliers increases for these parts in 1993, the price premium difference between rescreened and "true" 3V designs will diminish.

The 3V trend is being driven by four main points, as follows:

- Systems miniaturization
- Portability—extended battery life
- Shrinking line widths
- Faster access times

As the size of systems gets smaller and smaller, the need for more integration pushes for higher chip densities. Smaller systems are often portable, requiring batteries. The lower the supply voltage, the longer the battery life. As process geometries decline below 0.5 microns (higher chip density), voltages above 3.5V often short out circuits, so 3V circuits are being mandated by physics. With clock speeds of some microprocessors approaching upward of 50 MHz or more, the combined need for speed and low power is driving 3V devices. Research is ongoing for even lower supply voltage devices. These are long-term issues and will continue to push for 3.3V-and-lower devices.

Dataquest Perspective

This year's client survey highlights the need for continued focus on cost control and all of the issues needed to accomplish it. The concern of many semiconductor users over availability and lead times coincides with competitive pricing requirements and the instigation by many companies of formal benchmarking programs. Legal issues and supply status both will continue to affect the procurement of microprocessors and commodity memory into the 1993 time frame. Barring an unlikely strong resurgence of domestic Japanese demand, memory supplies in the upcoming months should remain adequate, with predictable pricing. A key unresolved issue is the impact if DRAM suppliers moderate 1993 capacity plans. The microprocessor supply equation is even more obtuse, but supply should become more competitive as 1993 progresses, especially in the x86 market.

The emergence of flash memory technology and the overriding trend for lower voltages (that is, 3.3V) are being pushed by shrinking process geometries, the portability trend requiring batteries, shrinking process geometries, and the increasing speeds of systems.

The 1993 economic outlook at best foresees moderate worldwide electronics growth compounded by competitive pricing. This environment is conducive to the implementation of finance-driven cost control measures such as benchmarking. Semiconductor procurement operations need to continue their cost-control programs and enhance their efficiency by utilizing increased forecast discipline, regular price and delivery reviews with suppliers, and demanding no less than the absolute best quality level available. Dataquest is now conducting a semiconductor user wants and needs survey as to what constitutes standards in these and other key areas of interest. Dataquest plans to ship this report by the end of the year.

By Ronald Bohn
Mark Giudici

News and Views

Procurement Pop

The book-to-bill ratio gathered for the National Electronic Distributors Association (NEDA) has risen to a strong 1.10 from an unseasonably strong July ratio of 1.08 (see Table 1). The continued strength of the data processing market is keeping business brisk and the increase in inventory turns is ensuring that the increased business is not catching dust on the shelf. Demand for some Intel microprocessors is so strong that the volume market price exceeds the asking price by Intel for 1,000-piece orders. The continuing price wars at the system level are fueling this demand for semiconductors and distributors are in a good position to provide users with product as market conditions continue to change.

Table 1
Book-to-Bill Ratio

	May	June	July	August
SIA Book-to-Bill	1.11	1.14	1.08	1.08
NEDA Book-to-Bill	1.06	1.08	1.08	1.10
NEDA Inventory Turnover Rate	4.20	4.19	4.12	4.17

Source: NEDA/SIA

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9209 September 28, 1992

In This Issue...

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Korea
74AC00	0.18	0.17	0.15	0.12	0.15
74AC138	0.28	0.31	0.24	0.23	0.22
74AC244	0.42	0.43	0.37	0.34	0.37
74AC74	0.24	0.20	0.18	0.14	0.16
Lead Time: (Weeks)	4	3	12	4	5
4F00	0.11	0.11	0.10	0.11	0.10
4F138	0.15	0.17	0.14	0.14	0.15
4F244	0.22	0.26	0.21	0.24	0.24
4F74	0.13	0.14	0.12	0.12	0.11
Lead Time: (Weeks)	4	4	4	4	5
7805-TO92	0.13	0.15	0.11	0.09	0.15
CODEC-FLTR 1	1.73	1.99	2.50	1.60	1.45
CODEC-FLTR 2	3.95	4.30	5.00	4.25	
Lead Time: (Weeks)	6	3	6	3	
DRAM 1Mbx1-8	2.98	3.12	3.00	2.70	2.85
DRAM 1Mbx9-8	28.50	29.57	25.50	28.00	28.50
DRAM 256Kx1-8	1.13	1.56	1.50	0.75	1.05
DRAM 256Kx4-8	3.00	3.16	3.00	2.70	2.85
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
Lead Time: (Weeks)	4	4	4	4	4
68020-16	27.00	29.57	26.00	32.00	
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		
Lead Time: (Weeks)	2	7	4		

*Prices in U.S. dollars
Source: Dataquest (September 1992)

Market Analysis

September Procurement Pulse: Orders, Inventories Decline while Lead Times Remain Steady

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rate Expected to Slip while Overall Prices Stabilize

The overall semiconductor order rates of this month's respondents for September again are expected to decline about 16 percent compared with last month (see Figure 1). This lowering of order levels directly corresponds with the seasonally affected lower system sales noted last month by some of the current noncomputer company respondents. Even though the respondents' system sales levels are slightly down for August, the overall six-month outlook for system sales improved from 8.0 percent noted last month to a current 9.1 percent forecast now through the end of March 1993. The computer segment of the survey buoyed the overall six-month forecast average from last month's 6.25 percent six-month outlook to a 9.0 percent average forecast reported as the latest computer update.

Prices on average are expected to remain flat with last month; one respondent noted an average price increase since then. This is

Figure 1
Averaged Monthly Semiconductor Orders

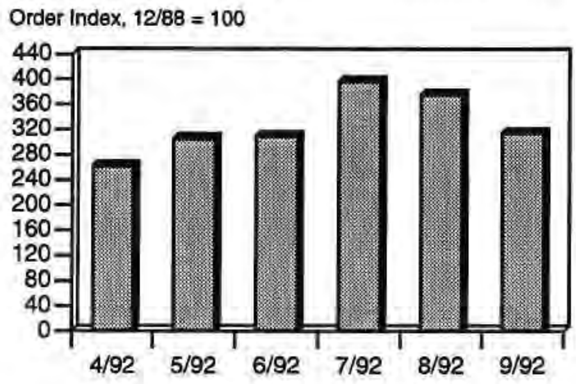


Figure 2
Averaged Semiconductor Lead Times

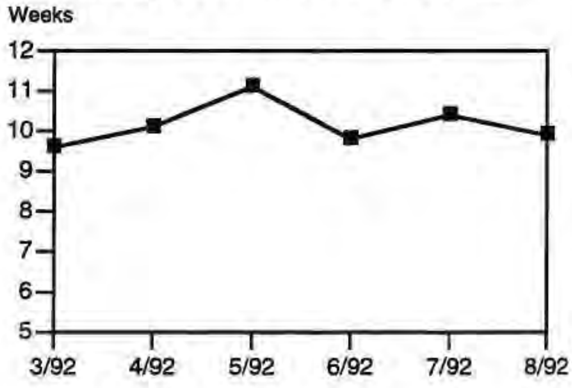


Figure 3
Actual vs. Target Inventory Levels (All OEMs)

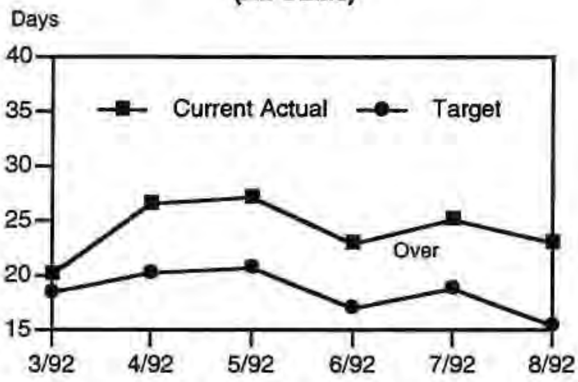
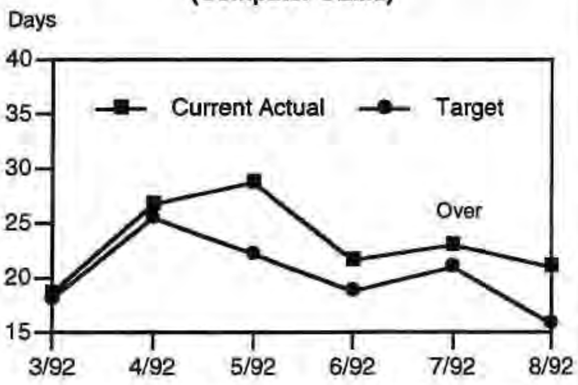


Figure 4
Actual vs. Target Inventory Levels (Computer OEMs)



Source: Dataquest (September 1992)

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primarily because of shortages in SMT standard logic and selected analog devices. Overall prices have stabilized as demand continues to slowly build in the United States across the board, but mainly in the data processing segment of the market. Capacity to meet incremental demand increases remains available to meet long-term commitments, yet many suppliers are chary to commit capacity to newfound customers without a probationary lengthened lead time. The SOIC standard logic situation continues to cause headaches, as the major suppliers add back-end test capacity that is expected to alleviate allocations by the November/December time frame. Look to long lead times and higher prices for these parts in particular for the next few months. In addition to SMT logic, other problem products noted this month were ASICs, analog, and some discrete devices in surface mount packages. Emphasizing the surface mount problem is that nearly three-fourths (72.7 percent) of the respondents noted problems with surface mount device availability.

Semiconductor Lead Times Again Slip Under 10 Weeks

The 9.9-week average lead time shown in Figure 2 reflects the stable availability of large-volume commodity memory, microprocessor, and DIP package logic devices. Lead times of up to 26 weeks for some SOIC standard logic parts make the headlines, but the majority of logic is still shipped in DIP packages that have 4- to 8-week lead times. Besides SMT logic, most products still have manageable lead times primarily because of a larger number of suppliers able to cushion demand fluctuations. Lead times in the United States (and the world) are stable in part because the level of Japanese demand is down, freeing supplies planned for Japanese consumption to be used elsewhere. Although the Japanese market is still sluggish, when demand there increases then overall lead times will stretch out because most Japanese suppliers are not increasing long-term capacity at this time to account for a general market upturn.

Inventory Levels Correct Themselves—Again

Semiconductor inventory levels for both the overall and computer sample fell last month, thus highlighting that cost control is alive and well (see Figures 3 and 4). The overall targeted and actual semiconductor levels this month were 15.4 and 23.0 days, compared with last month's respective 18.0- and 25.1-day levels. The computer company respondents averaged a targeted 15.8- and an actual 21.0-day level relative to last month's respective 21.0- and 23.0-day target/actual range. Inventory levels have almost correlated with semiconductor order expectations, and this month is no exception. Availability of product is key to this tight inventory control. Ensuring adequate deliveries requires consistent forecast/availability information exchange between user and supplier that has gotten better over the years, but there is always room for improvement.

Dataquest Perspective

The anticipated summer slowdown of 1992 has not occurred primarily for two reasons: Ready availability caused continued competitive pricing (for both semiconductors and systems); and rigorous cost control measures kept inventories low, forcing continual reordering to meet demand. Overall electronics demand continues to grow slowly, with much of semiconductor growth now going to the data processing applications for upgrades or low-end personal computer markets. As competition increases in this low-end market, prices for these systems will continue to fuel demand for the chips that go into them. The question arises, "For how long?" With big players such as IBM, Compaq, and Apple entering the low-price fray, it is possible that price-fueled demand could continue through the end of the year and more likely through mid-1993. If Japanese demand picks up by then, the overall availability of semiconductors may shift back to a sellers' market. Until then, though, Dataquest foresees good availability and predictable prices for the majority of semiconductors. As the 1993 contract sessions begin, being aware of "exogenous variables" not directly impacting local regional supplies of semiconductors should be included in contract decisions.

By Mark Giudici

Product Analysis

Dataquest's Fourth Quarter 1992 Perspective on Key IC Pricing Trends

This article presents key results from Dataquest's August 1992 North American bookings price survey. The economic backdrop is as follows: the North American economy remains sluggish as the November presidential election approaches. However, the IC business has not experienced the typical summer downturn. For example, lead times in general increased somewhat during the third quarter and—notwithstanding recent press reports to the contrary—DRAM pricing has not collapsed.

This article will provide a second-half 1992 perspective on pricing trends for devices that usually command less marketlike standard logic, ROMs, and SIMMs, although we will not ignore 4Mb DRAMs nor 32-bit MPUs. The goal will be to present Dataquest's perspective on the IC pricing scenario as the market moves to year-end 1992—and to anticipate for users some likely market breaks as suppliers refine and revise 1993 product and pricing strategies. A snapshot use of product life cycle analysis will guide the assessments.

(Survey information was collected by Dataquest's Research Operations. For SPS clients that use the SPS On-Line service, the pricing presented here correlates with the quarterly and long-range price tables dated September 1992. The price tables are available in the Source: Dataquest document entitled *North American Semiconductor Price Outlook: Fourth Quarter 1992*, dated September 1992. For additional product coverage and more detailed product specifications, refer to those sources.)

Memory Trends

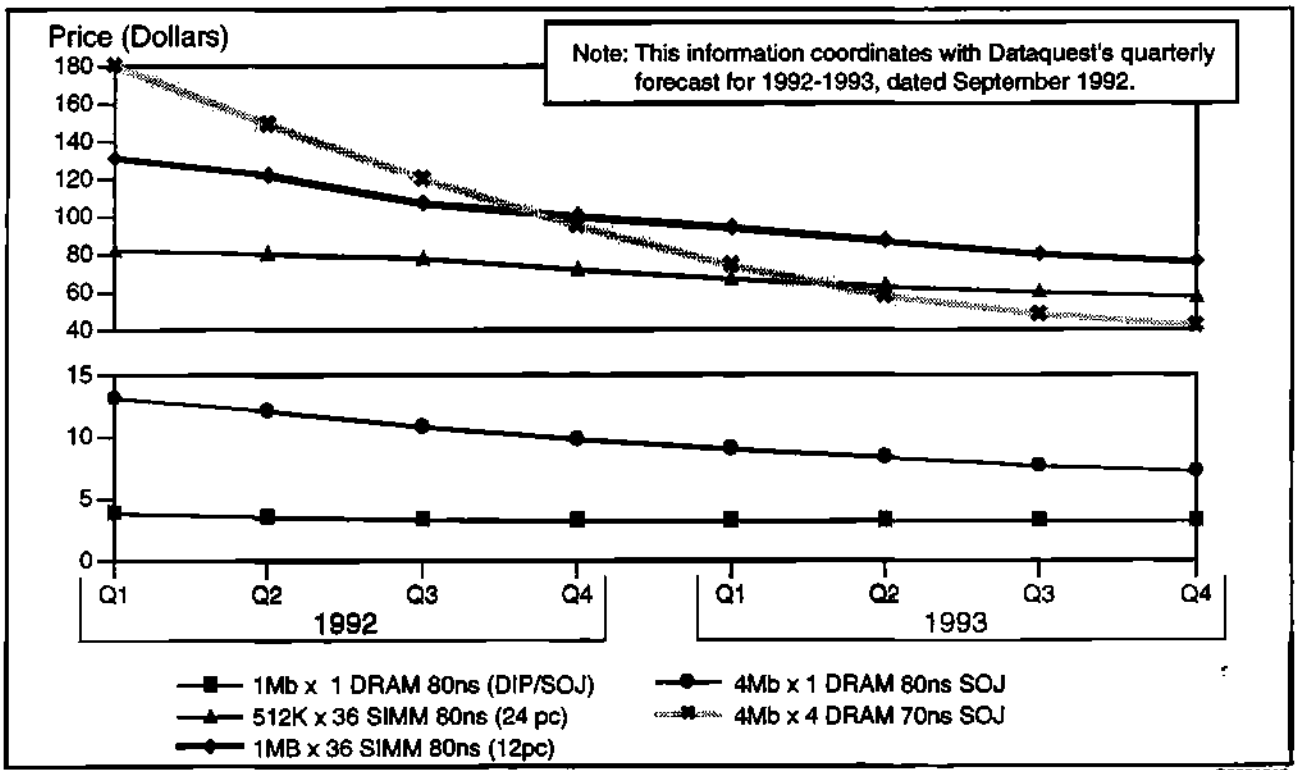
The results of the quarterly price survey signal a continuation of competitive memory pricing in North America during the last quarter of 1992. DRAM suppliers will resist, however, a collapse in pricing as we advised in the DQ Alert entitled "DRAM Advisory: Dataquest's Latest Price Survey Signals Continued Price Erosion but No Fourth-Quarter Collapse!" dated August 21, 1992. As noted there, the short-term strategy of some Japan- and North American-based suppliers of DRAMs focuses on profits—and not market share—meaning resistance to a year-end 1992 "lowball" pricing scenario. In addition, Micron's dumping allegations against Korean suppliers continues to moderate against an aggressive downward trend in megabit-density DRAM pricing in North America (see Table 1 and Figure 1).

Table 1
Estimated Semiconductor Pricing Trends (North American Bookings, Volume Orders)
(per Third-Quarter Survey of Pricing Trends) (Dollars)

Part	Estimated for Fourth Quarter 1992 ($)	Estimated Fourth Quarter 1992 Price Range ($)	First Quarter 1993 Price ($)	Lead-Time (Weeks)
1Mbx1 DRAM	3.20	3.00 to	3.20	1-6
80ns, DIP/SOJ	3.45	3.45		
4Mbx1 DRAM	9.85	9.50 to	9.00	2-12
80ns, SOJ		10.40		
32x8 SRAM	3.90	3.60 to	3.85	4-9
100ns SOJ		4.00		
68040-25	375.00	375.00	350.00	4-8
CPGA				
80486DX-33	325.00	325.00 to	288.00	6-8
CPGA		335.00		

Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated September 1992.
Source: Dataquest (September 1992)

Figure 1
DRAM Price Trends (North American Bookings; Volume: 100,000-200,000)



Source: Dataquest (September 1992) G2001612

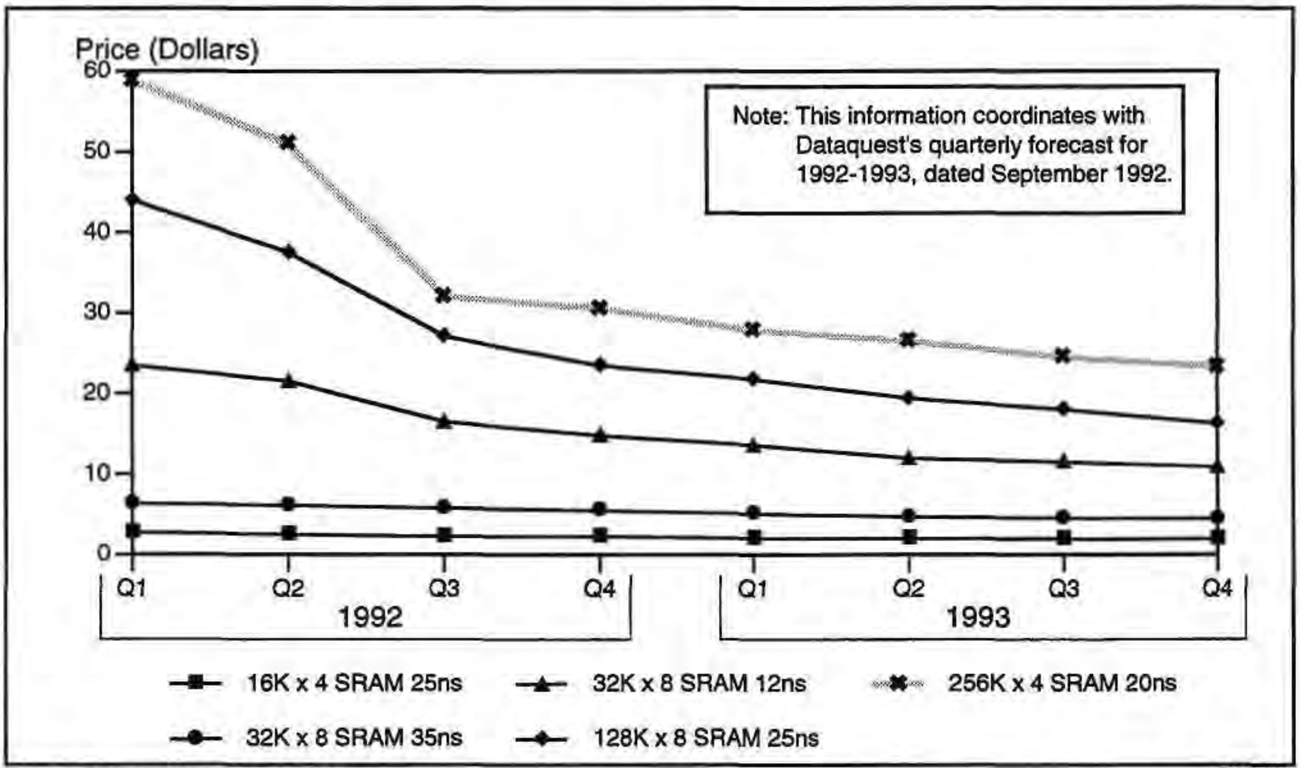
Life cycle analysis in part explains these fast SRAM pricing trends. 64K and 256K fast SRAMs now approach the peak stage of the cycle. Manufacturers have the fast SRAM manufacturing process under control, augmented by adequate capacity. For example, regarding price premiums based on speed or configuration, Dataquest sees a disappearance of configuration-based pricing differentials (for example, x1 versus x4 versus x8), although some premiums could recur periodically because of shifting supply/demand patterns. A similar trend emerges regarding speed-based price premiums for 64K and 256K devices that operate at speeds of 25ns through 45ns. As these products mature in terms of life cycle analysis, they move toward parity pricing. A similar trend is emerging at the 1Mb density, although the pattern should become more clear to users during 1993.

Figure 2 shows, however, that devices—of whatever density—that operate at speeds of 15ns or faster still command healthy premiums. Why? These devices in effect are still in the growth stage of the life cycle and supported by a more narrow supplier base, for example, two to three proven suppliers in some cases.

Slow SRAM Pricing? Keep an Eye on DRAM Price Trends

Over the years, Dataquest has identified a relationship between DRAM and slow SRAM pricing that continues to hold: the symmetry and correlation—sometimes with a lag—between any given density of DRAM and the next lower density of slow SRAM, for example, 4Mb DRAM/1Mb slow SRAM or 1Mb DRAM/256K slow SRAM. Typically, the slow SRAM product price is somewhat higher than that of the corresponding DRAM price, but clearly within the same range. The reason is that DRAM suppliers that also produce slow SRAMs—traditionally, vertically integrated Japan-based suppliers joined more recently by vertically integrated Korea-based suppliers—can shift capacity back and forth with a lag between a given density of DRAM and the lower-density slow SRAM, which translates into parallel price trends.

Figure 2
Fast SRAM Price Trends (North American Bookings; Volume: 20,000; PDIP)



Source: Dataquest (September 1992)

G2001613

In terms of product life cycle analysis, for users of slow SRAMs in the growth stage (1Mb devices for 1992-1993), the DRAM price trend often can provide—one or two quarters in advance—a "preview" of the slow SRAM price trend.

For users of slow SRAMs in the mature stage (256K devices for 1992), the corresponding DRAM price trend (here, the 1Mb device) can provide a signal of how low suppliers might be able to go in terms of slow SRAM pricing. For example, the low-end of the fourth quarter 1992 price range as shown in Table 1 is conservative. Information from Dataquest's SPS On-Line service shows that pricing for 32Kx8 slow SRAM already approaches the $3 level in North America—which is close to the low end of the 1Mb DRAM price range.

What's Happening in the ROM Business?

Most major North American users of ROM demand high-speed devices that operate at a speed of 120ns and faster, while the Japan-based supplier base historically has geared output to demand from video game manufacturers—who use slower-speed parts. The supplier base appears to have shifted more of its effort to the higher-density/higher-speed devices, leading to some recent reports of more aggressive pricing in North America for users of the high-performance parts. Sharp has positioned itself to protect and expand its stake in the North American market. Dataquest will continue to monitor developments in this segment as ROM suppliers make fourth quarter 1992 decisions regarding 1993 plans.

EPROM versus Flash Memory versus DRAM

Intel's 1992 leapfrog strategy in flash memory—highlighted by the second quarter effort to position flash pricing against DRAM pricing in long-term theory if not current reality—continues to reverberate through the nonvolatile memory user/supplier community. At press time, lead times for higher-density flash memory had increased to a range of 6 to 10 weeks—with reports that the relatively small supplier base was coping to meet mounting North American demand. With Intel moving from the EPROM marketplace, the likelihood of a fourth quarter 1992 EPROM supply base disruption becomes likely.

The flash product technology stands at the early stage of the technology life cycle, although some sub-1Mb density devices in effect already approach the maturity stage. Flash memory represents a key growth product technology for the 1990s and beyond—and certainly for 1993.

Regarding suppliers, most suppliers of nonvolatile memory claim a commitment to a flash memory product portfolio—if not this year and quarter, then next year, or the year after. Less humorously, though, these suppliers are under great pressure as the year 1992 ends to refine their flash memory and EPROM product strategies because many suppliers run the risk of permanently falling behind Intel, the early market leader. Advanced Micro Devices' (AMD) 3V product appears to be the most serious threat to Intel's market leadership position at this time.

For the fourth quarter of 1992 and early 1993, Intel's de-emphasis of EPROM could leave some EPROM users—and also suppliers—figuratively twisting in the wind. The EPROM product technology has somewhat suddenly started a rapid "aging" process. As Intel departs the market, it will make some departing shots in terms of low-level EPROM pricing—which for remaining suppliers could throw gas onto smoldering EPROM prices. More likely, EPROM suppliers will resist an aggressive pricing scenario as the year 1992 ends. Should EPROM lead times stretch somewhat, pricing should firm for major buyers and might rise on the spot market. Regardless, during the fourth quarter of 1992 users should give serious consideration to their post-1992 and -1993 commitment to the EPROM product technology—especially with the clear applications trend being toward portable systems that in effect mandate 3V memory cards.

Standard Logic: Decline versus Growth

Figure 3 shows long-range standard logic price trends for products in the PLCC package. Pricing for bipolar families generally should be flat but at competitive levels. Survey results indicate a continuing if not steep decline in pricing for CMOS-based devices. Life cycle analysis supports this forecast—the bipolar products are now moving toward or through the decline stage while the AC and BiCMOS families are still in the growth or maturity stage.

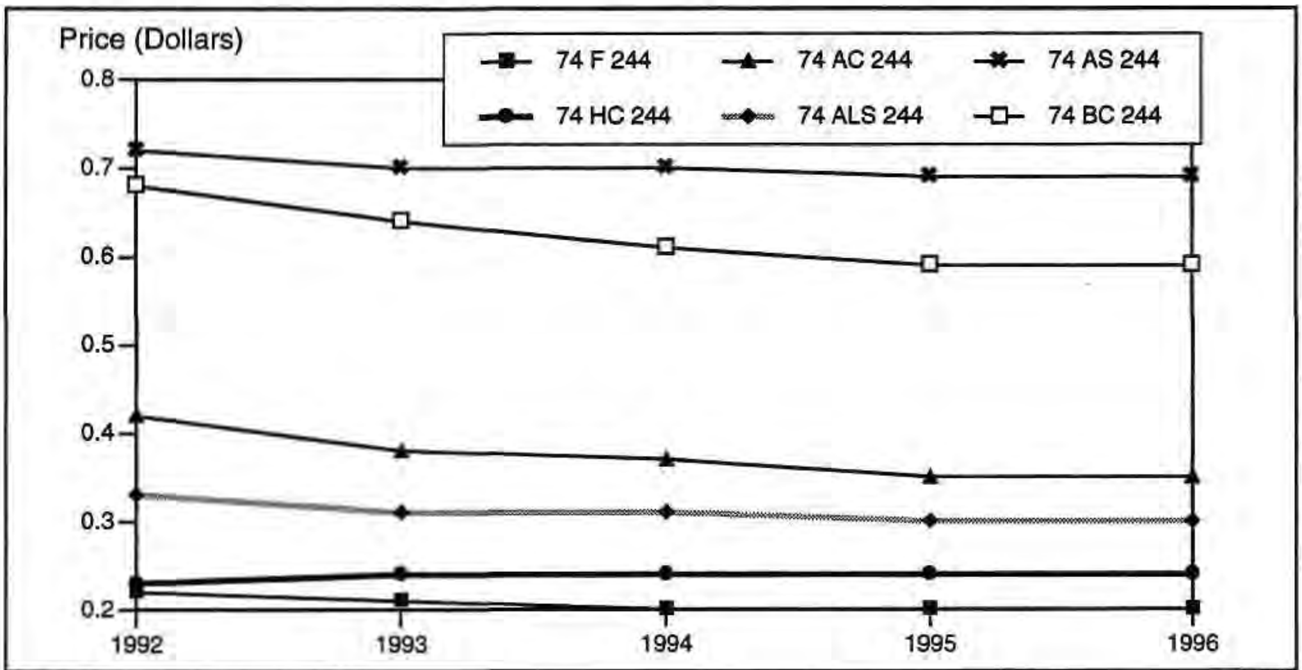
Users of bipolar standard logic in the SOIC package should expect firm pricing or a price increase in the case of some suppliers. There are two reasons for this trend. First, pricing for many bipolar products already stands near the break-even level, meaning marginal business opportunity at best for suppliers. Second, suppliers of standard logic will focus more on profitability and less so on market share during the second half of 1992 and for 1993. The emerging strategy by key standard logic suppliers especially of the older bipolar parts is as follows: users that truly need SOIC parts must pay for the increased cost suppliers incur by allocating capacity for SOIC assembly and test. Users that buy standard logic in the SOIC package on the spot market must brace for erratic pricing trends for the next half year. Users that purchase by contract order should consider a longer-term arrangement, for example, one- or two-year contracts at a flat price.

Brutal Gate Array Pricing Trends

As shown by the recent financial travails of LSI Logic, pricing for commodity- type gate arrays and cell-based ICs remains brutally competitive in North America. For example, for mainstream density arrays—between 7,500 and 20,000 gates—in a volume of 50,000 units or more, some 1992 price quotes excluding NRE hover near the 30 millicent-per-gate level.

In terms of life cycle analysis, these are mature devices in a market segment that continues to experience recession. For a recent detailed look at ASIC life cycles and the supplier base, see "The User's View on ASICs—Is Supply Base Contraction Ahead?" in the Semiconductor Procurement *Dataquest Perspective* dated August 24, 1992. LSI Logic announced its intention during August 1992 to focus on higher-density/higher-performance segments, which may ease North American gate array pricing competition in North America somewhat during 1993, but not before year-end 1992.

Figure 3
Long-Range Standard Logic Price Trends (North American Bookings; Volume: 100,000; PLCC)



Source: Dataquest (September 1992)

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PLDs

Although recent reports of the death of bipolar PLDs remain a bit premature, the market move is clearly toward the CMOS technology. As with bipolar standard logic, bipolar PLDs carry an "aged" product connotation in terms of company 1993 product strategies. Suppliers of bipolar devices must carefully evaluate their ability to earn a profit in this marketplace, meaning a gradual de- emphasis during 1993 and perhaps more abruptly so thereafter. The supplier base for high-speed CMOS parts that operate at a speed of faster than 10ns aims to price these devices equal to if not lower than the traditionally lower-priced bipolar alternative.

Microprocessors: Legal and Other Trends

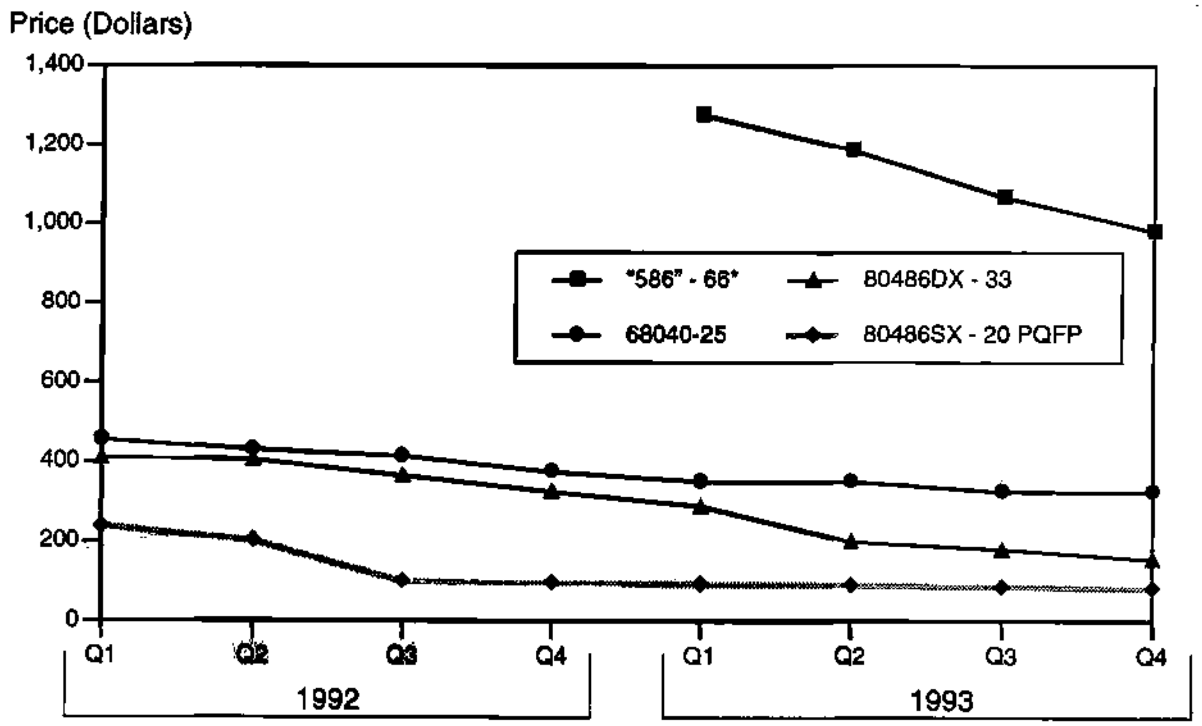
Price forecasting for 32-bit MPU increasingly calls for a review of suppliers' legal dockets. For example, AMD and Intel were scheduled to meet twice in court during the September. An early September case date involves AMD's effort— unlikely—to overturn or otherwise minimize the effect of Intel's victory in the federal 287 microcode case. The second case concerns Intel's effort to have a federal court proceed with Intel's intellectual property claims against AMD for alleged 386 microcode violations—notwithstanding the 386 remedy granted to AMD by California state courts via the arbitrator's decision. Intel's action is more likely to succeed—which would eventually threaten AMD's "right" to the 386 technology.

The September 1992 docket barely describes the list. For example, Intel might be headed toward the U.S. Supreme Court because of an apparent federal court judicial split in cases on the right, if any, of Intel's foundry partners and/or Intel's foundry partners' partners to X86 technology. Also, the U.S. Federal Trade Commission investigation quietly proceeds.

A Fourth-Quarter Step Function Down in 80486DX Pricing?

Against this backdrop, Figure 4 shows Dataquest's estimate of the 80486DX price curve based on the results of SPS August 1992 price survey. Since the midyear victory in the 287 microcode case, Intel has geared itself for the rest of 1992 to protect the 80486DX price structure in order to maintain corporate revenue and profit goals. The figure also presents the forecast on 80486DX, 80486SX, and 68040 pricing—and a first look at the 1993 curve for the as-yet-unnamed "586" device.

Figure 4
32-Bit MPU Price Trends (North American Bookings; Volume: 1,000-5,000; CPGA)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated September 1992.
* Includes cache memory on chip, volume of 100-1,000 for the first quarter of 1993, estimated but not by survey.

Source: Dataquest (September 1992) G2001615

In last quarter's price report, we stated that "(f)or the second half of 1992, Intel has at least three options: first, to slash 486DX pricing before or during the anticipated late third quarter/fourth quarter 1992 introduction of the "586" part; second, to slash 486DX pricing after the introduction of the "586" part—toward the end of 1992; or third, to not aggressively cut 486DX pricing till 1993 or later.

"An examination of the assumptions behind Dataquest SPS's long-range X86 price forecast indicates that Intel will pursue the second option. This approach would enable Intel to enjoy higher 486DX pricing for most of 1992 and also to protect the "586" price curve—should that be Intel's intent for this year—while still allowing an ultimate response to merging competition in the 486DX marketplace."

Our viewpoint this quarter remains consistent with last quarter. During the fourth quarter of 1992, for example, the November-December time frame, Intel likely will ease pricing on the 80486DX family of parts. A similar scenario occurred with 80486SX pricing during May 1992 for pricing effective the third quarter.

The underlying rationale is that, for Intel, the mainstream 80486DX-33 device now approaches the maturity/saturation stage of the life cycle—in Intel's strategic eye if not the market's mind. The 80486DX2 series still moves through the growth stage, but Intel now wants to position leading-edge users for a first-half 1993 migration to the successor "586" (also known as P5) product.

Intel Will Not Go Gently into the Night with Its 80486DX Price Cut

Should Intel cut 80486DX pricing as the year 1992 ends, Intel is likely to duplicate its approach to the 80486SX price cut—a blaring well-publicized action during the middle of the quarter (that is, November) for pricing effective the next quarter, being January of 1993, regarding the 80486DX products. This approach will enable it to protect the 80486DX price curve for the remainder of 1992, yet also create considerable uncertainty for users as they make critical fourth-quarter decisions regarding the possible use of other MPU alternatives. Intel is not likely to quietly cut 80486DX pricing, as occurred recently with the muted announcement of the 80386SL price drop.

What about Motorola's 68040?

In the midst of all the X86 legal/marketing/pricing noise, we should also note that Motorola has been making some impressive strides during 1992 with its 68020, 68030, and 68040 family of products. For example, Motorola reports robust demand for the 68040 and 68EC040 devices. For Motorola, the 68040 product did not move through the early growth stage in line with the original expectation. However, the length of the life cycle now starts to conform with the company's original expectations—which call for a cycle that extends into the latter half of this decade.

Dataquest Perspective

As the year 1992 moves to a close, semiconductor suppliers are evaluating and adapting their product strategies for a North American market that appears headed upward. As suppliers anticipate 1993 revenue and profit growth, however, they will encounter a North American purchasing community under enormous organizational pressure to achieve the best possible market price for critical devices—with users' 1992 and 1993 performance evaluations in some cases directly tied to the price paid for these products. For the rest of 1992 and beyond, "bench marking"—based on inquiries received by SPS analysts—should take on hallmark status in the IC user lexicon.

Some leading suppliers of 4Mb DRAM that predicted worldwide shortages during 1992 continue to call for a shortage—but six months later than originally expect, or the first half of 1993. Dataquest does not foresee this scenario. However, we do not blindly ignore the perspective of industry players with 20-years-plus experience. For example, the preliminary result should be known by the end of September 1992 of the investigation by the International Trade Commission/U.S. Department of Commerce into Micron's dumping complaint against Korea-based suppliers. Should a dumping penalty in excess of 5 percent be imposed on Korean suppliers—and at this time we do not know what the preliminary result will be—then Korean suppliers likely will re-evaluate their 1993 position in the North American market. As always, the specter of a DRAM shortage continues to pervade the volatile North America DRAM marketplace and especially as first-tier Japan- and North American-based suppliers re-evaluate their 1993 capacity plans.

As noted, pricing should remain quite competitive for growth products such as CMOS PLDs, 0.8-micron gate arrays, and 1Mb SRAMs. Recent lead-time extensions (see the "Procurement Pop" elsewhere in this document), however, augur potentially unsettling market conditions not only for users of older product technologies such as EPROMs and bipolar standard logic but also newer technologies such as flash memory and video RAMs. Major buyers likely will experience some supply base headaches such as unfavorable lead times—and suppliers might try to increase some prices—but users that purchase on a contract-volume basis should largely avoid the havoc that may soon hit gray market players.

By Ronald Bohn

News and Views

Procurement Pop

The information in Table 1 compares lead times for a host of critical devices as reported by participants in the SPS quarterly survey during August 1992 versus February 1992. Semiconductor users should be aware that the general second-half 1992 trend toward longer lead times continues and becomes more ominous. Not all lead times are increasing. For example, the lead time for Motorola's 68040 device has contracted dramatically over the past half year. Even so, several recent reports to SPS analysts indicate longer lead times for users of EPROMs and flash memory. The 1Mb VRAM supply constraint has not been alleviated, although supply should move more in line with demand as the year ends.

Table 1
Estimated Semiconductor Lead-Time Trends (North American Bookings, Volume Orders)
Lead Time (Weeks)

Part	February 1992	versus August 1992
256Kx4 VRAM 100ns, ZIP	8-12	3-20
4Mbx1 DRAM 80ns, SOJ	2-10	2-12
74ASxx PLCC	0-7	8-10
128Kx8 Flash Memory, 150ns TSOP	4-12	6-10
CMOS PLD, 7.5ns PDIP/PLCC 24-pin	4-10	1-20
68040-25 CPGA	14-20	4-8
80486DX-25 CPGA	6-8	6-8

This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated September 1992.
Source: Dataquest (September 1992)

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

Q. What are the military price conversion multipliers for parts in the Quarterly Price Survey?

A. See Table 1.

Table 1
Military Price Conversion for Quarterly Price Survey Parts

Product	883/SMD Multiplier
STD Logic (10,000 Units)	
LS245	5.6
HC245	5.9
DRAM (10,000 Units)	
1Mbx1-100ns	8.0
SRAM (10,000 Units)	
8Kx8-120-150ns	11.8
8Kx8-45ns	6.3
Microprocessing (1,000 to 5,000 Units)	
68000-8 MHz	21.9
80286-10 MHz	35.8

Source: Dataquest (September 1992)

Errata

Table 2 in the article entitled "Semiconductor Cost Trends 1992" in the Semiconductor Procurement *Dataquest Perspective* dated July 27, 1992 contained incorrect data. The corrected Table 2 can be found on page 14 of this document.

Table 2
1992 Package Cost Estimates—Total Assembled Cost (Die-Free)

No. of Pins (Vol.)	Plastic DIP (500K)	CERDIP/ QUAD (100K)	Side-Braze (25K)	SOIC/ SOJ (500K)	PLCC (500K)	LDCC (25K)	CLCC (100K)	Ceramic PGA (25K)	Plastic PGA (25K)	QFP (EIAJ) (100K)	PQFP-JEDEC (100K)	TSOP (50K)	TAB (TAPE) (per site)
8	0.08	0.30	1.95	0.12									
14	0.14	0.35	2.00	0.18									
16	0.16	0.36	2.05	0.18									
18	0.18	0.56	2.20	0.19	0.16		1.08						
20	0.20	0.62	2.40	0.19	0.18	3.00	1.20						
22	0.21	0.65	2.86	0.24									
24	0.22	0.67	3.12	0.25		3.69	1.44						
28	0.26	0.90	3.64	0.32	0.25		1.68					0.77	
32	0.30	0.99	4.12	0.36	0.29	4.59	1.92					1.20	
40	0.38	1.25	5.15	0.40		6.64	2.80			0.38		1.20	
44	0.50				0.37	7.31	3.08					1.32	
48	0.45		6.15				3.36			0.48			
52					0.51		3.84			0.52			
64	0.74						4.42		2.88	0.68			1.28
68		3.00			0.60		4.70	9.28	3.69	0.68			1.28
84		3.97			0.75		5.74	11.48	4.56	0.70 (80ld)			1.28
100								13.10	5.50	0.95	1.20		1.28
128								13.80	6.45	1.50	1.70 (132ld)		1.28
144								16.78	7.65	1.97			1.28
160								18.46	9.20	2.60	2.65 (164ld)		2.35
208								24.01	11.97	3.65			2.35
244									14.05	4.80			2.35
256									14.75				3.83
308								35.54	17.75				3.83
Material Consideration:													
Ld Frame Mat'l	C194	A42	A42	C194	C151	A42	None	A42	Cu	A42	C194	A42	Cu w/Sn plate
Ld Form	TH	TH	TH	Gull/J	J	Gull	None	TH	TH	Gull	Gull	Gull	Gull
Wire	Au	Al	Al	Au	Au	Al	Al	Al	Au	Au	Au	Au	NA
Lid	Epoxy	Ceramic	Au/Kovar	Epoxy	Epoxy	Au/Kovar	Au/Kovar	Au/Kovar	Au/Epoxy	Epoxy	Epoxy	Epoxy	NA
Preform	NA	Glass	Au/Sn	NA	NA	Au/Sn	Au/Sn	Au/Sn	NA	NA	NA	NA	NA

Note: Costs reflect offshore assembly. Plated metal not included in lead-frame cost (except TAB).
NA = Not available.
Source: Dataquest (September 1992)

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
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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9208 August 24, 1992

In This Issue...

Dataquest

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File inside the *Dataquest Perspective* binder labeled Semiconductor Procurement

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.15	0.15	0.14		0.14
74AC138	0.28	0.29	0.24	0.22		0.21
74AC244	0.43	0.40	0.37	0.34		0.36
74AC74	0.24	0.18	0.18	0.18		0.17
Lead Time: (Weeks)	3	3	12	4		5
4F00	0.11	0.10	0.10	0.09		0.09
4F138	0.15	0.18	0.14	0.13		0.14
4F244	0.22	0.24	0.21	0.20		0.23
4F74	0.13	0.12	0.12	0.10		0.11
Lead Time: (Weeks)	3	4	4	4		5
7805-TO92	0.14	0.15	0.11	0.09		0.11
CODEC-FLTR 1	1.75	1.81	2.50	1.60		1.45
CODEC-FLTR 2	4.05	3.91	5.00	4.25		
Lead Time: (Weeks)	6	3	6	3		
DRAM 1Mbx1-8	2.95	2.87	3.20	2.90		3.00
DRAM 1Mbx9-8	30.00	28.52	25.50	30.00		28.50
DRAM 256Kx1-8	1.10	1.42	1.55	1.00		1.05
DRAM 256Kx4-8	2.95	2.89	3.20	3.10		3.00
DRAM 4Mbx1-8	10.90	9.98	10.80	10.50		10.40
EPROM 1Mb 170ns	3.03	2.93	2.60	2.50		2.40
EPROM 2Mb 170ns	6.53	5.99	4.55	4.50		4.70
SRAM 1MB 128KX8	11.15	9.87	9.25	11.50		
SRAM 256K 32Kx8	3.10	2.96	3.20	3.00		3.10
SRAM 64K 8Kx8	1.65	1.43	1.55	1.20		1.10
Lead Time: (Weeks)	4	4	4	4		4
68020-16	27.25	28.13	26.00	32.00		
80286-16	7.15	8.22	10.00	8.00		6.90
80386DX-25	93.50	98.62	94.00	78.00		70.00
80386SX-16	41.50	41.27	45.00	40.00		37.00
R3000-25	94.50	104.09	80.00			
Lead Time: (Weeks)	2	7	4			

*Prices in U.S. Dollars
Source: Dataquest (August 1992)

Market Analysis

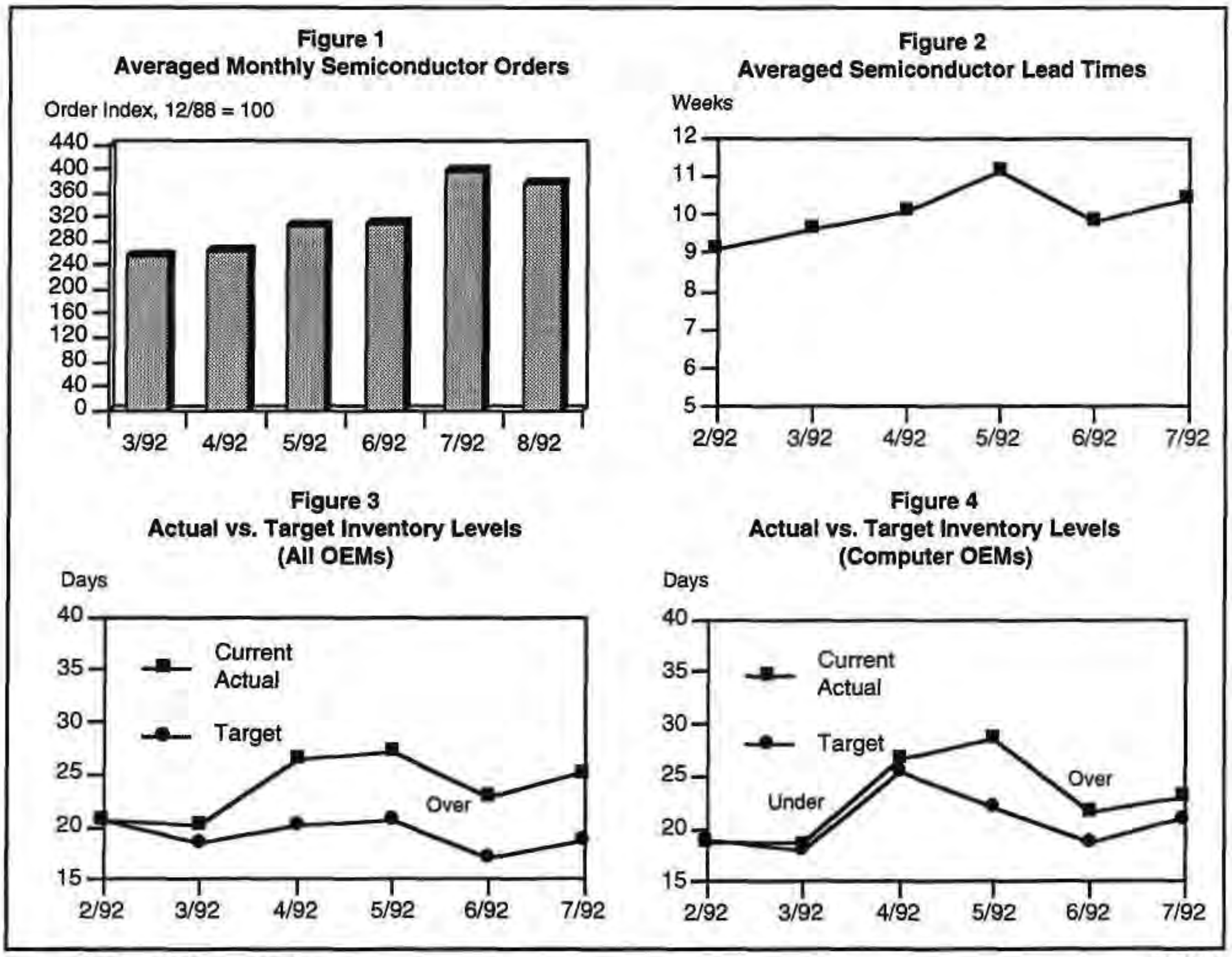
August Procurement Pulse: Orders and Lead Times Stabilize, While Inventories Remain Controlled

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rates Dip, but Long-Term Trend Is Still Up

Although the outlook for semiconductor orders is lower than it was last month, the overall six-month trend remains positive at a time when summer slows normally accelerate a seasonal decline in order levels (see Figure 1). The 5 percent decline in order activity from July's high level is still close to 21 percent (20.9 percent) over June expectations. Many of the suppliers that Dataquest has spoken with also see the relatively positive order outlook. Along with the semiconductor order outlook, the system sales expectations for the next six months remains positive, rising from last month's overall forecast of 6.8 percent to 8.0 percent for the next six months through February 1993. The computer subset also has raised its sales expectations to 6.25 percent, up from last month's 4.0 percent forecast.

Overall prices are expected to fall by 2.1 percent from last month, resuming the trend that was stalled because of the Micron ITC complaint over Korean DRAM dumping. Memories and



Source: Dataquest (August 1992)

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ASICs are leading the price declines, while selected 386 microprocessors also have seen aggressive price cuts. On the other side of the availability/price coin is the continuing problem of surface mount standard logic combined recently with some high-end 386/486 microprocessor products. The SOIC standard logic shortage apparently is being caused by suppliers that do not expect to see large demand in this package type later being swamped by unforecast demand in the short one- to two-month period that began in May. The uncertainty of a return on additional SOIC test capacity costs weighed heavily in the supplier decisions, the consequences of which are now being felt. Prices for these SOIC parts now take an additional 5 percent over similar DIP product. For the first time in recent memory, selected high-end X86 microprocessors are becoming difficult to obtain without solid forecasts primarily because of demand for system upgrades.

Lead Times Seesaw Up to 10.4 Weeks

This month's respondents noted an average lead time of 10.4 weeks, an increase from last month's reported 9.8 weeks (see Figure 2). Although commodity memory products, DIP standard logic, and sub-33-MHz microprocessors remain readily available, there are some products with lengthening delivery schedules. Lead times of up to 26 weeks for selected SOIC logic devices have been quoted, with an average of 12 to 16 weeks now normal. DIP packaged logic parts still have lead times under 8 weeks, highlighting the need for SMT test capacity for these devices. T092 packaged discrete parts also have extended lead times as high as 20 weeks for some parts. Both of these situations revolve around a contracted supply base that was not given adequate notice of short- and long-term demand trends. Common sense dictates that the smaller the number of suppliers, the longer and more accurate forecasts need to be. The longer lead time (12-plus weeks) situation with high-end Intel X86 microprocessors is now isolated to some users, but again highlights the need for accurate forecasting when the number of suppliers is low. Dataquest is also hearing of isolated longer lead times for some wide-word 4Mb DRAMs that should be rectified within one to two months, if not sooner, because of current available memory capacity levels.

Inventory Levels Bounce Up Two Days—Not a Big Deal

Although inventory levels for both the overall and computer sample rose slightly since last month (see Figures 3 and 4), the delta between target and actual has declined. The overall targeted and actual semiconductor levels for this month were 18.8 and 25.1 days, compared with last month's respective 17.0-and 22.9-day levels. The computer respondents averaged a targeted 21.0- and actual 23-day level relative to last month's 18.8- and 21.6-day target/actual range. While rising inventories often correspond with rising sales, some inventory build may be due to critical component inventory that recently had lead times stretch. Increased popularity in long-term contacts is being noticed for many semiconductors while users with procurement mixes of both street and contract pricing are shifting more of their total buy to contracts.

Dataquest Perspective

The summer of 1992 is so far breaking pattern with most, if not all, previous summer month slowdowns in business activity. Inventory levels waver between 20 and 30 days while overall availability remains very good. Although there are continued supply glitches in SMT standard logic and selected discrete and high-end X86 microprocessors, the overall market in North America continues to grow at a healthy pace. End market demand forecasts remain steadily positive with no large swings up or down to give credence to extended shortage scenarios often heard beginning at this time of the year on through November. Contract negotiation season is fast approaching and expected demand levels warrant close attention paid to those semiconductors that have limited numbers of suppliers and are critical to system manufacture.

By Mark Giudici

Product Analysis

The User's View on ASICs—Is Supply Base Contraction Ahead?

This article is based on Dataquest's final estimate of suppliers' 1991 application-specific IC (ASIC) market shares and related information and examines the technology life cycle for ASIC products as of August 1992. It also provides users with an evaluation of the supply/supplier base for these ICs during the 1990s. The primary focus will be MOS\BiCMOS gate arrays, but will include assessments for users of bipolar arrays and MOS\BiCMOS CBICs.

This report provides ASIC users with practical and strategic information for choosing devices to use, and from which supplier or suppliers. This article contains three sections, as did other articles in this product trends series. The first section develops a guide to cost-effective, long-term procurement by analysis of the ASIC technology migration path. The second section examines the product strategies, merchant/captive market postures, strategic alliances, and fab networks of the leading ASIC suppliers. The third section combines the analyses of ASIC life cycles and the supplier base. This formation gives users a practical way of assessing their ability to obtain a supply of these devices from the various suppliers during the 1990s. The goal of this report is to enable users to develop a sound strategy for satisfying ASIC demand on a consistent cost-conscious basis over the long term, despite shifts in supplier base.

Definitions

An ASIC is a logic product customized for a single user. Dataquest defines ASICs as including gate arrays, cell-based integrated circuits (CBICs), programmable logic devices (PLDs), and full-custom ICs. Gate arrays are defined as semicustom digital or linear/digital ICs containing a configuration of uncommitted logic elements, which are customized by interconnecting the logic elements with one or more routing layers. CBICs are digital or mixed-linear/digital ICs that are customized using a full set of masks; the product consists of precharacterized cells or macros including standard cells, megacells, and compilable cells.

At the outset, we should note that the ASIC supplier base—especially suppliers of MOS gate arrays and CBICs—has been under intense competitive pressure for the past several years. The wide supplier base for MOS\BiCMOS gate arrays means intense supplier competition—augmented by competition from alternative ASIC choices such as programmable gate arrays, a type of PLD. For suppliers of MOS/BiCMOS gate arrays, the business has not been especially profitable, with suppliers eyeing each other for potential market departures.

Section 1: ASIC Technology Life Cycles

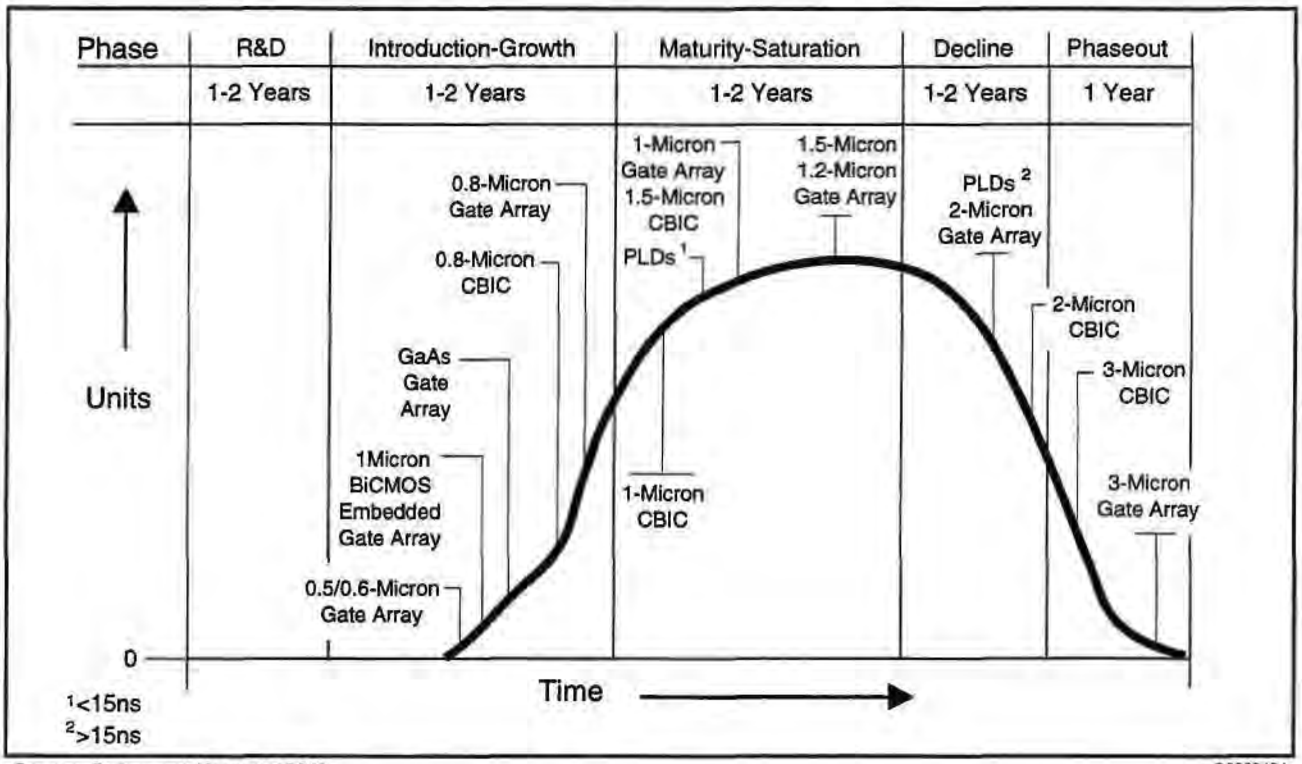
This section uses information on ASIC product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over both the short and long term. To some extent, an ASIC does not easily lend itself to product life cycle analysis because an ASIC is as much a technology as a product. Nevertheless, a look at ASIC product technology life cycle curves can assist users in positioning ASIC products among other IC life cycles such as standard logic. For example, although any given gate array is not at a specific point on the life cycle curve, the various gate array technology levels as measured in line geometry tend to follow the movement of the curve.

Figure 1 shows the life cycle stage for gate arrays, CBICs, field-programmable gate arrays (FPGAs), and PLDs as of August 1992. The ASIC product technology life cycle, which typically runs four to seven years excluding R&D, is shorter than most IC life cycles. ASICs can approach the peak stage within two or three years after introduction.

The life cycle of ASICs in the growth stage should extend until the latter half of this decade. As shown in Figure 1, these devices include 0.8-micron gate arrays, 0.8-micron CBICs, gallium arsenide (G As) gate arrays, 1.0-micron BiCMOS gate arrays, embedded gate arrays, 0.5-micron gate arrays, and 0.6-micron gate arrays.

In terms of product technologies, CMOS remains the workhorse technology. BiCMOS and GaAs will grow in terms of market share with bipolar technology on the decline. For 3V applications, a debate wages regarding the value—if any—of BiCMOS over the CMOS technology. The BiCMOS and GaAs technologies stand at virtual price parity (about $0.005 per gate).

Figure 1
ASIC Product/Technology Life Cycle as of August 1992 (Production Unit Volume)



Source: Dataquest (August 1992)

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The information in Figure 1 reveals that 1.5-micron gate arrays and 1.2-micron gate arrays have neared the decline stage of the cycle. This development marks a change from the perspective of last year's report. As will be discussed, the life cycle expectation for these devices does vary in some cases on a supplier-by-supplier basis. The 2-micron gate array and 2-micron CBIC products are moving through the decline stage—with phase-out to occur about 1994. Figure 1 also shows that the life cycle for 3-micron gate arrays and 3-micron CBICs is winding down, except for some military/aerospace applications.

Section II: Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of ASIC products. This analysis covers product positioning, market ranking, geographic focus, and related issues. Table 1 shows Dataquest's final 1991 worldwide ASIC market share ranking of the top 10 suppliers in dollars. Table 2 shows Dataquest's estimate of these suppliers' worldwide ASIC fab capability as of 1991. The information in these tables serves as the background for the analysis of the top 10 suppliers and also the analysis of product life cycles/supplier base.

Fujitsu

Fujitsu, a vertically integrated electronics manufacturer, continues to maintain its position as the top-ranked supplier of ASICs in terms of total factory revenue, which comprises captive consumption and merchant market sales. Captive consumption is a key element to Fujitsu's ranking.

Fujitsu ranks first among suppliers of bipolar gate arrays and third in the MOS/BiCMOS array business. Fujitsu has established an excellent reputation in the merchant marketplace as a supplier of bipolar ECL and TTL gate arrays. Fujitsu holds sixth position among suppliers of MOS/BiCMOS CBICs versus an eighth place ranking the year before. ASIC users can expect a firm commitment by Fujitsu to serve demand for these products. However, the company focuses somewhat more strongly on Asian markets than on other regions (for example, North America).

Table 1
ASIC Suppliers Ranking (Factory Revenue in U.S. Dollars)

1991 Overall Ranking	Market Share (%)	Company	Product Ranking: Gate Arrays MOS/BiCMOS	Gate Arrays Bipolar	CBIC MOS/BiCMOS	PLDs MOS/BiCMOS
1	11.6	Fujitsu	3	1	6	
2	10.0	NEC	2	2	9	
3	7.8	LSI Logic	1		12	
4	6.3	Texas Instruments	16	17	2	10
5	6.0	AT&T		5	1	9
6	5.9	Toshiba	4		7	
7	5.8	Hitachi	5	3	17	
8	3.7	AMD		12		4
9	3.5	VLSI	6		4	
10	3.1	Motorola	10	4	21	
Subtotals of Segments ($B)			2.84	1.07	2.17	0.56
Total Market ($B)*			7.07			

*Includes some segments not shown
Source: Dataquest (August 1992)

Table 2
Estimated Number of Wafer Fabrication Production and Pilot Lines of Top-Ranked ASIC Suppliers (As of July 1992)

	North America	Japan	Europe	Asia/ Pacific-ROW	Total	Total Theoretical Capacity[4]
Fujitsu	1	20	1	0	22	111.1
NEC	2	24	2	0	28	149.1
LSI[1]	1	2	1	0	4	NA
Texas Instruments[2]	10	5	4	3	22	95.1
AT&T	9	0	1	0	10	22.4
Toshiba[3]	0	28	0	0	28	158.6
Hitachi	1	27	1	0	29	141.3
AMD	4	0	0	0	4	16.8
VLSI	3	0	0	0	3	7.3
Motorola	21	2	5	1	29	103.6

NA = Not available
[1]Includes LSI/MTG Arrangement
[2]Includes TI/Acer
[3]Does not include Tohoku Semiconductor
[4]Theoretical capacity stated in millions of square inches per year
Source: Dataquest (August 1992)

Fujitsu's critical strategic alliance is the relationship with Amdahl for supplying ECL gate array products used in Amdahl's high-performance computers.

NEC

Second-ranked NEC also capitalizes on its position as a vertically integrated manufacturer to achieve economies of scale in ASIC production. NEC ranks second among suppliers of MOS/BiCMOS gate arrays and second in the bipolar (ECL) array business. Its expansion during 1991 stemmed in part from strong growth in Japan and Asia/Rest of World. The BiCMOS process represents a key element of NEC's product direction in ASICs.

NEC has set a long-term strategic goal to advance in the CBIC market. A result is that during 1991 NEC moved into the top-10 tier of suppliers of MOS/BiCMOS CBICs, advancing five places in the process. NEC's cell library includes 8-bit Intel microprocessor architectures.

LSI Logic

Third-ranked LSI Logic continues to rank first in the MOS/BiCMOS gate array marketplace. The company serves only merchant market customers. LSI holds 12th position among MOS/BiCMOS CBIC suppliers.

LSI Logic's strategy has remained consistent over time: Push ASIC technology as hard and as fast as possible into submicron line geometry and into high-density configurations. For example, LSI has announced a 600,000-gate array (utilized gates) based on a 0.6-micron CMOS process. Volume shipments of this device are expected for the first half of 1993. LSI Logic's long-term product direction in ASICs calls for more of the same—pushing the development of MOS/BiCMOS gate arrays and CBICs in terms of technology, performance, and software, including silicon compilers.

Although it should continue to withstand the intense competition from huge vertically integrated companies, LSI publicly expresses its concern regarding the long-term challenge of earning profits in part because of the billion-dollar-plus investment required for competitive state-of-the-art ASIC fabs (see Table 2). LSI likely will continue to rely on strategic alliances as a way of strengthening its competitive position in the ASIC business.

Texas Instruments

Fourth-ranked Texas Instruments (TI) holds second ranking among suppliers of MOS/BiCMOS CBICs. The company has been a rising star in this segment of the ASIC marketplace, with a strong showing in the Japan market.

Along with its 10th-place ranking among suppliers of MOS/BiCMOS PLDs, TI ranks second in the now declining bipolar PLD business. TI also ranks among the top 20 companies in gate arrays: 16th in the MOS/BiCMOS gate segment, and 17th in the bipolar gate array arena.

AT&T

Fifth-ranked AT&T continues to rank first among suppliers of MOS/BiCMOS CBICs and fifth among suppliers of bipolar gate arrays. The company jumped several notches during 1991 in terms of worldwide market ranking.

This vertically integrated manufacturer's position derives in part from captive consumption. However, merchant market sales represent a key element of AT&T's long-range ASIC strategy. For example, AT&T's recent advance in the CMOS PLD sector—a ninth-place ranking for 1991—was highlighted by its competitive entry into the field-programmable gate array (FPGA) segment with device densities of 20,000 gates and less. In addition to its own line of FPGAs, AT&T formed a second-source arrangement with Xilinx on some lower-gate-count products and with NEC on gate arrays.

Toshiba

As do other Japan-based suppliers, sixth-ranked Toshiba draws on its position as a vertically integrated manufacturer to achieve competitive economies of scale in ASIC production. Table 1 shows that Toshiba ranks fourth among suppliers of MOS/BiCMOS gate arrays and seventh in the MOS/BiCMOS CBIC marketplace. Toshiba experienced (slow) growth in North America and Europe during the past year.

For users of high-gate-count gate arrays and CBICs, the merchant market represents a key strand of Toshiba's leading-edge ASIC strategy. For example, on pace with its alliance partner LSI Logic, Toshiba has announced a 500,000-gate-array (utilized gates, 0.5-micron process) with volume production schedule for the first half of next year.

Hitachi

Seventh-ranked Hitachi ranks third among bipolar gate array suppliers, fifth in the MOS\BiCMOS segment, and seventeenth in the MOS\BiCMOS CBIC segment. Hitachi views the BiCMOS process as a key product technology for the long term. For this large vertically integrated company, captive consumption accounts for a substantial share of ASIC revenue.

This supplier has shown impressive performance over recent years in the CIBC market through its 0.7-micron and 1.0-micron technologies. Key applications for these CBICs include disk drives and telecommunications systems.

Advanced Micro Devices (AMD)

Eighth-ranked AMD ranks fourth among suppliers of MOS/BiCMOS PLDs and twelfth in the bipolar gate array business. AMD continues to hold first ranking among suppliers of bipolar PLDs, a declining business segment. This supplier is making the migration to CMOS PLDs, offering a product portfolio that includes both simple and complex devices.

VLSI Technology

Ninth-ranked VLSI holds fourth position among MOS/BiCMOS CBIC suppliers. The company has been maintaining its position in the competitive CBIC segment. The company ranks sixth in the MOS/BiCMOS gate array marketplace—which represents an impressive rebound versus prior years' performance in this highly competitive marketplace. How impressive? VLSI vaulted five notches during 1991. In two to three years, the alliance with Intel on 386SL chip sets should mean an attractive market opportunity for VLSI as the requirements of hand-held PCs shift from chip sets to ASICs.

Motorola

Motorola moved into the top-10 tier of worldwide ASIC suppliers during 1991. Tenth-ranked Motorola holds fourth position among bipolar gate array suppliers, tenth in the MOS/BiCMOS gate array segment, and twenty-first in the MOS/BiCMOS CBIC arena. The company jumped two places in terms of MOS/BiCMOS gate array ranking during 1991.

Part III: Supply Base Analysis

This section uses information on ASIC product/technology life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for gate arrays and CBICs. The goal of this section is to provide users with a practical means of gauging the long-term supply base for these ASICs and direction for selecting suppliers of the devices.

Each section contains a table showing the size of the market in terms of factory revenue during 1991 and a ranking including suppliers' shares in each product segment. The product/technology life cycle analysis serves as the basis for a summary assessment from a user's perspective on anticipated availability of MOS/BiCMOS gate arrays and MOS/BiCMOS CBICs. The summary includes a succinct statement on whether the user faces a favorable or a critical supply base for each product technology. Building on the prior sections, factors affecting the supply base such as supplier strategies are discussed here.

Supply Base for MOS/BiCMOS Gate Arrays

Table 3 provides information on the market size and leading suppliers of MOS/BiCMOS gate arrays.

Worldwide factory revenue totaled $2.84 billion during 1991. The table also shows that the top four suppliers continue to account for nearly 60 percent of MOS/BiCMOS gate array market share.

Mainstream Gate Array Technology: 0.8- and 1.0-Micron CMOS

Figure 1 reveals that in Dataquest's estimate arrays in line geometries between 0.8 and

Table 3
Supply Base for MOS/BiCMOS Gate Arrays
(Percentage Share of Factory Revenue)

Company	Market Share (%)
LSI Logic	17.5
NEC	15.5
Fujitsu	15.0
Toshiba	11.7
Hitachi	7.1
VLSI Technology	3.5
Seiko-Epson	3.2
Matsushita	2.9
GEC Plessey	2.7
Motorola	2.7
Others	18.2
Total	100.0
Total Market ($B)	2.84

Source: Dataquest (August 1992)

1.0 microns represent the mainstream MOS gate array technology for 1992 and 1993. This trend applies especially to arrays in gate counts of greater than 5,000 and 20,000 gates. The life cycle for these arrays should extend until 1994 or 1995. For arrays in gate counts of greater than 20,000 gates (for example, 0.8-micron technology), the greater complexity and associated higher development cost should extend the life cycle to the 1996 time frame.

In terms of regional segments, the leading suppliers of MOS/BiCMOS gate arrays in North America (in descending order) are LSI Logic, Motorola, VLSI Technology, National Semiconductor, AT&T, and Raytheon. For Europe, they are GEC Plessey, SGS-Thomson, Siemens, Matra-MHS, and Philips.

Users of gate arrays in line geometries of 1.0 microns and less—which are typically higher-gate count devices with average densities in excess of 10,000 gates—can expect an ample supply situation for the next several years, barring a major and unexpectedly severe contraction of the supplier base. Leading-edge suppliers such as LSI Logic, NEC, Fujitsu, Toshiba Hitachi, and VLSI will compete to meet user demand for these parts. Figure 1 also shows other products for which Dataquest expects growth over the next several years: 0.8-micron CBICs, GaAs gate arrays, 1.0-micron BiCMOS gate arrays, embedded gate arrays, and 0.5-/0.6-micron CMOS gate arrays.

By contrast, the 2.0-micron technology now declines while 3.0-micron arrays face phase-out except for some highly specialized military/ aerospace applications.

1.5-Micron Gate Array Life Cycle: Varies Supplier by Supplier

The advisory issued in last year's report—that users can expect some contraction of the MOS/BiCMOS gate array business during the medium-term—continues to hold true. The intense level of supplier competition, as indicated before, has meant low levels of profitability or losses for many suppliers over the past two years. In response, during late 1991 and early 1992, a number suppliers of 1.5-micron arrays reassessed their strategy for this market segment.

The result in effect was that the life cycle for 1.5-micron arrays has been truncated somewhat vis-a-vis original expectations—with the life-cycle outlook varying during the 1992 to 1993 period on a supplier-by-supplier basis. For example, during the first quarter of 1992, VLSI closed its 1.5-micron gate array lines. Based on information provided by industry sources, Dataquest believes that LSI Logic and Motorola have in effect left the 1.5-micron MOS gate array business. Fujitsu's view for 1992 is that it will continue to support users but expects the life cycle to terminate during 1993. By contrast, National Semiconductor and Toshiba remain committed to serving user demand over the medium term—meaning a somewhat longer 1.5-micron cycle in the case of these suppliers.

Supply Base for Bipolar Gate Arrays

The bipolar ECL gate array technology will experience a steady but nondramatic decline during the 1990s. The BiCMOS technology and the GaAs technology will each take share from the bipolar ECL approach, although the bipolar technology is not nearing the end of the product/technology life cycle. Users can expect a dependable supply of the high-performance bipolar technology during the 1990s. However, users should be prepared over time to forge long-term relationships with key suppliers.

Table 4 provides information on the market size and leading suppliers of bipolar arrays.

Table 4
Supply Base for Bipolar Gate Arrays
(Percentage Share of Factory Revenue)

Company	Market Share (%)
Fujitsu	26.3
NEC	18.5
Hitachi	16.9
Motorola	11.3
AT&T	4.7
Raytheon	4.2
GEC Plessey	3.3
AMCC	2.9
National Semiconductor	2.6
Siemens	2.0
Others	7.3
Total	100.0
Total Market ($B)	1.07

Source: Dataquest (August 1992)

Worldwide factory revenue totaled $1.07 billion during 1990, down from $1.12 billion during 1990. The table reveals a highly concentrated supplier base: The top four suppliers—Fujitsu, NEC, Hitachi, and Motorola—account for more than 70 percent of bipolar gate array factory revenue. In terms of regional segments, the leading suppliers of bipolar gate arrays in North America (in descending order) are Motorola, AT&T, Raytheon, Applied Micro Circuits Corp. (AMCC), National Semiconductor, and Exar. For Europe, they are GEC Plessey and Siemens.

Supply Base for MOS/BiCMOS CBICs

Table 5 provides information on the market size and leading suppliers of MOS/BiCMOS CBICs. Worldwide factory revenue totaled $2.17 billion during 1991. The table shows key differences vis-a-vis the gate array markets: less concentration of the supplier base, and US. leadership in terms of market share. In terms of Europe, the leading suppliers (in descending order) are Mietec, GEC Plessey, SGS-Thomson, Austria Mikro Systeme, European Silicon Structures, and Siemens. Mietic has grown impressively in Europe.

Figure 1 reveals that the product technology life cycle for MOS/BiCMOS CBICs parallels that of MOS/BiCMOS gate arrays. However, in most cases the CBIC life cycle likely will persist for a somewhat longer period because CBICs are better suited for more complex functionality including analog, mixed-signal, and/or microperipheral applications—which means slower rates of system/CBIC redesign.

Table 5
Supply Base for MOS/BiCMOS CBICs
(Percentage Share of Factory Revenue)

Company	Market Share (%)
AT&T	16.4
Texas Instruments	13.5
Hewlett-Packard	9.5
VLSI	7.0
Mietec	4.3
Fujitsu	4.2
NCR	3.9
Toshiba	3.9
NEC	3.2
Harris	3.0
GEC Plessey	3.0
Others	28.1
Total	100.0
Total Market ($B)	2.17

Source: Dataquest (August 1992)

Dataquest Perspective

Although ASIC technology life cycle analysis can serve as a tool for a long-term assessment of the supply/supplier base for these devices, the comparatively short ASIC technology life cycles can make management of the ASIC supply base a challenging task for procurement teams. To answer the question posed in the title of this article, users should prepare themselves for a nondramatic, long-term contraction of the supplier base, especially in commodity-type arenas such as MOS gate arrays.

Dataquest's final 1991 market ranking for ASIC suppliers shows that 6 of the top-10-ranked suppliers are North America-based companies. The other four are vertically integrated Japan-based suppliers whose ASIC factory revenue includes a substantial percentage of internal captive consumption. These companies are not likely candidates for market departure. However, their world geographic market orientation may shift periodically. For example, some North America-based companies quite active today in the European region might be forced to reevaluate their positions should trade friction increase. Another example is that Japan-based companies are taking differing approaches this year to serving demand in North America, given rising trade tension in this region. Some Japan-based suppliers are increasing their focus on North America, despite the current trade tension, while other suppliers are focusing on Asian regions.

Despite some consolidation of the supplier base for commodity-type gate arrays and CBICs, users can continue to also expect less familiar market players such as Mietec and Xilinx to make their mark in the complex ASIC arena, which still offers windows of opportunity for entrepreneurial companies—as well as entrepreneurial divisions of large organizations. Indeed, given the even greater level of competition in other IC markets such as DRAMs, the ASIC marketplace likely will attract increased strategic emphasis over time from companies such as Siemens—even as other suppliers exit.

By Ronald Bohn

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

Q. What are the historical and current main component costs of a typical laptop computer?

A. Table 1 shows Dataquest's estimates costs of a typical laptop computer during the fourth quarter of 1991 and the third quarter of 1992. Note that the disk capacity is now more than two times that of the fourth-quarter 1991 machine. The following assumptions should be kept in mind while reading the table:

- Pricing for integrated circuits based on North American bookings (volume order) forecast dated December 1991 and July 1992
- Pricing for subsystems based on North American/Silicon Valley spot market estimates during December 1991 and July 1992
- Memory cost based on DRAM/SIMM pricing and not flash memory
- Screen assumed is a 10-inch triple super twisted nematic LCD (TSTN LCD), which ranged in price in North America from $850 to $1,150 during December 1991 and from $300 to $600 in August 1992

Table 1
Typical Laptop Computer Prices

Component	Description	Q4'91 Cost ($ Est.)	Q3'92 Cost ($ Est.)
Processor	80386SL-20 MHz with cache	135.00	67.00
System RAM	2MB	75.52	44.10
Expanded RAM	8MB	301.36	176.40
Screen*	LCD	950.00	450.00
Resolution	640 × 480 VGA		
Hard Disk	20MB (Q4'91)	90.00	
	42MB (Q3'92)	-	230.00
ROM on Board	2MB	13.00	11.90
Extension Card	4MB	150.68	88.20
Fax	9,600 bps**	80.00	76.00
Modem	2,400 bps**		
Battery	Rechargeable	27.00	25.00
Power Supply	Autosensing 110-220/240V	80.63	80.00
Total Cost		1,903.19	1,248.60

*Note assumptions
**Combined cost for fax/modem
Source: Dataquest (August 1992)

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9207 July 27, 1992

In This Issue...

Dataquest

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File inside the *Dataquest Perspective* binder labeled Semiconductor Procurement

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.17	0.15	0.16	0.15	0.14
74AC138	0.28	0.33	0.26	0.25	0.24	0.21
74AC244	0.43	0.44	0.35	0.38	0.39	0.36
74AC74	0.24	0.20	0.20	0.20	0.20	0.17
Lead Time: (Weeks)	5	3	12	4	5	5
4F00	0.10	0.12	0.09	0.10	0.09	0.09
4F138	0.15	0.20	0.15	0.16	0.16	0.14
4F244	0.22	0.27	0.21	0.23	0.23	0.23
4F74	0.11	0.14	0.12	0.12	0.12	0.11
Lead Time: (Weeks)	5	4	12	4	5	5
7805-TO92	0.12	0.17	0.11	0.11	0.11	0.11
CODEC-FLTR 1	1.75	2.13	2.50	1.80	1.94	1.45
CODEC-FLTR 2	4.05	4.39	5.00	4.55	4.70	
Lead Time: (Weeks)	7	3	6	3	4	
DRAM 1Mbx1-8	3.13	3.22	3.20	3.33	3.10	3.25
DRAM 1Mbx9-8	31.50	32.38	27.00	33.50	36.80	30.00
DRAM 256Kx1-8	1.13	1.60	1.55	1.05	1.20	1.05
DRAM 256Kx4-8	3.18	3.24	3.20	3.40	3.40	3.25
DRAM 4Mbx1-8	11.45	11.06	11.50	12.15	12.50	11.00
EPROM 1Mb 170ns	3.05	3.36	2.85	3.03	3.10	2.40
EPROM 2Mb 170ns	6.50	6.83	4.20	5.70	6.33	4.70
SRAM 1MB 128KX8	11.50	10.86	9.25	13.00	13.60	
SRAM 256K 32Kx8	3.53	3.28	3.25	3.45	3.80	3.20
SRAM 64K 8Kx8	1.73	1.56	1.55	1.40	1.37	1.40
Lead Time: (Weeks)	2	4	4	4	7	4
68020-16	27.25	34.36	26.00	33.75	31.50	
80286-16	7.28	9.28	10.00	9.50	10.10	6.90
80386DX-25	94.50	120.44	94.50	98.00	96.00	75.00
80386SX-16	44.00	47.78	45.00	47.50	47.20	37.00
R3000-25	100.00	116.49	110.00			
Lead Time: (Weeks)	2	7	4			

*Prices in U.S. dollars
Source: Dataquest (July 1992)

Market Analysis

July Procurement Pulse: Orders Take Off, While Lead Times and Inventories Correct Themselves

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Order Rates for Semiconductors Expected to Buck Summer Slows

As seen in Figure 1, the expected order level of semiconductors is expected to jump appreciably from the relatively static forecasts of the past five months. This 28 percent anticipated increase in order activity is coming primarily from nondata processing applications countering the traditional summer slowdown trend. Even if this forecast is cut in half, the next month's resulting double-digit growth level still attests to a steady growth pattern emerging that is involving the majority of electronic applications.

Even though the semiconductor order rate is expected to rise, the six-month system sales rate continues to slip. The outlook for the computer segment of this month's survey averaged plus 4.0 percent through January 1993, while the overall sample expects sales to increase by 6.8 percent over the same period. This is down from last month's relatively positive computer outlook of plus 6.2 percent and overall plus 8.0 percent system forecast. Part of this decline is due to seasonal end-of-year pull-in shipment expectations, yet some is also due to concern of a slackening of computer shipments. Some computer companies continue to do well in the current market by meeting upgrade and low-cost replacement needs.

Overall prices are expected to drop a flat 1.1 percent, very similar to last month's 1.3 percent

Figure 1
Averaged Monthly Semiconductor Orders

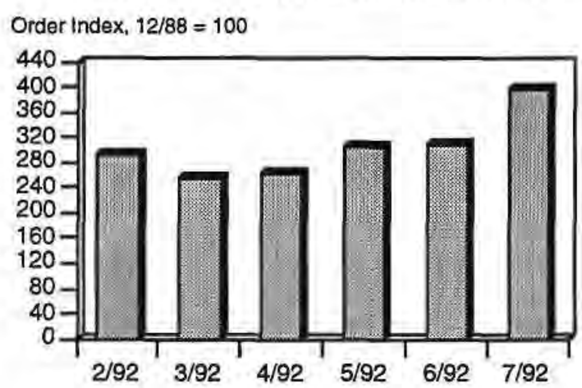


Figure 2
Averaged Semiconductor Lead Times

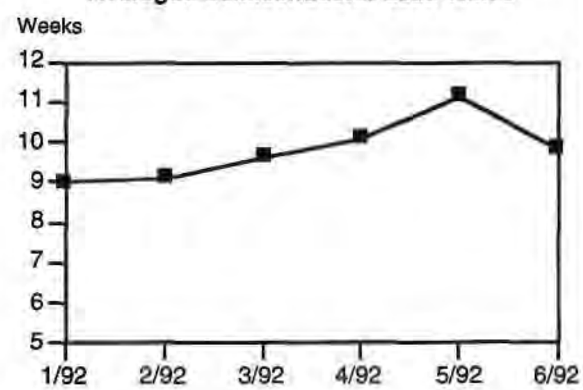


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

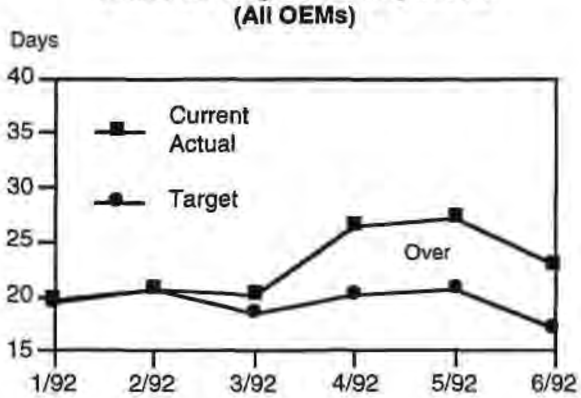
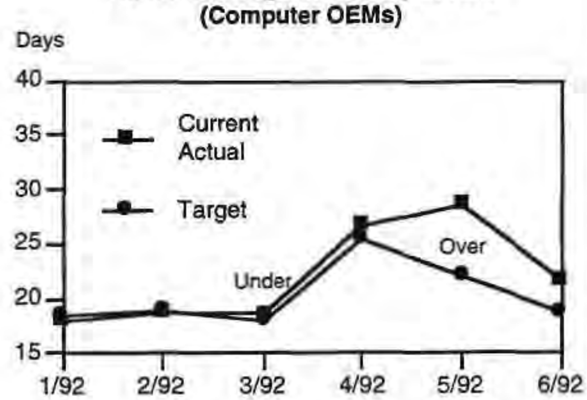


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (July 1992)

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decline. Memory prices have resumed their rate of decline now that the effect of the Micron dumping allegation has been absorbed. The main stabilizer of prices has been the surface mount logic market, where capacity levels have been stretched with resulting longer (up to 13 weeks) lead times and firmer/higher prices for these parts. Due to the condensed supply base of standard logic, the capacity strain on surface mount product is expected to remain for the next three to six months. Tied in with the contracted logic supply base is the need from suppliers to announce end of life buy in enough time for users to find adequate replacements or redesigns.

Lead Times Fall below 10 Weeks

The crisp decline of lead times down to 9.8 weeks relative to the gradual increases seen over the past five months, as noted in Figure 2, corresponds to the easing of memory availability and the aggressive delivery stance taken by AMD in the 80386 market after the 80287 microcode decision favoring Intel. As mentioned earlier, the surface mount standard logic market and some discrete packaging options (TO92) continue to prop up the overall lead time average, while the rest of the market continues to enjoy good availability and controllable lead times. The longer lead times noted for DRAM/VRAM last month have come down as hungry suppliers have increased output to meet demand. This correction of supply meeting demand has been noted in past articles and there remains additional capacity, should demand continue to grow. The SMT logic situation is the result of a contracted supply base in a marginally profitable market reluctant to add SMT capacity without a predictable return on investment.

Anticipated Semiconductor Inventory Corrections on Track

Figures 3 and 4 highlight the pervasiveness of cost containment in the current market and how inventory level adjustments generally correct imbalances within a two- to three-month period. The overall targeted and actual semiconductor levels for this month were 17.0 and 22.9 days, compared with last month's respective 20.7- and 27.1-day levels. The computer subset saw a similar shift with targeted and actual levels falling from last month's 22.2 and 28.7 days to a respective current 18.8- and 21.6-day range. This correction was anticipated (especially with the data processing companies) and is expected to continue as the longer-term demand picture appears to be returning to a slow growth mode. The contraction of inventory targets and actual levels while expecting increases in semiconductor orders implies confidence in good communication both internally and externally with suppliers. Dataquest expects the inventory balancing act to continue to be a good bellwether of future business conditions and testament to tight cost control.

Dataquest Perspective

The expected slowing of demand at the turn of the year, combined with above-acceptable target inventory levels noted over the past two months, has resulted in a back-to-basics approach in cost control and forecasting. The ability of suppliers (with the exception of SMT logic) to meet additional demands of the market has been tested but not stressed. While demand levels for end-use products appears to be leveling off, the slow growth juggernaut that was launched early this year continues to steam on. As price erosion for semiconductors continues, room will remain for system price competition. Dataquest continues to see steady growth in available semiconductor sales predicated on the consistent system sales expansion that is anticipated for the rest of this year.

By Mark Giudici

Everything You Need to Know about DRAM and 80X86 Pricing—Midyear 1992 to the Year 1996

Economic signals remain mixed as of midyear 1992. Although lead times for devices such as 256Kx4 VRAM ZIP stretched in North America during the second quarter, users and suppliers face uncertainty whether the industry will experience a typical summer seasonal slowdown this year—or sustain momentum toward robust second half 1992 growth. From this economic backdrop, our article presents key results from Dataquest's May-June 1992 North American bookings price survey.

The article's focus is the long-term price outlook in North America for DRAMs and 80X86 MPUs—along with an assessment of the market assumptions that guide the forecasts. The modest goal, as stated in the title, is to provide our clients with everything they need to know about DRAM and 80X86 pricing from now to 1996. Or at least, more realistically, to provide a structured framework for managing short- and long-term pricing strategies in these volatile markets.

Readers should note that the pricing analysis presented in this article correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement Service (SPS) clients dated June 1992. The survey information was collected by Dataquest's Research Operations. For SPS clients that use the SPS online service, the pricing presented here correlates with the quarterly and long-range price tables dated June 1992 in the SPS online service. The price tables are available in the Source: Dataquest document entitled "North American Semiconductor Price Outlook: Third Quarter 1992." For additional product coverage and more detailed product specifications, refer to those sources.

Dataquest added the following ICs, among others, to its quarterly survey of North American bookings pricing: 386SX-25 PQFP; 386SL-25 CPGA; 80486DX2-50; 4Mbx4 DRAM 70ns SOJ 400 mil; 1Mbx36 SIMM 80ns; and 1Mbx16 ROM. Let us know your recommendations on price survey coverage.

Memory Trends

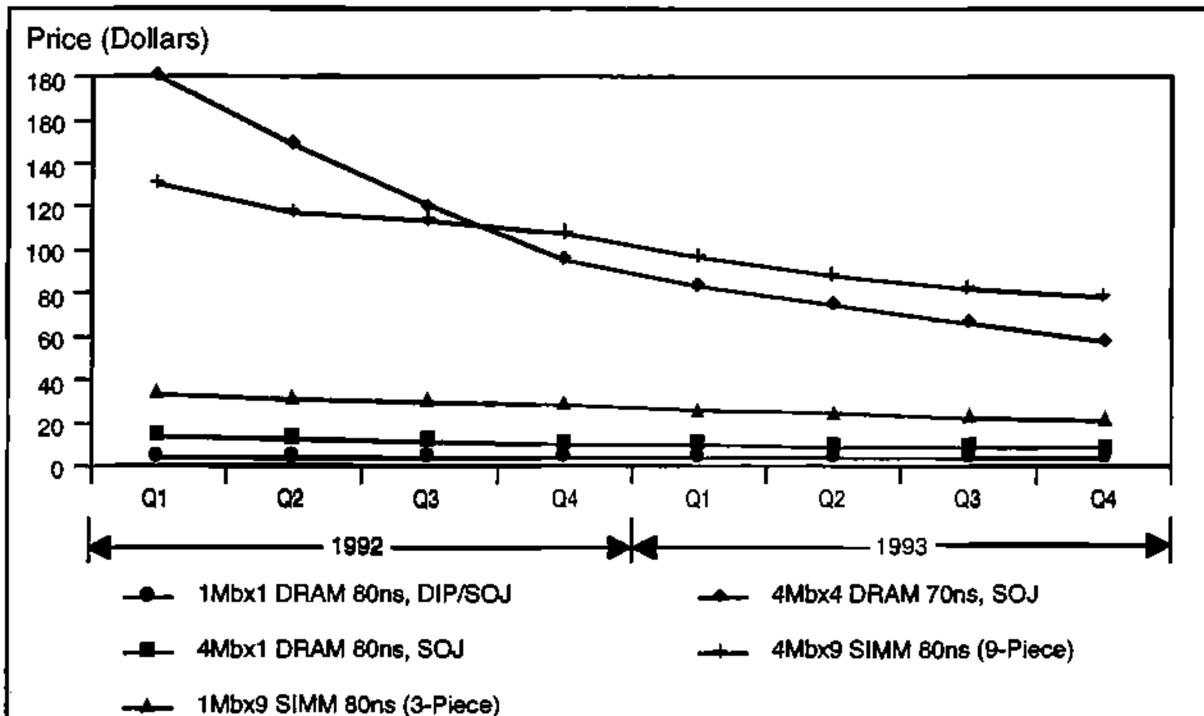
The recent pickup in IC demand generates concern over the second half 1992 DRAM price outlook. Even so, the results of the quarterly price survey signal continued competitive DRAM pricing in North America during the last half of 1992—barring an unexpectedly drastic short-term change in the supply-demand equation (see Table 1 and Figure 1). Micron's dumping allegations against Korean suppliers should moderate against an aggressive downward trend in megabit-density DRAM pricing in North America.

Table 1
Estimated Semiconductor Pricing Trends (North American Bookings, Volume Orders) per Second Quarter Survey of Price Trends (Dollars)

Part	Forecast for Third Quarter 1992 ($)	Estimated Fourth Quarter 1992 Price Range ($)	Estimated Fourth Quarter 1993 Price Range ($)	Forecast for 1996 ($)
1Mbx1 DRAM 80ns, DIP/SOJ	3.45	3.10 to 3.55	2.90 to 3.55	3.70
4Mbx1 DRAM 80ns, SOJ	11.05	10.00 11.02	8.95 to 10.06	5.50
256Kx16 DRAM 70ns, SOJ	13.99	12.00 to 13.60*	9.45 to 10.45*	5.72
4Mbx4 DRAM 70ns SOJ 400 mil	119.60	95.00 101.00	55.00 to 59.10	14.00
1Mbx36 SIMM 80ns (9 piece)	107.00	100.00 107.30	75.90 88.25	56.10
386SX-25 PQFP	68.99	57.75*	34.00*	20.00
386DX-25 PQFP	74.00	68.00*	57.00*	34.00
80486SX-20 PQFP	99.00	96.00*	82.00*	53.00
80486DX-33 CPGA	365.00	325.00 to 370.00*	160.00*	80.18
80486DX2-50 CPGA	465.00	415.00*	224.00*	80.99

*Estimated but not by survey.
Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (July 1992)

Figure 1
DRAM Price Trends (North American Bookings; Volume: 1,000,000)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated June 1992.

Source: Dataquest (July 1992) G2000309

The DRAM Price Outlook: This Year, Next Year, and 1996

Table 1 shows the price outlook for DRAMs for select periods between 1992 and 1996. For example, the table shows that pricing for standard 1Mbx1 DRAM should range from a low of $3.10 to a high of $3.55 for major buyers in North America for the fourth quarter of 1992. The survey results indicate that low-end pricing for 1Mb DRAM in some cases should decline to a price of just under $3 during the second half of 1993, although Dataquest expects that the market average likely will be higher. For 1996, Dataquest's projected price of $3.70 stems in part from the product's being in the decline stage of the life cycle at that time.

Table 1 reveals the following price outlook for major North American users of standard 4Mbx1 DRAM: Pricing should range from $10 to just more than $11 for the fourth quarter of 1992. Because of a possible change in the DRAM capacity outlook, 1993 should be a critical year in terms of the long-range 4Mb DRAM price outlook. Under current market conditions, the survey results call for a price range from $8.95 to just more than $10 for the 4Mb part during the fourth quarter of 1993. The North American price for 4Mb DRAM should decline to a conservative level of $5.50 or less for the 1995 to 1996 period.

The 16Mb DRAM is just now approaching the early growth stage of its life cycle. For first-tier North American buyers pricing for 4Mbx4 DRAM—as shown in Table 1—prices should hover near $100 as 1992 ends.

Survey respondents foresee a price in the range of $55 to $60 for the fourth quarter of 1993. However, pricing for this next-generation device likely will be volatile and uneven between now and the end of 1993 if the history of the DRAM marketplace serves as any guide. For example, a recent analysis of full-year 1993 pricing for this device indicates that pricing should range from $44 to just more than $100. If so, the low end of the range for the fourth quarter of 1993 could approach $25.

Talk today of a North American price during 1996 of $14 for 16Mb DRAMs might sound premature, but users already seek information on price projections for later years (for example, year 2000). A less distant concern is managing the next DRAM price crossovers, from 4Mb- to 16Mb DRAM, which Dataquest projects for the first half of 1994.

Assumptions behind the Long-Range DRAM Price Forecast

As noted in prior articles, five assumptions guide Dataquest's long-range DRAM price forecasts (see Table 2).

The Interplay of the Pricing Assumptions and Price Forecast

The range of DRAM prices garnered through the recent quarterly price survey reveals the uncertainty that leading users and suppliers experience when making forward price projections in this volatile market. An assessment of the interplay between Dataquest's price assumptions and the price forecasts should enable SPS clients to better understand the message behind Dataquest's price "numbers" and to adapt as the DRAM market evolves.

An assessment of the DRAM pricing assumptions for the 1Mb, 4Mb, and 16Mb devices certainly shows similarity regarding the assumptions at each density. Equally significant, however, the evolution of the DRAM market also means emerging long-term differences regarding the five assumptions—differences that become noticeable at the 4Mb density vis-a-vis the 1Mb part and pronounced at the 16Mb density.

1Mb DRAM: Justifiable "Conservatism"

Dataquest's long-term outlook on 1Mb DRAM pricing—which calls for a market average that does not drop below $3.40—has been described as conservative. The assumptions explain the rationale for our "conservatism."

The first assumption in Table 2 states that users can expect continued DRAM cost reductions because of suppliers' manufacturing technology improvements (hereafter, the "cost-reduction" assumption). The information in Table 1—which shows a low-end price of just under $3 for this product for year-end 1993—confirms the validity of cost-reduction assumption. The third assumption in Table 2—that non-Japanese/Asian suppliers will increase DRAM market share (that is, "Asian supplier" assumption)—also signals an aggressive long-term price curve for 1Mb DRAMs, signaling sub-$3 pricing.

Several factors mitigate, however, against a long-term market price of less than $3 for 1Mb DRAMs in North America. The impact of the fourth assumption—that the legal jurisdiction of intellectual property law and related laws will be more aggressively enforced at the local level (the "legal assumption")—manifested itself during the first half of 1992 when North America-based Micron accused Korean-based suppliers of dumping in the local North American market. The allegations abruptly moderated low-ball pricing competition among some suppliers and caused North American spot market pricing to increase after temporarily falling—according to some reports—below

Table 2
Assumptions for Long-Range North American DRAM Price Forecast
(Descending Order of Significance)

1. Users can expect continued DRAM cost reductions because of suppliers' manufacturing technology improvements.
2. DRAM capacity should adequately meet long-term demand.
3. Non-Japanese Asian suppliers will increase DRAM market share.
4. The legal jurisdiction of intellectual property and other laws will expand across the globe and be more aggressively enforced at the local level.
5. Alliances—not only involving DRAM suppliers but also other players such as users and governments—will exert growing influence over market trends such as pricing.

Source: Dataquest (July 1992)

$3. Independently, but simultaneously, the European Commission (EC) nears the likely imposition of antidumping penalties against Korean suppliers in the European market.

Another factor indicates that 1Mb DRAM pricing should continue at $3 or more over the long term. Not all suppliers are capable of achieving the manufacturing efficiencies that would enable them to earn a profit at a price of less than $3. Still other suppliers might be able to pursue a low-cost 1Mb DRAM strategy, but have no strategic interest in doing so.

4Mb DRAM: $4 Pricing by 1995?

Dataquest's long-range 4Mb DRAM price forecast—which calls for a price of $5.50 for 1996 in North America—has been described by some as overly aggressive on the low side but by others as too conservative on the high side. Why too high? Because some market players believe 4Mb DRAM pricing will eventually decline to the same low level as expected for 1Mb DRAM—the mid-$3 range. Why too low? Because some users and suppliers believe that there will be a long-term shortage of 4Mb DRAM capacity.

Cost-Reduction Assumption

In terms of the cost-reduction assumption, users of 4Mb DRAMs can anticipate that some suppliers such as Micron will continue to achieve 4Mb DRAM manufacturing efficiencies over the long term. The issue then becomes: on the low side, how far could 4Mb DRAM pricing sink, allowing for a reasonable suppliers' profit of about 8 percent?

At a conference held during June 1992 for Dataquest clients attending SEMICON/West in San Francisco (Dataquest's SEMICON/West Seminar), Lane Mason, Dataquest's Director and Principal Analyst for Memory ICs, made the following salient observation: Since the 64K density—in part because of increased DRAM R&D/fab expenses—the low-end price for each density of DRAMs has increased vis-a-vis the low-end price of the prior-generation part. For example, in North America, pricing for 64K DRAM fell as low as $0.75 for million-piece orders during the late 1980s. By contrast, the low-end price for 256K DRAMs in North America was higher—at $1—during the early 1990s. As noted, Dataquest does not expect the low side of 1Mb DRAM pricing in North America to fall near the $1 level.

In light of this historic market trend, users should expect that the low-end North American price for 4Mb DRAM will be higher than low-end 1Mb DRAM pricing. As shown in Table 1, Dataquest calls for a low-end North American price for 4Mb DRAMs of $5.50 during the 1995 to 1996 period. By contrast, Dataquest expects the North American booking price to hit $3.40 or lower in the 1992 to 1994 time frame for the 1Mb device.

Asian Suppliers in a Hostile Legal Environment

Another assumption, the Asian-supplier assumption, signals intensifying 4Mb DRAM pricing competition but only under the correct legal/trade conditions. For example, as noted, Korean-based suppliers were slashing 4Mb DRAM pricing in North America during early second quarter of 1992, which dropped the low-end price to $11.50 on some orders, until Micron filed dumping allegations. The timing of a legal decision—let alone the ultimate North America market impact—is uncertain this time. However, the story should unfold by the first half of 1993.

The main point is that, depending on the direction in which the trade winds blow, the legal/trade environment will cause 4Mb DRAM pricing competition, in uneven alternating fashion, to ease and intensify in different world markets. Should legal and trade tensions ease over time in regions such as North America and Europe, non-Japanese Asian suppliers likely would compete more aggressively on 4Mb DRAM pricing than warranted by the current trade and legal environment.

Adequate 4Mb DRAM Capacity: A Changing Assumption?

For users of 4Mb DRAM, a key difference between the 1Mb and 4Mb DRAM price assumptions shown in Table 2 emerges with the second assumption—that DRAM capacity should adequately meet long-term demand ("adequate capacity" assumption). Why? Users of 1Mb DRAM enjoyed adequate supply/capacity for this part during the peak stage of its life cycle, which now approaches the decline stage. By contrast, the assumption of adequate 4Mb DRAM capacity undergoes close re-examination just as the 4Mb product nears the critical peak stage.

Overview to Table 3 and Table 4

At Dataquest's SEMICON/West Seminar, Dataquest's Mark FitzGerald, Senior Industry Analyst in the Semiconductor Equipment, Manufacturing, and Materials Service (SEMMS), provided a midyear 1992 update regarding the adequacy of 4Mb DRAM capacity for 1992 to 1993.

Tables 3 and 4—which were presented at the seminar—demonstrate why there are two differing market perspectives regarding the 4Mb DRAM capacity outlook for the second half of 1992 and 1993.

Readers should note at the outset of this analysis—as will be shown—that Dataquest has not changed its stated assumption that North American users can expect adequate 4Mb DRAM capacity for the next several years. Even so, Dataquest analysts continue to examine the worldwide supply-demand equation to determine whether there should be any

Table 3
Capacity Utilization, Distribution of 1992 Slices (≤0.5 and <0.8 Micron) into 4Mb DRAM Die*

1.	Forecast 4Mb DRAM, Million Units per Month 1992	34.3	34.3	34.3	34.3	34.3	34.3
2.	Theoretical Die Capacity Million Units per Month in 1992	113	113	113	113	113	113
3.	Assumption of Percent Theoretical Die Capacity in 4Mb Production	50	60	70	80	90	100
4.	Adjusted Theoretical Die Capacity Assuming 70% Yield	39.6	47.5	55.4	63.3	71.2	79.1
5.	Capacity Utilization (%)	86.8	72.3	62.0	54.3	48.2	43.4

*77mm² die size/170 die per wafer
Source: Dataquest (July 1992)

Table 4
Delayed 200mm Fab Plans in Japan

	Products	Type of Fab
Fujitsu	16Mb DRAM	Production
Hitachi	4Mb/16Mb DRAM	Production
KTI	ASIC	Production
Matsushita	16Mb DRAM	R&D
Matsushita	16Mb/64Mb DRAM	Production
NEC	16Mb, MPU	Production
NEC	4Mb/16Mb DRAM, EPROM	Production
NKK	4Mb SRAM, ASIC, MPU	Pilot
Oki	16Mb DRAM	Production
Sanyo	16Mb DRAM	Production
Sharp	4Mb DRAM, ROM	Production
Toshiba	16Mb DRAM	Pilot
Toshiba	4Mb/16Mb DRAM	Production
Toshiba	4Mb/16Mb DRAM	Production
Toshiba	16Mb DRAM	Production

Source: Dataquest (July 1992)

change to the assumption of adequate 4Mb DRAM capacity.

The Message of Tables 3 and 4

Table 3 provides an estimate for June 1992 of worldwide 4Mb DRAM capacity utilization. As shown in the footnote to Table 3, this capacity analysis assumes the availability of 170 4Mb DRAM die from each 0.5- through 0.8-micron wafer slice. The 4Mb DRAM capacity analysis in Table 3 flows on the basis of the following assumptions and estimates:

- Line 1. Dataquest estimates worldwide 4Mb DRAM at 34.3 million units per month during 1992.
- Line 2. Dataquest estimates theoretical die capacity from 0.5- through 0.8-micron fabs at 113 million units per month in 1992, as stated in the note to Table 1.
- Line 3. Dataquest assumes the percentage theoretical die capacity in 4Mb DRAM production in a range from 50 percent to 100 percent.
- Line 4. Dataquest assumes a 70 percent yield rate for 4Mb DRAM manufacturers and then adjusts the information in Lines 2 and 3 into an estimate of 4Mb DRAM theoretical die capacity as measured in millions of units.

  Formula: Line 4 = Line 2 × Line 3 × 0.70.
- Line 5. Shows an estimate of 4Mb DRAM capacity utilization based on the estimate in Line 1 and the estimates/assumptions in Lines 2, 3, and 4.

  Formula: Line 5 = Line 1 / Line 4.

Table 4 shows 200mm fab plans that have been delayed in Japan by suppliers of 4Mb and 16Mb DRAMs.

Adequate 4Mb DRAM Capacity: Dataquest's Midyear 1992 Perspective

In his presentation at the Dataquest's SEMICON/West Seminar, Mr. FitzGerald noted that the conclusion he makes can be viewed as conservative. He assumed that just 70 percent of the 0.5-/-0.8-micron capacity is being used for 4Mb DRAMs during 1992—when in fact market reality would allow Dataquest to assume a higher percentage.

The salient point from Table 3 and the SEMICON/West Seminar is that Dataquest estimates current 4Mb DRAM capacity utilization at a 62 percent rate, which should mean adequate worldwide supply for users barring a major market change. Dataquest also believes that additional capacity will be available in the Republic of Korea over the next 12 to 18 months. Mr. FitzGerald's conclusion is that adequate 4Mb DRAM capacity exists as of midyear 1992.

A 4Mb DRAM Shortage?

A DRAM shortage should never be discounted. For example, what about the latest unverified reports (aka rumors) of a 1992 or 1993 DRAM shortage?

Table 4 shows that the worldwide network of 4Mb DRAM users must continue to monitor DRAM capacity trends. The main point from this table is that, in response to harsh DRAM market realities, Japan-based suppliers such as Fujitsu, Hitachi, NEC, and Toshiba have chosen to delay the opening of some 4Mb/16Mb DRAM fabs that otherwise would be open by now or else be opened during the period from mid-1992 through 1993. The table does not speak of cancellations nor close-downs of operating fabs, but rather of delays in schedule openings. Nevertheless, Dataquest expects that some of the delays will become permanent scuttles, which could over time change the long-term DRAM supply-demand scenario.

To answer the question posed earlier regarding a near-term shortage, the information in Table 3 indicates that any shortage during the second half of 1992 or the first half of 1993—should one occur—likely would be a short-term spot shortage. The impact would be much less than the massive DRAM supply base disruption that occurred during the 1987 to 1988 shortage.

The Next-Generation 16Mb DRAM

The assumptions in Table 2 apply to the 16Mb DRAM price forecast. However, over time the order of significance might reshuffle given the evolving nature of the DRAM marketplace. In summary fashion, Dataquest assumes the following market impacts on the 16Mb DRAM price curve:

- Cost-reduction assumption: akin to the 1Mb and 4Mb DRAM outlook

- Adequate capacity assumption: akin to the 4Mb DRAM scenario
- Asian supplier assumption: akin to 1Mb and 4Mb DRAM outlook
- Legal assumption: akin to 1Mb and 4Mb DRAM perspective

Of these four assumptions, the capacity assumption could have the greatest impact on the long-term 16Mb DRAM price outlook, especially if the worldwide network of suppliers decide to significantly reduce capacity.

The fifth assumption in Table 2, which assumes that DRAM technology alliances will exert growing influence on pricing trends, should have greater impact at densities of 16Mb and greater than at lower densities. For example, some 1Mb DRAM alliances (for example, Hitachi-Goldstar) affected pricing trends but not until the product was beyond the critical forward, or introductory/early growth, stages of the life cycle.

By contrast, Dataquest foresees a strong impact on 16Mb DRAM price trends from alliances among others such as the IBM-Siemens and Hitachi-Texas Instruments arrangements. Some alliances likely will evince an impact on 16Mb DRAM pricing during 1993, which could set the tone on long-range pricing.

(For a full listing and report on DRAM alliances, see "Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest," in the Semiconductor Procurement *Dataquest Perspective,* Vol. 1, No. 17.)

Microprocessor Trends

Intel's recent victory in the U.S. federal court over Advanced Micro Devices (AMD) in the 287 microcode case, which remains subject to appeal and other legal maneuvering by all parties, keeps the spotlight on the X86 MPU marketplace. These two litigants should return to the court during July when, among other issues, AMD will strive to preserve 386 "rights" that derive from the California arbitration case. As we wrote in last quarter's pricing article, reports of the AMD's impending death at the hands of Intel remain greatly exaggerated. However, rejection by the federal court of the remedy granted to AMD by the California arbitrator—AMD's so-called 386 "rights"—likely would have a profoundly negative impact on AMD during the medium term. Regardless, AMD's entry into the 486 segment likely will not occur this year, and at earliest perhaps not until the second quarter of 1993.

Intel's victory shifts attention to other X86 competitors, specifically the Cyrix/Texas Instruments team, which now stands to gain at AMD's expense. Cyrix/TI is currently embroiled in a lawsuit with Intel over the X86 technology/manufacturing rights. And at this writing, unverified reports of an AMD alliance with Chips & Technologies were circulating.

X86 Price Trends: Today, Tomorrow, and the Distant Future

Against this legal/marketing background, Table 1 and Figure 2 show price trends for key X86 devices. Table 1 and Figure 2 show more aggressively priced forecasts for 80X86 devices than did prior forecasts. The reasons are straightforward: The 32-bit CISC marketplace has evolved partially to date from a sole source arena into an oligopolistic market, and suppliers of 32-bit CISC MPUs face increased competition, not only from each other but also from suppliers of 32- and 64-bit RISC devices.

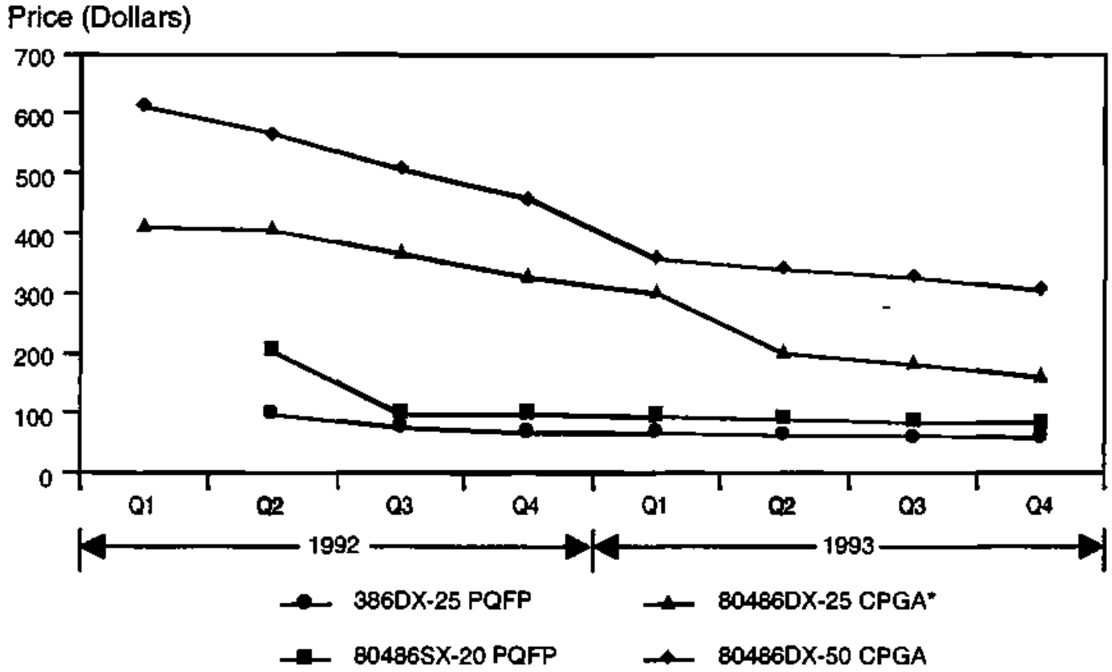
The Multisourced 386 Marketplace

Subject to ultimate legal reversal, AMD's success in the arbitration case in effect makes the 80386 marketplace a second-sourced marketplace. Cyrix adds to the X386 party. However, the company has not truly entered the 80486 marketplace—Cyrix's product nomenclature notwithstanding.

The effect of competitive multiple sources is stamped on the price forecast for 386SX-25 and 386DX forecasts. For example, in North America the 386DX PQFP (1,000-to 5,000-unit volume) broke below the $100 barrier in terms of Intel list pricing as of the second quarter of this year. Dataquest expects additional price erosion during 1992, resulting in a year-end price of less than $60. The volume discount curve is steep as of midyear 1992.

Dataquest estimates the cost of manufacture for the 386DX device to be less than $35 to $40. Dataquest foresees a fourth-quarter 1993 price of $34 in the current intensely competitive environment. For the distant future (that is, 1995 to 1996), manufacturing improvements should allow North American pricing to drop to $20.

Figure 2
x86 Price Trends (North American Bookings; Volume: 1,000 to 5,000)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated June 1992.
*Pricing for 80486DX-33 is the same as the 25-MHz version.

Source: Dataquest (July 1992) G2000310

The price outlook for 386SX devices parallels the 386DX scenario.

The Emergence of Multiple Sources for 486 MPUs

Subject to legal appeal, with reversal not likely, AMD's loss in the 287 microcode case means that Intel should remain the sole source of 80486 MPUs during most of 1992. The year 1993 should be a different scenario, with the race continuing between suppliers such as AMD and Cyrix to crack Intel's 80486 monopoly as soon as possible.

As shown in Table 1 and Figure 2, under these market conditions Dataquest foresees multiple sources in the 486 arena but not until the first half of 1993. For example, in North American pricing for the 80486DX PQFP (1,000- to 5,000-unit volume) should run more than $300 over the second half of 1992.

With sub-$100 pricing for Intel's 80486SX products hitting the markets effective July 1, 1992, users continue to anticipate more competitive pricing for the 80486DX devices during the second half of 1992. In prior reports we assessed the likelihood and timing of any 80486 price cuts.

The scenario we outlined before remains consistent—although the time should shift toward early 1993. Users can expect that the price curve for the 80486DX-25 and 80486DX-33 devices will take a step-function downward, but likely not until after the introduction of the 80586 chip and/or a competitor's successful 80486DX market entry. As noted, the 287 microcode decision likely will prevent AMD from entering the 486DX market until the first half of 1993 at the earliest. Cyrix might enter the 486DX arena sooner, but any market impact would not be felt until the first half of 1993.

Intel's Wild Card, and Options

Under this scenario, the wild card in the 486DX pricing equation becomes the timing of the "586" introduction, which appears to be September 1992. The microcode decision provides Intel with a vital respite as of midyear 1992 regarding 486DX pricing competition.

For the second half of 1992, Intel has at least three options: first, to slash 486DX pricing before or during the anticipated late third quarter/fourth quarter 1992 introduction of the 586 part; second, to slash 486DX pricing after the introduction of the 586 part—toward the end of 1992; or third, to not aggressively cut 486DX pricing till 1993 or later.

An examination of the assumptions behind Dataquest SPS's long-range X86 price forecast indicates that Intel will pursue the second option. This approach would enable Intel to enjoy higher 486DX pricing for most of 1992 and also to protect the 586 price curve—should that be Intel's intent for this year—while still allowing an ultimate response to merging competition in the 486DX marketplace.

Assumptions for the 80486 Price Forecast: Deja Vu, All Over Again

The assumptions behind the X86 price forecasts might make SPS clients who have tracked X86 pricing trends over the past several years feel—to quote the U.S. baseball player Yogi Berra—that "It's deja vu all over again!" For example, despite enormous changes in the competitive environment, several keynote assumptions remain remarkably consistent with assumptions stated in prior years. Certainly, the altered competitive MPU landscape means modification of original assumptions—and some entirely new ones—but readers should not be surprised if they experience some deja vu while reading this section.

The following summarizes the assumptions that guided our long-range X86 price forecast during the first half of 1991:

- Assumption 1: Best to be synchronized with Intel product migration plans
- Assumption 2: New and shifting rules of the MPU game
- Assumption 3: Intel will remain impervious to pricing competition
- Assumption 4: No Intel price war against the AM386

Table 5 shows the assumptions as of July 1992 that guide Dataquest's SPS forecast on X86 pricing for the 1992 to 1996 period.

Assumption 1: A Reshaped Environment Means Competitive 80X86 Pricing

The first assumption—that Intel is not impervious to pricing competition—may seem old news. However, this assumption still causes lingering shock for market players that remember the sole-sourced 32-bit MPU world of just two years ago. The level of pricing competition during the 1980s between Intel-AMD or Intel-Motorola should pale against the competitive pricing tactics likely from the set of X86 market players that includes AMD, C&T, Cyrix/TI, and UMC. Subject to ultimate legal decision, the long-term 80X86 environment has been reshaped into an oligopoly if not a purely competitive market, which translates

Table 5
Assumptions for Long-Range North American x86 Price Forecast (Descending Order of Significance)

1. Intel is not impervious to pricing competition. However, it will accelerate the shift to higher-priced/leading edge parts—where competitive pressures are less—with a goal of leaving competitors such as AMD, Chips & Technologies, Cyrix/TI and UMC (Taiwan) to battle on price in mature product markets like the 80386.
2. Users are best advised to be synchronized with Intel product migration plans, which should accelerate during the 1992 to 1996 period.
3. The shifting rules of the MPU game mean complicated price/performance comparisons and choices for users of x86 devices.
4. Intellectual property lawsuits and related legal action will also complicate x86 price forecasting, signaling—with a time lag—less competitive pricing when Intel wins and more competitive forecasts when Intel loses, subject of course to appeal.
5. The current investigation of Intel by the U.S. Federal Trade Commission will cause Intel to compete defensively on price—and not offensively—against competitors such as AMD, Chips & Technologies, and Cyrix/TI until the case is adjudicated.

Source: Dataquest (July 1992)

into the aggressive long-range 80X86 price forecasts shown in Table 1 and Figure 2.

A central element to be discussed, however, has not changed: Intel's adherence to a migration strategy by which it will shift its focus to higher-priced/leading-edge parts where competitive pressures are less and profit margins are greater. Competitors will be left to battle on price in more mature MPU product markets.

Assumption 2: Intel Will Accelerate X86 Migration Schedules

As stated in prior reports, Intel will most favorably support users that coordinate system life cycles in line with Intel's product migration schedule—meaning procurement headaches for users not synchronized with Intel's plans. Users should expect Intel to accelerate the pace of new product and technology introductions in the years ahead.

Looking at the recent past, the following top the list of examples of Intel's eventual willingness to "reward" users who timely migrate with Intel a step-function decline in price: the 1991 price curve for the 80486DX products, and the 1992 curve for the 80486SX devices.

Dataquest realizes that users have a range of reasons for not avoiding synchronization with Intel's migration plans. In addition, we realize that nonfirst-tier customers of Intel face a challenge in terms of being in synchronization with Intel even if these smaller customers aim to synchronize with Intel. For examples, some users were late to learn that Intel would introduce the following devices: 80386SX-25, 80486SX, and 80486DX2.

As indicated earlier, users must be prepared because Intel plans to accelerate the pace of new product and technology introductions during the 1992 to 1996 period. Table 6 shows the introduction year and the first year of volume production for X86 products, including an estimate for next generation "586" and "686" devices.

The key point for users is that, unlike the 1980s, when system manufacturers had an interval of four years in which to absorb new X86 technology, during the 1990s users will face a flow of new technology every one to two years.

Table 6
X86 Life Cycle Analysis: The Introductory Stage

Part	Year of Introduction	Year of First Volume Production
80386	1985	1986
80486	1989	1990
"586"*	1992	1993
"686"*	1993	1994

*Future, unannounced x86 product families
Source: Dataquest (July 1992)

Assumption 3: Market Shifts Mean More Complicated 80X86 Product Choices

This assumption augurs a challenging future for all users of MPUs—CISC-based as well as RISC-based. As noted in prior reports, Dataquest assumes that Intel will strive to establish new and shifting rules as users move to the 80486 and its likely successor, the "586". There will be short-term periods of market confusion while Intel varies the mix of MPU architectures and/or packaging to tailor device specifications in line with customer needs regarding MPU price/performance trade-off. For example, the 80486DX2 product exemplifies Intel's willingness to respond to user demand—whether system manufacturers or ultimate end users—in order to respond to marketplace demand.

Another example is that Intel might name the "586" product in an entirely different fashion than originally expected—that is, some name other than "586"—in order to protect intellectual property claims. This is a small point, perhaps, but still reflective of the shifts that users must prepare for as Intel battles to maintain market leadership position.

A more fundamental example is that Intel's "586" and successor product technology should drive CISC-based MPU technology upward from the PC market into a new and less familiar system market—workstations, which have been dominated to date by RISC-platform processors.

Assumption 4: Legal Actions Will Have Increased Impact on 80X86 Price Trends

As indicated, also consistent with prior MPU pricing assumptions is that Intel will continue to ground its strategy on aggressive legal protection for what Intel claims as its intellectual property. Although AMD to date has undercut Intel's claim to a 80386 legal monopoly—and other competitors such as Cyrix and Integrated Information Technology (IIT) have apparently developed "clean room" versions of some Intel-developed microcodes—Intel will continue to make would-be competitors prove in the courtroom adherence to U.S. and international intellectual property laws.

Users can expect the wild first-half 1992 swing in legal momentum to recur—from AMD's early stunning arbitration case victory to Intel's subsequent equally stunning victory in the 287 microcode case—with concomitant impact on pricing tactics and strategies. In order to gauge 80X86 pricing trends, users will need to track the host of legal actions and anticipated decision days—and not ignore the appeal process. The key point is that more so than ever before, MPU marketing and manufacturing teams aim to aggressively exploit every window of opportunity opened by the legal process—and minimize the marketing downside associated with any loss.

Assumption 5: The FTC Investigation Keeps Intel in a Defensive Pricing Posture for the Short Term

Government intervention into the economy always has an effect—often unintended. The current FTC investigation into Intel's business practices to some extent thwarts Intel from pricing its parts as aggressively as it could in the absence of such government scrutiny.

For example, sub-$100 pricing for the 80386DX device becomes less impressive with the realization that the cost of manufacture is likely less than $40. At this time, Intel must avoid any appearance of product dumping in North America vis-a-vis competitors such as AMD. In the absence of the FTC investigation, the 80386 pricing shown in Table 1 for 1995 likely would become a reality for 1993—if not sooner.

The central point is that the FTC rather quietly continues its investigation of Intel—keeping the company somewhat defensive on pricing tactics as of midyear 1992. Users should monitor the government's legal proceedings over the second half of this year—with an eye to 1993 market impacts.

Another Look at "586" Price Estimates

In prior reports, Dataquest SPS has used MPU life cycle price analysis to generate an estimate of pricing during the forward stages of the life cycle. Table 7 presents the results of that assessment. (For analysis behind the "586" price estimate, see "The Risky, CISC-y, Sexy World of 32-Bit MPUs Means Stressful Opportunity for Procurement Managers," in the Semiconductor Procurement *Dataquest Perspective* dated May 25, 1992.)

During early June 1992, Dataquest learned that Intel might be considering a more aggressive introductory price for the "586" than is shown in Table 7. In effect, some large customers would receive the same 58 percent discount—off the price estimate shown in Table 7—that Intel recently gave to users of the 80486SX device. If Intel were to pursue this strategy, the introductory price shown in the table would fall to $533. We noted before that the introductory date may shift to the end of the third quarter of 1992.

For several reasons, most users should not expect a sub-$600 introductory price for the "586" part. First, the volume assumed in Table 6 for the introductory price is stated as 100 to 1,000 units, whereas first-tier buyer volume most likely would be much higher (1,000 to 5,000 units, if not more). Second, Intel's recent victory in the 287 microcode case eases somewhat its need to demonstrate aggressively pricing on this state of the device at this time. Third, the lurking FTC investigation should have the same effect.

Table 7
Estimated "586" Pricing by Product Life Cycle Stage

Stage:	Price ($)
Introduction (Second Half 1992) First Volume Production[1]	1,268
Early Growth (1993) Price at First Full Year of Production[2]	788
Growth (1994) Price at Second Full Year of Production[2]	694

Assumptions: Specs: 3 million transistors; 50 MHz; CPGA (not multichip module). Intel's strategy: conforms more so with historic forward-pricing strategy associated with competitive market environment and less so with monopoly-pricing power. Life cycle: starts by second half of 1992
[1]Volume of 100-1,000 units
[2]Volume of 1,000-5,000 units
Source: Dataquest (July 1992)

Dataquest Perspective

Dataquest's most recent North American bookings price survey was conducted under typically volatile market conditions: Intel crashed down the 80486SX price curve—just before its stunning victory over AMD in the 287 microcode case. Meanwhile, as some DRAM suppliers ponder their long-term role in the DRAM business, IBM announced its plan to become a merchant market IC supplier. In the midst of these swirling market dynamics, the report provides Dataquest SPS's perspective on the "scenario"—the set of assumptions—which we believe will guide DRAM and X86 price trends during the 1992 to 1996 period.

For users of DRAMs—as shown in Tables 3 and 4—capacity should adequately meet demand during the 1992 to 1993 time frame—barring a wholescale cutback in 200mm fab plans. DRAM pricing should continue to be competitive over the long term.

For users of X86 processors, Intel is not as impervious to pricing competition as during prior years. However, it will use an accelerated X86 product migration schedule during the 1992 to 1994 period to protect the 486DX/586/686 price curves in line with corporate profit dictates. The threatening tide of X86 market entrants—which apparently can not be stifled on legal grounds alone—might be obviated by Intel's rapid move to higher technology grounds.

By Ronald Bohn

Product Analysis

1992 Semiconductor Cost Trends

Applications of Cost Model Analysis

Cost model use falls into two broad areas: near-term cost/price optimization planning and long-range system cost analysis. A usable model allows for both applications. The Dataquest semiconductor cost model uses 17 key variables of semiconductor manufacture after raw silicon wafers have been processed.

Semiconductor cost models are predominantly used to compile costs for use in near-term contract negotiations. By identifying areas where costs can be reduced, price negotiation results often benefit the parts buyer. Applying experience-curve theory to cost model applications can give both short- and long-term cost price scenarios that can be a basis for strategic planning.

Strategic use of cost models in long-range planning has been underutilized mainly because long-range variables are perceived as too erratic to model, let alone base plans on. By utilizing different learning curves to individual variables in the model and then modeling these derived inputs, one can better understand future trends and have alternative strategies at hand if any variable actually differs from its expected trend line. This method of cost model use can easily be made part, or the basis, of a proactive strategic plan.

The high rate of technological change in the semiconductor industry has caused the cost per function to decrease at an average rate of 35 percent per year for the last 20 years. This high rate of change is expected to continue.

Cost Analysis

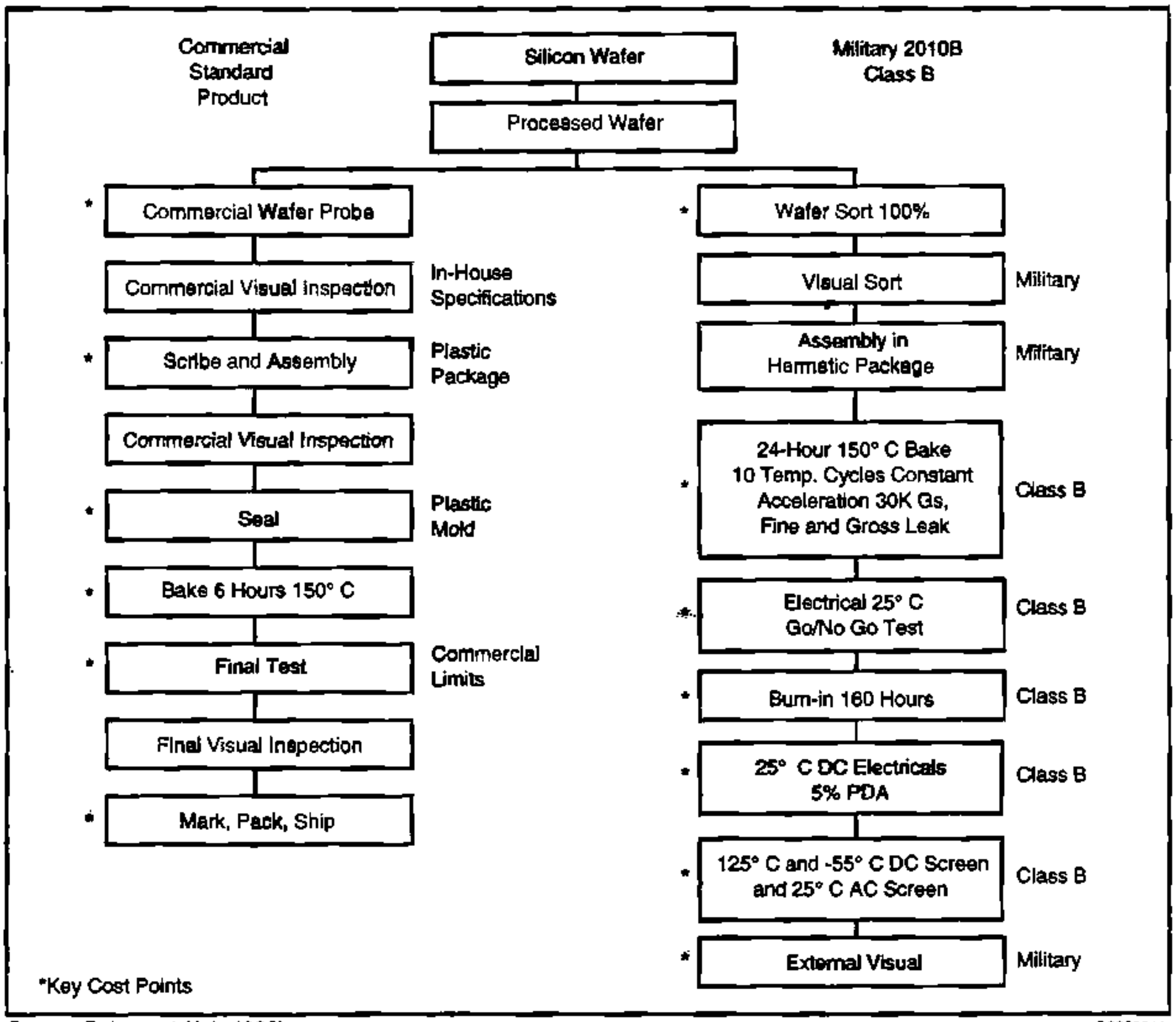
Cost versus Price

In a competitive market, semiconductor manufacturers pass cost reductions on to their customers. Therefore, a knowledge of semiconductor costs and cost trends is useful for projecting long-term procurement costs and selecting the most cost-effective semiconductor device for a particular application.

The cost/price relationship for semiconductor products varies from product to product, from company to company, and with time as a function of business conditions. A good way to perform cost/price analysis is to monitor prices and costs over a period of several years for selected product types and identify the average gross margin for these types. By using this procedure, semiconductor users can develop a good feel for the cost/price relationship for the semiconductor products they buy. Buyers can use the cost/price data provided here to estimate the cost of purchased materials and determine target prices for future price negotiations.

This article provides semiconductor users with the cost data necessary for cost/price analyses of specific semiconductor products.

Figure 1
Commercial and MIL-STD Manufacturing Flow



Source: Dataquest (July 1992) G2000311

Cost Factors

The cost of a semiconductor device is developed by adding the cost of each step in the manufacturing process. Figure 1 shows the manufacturing process flow for semiconductor devices and identifies the important cost steps in the process.

Our cost model categorizes costs into the following four areas:

- Wafer processing and die sort
- Assembly
- Final test
- Screening, qualification, mark, pack, and ship

Screening and qualification tests include burn-in and MIL-STD quality and reliability assurance processing requirements.

In our analyses, we have assumed that the product being modeled is being manufactured with technology that has passed the start-up phase. For example, shifts to 6-inch wafers will be indicated at a time when most manufacturers have made the change, rather than when the first manufacturer begins production.

The manufacturing process starts with an unprocessed silicon wafer that costs from $15 to $25. After completing more than 100 processing steps, the cost of a processed wafer is 10 to 30 times the initial cost of the unprocessed wafer. The wafer cost is a function of the following:

- The number of mask layers required
- The photolithographic requirements
- The quality of chemicals and purchased wafers
- The clean room environment

A complex relationship exists among each of these elements, the processed wafer cost, and the end cost of the product.

Number of Mask Layers

The cost of the wafer increases with each layer required. Additional mask layers could introduce more defects and decrease yields. Generally speaking, more complex processes produce more expensive die. Table 1 lists the typical number of mask layers for most common integrated circuit processes.

Photolithographic Requirements

Wafer costs increase as device features become smaller. However, smaller features result in more die or more functions per wafer. Although the wafer cost will be higher, the cost per function will often be lower.

Quality of Materials and Clean Room Environment

As device features become smaller, semiconductor circuits become more susceptible to defects in the semiconductor material. These defects result in lower yields. Defects occur in the purchased silicon wafers and masks; the defects are introduced during processing by chemicals and particles in the air.

Table 1
Number of IC Process Mask Layers

Process	Single-Layer Metal	Multilayer Metal
Schottky TTL	7	9
Bipolar Linear	7-9	9-11
ECL	8	10
NMOS	8	10
HMOS	9	11
CMOS	10	12-15
HCMOS	11	13-16
BiMOS	14	16-18

Source: Dataquest (July 1992)

Increasing the quality of materials and improving the clean room environment increases the cost of processed wafers. However, the resulting lower-defect material produces higher yields and lower unit costs. This is especially true for VLSI products.

Finished wafers are then tested and electrically sorted to separate the good die from the bad. The primary cost factors at wafer sort are the yield (percent) of good die on the wafer and the testing costs, which are a function of the cost per hour of using the test equipment and the time required to test each die. Increased wafer sort yield is the single most important factor in reducing the cost of VLSI products.

Package Costs

Electrically sorted die are then assembled into packages. Packaging costs vary from pennies to several dollars, depending on the type of packages needed. Table 2 provides cost estimates for representative packages used for integrated circuit products. As automation increases, labor content per device decreases.

Assembled units then receive their final tests. The most important final test costs are the equipment operating cost, test time, and yield. The cost of performing tests over time is assumed to increase moderately, while yields increase as test methods and manufacturing methods are improved.

The final mark, pack, and ship step has only a minimal effect on the total product cost. Labor, shipping containers, and a 1 percent yield loss are the primary cost factors at this stage of manufacturing.

Cost Model

This cost model determines the variable cost for the device modeled. The variable cost includes the cost of direct labor and materials for each product modeled.

Processed wafer cost, number of die per wafer, test cost per hour, and assembly cost are all empirical data; so are the yield percentages used in each step. Table 3 shows how each line of the cost model is developed.

Understanding Yields

Only a portion of die on a given wafer will meet the electrical test specifications to which

Table 2
1991 Package Cost Estimates—Total Assembled Cost (Die-Free)

No. of Pins (Vol.)	Plastic DIP (500K)	CERDIP/ QUAD (100K)	Side-Braze (25K)	SOIC/ SOJ (500K)	PLCC (500K)	LDCC (25K)	CLCC (100K)	Ceramic PGA (25K)	Plastic PGA (25K)	QFP (EIAJ) (100K)	PQFP-JEDEC (100K)	TSOP (50K)	TAB (TAPE) (per site)
8	0.10	0.30	1.95	0.12									
14	0.16	0.35	2.00	0.18									
16	0.16	0.36	2.05	0.18									
18	0.18	0.56	2.20	0.19	0.16		1.08						
20	0.24	0.62	2.40	0.19	0.18	3.00	1.20						
22	0.24	0.65	2.86	0.24									
24	0.26	0.67	3.12	0.25		3.69	1.44						
28	0.30	0.90	3.64	0.32	0.25		1.68					0.77	
32	0.38	0.99	4.12	0.36	0.29	4.59	1.92					1.20	
40	0.45	1.25	5.15	0.40		6.64	2.80			0.38		1.20	
44	0.50				0.37	7.31	3.08					1.32	
48	0.56		6.15				3.36			0.48			
52					0.51		3.84			0.52			
64	0.74						4.42		2.88	0.68			1.28
68		3.00			0.60		4.70	9.28	3.69	0.68			1.28
84		3.97			0.75		5.74	11.48	4.56	0.70 (80ld)			1.28
100								13.10	5.50	0.95	1.20		1.28
128								13.80	6.45	1.50	1.70 (132ld)		1.28
144								16.78	7.65	1.97			1.28
160								18.46	9.20	2.60	2.65 (164ld)		2.35
208								24.01	11.97	3.65			2.35
244									14.05	4.80			2.35
256									14.75				3.83
308								35.54	17.75				3.83

(Continued)

Table 2 (Continued)
1991 Package Cost Estimates—Total Assembled Cost (Die-Free)

No. of Pins (Vol.)	Plastic DIP (500K)	CERDIP/ QUAD (100K)	Side-Braze (25K)	SOIC/ SOJ (500K)	PLCC (500K)	LDCC (25K)	CLCC (100K)	Ceramic PGA (25K)	Plastic PGA (25K)	QFP (EIAJ) (100K)	PQFP-JEDEC (100K)	TSOP (50K)	TAB (TAPE) (per site)
Material Consideration:													
Ld Frame Mat'l	C194	A42	A42	C194	C151	A42	None	A42	Cu	A42	C194	A42	Cu w/Sn plate
Ld Form	TH	TH	TH	Gull/J	J	Gull	None	TH	TH	Gull	Gull	Gull	Gull
Wire	Au	Al	Al	Au	Au	Al	Al	Al	Au	Au	Au	Au	NA
Lid	Epoxy	Ceramic	Au/Kovar	Epoxy	Epoxy	Au/Kovar	Au/Kovar	Au/Kovar	Au/Epoxy	Epoxy	Epoxy	Epoxy	NA
Preform	NA	Glass	Au/Sn	NA	NA	Au/Sn	Au/Sn	Au/Sn	NA	NA	NA	NA	NA

Note: Costs reflect offshore assembly. Plated metal not included in lead-frame cost (except TAB).
NA = Not available
Source: Dataquest (July 1992)

Table 3
Semiconductor Cost Model Algorithms or Variables

Wafer Sort	Algorithm or Variable
Wafer size (diameter in inches)	= A
Capacity utilization (%)	= B
Geometry (microns)	= C
Processed wafer cost ($)	= D
Die area (square mils)	= E
Active area factor	= F
Number of masks	= G
Defect density per square inch per mask	= H
Gross die per wafer	= I = $(0.9 \times \pi \times (A/2)^2 \times 10^6)/E$
Processed wafer cost per gross die ($)	= D/I = J
Test cost per hour ($)	= K
Wafers tested per hour	= L = $1/(((* \times I)/60)/60)$
Wafer sort cost per gross die ($) (K/L)/I	= M
Cost per gross die at wafer sort ($) J + M	= N
Wafer sort yield (%)=$(((E/F/10^6)*G\text{x}H)*100)$	= O
Cost per sorted die ($)=Nx100/0	= P
Assembly	
Material cost/sorted die-SOJ pkg. ($)	= Q
Number of Pins	= R
Assembly yield (%)	= S
Cost per assembled die ($)=(P + Q)/S*100	= T
Final Test	
Test time per die (sec.)	= U
Cost per hour of testing ($)	= V
Test cost per die ($) U * V/3600	= W
Final test yield (%)	= X
Cost per final tested unit ($)	= Y = (T + W)/X*100
Mark, Pack, and Ship	
Cost at 99% yield (%) = 0.01*Y	= Z
Total fabrication cost per unit ($)	= AA = Y+Z
Foreign Market Value (FMV) Formula Adders	
R&D expense (15%) = 0.15*AA	= AB
SG&A expense (10%) = (AA + AB)*0.10	= AC
Profit (8%) (AA + AB + AC)*0.08	= AD
Constructed FMV = AA + AB + AC + AD	

* = Test seconds per die
Source: Dataquest (July 1992)

the die was designed. The percentage of good die per wafer is known as yield. As a silicon wafer is processed, each step decreases the final yield of good parts that meet specification and are shippable.

Calculating Yield

There are several methods to calculate electrical test yields of semiconductor wafers. Dataquest uses an exponential equation called Murphy's formula to approximate yield:

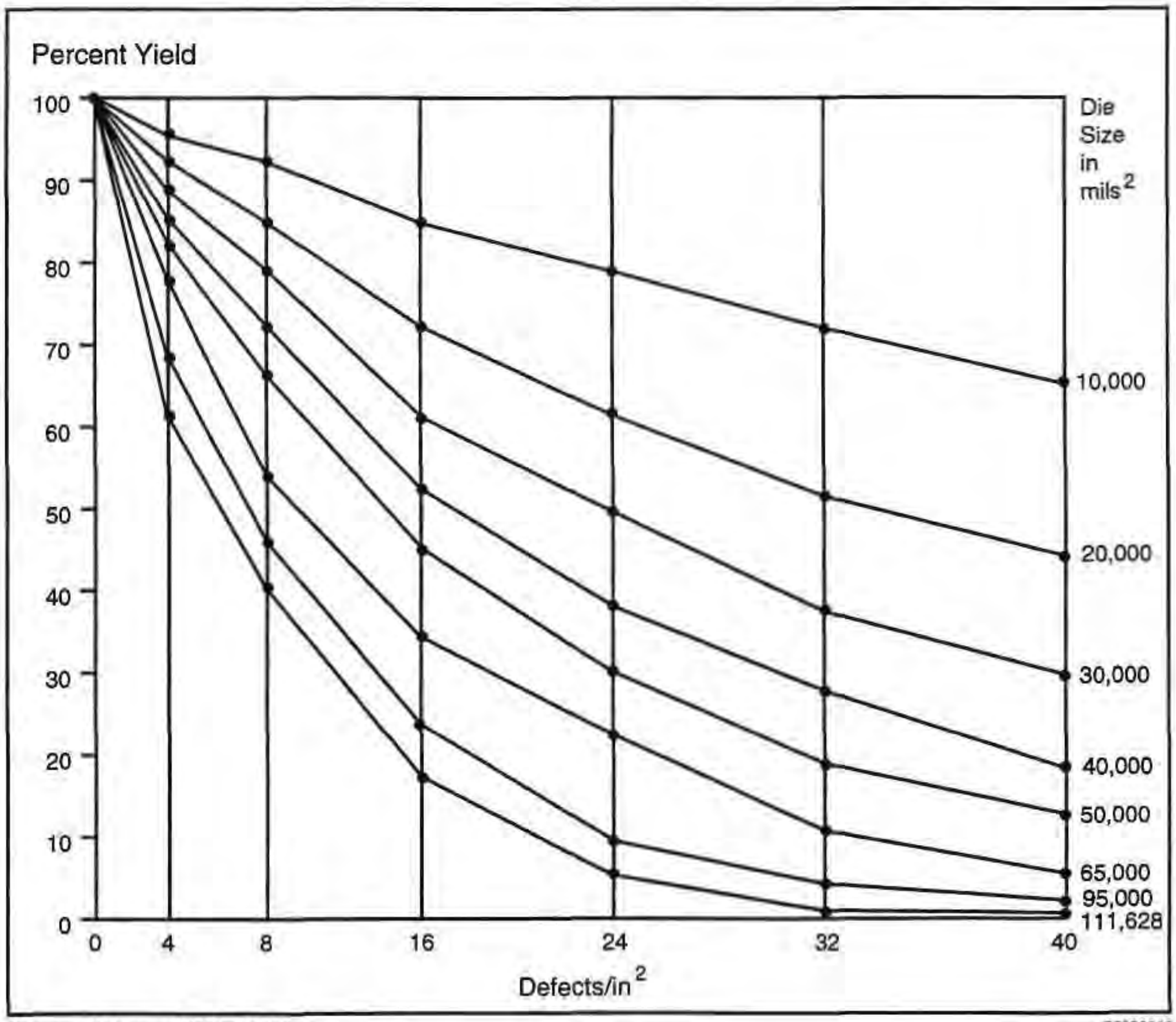
$$\text{Yield} = e^{(-DA)};$$

where e is the constant 2.72, D is the defect density in defects per square inch, and A is the area of the chip in square inches. This mathematical formula is useful for analyzing the key factors that affect semiconductor yields: the number of defects on the wafer and the number of chips on the wafer. The number of chips per wafer is determined by the area of each chip. Defects on a wafer are caused by particles in the air falling on the wafer during semiconductor manufacture. The number of defects on a wafer is determined by the number of particles in the air and the number of mask steps required in the processing of the wafer. An increase in mask levels requires more time in the fab area, thus increasing the chances of particles falling on the wafer and causing a reduction in yield.

Yield Trade-Offs

Figure 2 describes graphically the effect of defects on wafer electrical test yield. Each line represents the yield curve size for a given defect density. Many facilities now in production produce 8 to 20 defects per square inch, while state-of-the-art VLSI facilities will produce only from 1 to 5 defects per square inch. As the size of a die continues to increase, the effects of defects per square inch become increasingly detrimental to yield. In response to this necessity, Class 10 and lower clean rooms are becoming the norm for

Figure 2
Semiconductor Yield Defect-Density Effect



Source: Dataquest (July 1992)

G2000312

competitive semiconductor manufacturers. (Class refers to the amount of particulates of a certain size per square foot that exist in a clean room. For example, a Class 10 clean room has no more than 10 particulates per square foot.)

By taking a typical 4Mb DRAM with two different die sizes (approximately 112K square mils and 142K square mils) in two different manufacturing areas, one with 5 defects per square inch and the other with 1 defect per square inch, one can easily see in Table 4 the advantages of utilizing a clean room with less particulates. This points out why it is more economical to ship larger die if the fabrication area is cleaner, because more die per wafer are shippable.

Yield and Related Costs

Semiconductor chips are electrically tested several times to separate die that meet specifications from those that do not. Wafer sort, assembly, and final test are the three areas in semiconductor manufacturing where related testing occurs.

Electrical Wafer Sort

The first test, electrical wafer sort, is done on processed wafers by a computer-based tester at a test station specifically designed for that device. The tester automatically tests each die on the wafer by contracting each pad on each chip and marking with a dot of ink those die that do not pass the test. Test costs consist of equipment operating costs, direct operator costs, and the amount of time required to test each wafer.

Equipment operating costs are dominated by the depreciation of the test equipment. Semiconductor test equipment is generally depreciated over five years and can range in price from $250,000 to $1 million, depending on test requirements. Dataquest uses estimates of test costs per hour ranging from $25 to $100 per hour. The most complex integrated circuit test costs range from $50 to $100 per hour.

Table 4
4Mb DRAM Yield Loss to Defects
(Percentage Good Die/Number of Good Chips per 6-Inch Wafer)

Chip Size	Fab Area	
(Mils²)	5 Defects/In.²	1 Defect/In.²
127,000	52.9—105 die	88.1—176 die
110,583	57.4—132 die	89.5—205 die

Note: A cleaner fabrication area allows for more shippable product even if the die size is larger than in a "dirtier" area.
Source: Dataquest (July 1992)

Dataquest assumes that a test operator supports each piece of test equipment and estimates the labor cost per hour to be $17. The total test cost, including labor, then ranges from $40 to $115 per hour.

The time to test a wafer is determined by the circuit complexity, the number of chips per wafer, and the yield. Good die take about five times as long to test as bad die. Test programs are formulated and used to minimize test time by testing functions of the device statistically proven to most likely fail first. Test times for good die are kept to a minimum by performing only those tests that assure 85 to 90 percent test yield when packaged. Wafer sort test times for full-production VLSI chips takes no longer than 9 seconds for each chip.

Applying the above to a 4Mb DRAM example results in the following: there are 228 gross die per 6-inch wafer, and 118 (52 percent) are good. The test time for each wafer is about 51 minutes. For this example, we use a test cost per hour of $58 ($41 for equipment, $17 for the operator). Total test cost per wafer is $49.30, with the test cost per die totaling $0.239.

Assembly and Packaging

Semiconductor chips in the form of processed and tested wafers are electrically functional and could be used as they are. Functional die in wafer form, although theoretically functional, are too fragile in that state for commercial or other use. In order to have a protective container for a device, various packages have been created to provide different devices with different degrees of ruggedness. Ranging from ceramic packages with gold contacts to blobs of plastic covering chips on PC boards, the encapsulation method for electrically good die is determined by the end use of the system that the device is part of.

Packaging technology has continuously improved, but the basic assembly steps have not changed significantly during the past

20 years. The three main areas of assembly are as follows:

- Die separation
- Die attach and lead bond
- Encapsulation

Die Separation. This step refers to the method of separating the individual die on a wafer. One technique is very similar to the method of cutting and breaking glass. A diamond stylus automatically scratches the wafer in the areas between the die, called scribe lines. Once the total wafer has been scribed, the wafer is placed on a machine that fractures the wafer along the scribe lines. Some manufacturers use laser scribe machines to etch a line along the scribe line. Thick wafers require diamond sawing along the scribe lines.

After the wafer is completely broken into individual die, each chip is visually inspected under a microscope to remove any that have been physically damaged during manufacturing. Chips are also eliminated at this point if they do not conform to dimensional design rules. Good chips are separated and moved to the next step of manufacture, die attach and lead bond.

Die Attach and Lead Bond. Assuming the use of a standard plastic small outline J-lead (SOJ), good die are attached to metal lead frames with a small amount of molten gold or low-cost epoxy. It is imperative that a die be securely attached to the lead frame in order for it to withstand later testing requirements made of the finished device. The next step is bonding the pads of the chip to individual leads of the package with either gold or aluminum wire that is between 1.0 and 1.5 thousandths of an inch in diameter. Thermocompression bonding involves heating the lead frame and attached die to about 340° C. The bonding wire is automatically pressed against the bonding pad on the heated die, fusing the wire to the die. The wire is then drawn to its respective bonding pad on the lead frame, which is also fused. Automated bonding machines are capable of bonding more than 1,000 packages per hour. Once the die is attached with bonded leads, another visual inspection is performed to eliminate devices that were damaged or bonded incorrectly.

Encapsulation. Assembled lead frames for plastic SOJs are placed in molds into which molten plastic is injected, thus forming the body of the semiconductor device. Between 20 and 50 packages are encapsulated at once, resulting in low production costs. The molded packages are cured in a 200° C oven for 40 hours. Excess metal is then removed from the devices and the leads are formed to the finished product configuration. The parts are tested for open or shorted circuits that might have resulted during encapsulation. The packaged parts are now ready for final test.

Final Test

After the die have been packaged, they undergo one final test. Packaged parts are transferred from assembly to the final test area in static-free plastic tubes that are inserted into automated package handlers. The handler releases one package at a time into a test socket or head that is wired to an automated test computer. Many manufacturers are using multiple-head test systems to increase the throughput of a test system.

Each unit is stringently tested at this step, across "worst case" conditions. The circuits are tested for maximum and minimum speeds, for power dissipation, and for many combinations of inputs and outputs—that is, they are tested to ensure that they will meet all of the manufacturer's specifications and guarantees. The automatic test equipment performs thousands of separate tests in seconds. A typical final test by the manufacturer runs from less than one second on a TTL logic device to up to 10 seconds or more on some 4Mb DRAMs.

The final test must be stringent enough to ensure that the device performs over its guaranteed temperature range. The environmental conditions are usually ensured in one of the following two ways:

- All devices are tested at the high-temperature end of the specifications.
- The devices are tested at room temperature over sufficiently wide tolerances (guard bands) so that operation at the temperature extremes is ensured.

The first approach is obviously the safer method, but it is also much more expensive. As a result, many semiconductor manufacturers will correlate the room temperature characteristics with the characteristics at temperature extremes, add a safety guard band to the room temperature test parameters, and then test at room temperature. Samples are regularly taken from the production lots and tested across the full range of environmental conditions to ensure that the correlation parameters are accurate.

The functions of wafer sort and final test correlate very closely. Often both tests are performed in the same room and/or on the same test machine; the chief difference is the test program. One of the main functions of the wafer sort program is to minimize the amount of additional labor and materials that would be assigned in producing bad circuits. This is especially important to devices with low die costs and higher assembly costs.

Wafer sort cannot eliminate all potentially defective die, however, for the following reasons:

- Most sophisticated circuits such as 4Mb DRAMs cannot completely be tested in wafer form due to parasitic effects resulting from the probes and wiring, incident room light, and other factors involved with physically sorting the die.
- Some of the die may be damaged during the assembly process.
- The die cannot be tested across the temperature range in wafer form because the wafer and probes cannot be easily maintained at temperatures below the ambient.

The objective of wafer sort is to ensure that enough of the potentially rejectable circuits have been discarded so that final test yields will be high enough to support a desired level of profitability. Excessively high final test yields are not necessarily acceptable. This may mean that potentially good devices are being thrown away at wafer sort. As a result, many manufacturers will adjust the tightness of their internal wafer-sort test to allow the final test yields to fall in the range of 80 to 90 percent good units.

Cost Model Usage

As shown in Table 5, we expect improvements in yield to be made over time as specific product processes become better understood. Yield improvements result directly in lower costs. The more existing capacity (for example, plant and machinery) utilized, the lower the per-unit cost, because fixed costs are spread over more units. High capacity utilization combined with higher yields results in lower costs per unit that are directly reflected in lower prices under normal circumstances. This characteristic of the semiconductor industry can be used to knowledgeably estimate current and future price trends for product planning or price negotiation decisions.

The 4Mb DRAM

The 4Mb DRAM cost model shown in Table 4 reflects both yield improvement trends (1990, 1991, and 1992) and capacity use effects (1991; 100 percent to 25 percent utilization). Capacity utilization greatly affects unit cost even as yields improve. At a certain point, low utilization of capacity results in lower yields as process control procedures become difficult to monitor because of the lower volumes manufactured. This compound effect (higher fixed costs plus lower yields) in down markets is often cited in antidumping rhetoric as market prices temporarily dip below costs. The opposite occurs in growing markets under normal situations as shown in the 1991 and 1992 cost/price trends.

Dataquest Perspective

Individual unit costs of semiconductors form the most tangible variable in the total cost of a semiconductor device. The understanding of cost modeling and the variables that go into that model allows for more efficient allocation of resources both in planning and in the execution of those plans. By applying different assumptions to different variables in the model, one can uncover areas of cost not previously considered important. Many different "what if" scenarios are often required to utilize cost modeling fully in long-range system analysis.

Modeling is inherently flexible and can be updated if proven historical data basically differ from calculated model results. Checking and updating a model against known data ensures that the model is correct and current. Revisions to existing algorithms to better match reality are made when basic changes occur, not for perturbations that deviate from the norm.

Those in procurement can use cost modeling and experience curve analysis for both short- and long-term contract negotiations. Periodic

Table 5
Semiconductor Cost Model, 4Mb DRAM

	1991	1992	1992	1992	1992	1993
Wafer Sort						
Wafer Size (inches diameter)	6	6	6	6	6	6
Capacity Utilization (%)	100.00	100.00	75.00	50.00	25.00	100.00
Geometry (microns)	0.90	0.80	0.80	0.80	0.80	0.70
Processed Wafer Cost ($)	520	487	609	761	951	456
Die Area (square mils)	127,000	110,583	110,583	110,583	110,583	92,000
Active Area Factor	1.00	1.00	1.00	1.00	1.00	1.00
Number of Masks	14	14	14	14	14	14
Defect Density per Square Inch	0.350	0.200	0.200	0.200	0.200	0.150
Gross Die per Wafer	200	230	230	230	230	277
Processed Wafer Cost per Gross Die ($)	2.5952	2.1163	2.6454	3.3068	4.1334	1.6486
Test Cost per Hour ($)	90.00	90.00	171.90	214.87	302.97	90.00
Wafers Tested per Hour	2.25	3.13	3.13	3.13	3.13	2.60
Wafer Sort Cost per Gross Die ($)	1.0088	1.2237	2.3373	2.9216	4.1195	0.8470
Cost per Gross Die at Wafer Sort ($)	3.6040	3.3400	4.9827	6.2284	8.2529	2.4956
Wafer Sort Yield (%)	54	73	55	37	18	82
Cost per Sorted Die ($)	6.7150	4.5522	9.0547	16.9776	44.9926	3.0275
Assembly						
Material Cost/Sorted Die—SOJ Pkg.($)	0.1800	0.1800	0.1800	0.1800	0.1800	0.1800
0.1800						
Number of Pins	20	20	20	20	20	20
Assembly Yield (%)	91	92	92	92	92	93
Cost per Assembled Die ($)	7.5769	5.1437	10.0378	18.6496	49.1006	3.4489
Final Test						
Test Time per Die (sec.)	12.00	10.00	10.00	10.00	10.00	10.00
Cost per Hour of Testing ($)	90.00	90.00	171.90	214.87	302.97	90.00
Test Cost per Die ($)	0.3000	0.2500	0.4775	0.5969	0.8416	0.2500
Final Test Yield (%)	90	91	88	86	82	93
Cost per Final Tested Unit ($)	8.7521	5.9272	11.9221	22.2667	60.8204	3.9773
Mark, Pack, and Ship						
Cost @ 99% Yield (%)	0.0875	0.0593	0.1192	0.2227	0.6082	0.0398
Total Fabricated Cost per Net Unit ($)	8.8396	5.9864	12.0413	22.4894	61.4286	4.0171
FMV Formula Adders						
R&D Expense (15%)	1.33	0.90	1.81	3.37	9.21	0.60
SG &A Expense (10%)	1.02	0.69	1.38	2.59	7.06	0.46
Profit (8%)	0.89	0.61	1.22	2.28	6.22	0.41
Constructed Foreign Market Value (FMV)	12.08	8.18	16.45	30.73	83.92	5.49

Source: Dataquest (July 1992)

"reality checks" of the model ensure that, when cost and price trends track in the same or different directions, plans can be made with confidence that the best information was available at that time. Cost modeling can also be used as an internal audit to note where actual costs compare with model costs. Traditional use of cost models in price negotiations combined with experience curve trends can fine-tune the final outcome of these important agreements.

By Mark Giudici

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

Q. What are the top 10 procurement issues over the past seven years?

A. See Table 1.

Table 1
Top Semiconductor User Issues

1992		Historical Rankings					
Rank		1991	1990	1989	1988	1987	1986
1	Pricing	1	2	2	2	1	1
2	Quality/Reliability	5	6	4	6	3	2
3	On-Time Delivery	6	1	3	3	4	3
4	Availability	2	4	1	1	2	4
5	New Products/Obsolescence	7	7	8	8	-	7
6	Cost Control	3	3	7	4	6	-
7	JIT/Inventories	4	5	6	9	7	5
8	Forecasting	-	9	-	-	-	9
9	Trade Restrictions	8	10	-	-	5	-
10	Developing User/Supplier Relationship	-	-	-	-	-	-

Source: Dataquest (July 1992)

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- August Procurement Pulse
- ASIC product update
- Regional pricing

For More Information . . .

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9206 June 29, 1992

In This Issue...

Dataquest

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File inside the *Dataquest Perspective* binder labeled Semiconductor Procurement

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Device Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.18	0.15	0.16	0.15	0.14
74AC138	0.29	0.34	0.26	0.25	0.24	0.21
74AC244	0.44	0.46	0.35	0.38	0.39	0.36
74AC74	0.24	0.22	0.20	0.20	0.20	0.17
Lead Time: (Weeks)	5	3	12	4	5	5
4F00	0.10	0.12	0.09	0.10	0.09	0.09
4F138	0.15	0.20	0.15	0.16	0.16	0.14
4F244	0.22	0.28	0.21	0.23	0.24	0.23
4F74	0.11	0.14	0.12	0.12	0.12	0.11
Lead Time: (Weeks)	5	3	12	4	5	5
7805-TO92	0.12	0.18	0.11	0.11	0.11	0.11
CODEC-FLTR 1	1.78	2.20	2.50	1.73	1.94	1.45
CODEC-FLTR 2	4.10	4.45	5.00	4.55	4.70	
Lead Time: (Weeks)	8	3	6	3	4	
DRAM 1Mbx1-8	3.20	3.27	3.15	3.33	3.10	3.30
DRAM 1Mbx9-8	31.50	34.20	30.00	34.00	36.80	31.00
DRAM 256Kx1-8	1.13	1.61	1.52	1.05	1.20	1.05
DRAM 256Kx4-8	3.25	3.30	3.15	3.40	3.40	3.30
DRAM 4Mbx1-8	11.73	11.25	12.00	12.25	12.50	11.30
EPROM 1Mb 170ns	3.15	3.50	2.90	3.03	3.30	2.40
EPROM 2Mb 170ns	6.85	7.00	4.40	5.70	6.33	4.70
SRAM 1MB 128KX8	11.75	11.01	9.30	13.50	13.60	
SRAM 256K 32Kx8	3.70	3.42	3.25	3.45	3.80	3.30
SRAM 64K 8Kx8	1.78	1.55	1.65	1.30	1.37	1.40
Lead Time: (Weeks)	2	4	4	4	7	4
68020-16	27.25	36.95	26.00	34.75	31.50	
80286-16	8.08	9.83	10.00	9.50	10.10	6.90
80386DX-25	94.50	135.62	95.00	100.00	96.00	75.00
80386SX-16	46.50	51.89	47.50	48.00	47.20	37.00
R3000-25	102.50	122.25	110.00			
Lead Time: (Weeks)	2	7	4			

*Prices in U.S. dollars
Source: Dataquest (June 1992)

Market Analysis

June Procurement Pulse: Orders and Inventories Plateau, While Lead Times Rise

The Procurement Pulse is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rate Correction Expected

As shown in Figure 1, the respondents to this month's survey expect to book approximately the same level of semiconductor orders in June relative to last month's strong increase. This flattening in semiconductor order rates correlates with the six-month system sales outlook that is expected to decline 4.2 percent, down to a positive 8.0 percent from last month's heady 12.2 percent forecast. The current 8.0 percent

Figure 1
Averaged Monthly Semiconductor Orders

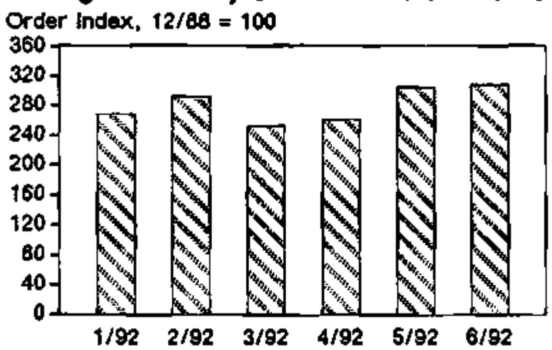


Figure 2
Averaged Semiconductor Lead Times

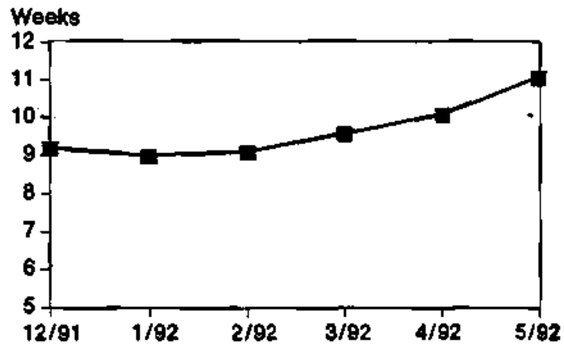


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

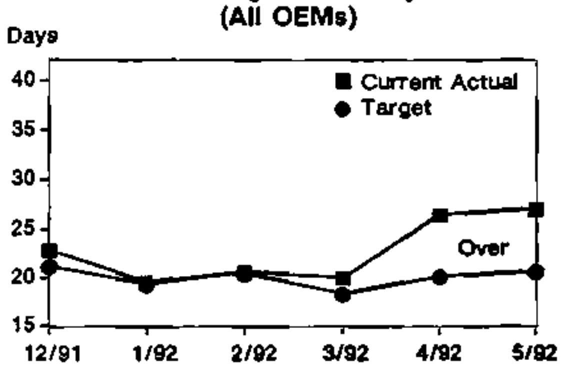
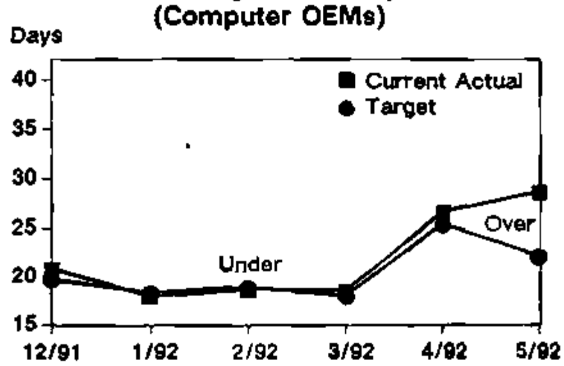


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (June 1992)
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six-month forecast is still even with the 8.0 percent outlook outlined two months ago.

The largest decline in system sales is expected to come from the computer segment of our survey, with the forecast dropping from last month's 10.6 percent to a current six-month outlook of 6.2 percent. Many of the computer company respondents are expecting flat sales relative to last month, which effectively lowers the averaged forecast rate. Sales estimates are relative and there were still no negative forecasts reported from our respondents.

Overall prices are expected to decline 1.3 percent since our last report, primarily due to the extreme caution in DRAM pricing brought on by Micron's antidumping action taken against Korean DRAM suppliers, as noted last month. Additionally, surface mount standard logic prices have inched upward for some users due to a short-term supply/demand imbalance. Based on key supplier inputs, there remains adequate semiconductor capacity to meet the needs of the gradual growth cycle that we are now seeing. Accurate forecast communications to suppliers should ameliorate the need to worry about shortage possibilities.

Lead Times Rise Above 11 Weeks

There has been a marked trend of average lead time increase since February (See Figure 2). There are several causes for this increase in average lead times. Directly impacting lead times is the steady increase of demand combined with some material shortages (discrete T092 packages and surface mount technology standard logic lead frames). Indirectly causing delays is the strong end-user demand for Windows software. Because Windows requires incremental DRAM and VRAM to run optimally, system companies are now ordering DRAM/VRAM in addition to their regular bill of material orders. Distributors are also experiencing lengthened lead times of standard logic and DRAM/VRAM due to unseasonable strong demand levels. The isolated lead time stretches will correct themselves in the DRAM/VRAM area because of the capacity levels available. The delays associated with surface mount logic may last longer because of the relative few numbers of suppliers remaining in this market. The situation is by no means dire enough to force buyers to the spot market, but accurate forecasting of order levels now will prevent shortage concerns for SMT standard logic in the future.

Semiconductor Inventory Correction Underway

While the overall semiconductor inventory levels remained flat for both target and actual levels as shown in Figure 3, the computer subset of our survey saw actual levels rise and target levels fall, creating a large target versus actual inventory delta (see Figure 4). The overall sample target and actual inventory levels went from a respective 20.2 and 26.5 days to the current comparable 20.7 and 27.1 days. The computer segment went from a 25.5 and 26.7 target versus actual inventory level to this month's respective target of 22.2 days, with 28.7 days of semiconductor inventory on hand. As mentioned in last month's Procurement Pulse, a correction in inventory levels is still anticipated, but the computer segment of our survey still requires additional work in getting actual inventory levels in line with target. With the aforementioned reduction in computer system sales expected relative to last month, a reduction in order activity from data processing companies is likely in order to keep inventory levels under control.

Dataquest Perspective

In today's economy, for every two steps forward it seems there is one step taken backward, and the current pickup in electronics activity is no exception. The ongoing gradual increases noted in demand over the past several months have had some lead time stretch-outs, inventory ups and downs, and price flattening; however, the underlying growth pattern remains. The nuts and bolts of procurement success is accessing material at low overall cost regardless of business level activity. As business levels increase, the stakes of this success are raised relative to the competition. The aggregate capacity level of the semiconductor suppliers remains good and will come to production levels as sustained demand levels are realized. Pickups and slowdowns in order activity need to be minimized in order to convince suppliers that the cost to activate capacity will be rewarded with consistent higher levels of sales.

By Mark Giudici

Product Analysis

DRAM User Alert: Managing Your "Year 2000" Supplier Base Starts Today

Eight years ago, the author of this report worked with the Korea Trade Center, which alerted the world that Korean-based firms like Samsung were intent on achieving world leadership in DRAMs—a ludicrous thought at the time. Today, Samsung ranks among the very top suppliers in the DRAM world, with Goldstar and Hyundai aiming to join Samsung as a member of this exalted rank. Looking ahead eight years from today, users of DRAM must start preparing now to manage anticipated major changes in the DRAM supplier base by the year 2000.

For many users, DRAMs rank along with microprocessors (MPUs) as their most critical supply base concern. Dataquest estimates that worldwide production of DRAMs totaled 1.3 billion units during 1991, a 5 percent increase from the 1990 level. Based on Dataquest's 1991 DRAM market share ranking, this report evaluates the life cycle stage for DRAMs in 256K through 16Mb densities and assesses the evolving supply/supplier base for these critical products not only today but for the remainder of this decade.

A key element to the Semiconductor Procurement Service (SPS) strategy for DRAM demand management is for users to match system life cycles with DRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans against DRAM life cycles for the purpose of managing DRAM costs and planning for DRAM product changes in those cases where system and DRAM life cycles do not match.

Modeled in the same fashion as previous Dataquest articles in our series of IC supply base reports, this article is organized in five main sections. The first section develops a guide to cost-effective procurement of DRAMs through the use of product life cycle analysis. The second section focuses on the top-ranked suppliers of DRAMs and looks at market positions, product strategies, technology strengths, strategic alliances, and the worldwide fab network of leading suppliers. The third section of this article combines the analyses of DRAM life cycles and the supplier base. This section supports users of DRAMs in assessing which direction to take for DRAM products and suppliers over the long term. The fourth section, on DRAM life cycle pricing, serves as a tool for "forward pricing" analysis—with the focus here on the next-generation 16Mb DRAM. The fifth and final section presents Dataquest's overall perspective on the DRAM market.

DRAM Product Life Cycles

This section uses information on DRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over time. This section also lays the basis for other analysis based on DRAM life cycle curves.

DRAM Life Cycles by Product Density

Figure 1 illustrates a series of curves that map the product life cycle of DRAMs in densities of 256K to 16Mb. This figure is based on Dataquest's historical DRAM unit shipments and forecast information.

Figure 1 reveals that DRAMs experience a life cycle in the range of 15 years, excluding the R&D phase. The figure also illustrates that the DRAMs with densities of 4Mb and below typically reach the peak stage of the life cycle during the sixth year.

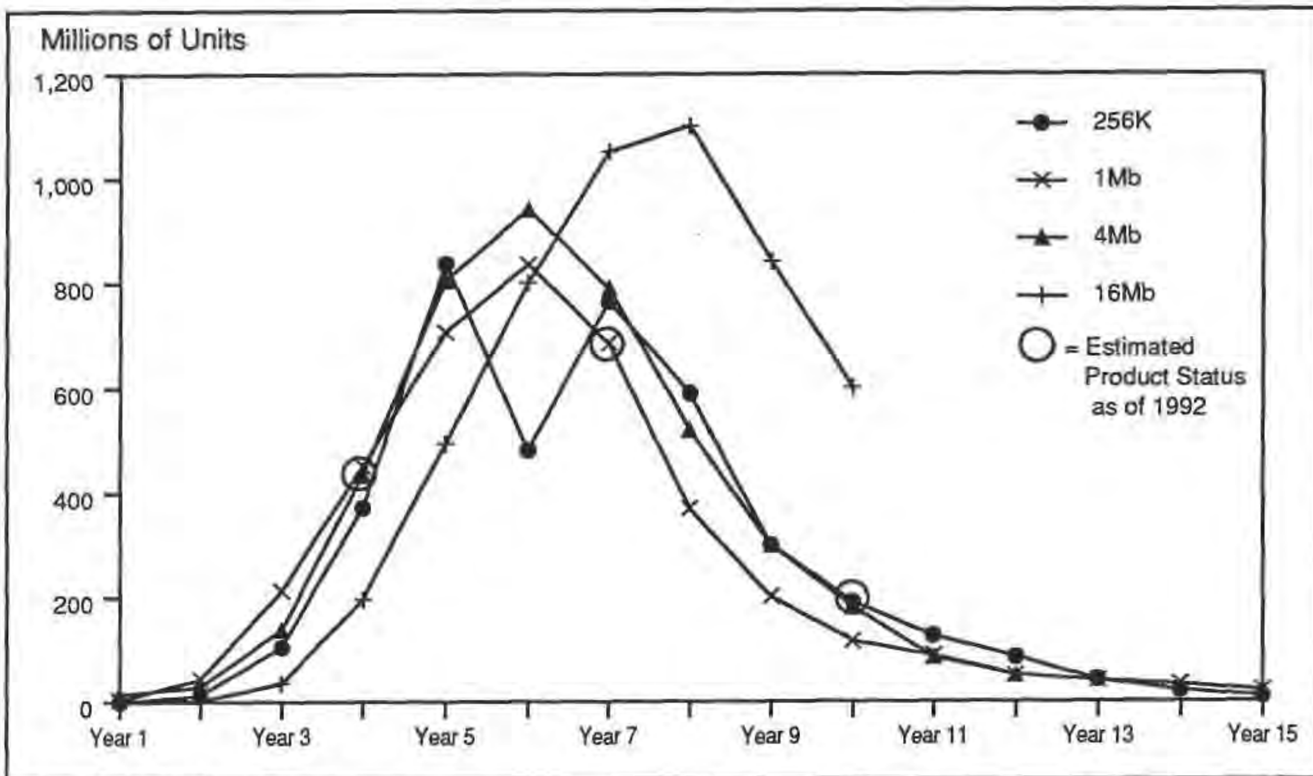
Historically a new density of DRAM has been introduced every three years—with a concomitant three-year interval for price-per-bit crossovers. The trend is toward longer DRAM life cycles as measured by the interval between price-per-bit crossovers.

Factors That Affect DRAM Life Cycle Behavior

The following factors are among those affecting DRAM life cycle behavior: system application trends, DRAM manufacturing trends, and the levels of R&D and capital spending. We believe that the huge R&D expense and fab costs associated with designing and manufacturing DRAMs with densities of 4Mb and greater account for the trend toward longer DRAM life cycles when compared to prior generations.

Key DRAM manufacturing trends include the following: the move to ever smaller submicron processes—which will face ultimate laws of

Figure 1
DRAM Product Life Cycles by Density as of June 1992



Source: Dataquest (June 1992)

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physics after the year 2000; the increased number of masks/processes; the rate of yield improvement; and the pace of the industry's shift to larger-size wafers (from 8-inch to 10- or 12-inch wafers).

Some significant application trends include the evolving relationship between system main-memory requirements and DRAM storage capacity. For example, growth in noncomputer DRAM demand (VCRs, telecom systems) means increased use of DRAMs with smaller storage capacity than that necessary for computer systems. Another application trend entails the growth in demand for low-voltage, low-power, high-speed systems—meaning increased consumption of wide DRAMs (x16).

A bottom-line financial factor that will affect megabit density DRAM life cycles is the industry's ability—or inability—to profitably sustain enormous levels of R&D and capital spending, which are needed to produce ever-denser and more complex DRAM devices on schedule (for example, 1-Gb DRAM prototypes by the year 2000).

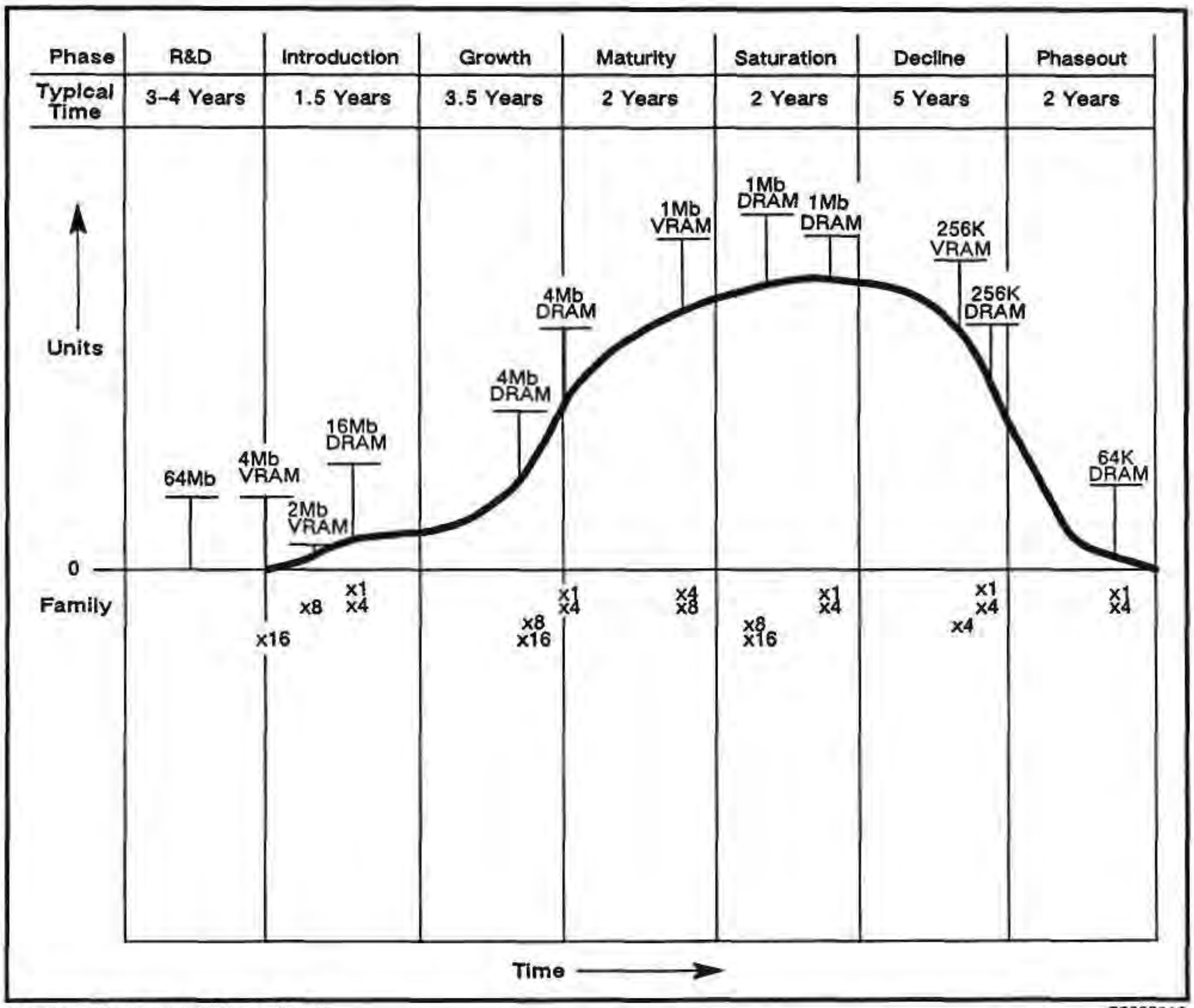
DRAM Life Cycles by Configuration

Figure 2 depicts the life cycles for DRAMs and video RAMs (VRAMs) on the basis of organization. The figure breaks each stage into specific time intervals.

DRAM Life Cycle Stages

Figure 2 shows that the DRAM R&D stage occurs over a three- to five-year period. The DRAM introduction and growth stages extend for five years. The maturity and saturation stages—which total four years—represent the peak of the life cycle. The decline/phaseout period typically persists for five to seven years. Figure 2 illustrates that the 1Mb DRAM life cycle—which peaked during 1991 in terms of unit shipments—should move through the decline phase starting in 1993. The 1Mb DRAM life cycle should extend well past 1995. Dataquest expects a long life for 4Mb DRAMs, with the life cycle peak not expected until the 1994 time frame. Figure 2 also shows that the 16Mb DRAM has entered the introductory stage of a cycle that should extend to the year 2000, and that 64Mb DRAMs are in the R&D

Figure 2
DRAM Product Life Cycles by Configuration as of June 1992



Source: Dataquest (June 1992)

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phase. At the other end of the curve, the 256K DRAM continues to move through the decline stage.

DRAM Product Configurations

The x1 and x4 designs have been the mainstream DRAM organizations; however, the DRAM trend should be toward product proliferation in terms of wide-word configurations (x8; x16/x18), single in-line memory modules (SIMMs), the range of speeds, package choices (TSOP, ZIP), and specialty applications like 2Mb VRAMs. Figure 2 shows that the life cycle for the newer wide-word organizations lags behind that of the more familiar x1 and x4 configurations. SIMM life cycles are virtually the same as those of the underlying DRAM devices. VRAM life cycle lags behind the stage of the equivalent-density DRAM by approximately one year.

DRAM Suppliers

This section analyzes the product and market strategies of leading DRAM suppliers. The analysis covers each company's DRAM market ranking, product positioning, strategic alliances, and global fab network.

Users of megabit-density DRAMs should be aware that the introductory stage of the DRAM product life cycle often means a sharp competitive advantage for early entrants, which are able to enjoy premium pricing through the introduction and growth phases of the product. Furthermore, the DRAM's extended maturity stage eventually tips the competitive balance to low-cost producers. Regarding the next-generation 16Mb DRAM, early 1992 reports to Dataquest indicate an aggressive pricing curve for the product during the forward stages of the life cycle; however, dumping allegations in North America against Korean suppliers have undercut that scenario.

Table 1 presents the 1991 worldwide ranking of DRAM suppliers by product. The table presents each company's ranking in terms of units for densities ranging from 256K through 4Mb.

Table 2 presents the estimated total worldwide fab capacity of leading DRAM suppliers, including percentage devoted to DRAMs.

Table 3 displays the worldwide network of DRAM technology alliances.

For a detailed analysis of DRAM technology alliances, see the Semiconductor Procurement *Dataquest Perspective* article "Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest," Vol. 1, No. 17, December 23, 1991.

Tables 1, 2, and 3 are guides in the analysis of the 256K, 1Mb, 4Mb, and 16Mb DRAM supplier base.

Toshiba

Table 1 reveals that Toshiba holds a second-place ranking in both 1Mb DRAMs and 4Mb DRAMs as measured in unit shipments. Toshiba is waging a neck-and-neck battle with Samsung during 1992 for total DRAM market share leadership.

Table 1
Top Worldwide DRAM Suppliers by Product

Supplier	Preliminary 1991 Revenue Ranking[1]	Unit Shipment Ranking By Product Density[2,3]			
		256K	1Mb	4Mb	16Mb
Toshiba	1	10	2	2	2
Samsung	2	1	1	3	
Hitachi	3	8	13	1	1
NEC	4	2	5	4	4
Texas Instruments	5	4	3	10	
Fujitsu	6	7	8	5	3
Mitsubishi	7	6	9	6	7
Micron	8	11	4	13	
Oki	9	5	11	7	6
Siemens	10	13	6	8	
Hyundai	11	3	10	9	
Motorola	12	19	7	11	
Goldstar	13	9	12	12	
Matsushita	14	12	15	14	5
NMB	15	17	14	15	
Vitelic	16	16	16		
Sharp	17	15	18	16	
Total (Million of Units)		299	835	138	0.1

Note: Total includes other suppliers not shown on table
[1]In terms of revenue
[2]Includes VRAMs
[3]In units
Source: Dataquest (June 1992)

Table 2
Estimated Number of Wafer Fabrication Production and Pilot Lines of Top-Ranked Dram Suppliers

	North America	Japan	Europe	Asia/Pacific Row	Total No. of Lines	Total Theoretical Capacity[1]	Estimate of Percent Theoretical Capacity for 4Mb Drams
Toshiba[2]	0	29	0	0	29	158.6	17.0
Samsung	0	0	0	7	7	57.9	57.1
Hitachi	1	27	1	0	29	141.3	38.5
NEC	2	24	2	0	28	149.1	20.6
Texas Instruments[3]	10	5	4	1	20	92.2	35.9
Fujitsu	1	20	1	0	22	111.1	18.4
Mitsubishi	1	17	0	0	18	88.1	18.6
Micron	3	0	0	0	3	22.4	50.4
Oki	0	8	0	0	8	65.9	40.4
Siemens	1	0	7	0	8	35.4	34.2
Hyundai	0	0	0	5	5	26.3	50.0

[1]Theoretical capacity stated in millions of square inches of silicon per year
[2]Includes Tohoku Semiconductor (Japan)
[3]Includes TI/Acer
Source: Dataquest (June 1992)

The vertically integrated Japan-based supplier positions itself as a leader in terms of DRAM manufacturing capability. Toshiba is well prepared to battle all suppliers for 4Mb and 16Mb DRAM market share. Even so, Toshiba has publicly expressed concern about the DRAM supply and demand outlook—not only for 1992 and 1993, but also the long term. A major concern for Toshiba is the accurate industry gauging of the DRAM fab capacity required to meet demand.

The industry giant should remain a leader in the DRAM market for the foreseeable future. During the short term, Toshiba will emphasize the 4Mb DRAM density. The information in Table 2 shows that Toshiba has started the shift to the 16Mb device that will become the mainstream product by the 1995/1996 time frame.

Toshiba's competitive product portfolio includes high-speed DRAMs, VRAMs, wide-word configurations, and SIMMs. Toshiba recently announced samples of its R-DRAM, which is based on Rambus' high-throughput DRAM. Based on 1991 unit shipments, Toshiba is the leading supplier of 1Mb VRAMs. During 1992, Toshiba introduced a 2Mb VRAM. The supplier should be a major player in the 4Mb VRAM segment as the market emerges during 1993.

A key DRAM alliance for Toshiba is the well-publicized DRAM/MPU arrangement with Motorola (Table 3). In this alliance, Toshiba provides the DRAM design and manufacturing technology. The alliance partners manufacture DRAMs in their joint Tohoku (Japan) fab, and Motorola resells them in world regions such as North America.

Users in Europe should monitor the evolution of the Toshiba-Motorola alliance as the rules on local diffusion become final. For example, Motorola has established five fabs in Europe. Toshiba has none outside Japan except for a small facility in North America (California); however, the firm has announced new fabs for Germany and North America (Oregon).

Table 3
Estimated Worldwide DRAM Technology Alliances as of June 1992[1]

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances	
Supplier	Second-Source Agreements	Fab Agreements	Joint-Venture Agreements	Fab Agreements	Joint-Venture Agreements	Joint Development
Goldstar		Vitelic-MOSel				
Goldstar			Hitachi (FA)			
Hitachi	Goldstar					
Hitachi						TI (and 64Mb DRAM)
IBM						Siemens
IBM			Micron (LA)			
Intel	Goldstar (OEM)		Goldstar (OEM)			
Matsushita		Intel (also Sales Agency Agreement)				
Micron	NEC (Mutual OEM)		NEC (Mutual OEM)		NEC (Mutual (OEM)	
Micron	Sanyo (64K×16 device)					
Motorola	Goldstar (OEM)		Goldstar (OEM)			
NMB			Hitachi (OEM arrangement based on Hitachi production technology)			
NMB			Ramtron International (JD)			
NMB					Ramtron	
Oki				Vitelic-MOSel	Vitelic-MOSel	
Sanyo			Mosaid			
TI			HP-Canon-Singapore		HP-Canon-Singapore	
TI			Acer			
TI	Mitsubishi					
Thorn-EMI	NMB (LA per Thorn's Inmos-based patent)					
Toshiba	Motorola		Motorola			
Toshiba	Siemens (LA)					

Definitions/Notes:
FA = Fab agreement: supplier offers fab capacity for partner's product technology. In most cases, the supplier provides fab capacity and produces the partner's DRAM design.
JD = Joint development: the companies jointly agree to develop new products, which may or may not be marketed separately.
JV = Joint venture: the companies form a new joint-venture company to develop, manufacture, and market new products.
LA = Licensing agreement: supplier receives or issues a license to partner for an an up-front fee and/or royalties.
OEM = OEM arrangement: supplier sells product to alliance partner, which is sold under partner's name.
SA = Sales agency agreement: supplier sells its partner's products as either a sales representative or a value-added reseller.
SS = Second-source agreement: the companies agree to develop consistent specifications to ensure a second source.
[1]Excludes SIMMs (e.g., Wang's X9 SIMM) and other patent royalties.
Source: Dataquest (June 1992)

Samsung

Samsung of the Republic of Korea continues its impressive advance in the global DRAM marketplace, now aiming to move a notch higher into a first-place ranking. Table 1 reveals that Samsung ranks first in the 256K and 1Mb segments, and third in the 4Mb arena. Samsung holds the No. 8 position in the 1Mb VRAM marketplace. A key factor is that the company has used a "low-cost" manufacturing strategy to gain share in world markets like North America and Europe.

Dataquest advised in last year's report that to protect its long-term position in the worldwide DRAM arena, Samsung must avoid trade friction—which would be challenging. A recent obstacle to Samsung's advance in North America are the dumping allegations by North America-based Micron Technology against Korea-based suppliers, allegations that have caused trade friction for Samsung. For example, during the first half of 1992, Samsung positioned itself for a forward-stage price strategy on the 16Mb device—similar to the 256K pricing scenario by Japan-based suppliers during the 1985-1986 period. Micron's allegations might throttle such aggressive pricing. Samsung also remains under trade scrutiny in Europe. Samsung's vulnerability to trade restraints is heightened by the lack of fabs outside of Korea and the absence to date of any key DRAM alliances.

Regardless, Samsung now positions itself as a DRAM technology leader and aims for a global leadership role in the 16Mb marketplace. Users can expect a competitive product portfolio. As shown by its second-place ranking in the 4Mb segment and competitive position in the early stage of the 16Mb life cycle, Samsung ranks among the world leaders in the DRAM technology race.

Hitachi

Hitachi, a Japan-based vertically integrated supplier, now battles Samsung and Toshiba, among others, to maintain its first-place ranking in the mainstream 4Mb segment, while migrating to the emerging 16Mb arena.

Hitachi's DRAM strategy continues to focus as in past years on the company's design expertise and manufacturing prowess augmented by marketing skill. Users can expect a competitive product portfolio from Hitachi in terms of a full range of product speeds, configurations, and packaging options toward a goal of DRAM product differentiation. For example, Hitachi's 4Mb DRAM product line includes wide-word configurations, single in-line memory modules (SIMMs), and high-speed DRAMs. Hitachi de-emphasizes 256K DRAMs and 1Mb DRAMs except for VRAM products. Hitachi ranks third in the 256K VRAM business (64Kx4) and sixth in the 1Mb segment (256Kx4; 128Kx8). The supplier will make an orderly move to 3-volt DRAM and 4Mb VRAM as those markets develop.

Hitachi's fab network includes one facility in both the European and North American markets—an important consideration in a period of rising trade tension (Table 2). A sign of Hitachi's DRAM manufacturing prowess is that the fab network includes state-of-the-art 8-inch wafer capability.

The information in Table 3 reveals that Japan-based Hitachi has forged two key DRAM technology alliances—one with Korea-based Goldstar, and the other with North America-based Texas Instruments. The alliances are still evolving. For example, the alliance with TI on 16Mb DRAMs resulted in two different DRAM designs—but a common package. The 64Mb alliance aims at a second-source arrangement. Hitachi's 1Mb DRAM alliance with Goldstar is a second-source deal. In the 4Mb foundry arrangement, Goldstar makes the device using Hitachi's design, with the product sold by Hitachi.

NEC

NEC holds a second-place ranking in the 256K DRAM segment, the No. 5 ranking in the 1Mb arena, and fourth place in the 4Mb marketplace. NEC has somewhat of a reputation as a DRAM "follower of the leader." For example, the information in Table 1 indicates that NEC acts somewhat from a DRAM technology "catch-up position"—but the firm does not trail the market leaders by far. The vertically integrated Japan-based company has successfully executed this strategy in past years by supporting superior manufacturing planning with deep-pockets financial strength.

NEC should remain a top worldwide DRAM supplier. Like other leading suppliers, NEC's long term strategy focuses on DRAM densities of 4Mb and greater; however, the firm is strong in some lower density segments as well. For example, NEC is the leading supplier of 256K VRAMs and holds the No. 5 spot in the 1Mb VRAM arena. During first half of 1992 this supplier started volume production of 2Mb VRAMs. Users of 4Mb DRAMs can look to NEC for a competitive product portfolio including high-speed 4Mb DRAMs, wide-word configurations, SIMMs, and VRAMs.

NEC has positioned itself nicely to withstand potential trade friction in regions like North America and Europe, having two fabs in each of those regions (see Table 2). The just-announced OEM arrangement with Micron (see Table 3) puts NEC onto the DRAM alliance map. Others should evolve.

Texas Instruments

Texas Instruments trails the market leaders in the 4Mb DRAM business. The North America-based supplier ranks fourth in 256K density, third in the 1Mb arena, and is No. 10 in the mainstream 4Mb arena. In terms of global coverage, however, TI stands in good position to make a DRAM market advance over the next few years in each world region (see Table 2).

The industry giant offers a competitive 4Mb DRAM product portfolio that includes wide-word configurations and SIMMs. TI, which invented the VRAM in 1983, ranks second among suppliers of 1Mb VRAMs and fifth in the 256K VRAM marketplace. TI will bypass any 2Mb VRAM and concentrate on the 4Mb VRAM product, aiming for volume production during the fourth quarter of 1992.

Texas Instruments centers one prong of its DRAM strategy on alliances that spread the risk and benefits of participation in the global DRAM business to a network of alliance partners that includes users, other suppliers, and governments. Table 3 presents information on a host of TI alliances. The joint venture agreement on 4Mb and 16Mb DRAMs between TI, Canon, Hewlett-Packard, and the government of Singapore—along with the TI-Acer (Taiwan) alliance on 4Mb DRAMs—might serve over the long term as industry models of user-supplier alliances not only in DRAMs but also with other ICs. The TI-Hitachi alliance has been discussed. Another alliance not shown in Table 3 is a venture between TI and the Italian government to produce 4Mb DRAMs in Italy.

A second prong of TI's DRAM strategy calls for aggressive protection of its entire IC patent portfolio—whether through litigation or negotiation—toward the goal of collecting royalty payments. In fact, TI reports patent royalties and related payments as operating income on its balance sheet.

Users should expect continuing adherence by TI to this set of strategies.

Fujitsu

Fujitsu holds the No. 5 spot in the 4Mb DRAM market, but lower rankings in the 256K segment and the 1Mb market (see Table 1). For this vertically integrated Japan-based supplier, internal demand reduces the company's exposure to DRAM merchant market volatility.

Fujitsu's product portfolio will be competitive. Fujitsu has a market reputation for good DRAM technology (small die sizes). Users can look to Fujitsu for VRAMs. The company ranks third among suppliers of 1Mb VRAMs and fourth in the 256K VRAM marketplace, and Fujitsu will evolve with the market to higher density VRAMs. Fujitsu has evolved its SIMM product portfolio in line with market demand trends (wide-word configurations). Fujitsu will place less emphasis on 256K and 1Mb DRAMs during 1992 and 1993.

Table 2 shows that Fujitsu has fab locations in Europe and North America in addition to Japan. To date, Fujitsu has not been a player in the world of DRAM technology alliances. Users can look to Fujitsu as a dependable and competitive long-term supplier of DRAMs.

Mitsubishi

Mitsubishi holds the No. 6 position among suppliers of 256K DRAMs and 4Mb DRAMs, and it is ninth in the 1Mb segment. The vertically integrated Japan-based company ranks second among suppliers of 256K VRAMs and fourth in the 1Mb VRAM segment. During the first half of 1992, Mitsubishi sampled 2Mb

VRAMs. Mitsubishi's 4Mb DRAM portfolio includes high-speed DRAM and wide-word configurations.

Mitsubishi's overall DRAM ranking has slipped somewhat in recent years; however, the company remains a competitive world-class supplier. For example, Mitsubishi strives for process and packaging technology expertise, which might translate into a market advantage at the 16Mb and 64Mb densities. The zig-zag in-line package (ZIP) and the thin small-outline package (TSOP) were Mitsubishi innovations. Even so, if success in the 4Mb DRAM business serves as a key indicator of long-term success, the signals remain mixed regarding any ultimate leadership role for Mitsubishi.

Micron

Micron, a relatively small North American supplier surrounded by industry giants, ranks fourth in the 1Mb DRAM arena. Micron did not crack the top 10 in the 256K and 4Mb segments based upon 1991 unit shipments. Micron gained one position during 1991 versus its 1990 ranking.

There are four prongs to Micron's competitive strategy. Unlike its vertically integrated competitors, Micron does not aim at leading-edge DRAM technology leadership. Instead, the first key prong of the company's strategy calls for leadership in low-cost DRAM manufacturing capability. For example, Micron is able to reduce its capital requirements—a critical concern for DRAM suppliers—through innovative mask-reduction techniques. Micron's product portfolio is weighted toward mature DRAM devices (1Mb DRAMs during 1992) because the market typically favors low-cost producers during this peak stage of the DRAM life cycle. A key to Micron's success is that the company gears its effort toward achieving die-shrinks for mature DRAMs, which means quality results in manufacturing and low market pricing.

Alliances, indicated by Micron's just-announced OEM arrangement with NEC, serve as another prong of the company's strategy. Another Micron alliance, outlined in Table 3, with IBM on DRAM manufacturing process technology has supported Micron to implement its low-cost manufacturing plan.

A third prong in Micron's competitive strategy is that the company utilizes the global legal system to protect its stake in the market. During the first half of 1992, Micron alleged that Korea-based suppliers dumped DRAMs into the North American market. The action could stifle the advance into North America and other world regions of suppliers like Goldstar, Hyundai, and Samsung.

The fourth and final prong is that Micron aims to meet specialty memory needs. For example, users of 1Mb DRAMs can look to Micron for 64Kx16 DRAMs and 128Kx8 VRAMs. Another example is that Micron offers a triple-port DRAM. Micron ranks sixth among suppliers of 256K VRAMs and hopes to start volume production of 2Mb VRAMs during the third quarter of 1992.

Users can expect Micron to become an increasing force in the 4Mb DRAM segment as the product nears and then moves through the maturity stage of the life cycle during 1993 and 1994.

Oki

Oki ranks fifth in the 256K DRAM segment, No. 11 in 1Mb density, and seventh in the key 4Mb marketplace. The vertically integrated manufacturer has encountered somewhat uneven results in the brutally competitive DRAM business over the last several years. For example, Oki slipped somewhat in overall market ranking during 1991 when compared to 1990.

Oki aims at leadership in the SIMM marketplace. As noted in last year's report, users can expect Oki to be a leader in the move to 4Mb SIMMs and later to 16Mb modules. For example, Oki likely will ship the majority of its 4Mb DRAMs in the form of SIMMs.

Siemens

Siemens ranks sixth in the 1Mb DRAM market and eighth in the 4Mb segment (see Table 1).

For this vertically integrated Germany-based company, the geographic focus has reverted to Europe given the immense geopolitical changes in that region during the past several years and concomitant long-term opportunity. Users in Europe are likely to become more dependent on Siemens for DRAMs—certainly until other suppliers are producing there and especially if trade friction in that region increases. For example, the alliance between Siemens and IBM on 16Mb DRAMs signals for users that Siemens's DRAM future aims more at serving European demand—including Eastern Europe—and less on North American or Asian demand (see Table 3).

There are other rationales for the alliance. For example, Siemens wants to reduce its risk exposure in the volatile DRAM marketplace. Significantly, Siemens plans a shift in its strategic direction over the long term from the highly competitive memory business to other products such as ASICs. At press time, Siemens announced withdrawal from a 64Mb DRAM alliance with IBM.

IBM

Another player has emerged on the scene, a player that could end up in Table 1 by next year. IBM, which at the time of this writing had just announced plans to enter the DRAM merchant market, should be a key wild card among DRAM suppliers.

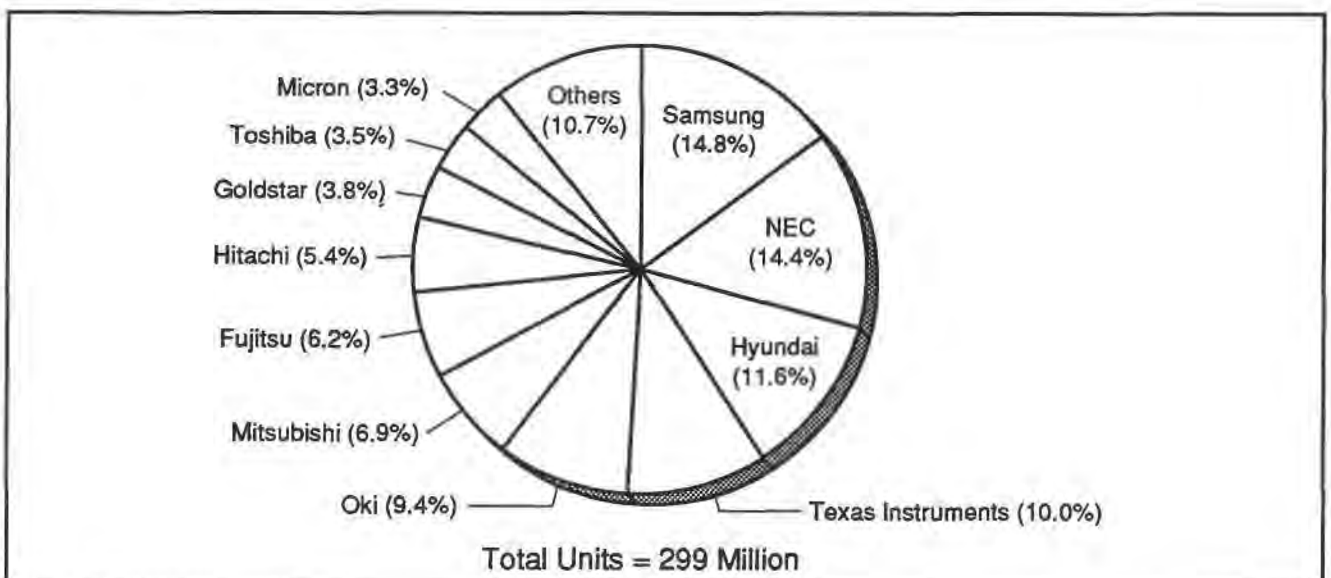
Supply Base Analysis

This section of the article uses information on DRAM product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for 256K through 4MB DRAMs. Like prior articles in this series of supply base reports, this section blends the DRAM life cycle analysis and supplier evaluations to generate a summary assessment from a user's perspective on the anticipated DRAM supply and supplier base outlook.

The goal of this section is not to present a detailed forecast on DRAM supply-demand trends, but rather to provide supply base managers with guidance as to whether users face a favorable or negative supply outlook for each density of DRAMs. Building upon the prior sections, factors affecting the supply base such as supplier strategies and strategic alliances are assessed here.

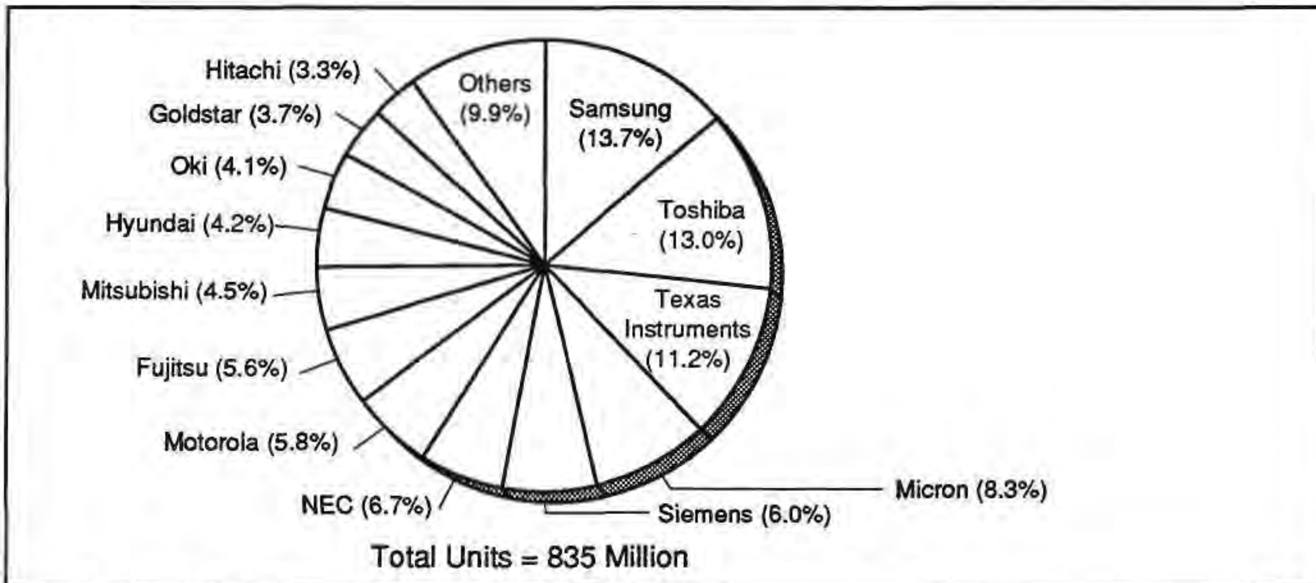
Figures 3, 4, and 5 guide the analysis in this section. Figure 3 shows the size of the 256K DRAM market in terms of units shipped during 1991 and a ranking of the suppliers of these devices including suppliers' shares. Figure 4 shows unit shipments and supplier ranking for 1Mb DRAMs. Figure 5 shows the same information for 4Mb DRAMs. Keep in mind that IBM's recent announcement does not specify its DRAM product strategy by density, although IBM's impact should be pronounced at densities of 16Mb and greater.

Figure 3
256K DRAM Supplier Base



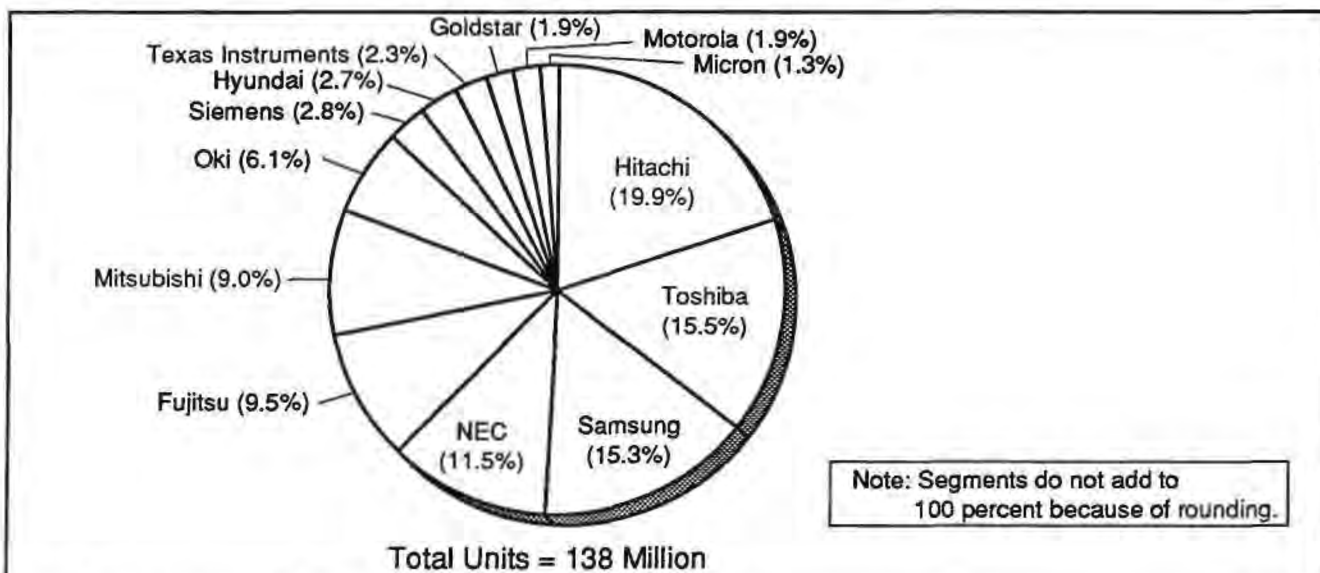
Source: Dataquest (June 1992)
G2000817

Figure 4
1Mb DRAM Supplier Base



Source: Dataquest (June 1992) G2000818

Figure 5
4Mb DRAM Supplier Base



Source: Dataquest (June 1992) G2000819

Supply Base for 256K DRAMs

Figure 3 shows the top-ranked 256K DRAM suppliers based on 1991 unit shipments. The figure reveals that leading suppliers, in descending order, are Samsung, NEC, Hyundai, TI, Oki, Mitsubishi, Fujitsu, Hitachi, Goldstar, and Toshiba. Table 1 shows the full range of suppliers.

Figures 1 and 2 show that the 256K DRAM product is moving through the decline stage. Worldwide production of 256K DRAMs fell to a 299 million units during 1991 versus a 1990 level of nearly 600 million units. The life cycle peaked during the 1988-1989 period.

Suppliers are migrating to higher density devices that could cause short-term supply constraints for some users. In general, however, users face a favorable outlook in terms of supply because of decreasing market demand.

To minimize the likelihood of any supply line disruption, users should be prepared to forge long-term supply arrangements with current suppliers or else qualify new suppliers. For example, Korea-based suppliers likely will support users of 256K DRAMs in an effort to win qualification on other devices such as higher density DRAMs. The life cycle for high-speed DRAMs lags behind that of general DRAM life cycles, so suppliers like NMB should remain supportive to users of the higher speed devices.

The 256K VRAM life cycle lags behind that of the garden-variety 256K DRAM by about a year, meaning somewhat longer support from suppliers on this device. NEC is the leading supplier followed by Mitsubishi, Hitachi, Fujitsu, and TI. Users should target these firms for continuing support.

Supply Base for 1Mb DRAMs

Figure 4 presents the top-ranked 1Mb DRAM suppliers based on 1991 unit shipments. The figure shows that the top-ranked suppliers in descending order are as follows: Samsung, Toshiba, TI, Micron, NEC, Siemens, Motorola, Fujitsu, Mitsubishi, Hyundai, Oki, and Goldstar. Table 3 shows 1Mb DRAM alliances between these suppliers, including Goldstar/Hitachi, Motorola/Goldstar, Micron/NEC, and Toshiba/Motorola. Table 1 shows the full line of suppliers and their rankings.

The information in Figure 1 and Figure 4 reveals that worldwide production of 1Mb DRAMs totaled 835 million units in 1991 versus a 1990 level of just over 700 million units.

The 1Mb DRAM stands at the saturation point—or peak stage—of its life cycle. Supply will decrease as the device moves along the decline stage of the curve, but volume should still exceed 100 million units for the year 1995. Barring an unexpectedly severe cutback in capacity, users who plan carefully can expect an adequate supply of 1Mb products for the next several years.

Standard versus Specialized DRAM

Nevertheless, users must accurately forecast long-term 1Mb demand in terms of specifications like speed, configuration, package, and application. Although the impact will be stronger at the 4Mb level, users of 1Mb DRAM will be affected by the market trend toward displacement in system applications of standard DRAMs by specialized DRAMs. Standard DRAMs refer to devices which are organized x1 or x4 and are contained in standard packages like SOJ, TSOP, or SIMMs. Specialized DRAMs include video RAMs (VRAMs), wide-word configurations, and other DRAMs that offer special I/O, that serve graphics-based applications, or that will become part of a cell-based IC (CBIC) library.

The challenge for users of 1Mb DRAMs is to align themselves with an appropriate supplier or set of suppliers as the supplier base shifts during the 1992 to 1994 period. In order to target 1Mb DRAM suppliers for long-term support, users should look for suppliers that have recently increased or decreased market share. For example, the following suppliers increased market share by more than 1 percent in 1991: Goldstar, Hyundai, Micron, Siemens, and TI. North America-based suppliers like Micron, Motorola, and TI likely will support demand from established customers, as will Europe-based Siemens. Korea-based suppliers like Goldstar, Hyundai, and Samsung likely will support new users as well.

Japan-based suppliers will continue to deemphasize 1Mb DRAM output. For example, the following suppliers lost more than 1 percent of market share during 1991: Fujitsu, Hitachi, Mitsubishi, NEC, Oki, and Toshiba.

Their emphasis will be on higher density 4Mb DRAM devices.

1Mb VRAMs

For users of 1Mb VRAMs, the supply base scenario is somewhat different. At the time of the writing of this report, some users had reported longer lead times during the second quarter of 1992 for 1Mb VRAMs such as the 256Kx4 device. A possible cause is a supply and demand mismatch stemming from booming demand for Windows software—a graphics application that requires VRAM. If so, suppliers likely will adjust capacity accordingly during 1992 to meet demand.

The leading suppliers of 1Mb VRAMs, in descending order, are as follows: Toshiba, TI, Fujitsu, Mitsubishi, and NEC. Users should target these firms for longer term support.

Supply Base for 4Mb DRAMs

Figure 5 presents the top-ranked 4Mb DRAM suppliers in terms of 1991 unit share. In descending order, the leading suppliers of 4Mb DRAMs are Hitachi, Toshiba, Samsung, NEC, Fujitsu, Mitsubishi, Oki, Siemens, Hyundai, Texas Instruments, Motorola, Goldstar, and Micron. Goldstar/Hitachi; IBM/Micron, Micron/NEC, Motorola/Goldstar, and Toshiba/Motorola were among the major 4Mb DRAM alliances (see Tables 1 and 3).

Global 4Mb DRAM production totaled 138 million units in 1991. The life cycle curves in Figures 1 and 2 show that the 4Mb DRAM device is now moving through the growth stage of the life cycle. The peak maturity stage of the life cycle should be reached during the 1994 to 1995 time frame, when annual output should exceed 800 million units. The 4Mb DRAM life cycle should extend toward the end of this decade.

Although the long-term supply base appears favorable for users of 4Mb DRAMs, there are some concerns. For example, the trend toward specialized DRAMs should mean continuing management challenges for users. The trend has picked up the pace in the 4Mb density marketplace—meaning periodic supply and demand mismatches as occurred during 1992 for some users of 1Mb VRAMs and/or ZIP devices. A more ominous example is public pondering by suppliers such as Toshiba regarding slower rates of DRAM capacity expansion compared to plans of two or three years ago—let alone outright capacity cutbacks. These public statements must not be ignored by the user community. Rising trade friction in world regions such as Europe and North America should add to users' wariness.

The upshot for DRAM supply base managers is that some long-established user/supplier relationships will likely be strained by increased emphasis on low-cost pricing by buyers. Suppliers in turn already search for more profitable product lines. To some extent, TI-type user/supplier alliances might become the best long-term protection for assured supply of 4Mb DRAMs. Nevertheless, under the current supply and demand scenario, users of 4Mb DRAMs still face a favorable supply base outlook through 1994.

Supply Base for 16Mb DRAMs

The life cycle curves in Figures 1 and 2 show that the 16Mb DRAM product is now moving through the introductory stage of its cycle. Table 1 shows which suppliers shipped 16Mb DRAMs during 1991. A host of other suppliers have entered or will soon enter this market.

The product life cycle of this part should extend beyond the year 2000. Early leadership for the next-generation product often signals future DRAM market leadership. For users looking ahead, Dataquest expects the 1994-1995 total ranking to be strongly influenced by 16Mb DRAMs. The battle during 1992 and 1993 in the 16Mb market between suppliers such as Hitachi, Samsung, Texas Instruments, and Toshiba should set the stage for DRAM market leadership during the second half of this decade.

Long-Term Supply Base Concerns

Users should be forewarned that the trend toward DRAM product proliferation should intensify at densities of 16Mb and above, meaning tremendous long-term supply base stress. For example, at ISSCC 1992, representatives from DRAM manufacturers such as Hitachi, IBM, Mitsubishi, Etron (Taiwan), Toshiba, and TI expressed some pessimism regarding suppliers' ability to profitably overcome the technical barriers associated with long-term DRAM development. Why? Suppliers in the future must make numerous cost trade-offs—perhaps leading to some wrong choices—to accommodate the market trend toward DRAM product proliferation in regard to voltage levels, power, access time, refresh schemes, configuration, and chip/die size.

A long term scenario shows standard DRAMs accounting for less than 50 percent of DRAM shipments. At the 16Mb and 64Mb densities, Dataquest believes that DRAMs contained in SOJ and TSOP packages will hit a plateau in terms of their share of total DRAM shipments—with the curve for specialty DRAMs pointing upward.

What are the industry implications? For suppliers, the DRAM's role as a process and technology driver should become accentuated as the market moves beyond the 16Mb density—not only regarding other memory ICs but also other products including CBICs and digital signal processors. A result under such a scenario is that standard DRAMs would eventually become fab-fillers akin to the role today played by slow SRAMs. A related scenario, according to one ISSCC panel member, is that flash technology will eclipse DRAM technology by the end of this decade. Suppliers of flash memory, such as Intel, claim this will happen even sooner.

Adequate Long-Term Supply?

Users and suppliers are already debating whether there will be adequate long-term supply of 16Mb DRAMs to meet demand. The pro argument by users and suppliers is made by pointing to past history. The con side says that huge costs in a time of changing financial and economic markets will translate into inadequate long-term supplies. This early debate should intensify during the second half of 1992.

DRAM Life Cycle Pricing

This section uses 1992 research information on DRAM life cycle pricing with a focus on the forward stage price outlook for the next-generation 16Mb device. The analysis, excluding the 16Mb device, was first discussed in a *Dataquest Perspective* article entitled "Is IC Life Cycle Pricing Creative Destruction or Industry Suicide?," SPWW-SVC-DP-9204, dated March 23, 1992. Price forecasts have changed somewhat since then, but the analysis remains consistent.

Figure 6 provides historic and forecast pricing in North America in dollars over the first years of the product life cycle for densities of 64K, 256K, 1Mb, 4Mb, and 16Mb DRAMs. Figure 7 converts the North America DRAM prices shown in Figure 6 into a common measurement: millicents per bit. Note that the 16Mb DRAM price curve rests at the bottom of Figure 7. Based on the information in Figures 6 and 7, Figure 8 presents the rate-of-price decline in North America for each density of DRAM relative to the prior generation device at each stage of the life cycle.

Forward Stage 16Mb DRAM Price Analysis

For users, a keynote DRAM supply base issue has become the 16Mb DRAM price outlook during the early volatile years of the product's life cycle.

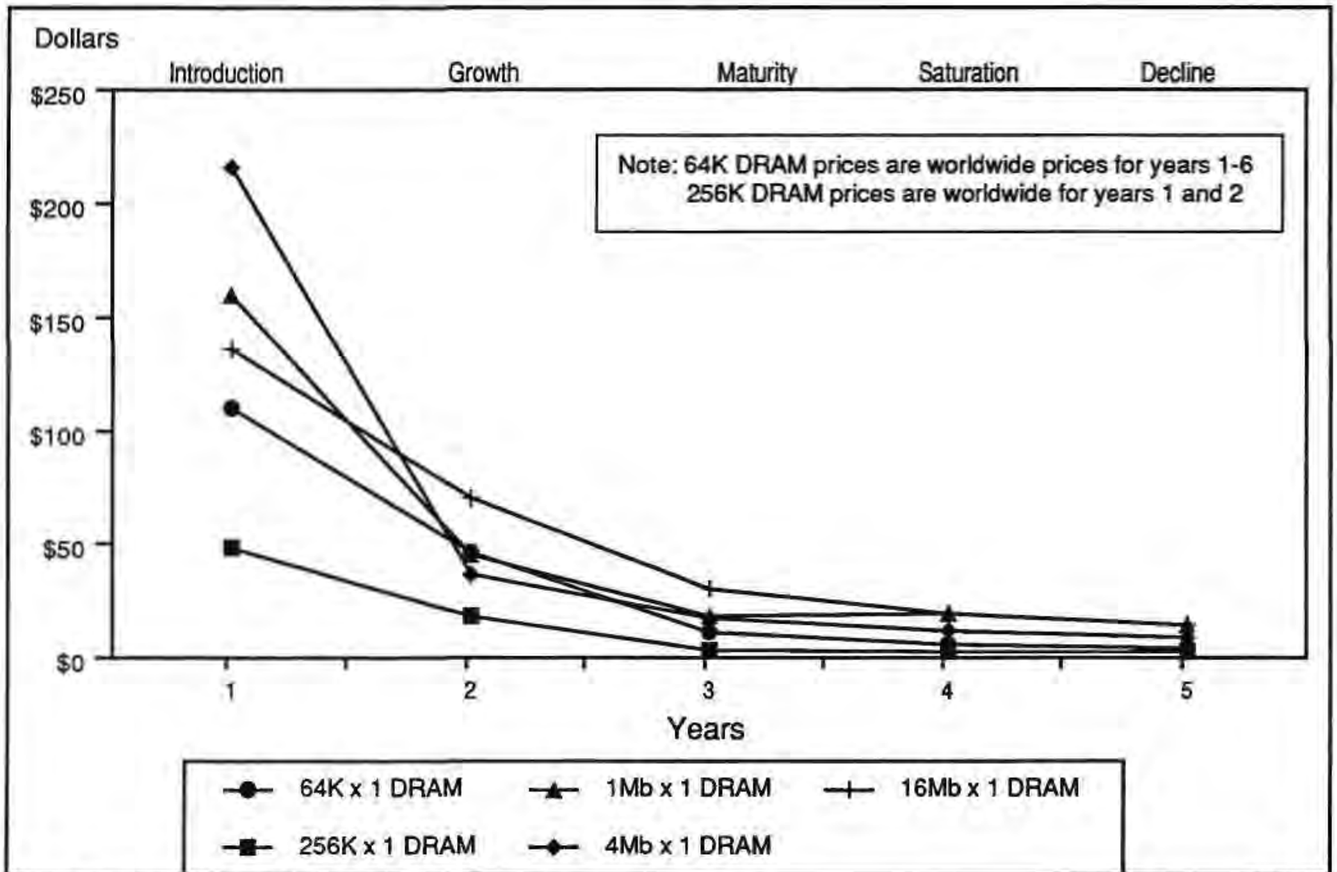
In regard to the early life cycle (forward stage) 16Mb DRAM price outlook for North America, Figure 8 shows that during 1992—the first year of the 16Mb life cycle—Dataquest expects that millicents-per-bit pricing for the 16Mb part will be 84 percent lower than millicents-per-bit pricing for 4Mb DRAMs during the first year of their life cycle, which was 1989. It is important to note that the first-year life price curve for 16Mb DRAMs most closely approximates the first-year curve for 256K DRAMs (1983), which in part led to U.S. allegations of dumping against Japan-based suppliers in the mid 1980s.

The 1993 Scenario

Prices in 1992 for 16Mb DRAMs in regions such as North America and Europe should be somewhat erratic and vary widely because suppliers are at different stages in terms of sampling, initial volume production, and full volume production. For 1993, however, the information in Figure 8 can be used to provide a forecast of the estimated high and low range of North America 16Mb DRAM pricing.

The information in Figure 8 historically depicts this range of percentage declines in DRAM pricing at the second year of any given product density relative to the prior generation device, from a low of a 35 percent decrease for 1Mb DRAM in its second year compared to 256K DRAM in its second year, to a high of a 90 percent decline for 256K DRAM versus 64K DRAM.

Figure 6
North American DRAM Pricing by Life Cycle Stage (Dollars per 100,000 Units)



Source: Dataquest (June 1992)

G2000820

The Estimated 1993 Range of 16Mb DRAM Pricing

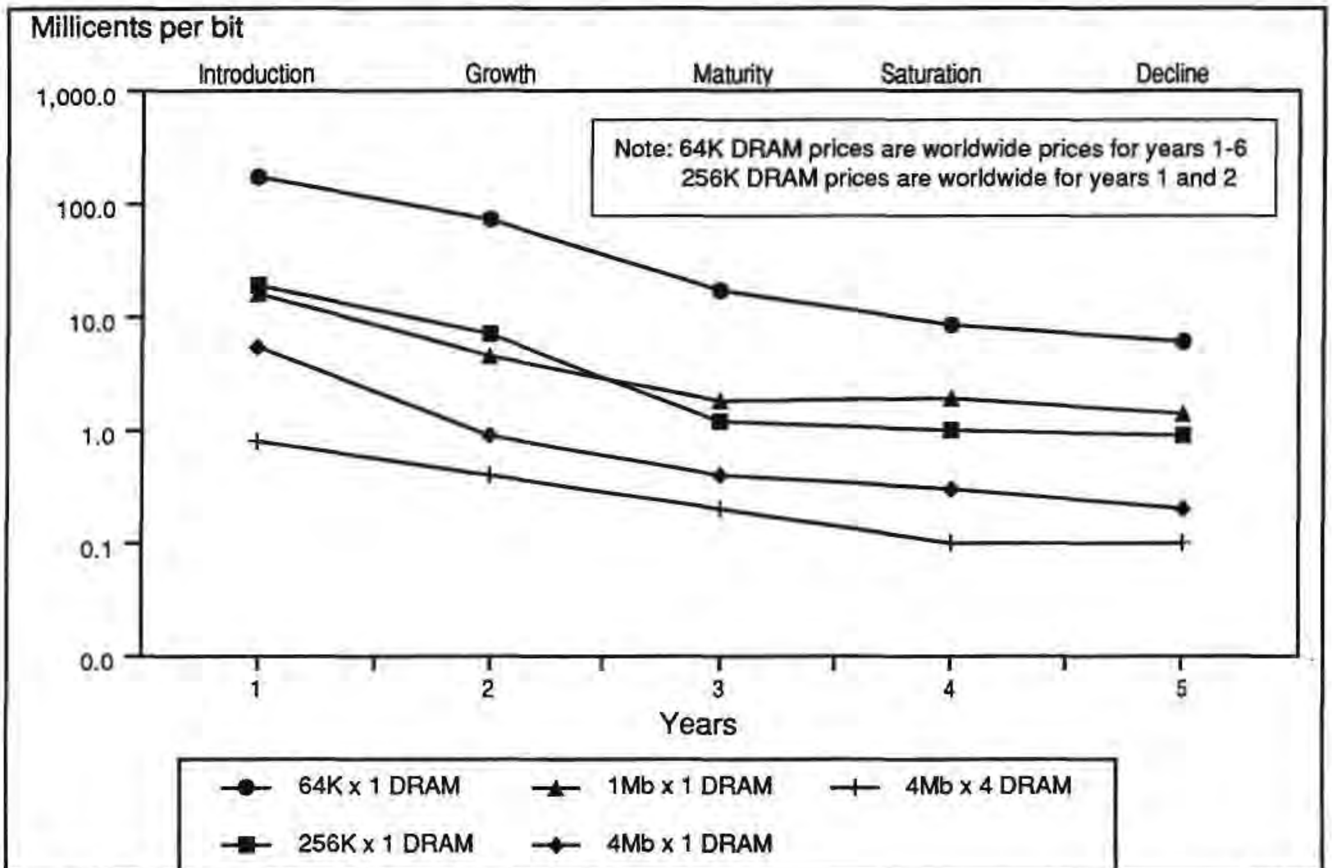
Four assumptions guide this analysis. First, the 256K scenario is unlikely to reoccur, not only because of trade friction but also because 16Mb DRAM require much larger capital outlays than did earlier generation devices, including 256K DRAM. The second assumption is that if trade friction recedes dramatically during 1993 and supplier competition increases, Dataquest assumes millicents-per-bit prices for 16Mb DRAM on the low side of the range will be 70 percent lower than the 4Mb DRAM price at the second year of its life. The third assumption is that if trade friction does not recede during 1993, Dataquest assumes millicents-per-bit prices for 16Mb DRAM on the high side will still be lower than the 4Mb DRAM price in its second year, but only 30 percent lower. The final assumption is that the U.S. government will avoid in any legal action a repetition of increased DRAM prices for North American buyers, whether measured in dollars or millicents-per-bit. (Should that scenario unexpectedly unfold, users could expect a flat 16Mb DRAM price profile for 1993).

Table 4, using the assumptions outlined above, predicts that 1993 North American 16Mb DRAM pricing should range from a low of $44, which represents a millicents-per-bit price that is 70 percent lower than 4Mb DRAM pricing during its second year, to a high of $102.50, which represents a millicents-per-bit price that is 30 percent lower than 4Mb DRAM pricing during its second year.

Dataquest Perspective

DRAM cost management represents a priority challenge once again for users during 1992. This report couples DRAM life cycle analysis with a

Figure 7
North American DRAM Pricing by Life Cycle Stage (Millicents per Bit; Volume: 100,000 Units)



Source: Dataquest (June 1992)

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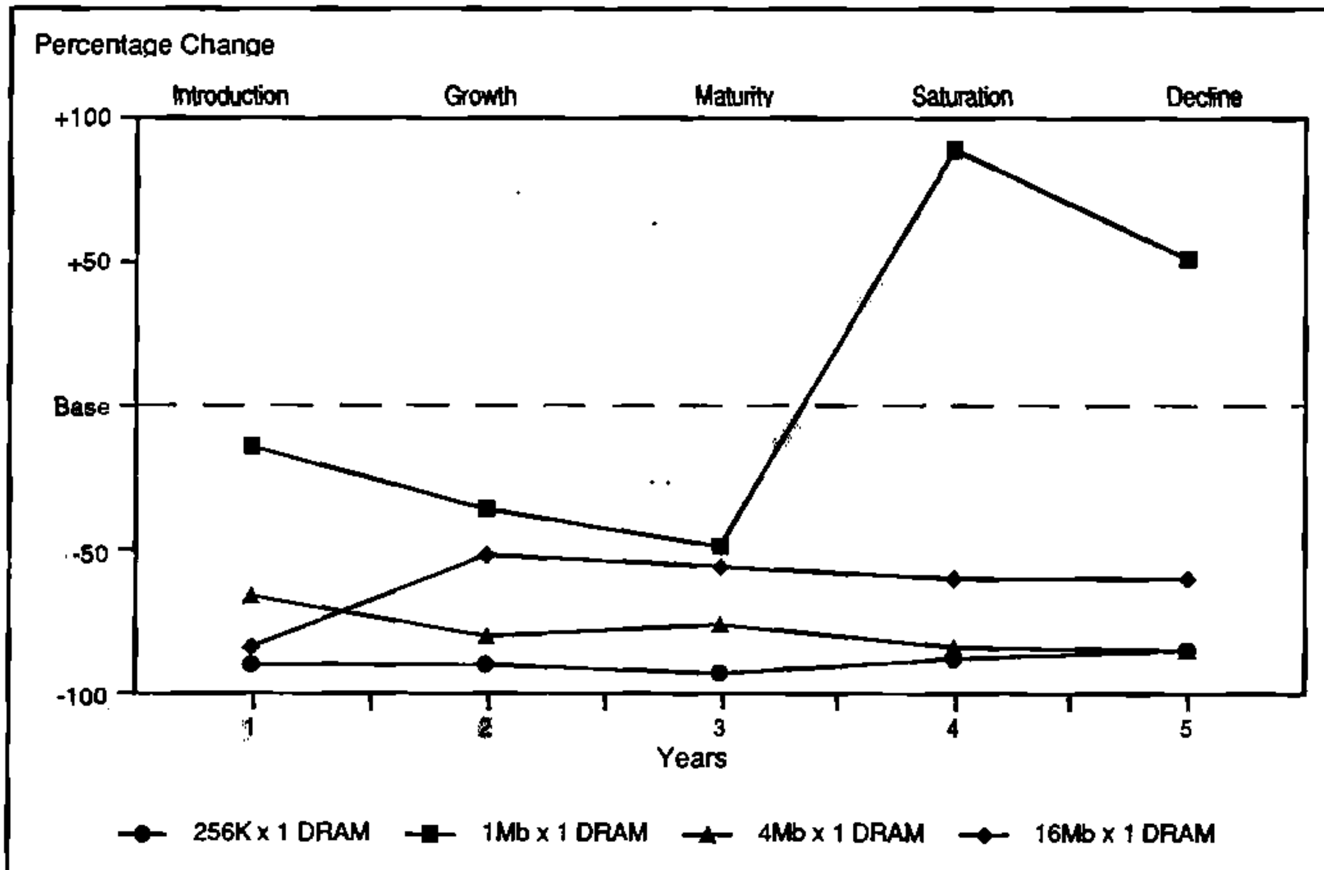
supplier base evaluation as a strategy for cost-effective DRAM demand management during the 1990s. A critical element of the strategy calls for users to assess system migration paths against Dataquest's DRAM life cycle forecasts.

During the remainder of this decade, DRAM users will continue to confront periodic supply and demand mismatches, such as 256x4K VRAMs during the middle of 1992, which typically recede after one or two quarters. Users in North America and Europe, however, face the specter of fundamental long-term market changes that should make life quite challenging.

First, new technologies such as flash memory aim to displace DRAMs from system applications. Second, DRAM/VRAM/SIMM supply and demand mismatches could become more drastic in the future as some suppliers reconsider their long-term strategy for profitably serving demand, which may mean some market withdrawals. For example, packaging technology might be a barrier to future market evolution, and package shortages might prove more enduring and longer term than is experienced in today's market. Third, IBM will be a key wild card in the entire worldwide DRAM business, not only in terms of demand and technology trends but also as a potential merchant market supplier. Fourth, users must manage continuing sharp shifts in the supplier base, as exemplified by Samsung's dramatic rise from the mid-1980s to worldwide DRAM market leadership by the early 1990s. Fifth, supplier survival means more DRAM alliances—alliances that will change, evolve, or terminate over time, meaning work and worry for users.

Figure 8
Rate of DRAM Pricing Decline at Each Stage in the Life Cycle Relative to Prior Density (64K DRAM = Base)



Source: Dataquest (June 1992)
G2000822

Table 4
Estimated 16Mb DRAM Price Range for 1993
(North American Bookings, Volume: 100,000-200,000)

Part	Estimated Low Price ($)	Forecast for Market Average ($)	Estimated High Price ($)
4Mbx4 DRAM			
70ns, SOJ 400 mil	44.00	70.20	102.50

Note: This information correlates with Dataquest's quarterly forecast for North American bookings dated June 1992.
Source: Dataquest (June 1992)

Even so, the ever-volatile DRAM market is huge and will not disappear. At the end of this decade, users most likely will still be grappling with DRAM management strategies, although their concern in the year 2000 will be with suppliers of then state-of-the-art 256Mb DRAMs. And some of those suppliers are nonexistent today.

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

Q1

What is the historical cost trend for a typical TTL logic device over the past five years?

A

Table 1 provides historical cost data for TTL octal standard logic devices, based on unit runs of 500,000.

Q2

Who are providing low voltage (less than 5 volts) logic products?

A

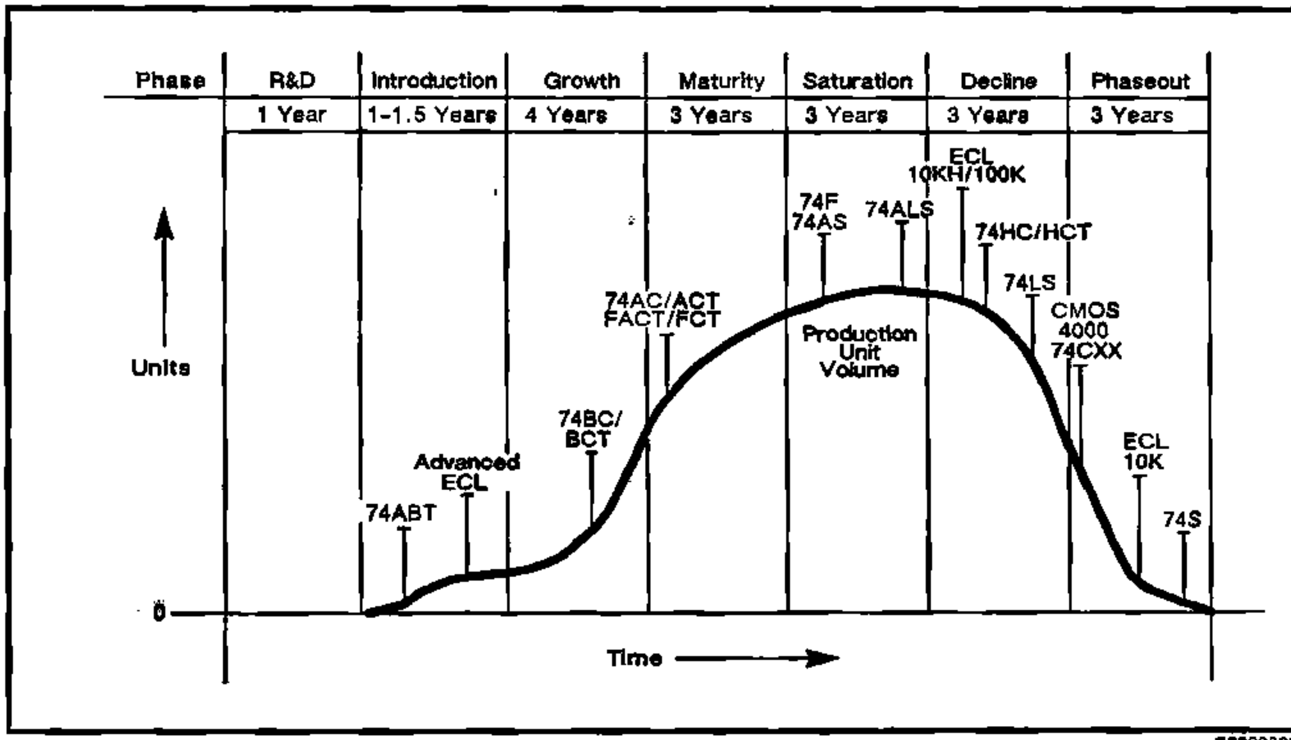
Performance semiconductor (FCT, 3.3 volts); Integrated Device Technology (FCT, 3.3 volts); National Semiconductor (FACT); Philips/Signetics (HC/HCT, HLL, 5.5 volts); and Texas Instruments (LVT) are currently providing these products (see Figure 1).

Table 1
Semiconductor Cost Model
TTL Octal Standard Logic—500K Unit Run

	1986	1987	1988	1989	1990	1991
Wafer Sort						
Wafer Size (inches diameter)	5	5	6	6	6	6
Processed Wafer Cost ($)	145	155	199	209	209	209
Die Area (square mils)	6,400	6,400	6,400	6,400	6,400	6,400
Active Area Factor	1.00	1.00	1.00	1.00	1.00	1.00
Number of Masks	8	8	8	8	8	8
Defect Density per Square Inch	0.50	0.50	0.50	0.50	0.50	0.50
Gross Die per Wafer	2761	2761	3976	3976	3976	3976
Processed Wafer Cost per Gross Die ($)	0.0525	0.0561	0.0500	0.0526	0.0526	0.0526
Test Cost per Hour ($)	34.84	34.84	36.58	38.41	40.33	42.35
Wafers Tested per Hour	1.20	1.20	1.00	1.00	1.00	1.00
Wafer Sort Cost per Gross Die ($)	0.0105	0.0105	0.0092	0.0097	0.0101	0.0107
Cost per Gross Die at Wafer Sort ($)	0.0630	0.0667	0.0592	0.0622	0.0627	0.0632
Wafer Sort Yield (%)	90	90	92	92	95	95
Cost per Sorted Die ($)	0.0700	0.0741	0.0644	0.0676	0.0660	0.0665
Assembly						
Material Cost per Sorted Die ($)	0.1800	0.1800	0.1800	0.1700	0.1700	0.1600
Number of Pins	20.00	20.00	20.00	20.00	20.00	20.00
Assembly Yield (%)	95	95	96	97	98	98
Cost per Assembled Die ($)	0.3053	0.3095	0.2963	0.2862	0.2816	0.2720
Final Test						
Test Time per Die (sec.)	0.18	0.18	0.18	0.18	0.18	0.18
Cost per Hour of Testing ($)	35	35	35	35	35	35
Test Cost per Die ($)	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Final Test Yield (%)	90	91	92	93	95	98
Cost per Final Tested Unit ($)	0.3412	0.3421	0.3239	0.3096	0.2983	0.2793
"Mark, Pack, and Ship"						
Cost at 99% Yield (%)	0.0034	0.0034	0.0032	0.0031	0.0030	0.0028
Total Variable Cost per Net Unit ($)	0.3446	0.3455	0.3272	0.3127	0.3013	0.2821

Source: Dataquest (June 1992)

Figure 1
Standard Logic Life Cycle as of June 1992



Source: Dataquest (June 1992)

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9205 May 25, 1992

In This Issue...

Dataquest
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File inside the *Dataquest Perspective* binder labeled **Semiconductor Procurement**

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.17	0.15	0.16	0.16	0.14
74AC138	0.30	0.32	0.26	0.25	0.24	0.21
74AC244	0.44	0.44	0.35	0.38	0.40	0.36
74AC74	0.23	0.21	0.20	0.20	0.20	0.17
Lead Time: (Weeks)	5	3	8	4	5	5
4F00	0.10	0.12	0.09	0.10	0.09	0.09
4F138	0.15	0.19	0.15	0.16	0.16	0.14
4F244	0.22	0.26	0.21	0.24	0.25	0.23
4F74	0.11	0.13	0.12	0.13	0.12	0.11
Lead Time: (Weeks)	5	3	4	4	5	5
7805-TO92	0.12	0.18	0.11	0.12	0.11	0.11
CODEC-FLTR 1	1.78	2.25	2.50	1.73	1.94	1.45
CODEC-FLTR 2	4.13	4.35	5.00	4.55	4.70	
Lead Time: (Weeks)	6	3	6	3	4	
DRAM 1Mbx1-8	3.20	3.29	3.20	3.48	3.60	3.35
DRAM 1Mbx9-8	35.00	37.11	30.80	35.75	37.80	31.00
DRAM 256Kx1-8	1.15	1.54	1.58	1.05	1.20	1.05
DRAM 256Kx4-8	3.20	3.34	3.20	3.45	3.60	3.35
DRAM 4Mbx1-8	12.03	11.24	13.00	12.90	13.90	11.50
EPROM 1Mb 170ns	3.15	3.68	2.95	3.10	3.50	2.40
EPROM 2Mb 170ns	6.88	7.05	4.50	5.80	7.00	4.80
SRAM 1MB 128Kx8	12.38	11.69	9.40	13.50	14.40	
SRAM 256K 32Kx8	3.60	3.49	3.25	3.45	3.80	3.30
SRAM 64K 8Kx8	1.75	1.52	1.70	1.30	1.37	1.40
Lead Time: (Weeks)	6	4	4	4	7	4
68020-16	27.25	37.85	26.00	35.50	33.90	
80286-16	8.08	10.39	10.00	10.35	11.10	7.00
80386DX-25	94.00	136.92	98.00	102.50	126.00	98.00
80386SX-16	46.50	53.43	48.00	50.00	52.10	48.00
R3000-25	105.00	125.05	110.00			
Lead Time: (Weeks)	6	7	4			

*Prices in U.S. dollars
Source: Dataquest (May 1992)

Market Analysis

May Procurement Pulse: Orders, Lead Times, and Inventories All on the Rise As Business Picks Up

The Procurement Pulse is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what the semiconductor inventory and order changes mean to semiconductor users.

Semiconductor Order Rate Expected to Jump

This month's respondents expect to order 17 percent more semiconductors over last month's relatively flat level (see Figure 1). Corresponding with this increased order expectation is the overall systems sales outlook, which rose 12.2 percent from last month's 8.0 percent six-month forecast. The computer segment also rose, but to a more modest 10.6 percent rate from last month's 8.3 percent expected level. Although the low-end personal computer pricing bloodbath continues, value-added systems at the high end (workstations, servers, and add-on level products) continue to show signs of gradual but accelerating growth. Prices continue to decline in a very gradual manner. In April the respondents averaged a 1.9 percent price slide, compared with a 1.7 percent price slippage noted in March. Micron Technology's announced request for dumping investigations against selected Korean DRAM suppliers has had the effect of solidifying the low end of the 4Mb DRAM spot price range at about $11.25. This has had a relative overall flattening effect on prices in general, since DRAMs make up a large portion of the semiconductor order list for most system companies. Despite abundant capacity to meet anticipated needs, fear of

Figure 1
Averaged Monthly Semiconductor Orders

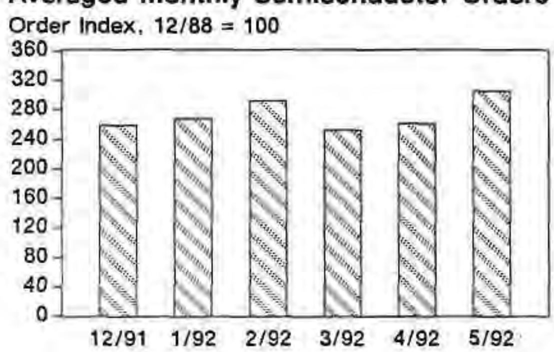


Figure 2
Averaged Semiconductor Lead Times

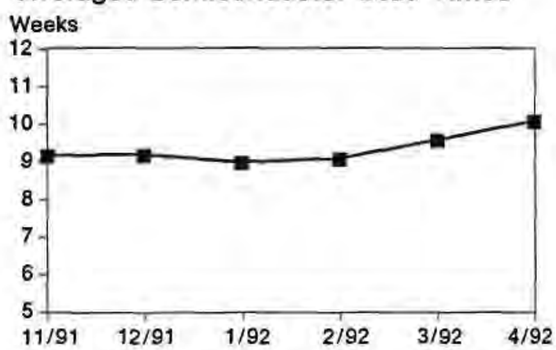


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

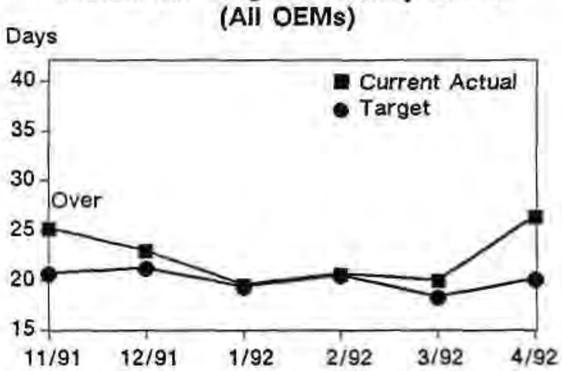
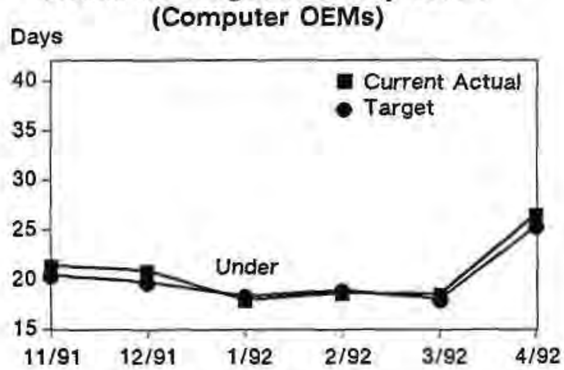


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (May 1992)

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market intervention is affecting pricing in key commodities and may have indirect impact on other products.

Average Lead Times Climb above 10 Weeks

For the first time in more than 18 months, the average semiconductor lead time has risen over 10 weeks to the 10.1 week level (see Figure 2). The lead time range continues to be from 8 to 12 weeks, with one respondent noting a 16-week lead time for new orders. Causing the average increase in lead time is the distribution of respondents now reporting lead time quotes closer to the midpoint rather than the lower end of the pre-existing range. In addition to the increase in lead times, there were noted problems in obtaining selected discrete, analog, and ASIC parts. Not happy with just reporting the actual rise in lead times, many respondents reported lead times, end-of-life buys, and assembly capacity as near-term issues needing attention. As demand begins to pick up for semiconductors, the short-term dislocation of some supplies is a natural occurrence as the balanced market shifts to a new level of activity. Keeping lead times moderated is the good communication between user and supplier, which also keeps each current on demand and supply status.

Semiconductor Inventories Also Creep Upward

The targeted and actual inventory levels for April all rose, compared with the recent past (see Figures 3 and 4). For the overall sample the respective target and actual semiconductor inventory levels were 20.2 and 26.5 days, compared with last month's similar figures of 18.4 and 20.1 days. The computer segment's inventory levels rose more dramatically to respective targeted and actual levels of 25.5 and 26.7 days, compared with the similar levels of 18.1 and 18.6 days noted last month. The combination of lead time increases, isolated problem products, and an overall increase in order activity is resulting in a near-term rise in inventory levels at the raw material level. Still within historical ranges, the current target and actual inventories highlight where improvements in communication between system sales forecasting and procurement can be made. Dataquest expects this blip in inventory levels to be corrected shortly, relative to the steady target inventory goal that has not wavered much over the past 12 months. As business levels in general improve, forecast accuracy and dissemination of market change information will be critical as the industry slowly pulls out of the current equilibrium.

Dataquest Perspective

The optimistic outlook noted in system sale expectations and order rate levels is materializing into a pickup in business activity both at the billing and inventory levels. Continued caution in commodity memory supply attributed to the threat of government intervention is keeping prices declining at a steady rate while capacity waiting in the wings is ready to fill needs as they materialize. Some isolated products (discrete packaging and mature ASIC devices) are becoming more of a problem for some respondents, yet more than half of this month's survey note no problems at all. Although there was a rise in lead times noted, availability remains very good and is expected to remain so for the upcoming six months. Dataquest's finalized semiconductor forecast, which will be released at the end of this month, will reflect this expansion in market growth.

By Mark Giudici

Product Analysis

The Risky "CISC-Y" Sexy World of 32-Bit MPUs Means Stressful Opportunity for Procurement Managers

In 1989 this author assessed the then-emerging 32-bit microprocessor market from a user's perspective in an article entitled "Semiconductor Users Eye the Risky 'CISC-y' World of 32-Bit Microprocessors." This article revisits that theme and provides users with Dataquest's annual assessment for 1992 of the long-term supplier/supply base for these product technologies.

Dataquest's preliminary 1991 estimate of suppliers' microprocessor (MPU) market shares shows a marketplace in the throes of change—which means challenge if not stress for the user community. Why such stress? By tying the company to the "right" MPU product technology, the supply base team can generate long-term growth and success; choosing a "wrong" processor engine could mean long-term demise. The MPU supply base outlook is for bruising supplier competition as workstation-based RISC technology drives downward and PC-based CISC technology migrates upward in the battle for system applications—with MPU buyers and system designers caught between.

Overview

This article contains five sections and its structure is similar to the annual supply base reports that the Semiconductor Procurement service (SPS) does for users on major IC product families. In addition, based on client recommendation, this article also looks at strategic alliances, fab networks, trends in process technology and die size, and forward pricing.

Section 1 serves as a guide to cost-effective procurement of MPUs through the use of product life cycle analysis. Section 2 examines the strategies of the leading suppliers of MPU products and technology. Section 3 combines the analyses of the life cycles and the supplier base and supports users of MPUs in assessing which supplier/technology direction to take over the long term. Section 4 examines trends in advanced MPU design and production. Section 5 on life cycle pricing—which can serve as a tool for "forward pricing" analysis—presents recent research results and advice for clients on how to make future use of this research.

It should be noted that, in terms of MPU word length, this article concentrates on 16/32-bit and 32-bit MPUs. In line with market evolution, Dataquest now tracks the MPU market by processor class—word length now serves as a secondary dimension. Within the new segmentation, the focus will be on the following processor classes: 80X86 family, 68XXX family, and platform RISC processors.

Section 1: MOS Microprocessor Product Life Cycles

This section uses life cycle information as a guide to assist users in adjusting to forces that continue to reshape the worldwide MPU marketplace.

Typical Life Cycles for MPU Products

Figure 1 shows the MPU life cycle, including the time span for each stage of the cycle. An MPU family's life cycle typically lasts in excess of 10 years.

For users, the lengthy R&D stage provides a valuable opportunity to monitor the vendor's pace of technical achievement as well as the supplier's timetable for bringing the state-of-the-art device to the marketplace. Based upon inquires to Dataquest, many users are evaluating these leading-edge MPUs among others for use in future systems: 80586; R4000; 21064 (ALPHA); SuperSPARC.

Figure 2 presents the product life cycle for select CISC 32-bit MPUs through the year 1991 using historical unit shipments data and shows that 1991 marked another year of growth in terms of unit shipments for 68020, 68030, 80386DX, and 80486DX products. The 1991 boost in the 80386DX shipment stemmed in part from the entry by Advanced Micro Devices (AMD) to this once sole-sourced market. The information in Figures 1 and 2 shows that users should *not* expect market saturation for any of these products to occur for several years.

Although life cycle expectations remain consistent in terms of product families, the dynamics of the life cycle curve are being reshaped by factors such as the increased pace of new product introductions (for example, device speed and packaging). Figure 3, which is based on the information in Figure 2, depicts the 80X86 and 68000 life cycles in terms of device speed.

Section 2: Supplier Analysis

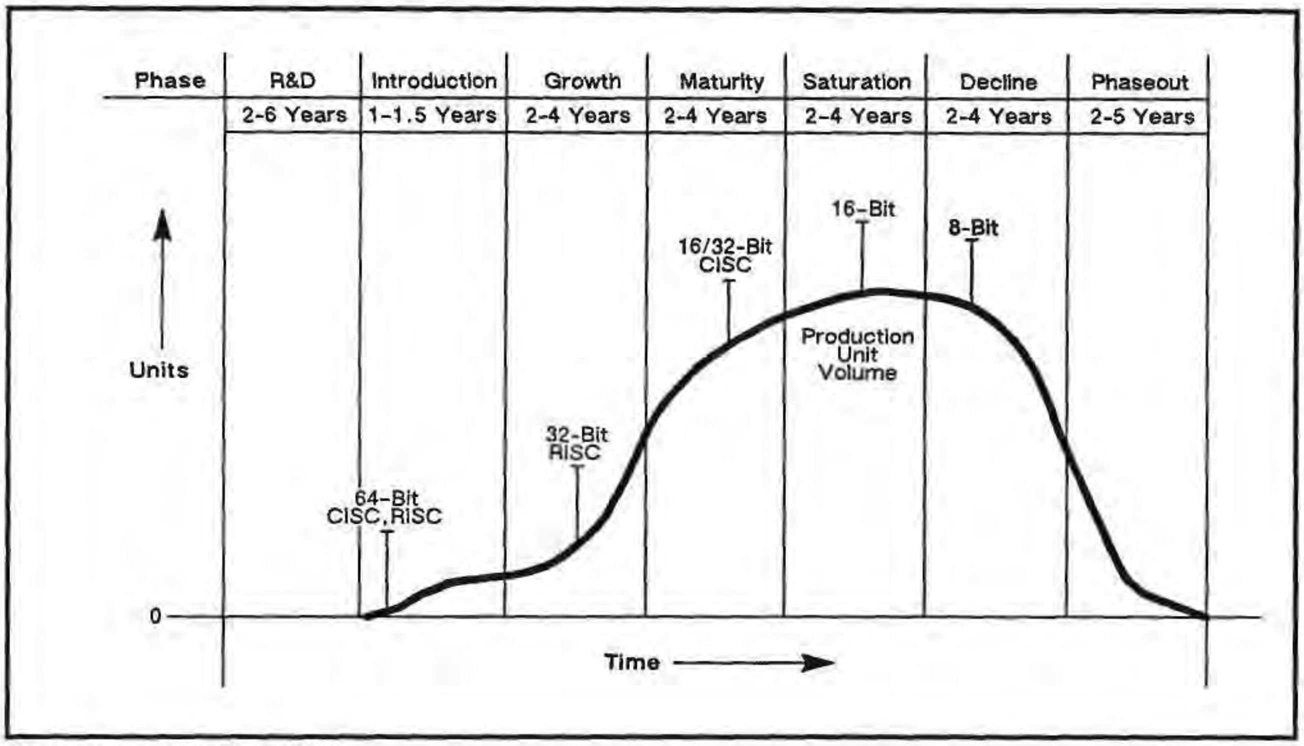
This section analyzes the product and market strategies of leading suppliers of MOS microprocessors. Because of the orientation of the SPS client base, this section focuses on suppliers that strongly serve demand in Europe and North America: Intel, Motorola, and AMD.

As the table shows, Intel remains the worldwide market leader by far with nearly 60 percent share. During 1991, the following suppliers outpaced the market's growth in terms of revenue: AMD, Cypress, and Intel. LSI Logic, National Semiconductor, and Motorola also achieved growth rates in excess of 20 percent for 1991.

Intel

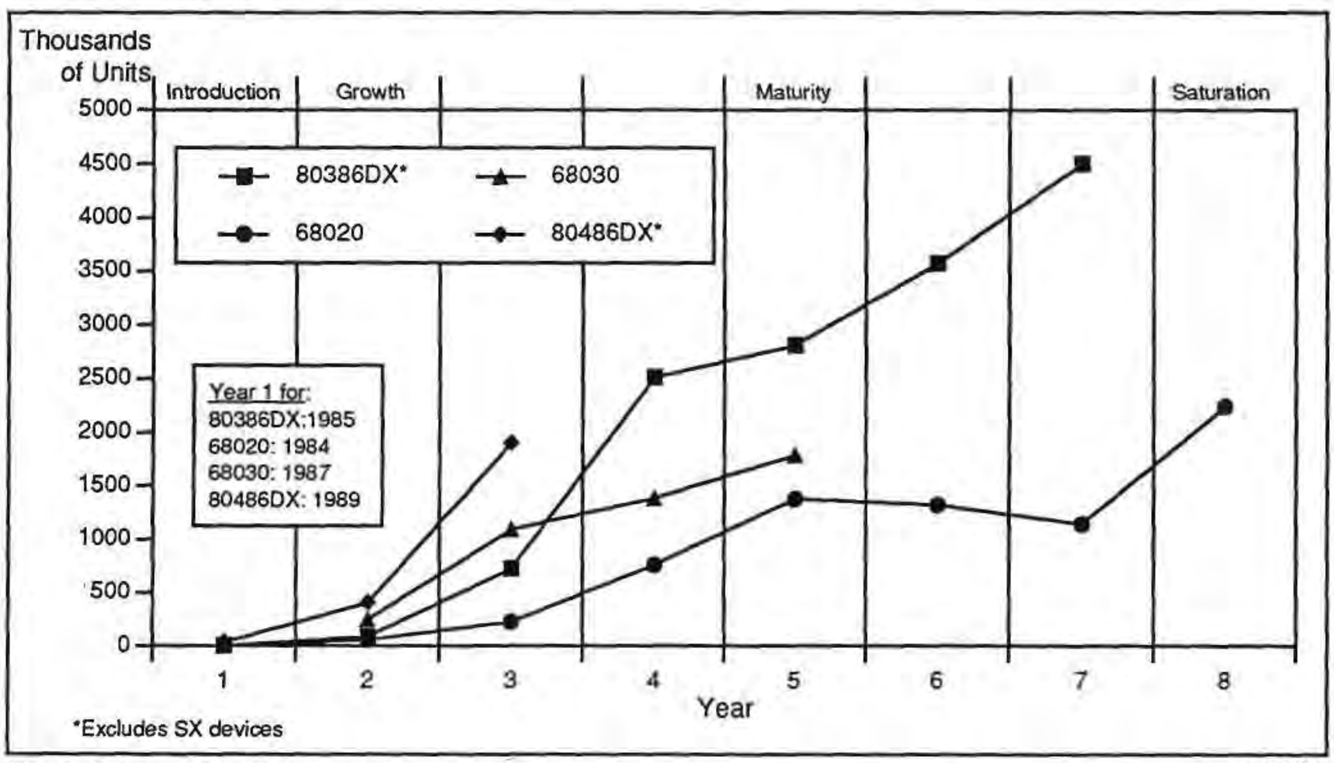
As shown in Table 1, an increase in shipments of high-priced CISC MPUs—80386 and 80486—translated into nearly $2 billion in MPU revenue during 1991 for top-ranked Intel.

Figure 1
Microprocessor Product Life Cycle As of May 1992



Source: Dataquest (May 1992)

Figure 2
CISC MPU Life Cycles through 1991



Source: Dataquest (May 1992)

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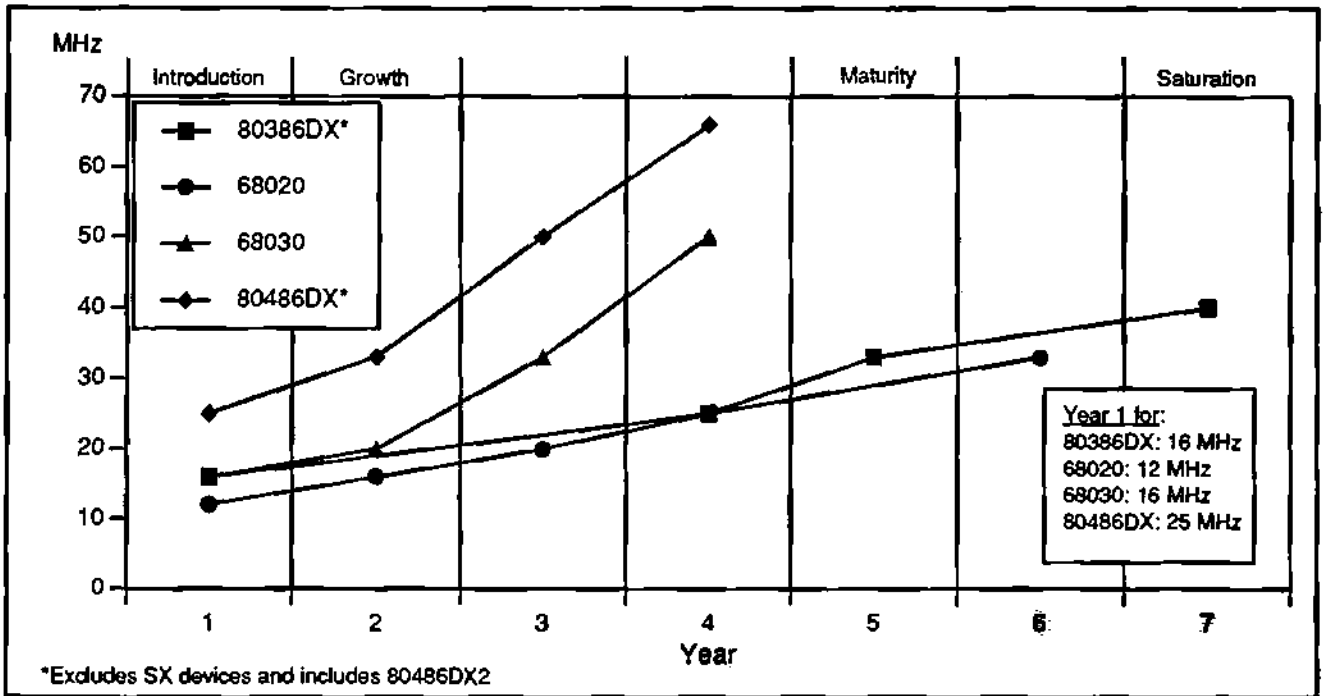
Figure 3
CISC MPU Life Cycles by Speed



Source: Dataquest (May 1992)

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Table 1
Preliminary 1991 Worldwide Microprocessor Market Share Ranking (Millions of Dollars)

Ranking	Company	Segment Revenue ($)	Market Share (%)	1990-1991 % Change
1	Intel	1,992	58.0	39
2	Motorola	359	10.8	23
3	AMD	251	7.6	130
4	Hitachi	90	2.7	10
5	NEC	86	2.6	8
6	National	85	2.6	29
7	SGS-Thomson	55	1.7	4
8	Toshiba	55	1.7	15
9	Cypress	46	1.4	254
10	LSI Logic	42	1.3	24
	All Others	321	9.7	16
	Total	3,312	100.0	36

Source: Dataquest (May 1992)

The Intel product portfolio for these families includes the following devices: 80386SX 16-, 20-, and 25-MHz; 80386SL 20- and 25-MHz (with on-board cache controller); 80386DX 16-, 20-, 25, and 33-MHz; 80486SX 16-, 20-, and 25-MHz (with on-board cache controller, plus low-power versions for each speed); 80486DX 25-, 33-, and 50-MHz (with built-in coprocessor and cache controller, plus low-power version for 25-MHz speed); and 80486DX2 25- and 50-MHz (with built-in coprocessor and cache controller).

The major long-term strategic issue concerns Intel's response to the move by AMD into the 386 market last year—with Chips & Technologies a prospective entrant—and the likely entry during this year or next year of suppliers such as AMD, Cyrix, and UMC into the 486 camp. Despite increased competition, key strands of the Intel's product strategy remain quite consistent with the plan of several years ago. Users must note, however, that the company now confronts a shift—from the mind of a monopolist to that of an oligopolist if not pure competitor—in terms of adhering to long-term strategic goals.

Consistent Elements of the Intel Strategy

As always, Intel aims at unparalleled technological leadership in the CISC MPU arena. A key element of the product strategy is to drive the 80X86 technology—via the soon-to-be-released 80586 device—upward into the RISC-based workstation marketplace. Intel continues its relentless push to develop and manufacture state-of-the-art MPUs in terms of density, functionality, and performance. Users can expect Intel to eventually make the 80586 device available in a multichip module (MCM). Intel will make massive expenditure on capital equipment and R&D during the 1990s in order to protect its leadership position. For example, for 1991 Dataquest estimates the company's capital budget at nearly $1 billion while R&D expenditure should hit $750 million.

Another consistent is that Intel firmly grounds its current success and plans on aggressive legal protection of what it claims as its intellectual property. AMD has made a major advance in terms of undercutting Intel's ability to preserve its prior 80386 legal monopoly—at least vis-a-vis AMD if not other would-be suppliers. Intel's powerful legal team in turn faces a full calendar of cases against powerful legal teams at AMD, Cyrix, Texas Instruments (TI), and other companies. The legal battles could eventually take financial and other tolls on some litigants.

Intel's Migration Strategy: Some Risk for System Users

A key consistent is that Intel strives to adhere to its higher-performance/higher-priced MPU migration strategy—which carries some risk for system users. For example, except for first-tier customers, users can expect Intel to keep its product direction somewhat veiled in order to keep competitors off balance. Some users report concern to Dataquest regarding Intel's plans during the 1992 to 1993 period for the 80386, 80486, and 80586 families of MPUs. Intel's pace of technological advance has accelerated in response to the AMD competitive threat, catching some systems manufacturers off guard or behind schedule. Specifically, some system houses did not anticipate Intel's introduction during the first quarter of 1992 of the 80386SX 25-MHz device. Intel developed this part based on first-tier customer demand—and in the face of a direct competitive AMD product offering. This new part should become the 80386SX family's mainstream part through 1993.

Intel aims to migrate users soon—if not already—from the lower-priced 80386 family to the higher-priced 80486/80586 families. Intel has indicated that the 80586 device will be introduced during the second half of 1992. AMD has been successful in extending the growth stage of the 80386SX/SL family, which counters Intel's 80486DX/SX migration plans.

For some users, the Intel migration strategy carries risks at the 80486 level and higher. The first risk is that the 80486 device includes a processor enhancement slot (PES) that enables ultimate end users to upgrade systems without buying an entirely new system. In this trade-off between system user and ultimate end user, Intel—in line with strategic market dictates—gives the nod to the ultimate customer at the expense of *some* intermediate customers. Another risk is the system user's inability to timely migrate in synchronization with Intel's migration path. For example, Intel's first-half 1992 introduction of its 80486DX2 series could soon erode market demand for 80486DX devices. In effect, 80486DX systems face prospective displacement during 1992 and 1993 by the 80486DX2 IC.

What about the 80586?

During 1992 Dataquest will closely track any developments on the Intel's 80586 device. To date, the following estimates are available: speed—50 MHz to 66 MHz; number of transistors—3.1 million; package—CPGA, later—MCM; introduction date—second half of 1992.

At press time Compaq Computer Corporation and Digital Equipment Corporation (DEC) separately indicated that they will ship 80586-based systems during the second half of 1992. For example, Compaq had just received 80586 engineering samples for use in technical evaluations.

Motorola

Motorola won Dataquest's Semiconductor Supplier-of-the-Year Award each year during the 1988 to 1991 period—in the large company category for the past two years. In general, Motorola will draw on its position as a vertically integrated captive manufacturer to generate a full range of microcomponents.

Second-ranked Motorola continues to target the MPU market as a key element of its long-term strategic plans. However, strategic alliances will play an increased role in the formulation and implementation of the company's MPU strategy.

Contrasting Scenarios: 68020/68030 MPUs and 68040/881000 MPUs

As shown in Figure 2, Motorola's penetration of the fast-growing technical workstation market meant a boost in demand during 1991 for its high-performance 68020 and 68030 32-bit MPUs. Motorola's delay during the 1990 to 1991 period in ramping the 68040 device, however, caused some key users (for example, Hewlett-Packard) to reevaluate long-term dependence on single-source suppliers for critical MPU technology. Market acceptance of Motorola's 88000 has been unimpressive.

Consequently, the life cycle expectations for the CISC 68040 and RISC 88000 architectures have become clouded. For example, the future role of the 68040 appears targeted over the long term for embedded applications. Users can expect the introduction of a 68EC040 series of parts during 1992 and 1993. Even so, Texas Instruments just announced an upgrade of its 1500 MP (multiprocessing computer) system, which uses Motorola's new 33-MHz 68040 MPU.

A Key Industry Alliance: RISC PowerPC MPUs

A crucial prong of Motorola's future MPU strategy is the alliance with Apple Computer and IBM on PowerPC RISC technology. First, the alliance keeps Motorola aligned with a key long-term MPU customer—Apple—and in turn enables Motorola and Apple to migrate to RISC MAC systems. Second, for Motorola, the alliance reduces some of the risky and expensive second-guessing associated with the development of a new MPU architecture that conforms to user wants and needs. Third, for Motorola, the alliance should enable Motorola to focus over the long term on its competitive strength—IC design and volume production at award-winning quality standards.

The latest word on the alliance is positive—including the development effort at the IBM-Motorola R&D (Somerset) facility in Austin, Texas. Although Silicon Valley sources report some uncertainty regarding the alliance strategy on multimedia objectives, the IBM-Apple team appears to be making consistent progress on the Taligent object-oriented operating system that will be necessary to run systems. The time frame for the IC/operating system remains consistent with original expectations—1994.

Advanced Micro Devices

As shown in Table 1, third-ranked Advanced Micro Devices grew its MPU revenue by 130 percent during 1991—directly at the expense of Intel. For AMD, the introduction of the AM386 device during 1991 marked a rapid de-emphasis of the prior-generation 80286 MPU.

AMD Walks a Fine Legal Line

In staking its long-term MPU and corporate future on the 386/486 architectures, AMD continues to walk—narrowly but successfully to date—through a legal minefield. For users in the 386 segment, AMD can position itself as a pure second source including identical microcode. AMD and Intel still await a final legal decision on the microcode law case.

Critical Steps to AMD's Long-Term Survival

For 1992, the recent step-function decline in 386 pricing should extend the 386 product life cycle—meaning strong 1992 demand—much to AMD's pleasure and Intel's chagrin. This achievement marks the first step to AMD's long-term success. There are two other steps.

The second step is that AMD's strategy calls for volume production of a 486 device by the fourth quarter of 1992. AMD's long-term MPU strategy is to dog Intel and take MPU revenue/profits at its competitor's expense. Slippage in the 486 schedule could mean closure of AMD's window of market opportunity.

For AMD, the 1992/1993 scenario could well shape its long-term future. From Dataquest's perspective, the scenario unfolds like this: having lowered its 80386DX/SX price curves because of competition from AMD, Intel during 1992 collapses the 80486SX price curve onto the AMD's 386 price curve—narrowing AMD's profit margins in the process. If AMD makes a timely move to the 486 device and survives Intel's legal onslaught—the third step—AMD should continue to survive.

Section 3: Supply Base Analysis

This section uses information on MPU product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for CISC 16/32-bit, CISC 32-bit and RISC 32-bit MPUs. The section includes information on the global MPU fab network of key suppliers.

With the supply base trend toward multiple MPU sources, procurement managers, component engineers, and system designers face a challenge in terms of the selection of the most competitive and dependable long-term suppliers of these product technologies. The approach in this section is to mesh the product life cycle and supplier analyses so as to generate a summary assessment from a user's perspective on the anticipated MPU supply/supplier base. The summary includes a statement on whether the user faces a favorable or a critical supply base for each density. Building upon the prior sections, factors affecting the supply base such as supplier strategies and strategic alliances are discussed here.

An Overview of Tables 2, 3, and 4

Table 2 shows the size of the CISC 16/32-bit MPU market in terms of units shipped during 1991, the relative market shares of the predominant devices, and a ranking of the suppliers of these devices, including suppliers' shares in each product segment.

Table 3 presents the information on the CISC/RISC 32-bit MPU market.

Although Tables 2 and 3 are based on Dataquest's prior segmentation of MPU word length, the analysis in this section conforms with Dataquest's new processor-class segmentation.

Table 4 shows the estimated worldwide MPU process technology and fab capability—including geographic locations—for the

Table 2
Supply Base for 16/32-Bit Microprocessors (1991)

Leading Products	Product's Share of Total 16/32-Bit MPU Market (%)	Suppliers' Share of Respective Product Segment (%)	
68000	60.59	Motorola	81.23
		Toshiba	8.84
		Hitachi	5.12
		SGS-Thomson	2.62
		Signetics	2.19
80386SX	36.83		
		Intel	86.97
		AMD	13.03
32000	2.58	National	100.00

Total Market Share = 27.085 million units
Source: Dataquest (May 1992)

Table 3
Supply Base for 32-Bit Microprocessors (1991)

Leading Products	Product's Share of Total 32-Bit MPU Market (%)	Supplier's Share of Respective Product Segment (%)	
80386DX	30.14	Intel	82.2
		AMD	17.8
80486DX	16.74	Intel	100.0
68020	15.00	Motorola	100.0
68030	11.96	Motorola	100.0
32x32	3.35	National	100.0
Sparc	2.01	Cypress	36.67
		LSI	31.67
		Fujitsu	27.67
		Weitek	4.00
		Bit	0.33
R3000	1.22	Performance	29.67
		IDT	24.73
		NEC	21.98
		LSI	13.74
		Siemens	9.89
Others	19.58		

Total Market Share = 14.93 million units
Source: Dataquest (May 1992)

following suppliers: AMD, Cypress, Fujitsu, Hewlett-Packard (HP), Texas Instruments, Intel, Motorola, and NEC. The table shows that the process technology in most cases runs in the range of 0.7 microns to 0.8 microns.

Tables 2, 3, and 4 guide the analysis in this section.

Supply Base for 16/32-bit MPUs

As shown in Table 2, unit shipments of 16/32-bit MPUs expanded at a 53 percent rate during 1991 to a total of 27.1 million devices. In terms of Dataquest's new MPU market segmentation, this arena includes elements of the 80X86 processor family and of the 68XXX processor family.

The 68000 family accounts for more than 61 percent of the 16/32-bit market—and Motorola commands more than 80 percent of the 68000 segment. The 80386SX product accounts for 37 percent of the market—a gain of 10 percent over the 1990 share. Intel—the former market monopolist—now holds less than 90 percent of the 80386SX/SL segment—with more loss of share likely during the 1992 to 1993 period. AMD gains at Intel's expense. National Semiconductor's 32XXX family holds just less than 3 percent share.

Table 4
Estimated Worldwide MPU Process Technology and Production Fab Capability

	Intel	Motorola	AMD	Fujitsu	TI	Cypress	NEC	HP
Process Technology	0.8 Micron CMOS	0.8 Micron CMOS	0.7 Micron CMOS	0.7 Micron CMOS	0.5 Micron CMOS	1.2 Micron CMOS	0.8 Micron CMOS	0.8 Micron CMOS
Geographic distribution of production and pilot lines by region of the world[1]								
Number of Wafer Fabrication Lines								
North America	8	5	2		5	2	1	2
Europe		2			1		1	
Japan		1		2	4		12	
Asia/Pacific-Rest of World	1[2]		1[3]		0			
Total	8	8	3	2	10			
Geographic Distribution of Estimated Clean Room Space (in Square Feet)								
North America	211,000	126,800	30,700		144,500	26,000	40,000	40,000
Europe		59,600			10,000		19,500	
Japan		23,800		56,500[4]	98,000		372,935[4]	
Asia/Pacific-Rest of World	24,000[2]		40,000[3]					

[1]Facilities in production or slated to begin operation during 1992.
[2]Intel Israel
[3]Fab line available to AMD through foundry relationship with TSMC, Taiwan
[4]Clean room square footage not available for each line
Source: Dataquest (May 1992)

A Long Life Cycle for the 68000 Family, with Several Exceptions

Users can expect a long life cycle for the 68000 family of MPUs, especially the 68000 and 68HC00 devices. By contrast, the 68008 device is being displaced by the 68EC000 product. The 68010 should also decline over time, although not as rapidly as the 68008.

Users of these devices clearly should turn to Motorola for long-term support. Table 4 shows that Motorola's extensive worldwide fab network puts the industry giant in good position to serve demand from whatever world region for the long term. For example, Motorola has already positioned itself for Europe's evolving requirements on local "diffusion."

Table 2 reveals that Toshiba, Hitachi, SGS-Thomson, and Signetics also have stakes, albeit small, in this arena.

AMD Likely to Prolong 386SX Life Cycle

AMD's entry to the 386SX marketplace reduces supply base uncertainty for users. What is the backdrop to this statement? In the March 1991 version of this report we stated that users of the 80386SX faced an uncertain outlook regarding long-term supply, given Intel's monopoly position and the company's then stated goal of migrating users during 1992 to 80486 and above parts. AMD has changed the long-term supply base equation in favor of users of 386SX/SL devices. The entry of any other suppliers would strengthen the supply base outlook, although prospective entrants such as Chips & Technologies have not yet executed on original plans.

Intel should continue to lose market share, not because of 80386SX/SL manufacturing constraint but rather because of the company's strategic decision to shift focus during the 1992 to 1993 period to higher-priced 80486/80586 devices. Table 4 shows that Intel clearly has ample fab capability for supporting North American and European user demand. AMD has strong manufacturing capability in terms of serving European and North American demand—with AMD *aiming* to fulfill such demand. European users must continue to monitor trade-regulation trends because these North America-based suppliers have no fabs running at this time in Europe. Regardless, the combined fab capability of Intel and AMD as shown in Table 4 should adequately support user demand during the 1992 to 1994 period.

Under current market conditions, the life cycle of most 386SX and 386SL parts should extend through 1995, although slower-speed devices (for example, 16-MHz versions) likely will be de-emphasized during the 1993 to 1994 period. AMD certainly aims to migrate with the market, but it will continue to accommodate market demand for 386SX and 386SL parts for the next several years. In effect, multiple sourcing should translate into a 386SX life cycle curve in line with historic expectations shown in Figure 1.

Supply Base for 32-Bit MOS Microprocessors

Table 3 provides information on the market size and leading suppliers of the predominant 32-bit CISC and RISC MPUs as of 1991. In terms of Dataquest's new MPU market segmentation, this arena includes the lion's share of the 80X86 processor family, and the 68XXX processor family plus platform RISC MPUs.

Unit shipments of 32-bit MPUs grew to 14.9 million pieces during 1991, a 76 percent increase over 1990. As indicated in Figures 1 and 2, MPU products such as the 80486DX and 68030 have life cycles that should approach the end of this decade, although the life cycle for lower-speed versions likely will terminate by mid-decade.

Intel: Tremendous Manufacturing Capability

Intel is the sole source for 80486 devices, although that scenario should start to change by the end of 1992. As shown in Table 4, Intel's worldwide manufacturing capability puts the company in a strong position to protect its position in the 80486 market unless AMD timely and aggressively executes on plan.

Cracks in Intel's 80X86 Monopoly: Good News for Supply Base Managers

Intel's 80386/80486 architectures account for nearly 50 percent of unit shipments of 32-bit MPUs. Having broken Intel's 80386 monopoly, AMD aims to break the 486 monopoly starting year-end 1992. If AMD wins the legal case on microcode during the 1992 to 1993 period, the company will emerge as a formidable second source for the 486 family of parts. In effect, supply base managers must adapt to a market transition from yesterday's monopoly environment to an an emerging two- or three-player oligopoly.

Under these market conditions, the 386DX/486 supply base outlook has become quite favorable for users. For users in North America and Europe, unless Intel wins an outright legal victory against AMD in the current litigation on microcode—which would stifle second sourcing—the Intel-related "constrained MPU supply" scenarios of the recent past are less likely to occur in the 80486 arena.

Users should note that strong growth in 80486DX/SX shipments during 1993 could push that MPU unit volume over the 80386 family volume by end of 1993.

Cloudy Outlook for Other 80X86 Market Entrants

The outlook is not so clear regarding other prospective entrants such as Cyrix—which has formed an alliance with Texas Instruments—or UMC of Taiwan. Should Cyrix/Texas Instruments win their legal battle against Intel and secure manufacturing rights to this family of parts, they could make a timely market entry. If not, they must forward-engineer their 386/486 devices, which could mean a time-consuming technical challenge associated with compatibility test. At press time Cyrix and TI had just announced their 486 version.

UMC faces the same scenario, and in addition must overcome Taiwan's recent inclusion on the U.S. list of violators of U.S. intellectual property rights. Chips & Technologies continued to experience financial loss at press time.

Motorola: A Shift to Embedded Applications

Table 3 shows that Motorola's 68020 and 68030 devices account for nearly 27 percent of 32-bit MPU unit shipments, down from 30 percent during 1990. Shipments of the 68040 MPU totaled less than 250,000 units, which is below original market expectations. Motorola's strategy calls for a shift to emerging embedded applications.

The information in Table 4 indicates that Motorola continues to be a worldwide manufacturing powerhouse among suppliers of CISC MPUs. The Apple-IBM-Motorola alliance likely will strengthen and advance Motorola's RISC MPU manufacturing expertise. Under current market conditions, users should anticipate continuing support by Motorola for the 68020 and 68030 architectures—meaning lengthy life cycles. Users of these devices face a favorable long-term supply scenario.

Motorola's new 68ECXXX series is targeted for high-performance embedded applications. The parts are in effect 68020, 68030, and 68040 devices minus the FPU and MMU. Another newer series—the 683XX—is in effect a fully static MPU with integrated I/O and without internal EPROM, which targets hand-held instrument applications.

The 68040 strategy is to evolve in line with market demands—which carries some risk for users depending on intended application. Why? Although the full-blown 68040 device aims at workstation applications, market interest in the 68040 has shifted to other applications. For example, during 1991 Motorola introduced a low-cost 68LC040 part—which disables the FPU—that targets PC applications. During the second half of 1992, Motorola likely will start volume shipments of the 68EC040 device for embedded applications.

As noted earlier, Motorola's long-term thrust into the RISC camp will be via the Apple-IBM-Motorola alliance on the PowerPC MPU family. Some uncertainty exists regarding the outlook for the RISC 88XXX processor.

Platform RISC Processors

In terms of Dataquest's platform RISC processor segmentation, the discussion here will focus on these processors families: SPARC, MIPS, PowerPC, and PA-RISC.

Table 3 reveals that RISC processors accounted for less than 5 percent of 1991 unit shipments of 32-bit MPUs—a gross understatement of the impact that these processors are having and will have on the entire MPU marketplace.

The impact of RISC technology in part can be shown through recent financial results. In terms of profitability for fiscal 1991, the following players in the RISC technology arena rank among the leaders among Silicon Valley companies: Hewlett-Packard (2nd ranking); Sun Microsystems (5th ranking via SPARC); and Cypress Semiconductor (15th).

The fact that RISC processor unit shipments and revenue remain dwarfed vis-a-vis the CISC marketplace requires somewhat different analysis to properly assess the supply base outlook. Because of the relative nascence of the RISC marketplace, the goal here will be to signal which RISC processor families are likely to emerge as long-term winners—and which suppliers most likely will be part of the long-term success paths.

For example, the goal here is not to assess each supplier's manufacturing capability—which tends to understate market positions—although Table 4 includes information for some suppliers of RISC MPUs. Another example is that this section does not directly assess Digital Equipment's yet-to-be-released ALPHA MPU family—which likely will become part of Dataquest's RISC processor class. However, information on the ALPHA processor is used to illustrate MPU design and manufacturing trends.

An Overview of Figures 4 and 5

Figure 4 shows RISC processor shipments by class—with SPARC leading the market. During 1991 IBM's PowerPC was not sold on the merchant market. Besides internal consumption, Hewlett-Packard's PA RISC MPUs ship to merchant customers.

Figure 5 presents preliminary 1991 RISC market shares by IC supplier for the SPARC and MIPS processors.

RISC: A World of Multiple Sources and Long-Term Alliances

Two key factors distinguish the RISC 32-bit supplier base from the CISC 32-bit supplier base. First, in order to establish RISC devices as viable long-term competitors to well-established CISC 32-bit processors, the early leaders in the RISC arena—Sun/SPARC and MIPS Computers—strategically positioned themselves to prospective users as offering multiple sources vis-a-vis the Intel and Motorola monopolies. Second, to grow the market in the face of the CISC camp's enormous entrenched market power, players in the RISC camp have forged a series of key industry alliances among the MPU inventors, prospective users, and chip suppliers. Each RISC processor class shown in Figure 4 in effect represents an industry alliance that aims to be a mainstream desktop computing system.

SPARC Processors

Figure 4 shows that Sun's SPARC family commands a 55 percent share of the RISC MPU marketplace. For SPARC processor suppliers, Figure 5 shows a three-way battle among LSI Logic, Fujitsu, and Cypress, with Cypress the new market leader based on outstanding 1991 results.

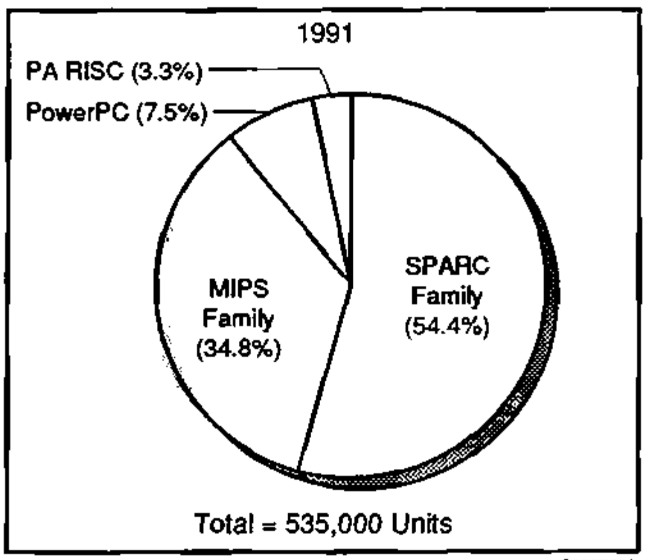
Sun's SPARC Strategy

As noted, Sun's alliance strategy won the company an impressive stream of revenue during 1991. A key element of the strategy, however, threatens to kill Sun's golden egg. Sun invited companies to clone the SPARC architecture but later—through domination of the distribution channel—in effect stifled meaningful growth of the clone competitors. At press time, Sun had announced a policy that would mitigate this effect. However, the market must await year-end 1992 results. A possible outcome is that the SPARC alliance will become an alliance of one on the systems side.

SPARC Processor Supply Side

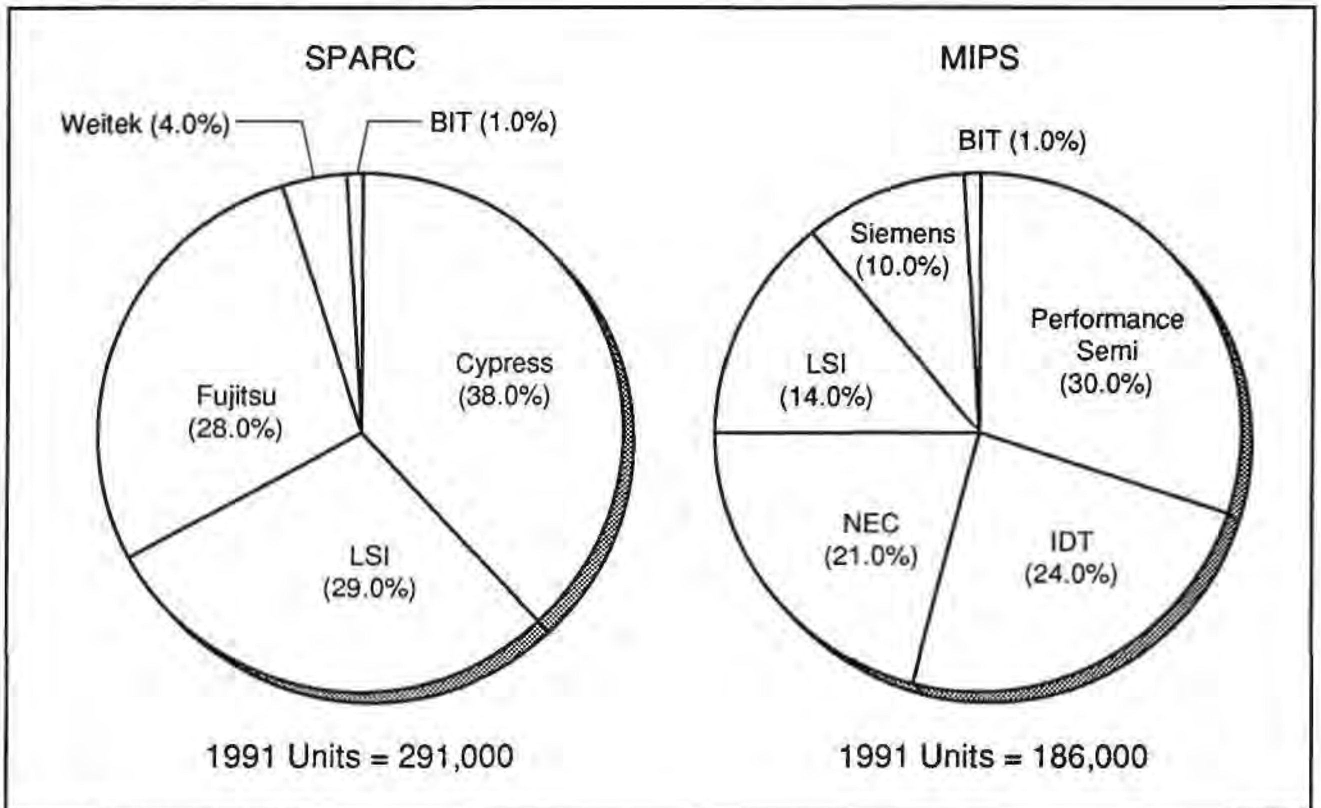
Regarding the IC supplier side of the SPARC alliance, Cypress and Fujitsu advanced during 1991 at the expense of LSI Logic, which formerly led the market. Regarding 1991 results and long-term trends, Cypress and Fujitsu supply integrated IU/FPU devices that are

Figure 4
RISC Processor Shipments by Family



Source: Dataquest (May 1992) G2000209

Figure 5
Final 1991 RISC Market Share (Units)



Source: Dataquest (May 1992) G2000135

attractive for some users. Fujitsu advanced when Sun introduced new systems and via the emergence of an embedded applications marketplace (that is, SPARC-Lite series). Cypress' advance during 1991 stems from increased business with Sun, among other accounts. The RISC market is not risk-free, however. Early in 1992 Cypress reported lower earnings attributed in part to slower demand for SPARC processors.

Fujitsu might be best positioned for long-term market leadership. For example, Table 4 reveals that Fujitsu has strong SPARC MPU manufacturing capability. This vertically integrated supplier likely can withstand the RISC market volatility. Fujitsu should be well-positioned for success in the home Japan market and/or key regional markets such as North America as either a supplier of either SPARC MPUs or SPARC-based systems, or both. Cypress and LSI Logic are relatively small vis-a-vis Fujitsu. However, the companies are aggressive, competitive, and well-managed.

For these suppliers, competition in the SPARC market has intensified with TI's recent market entry, although merchant customers will not receive TI's Viking SuperSPARC product until the fourth quarter of 1992 (Table 5 provides device/technology specifications).

Cypress aims to return the volley with its just-announced Pinnacle family.

MIPS Processors

Figure 4 shows that the MIPS processor family holds a 35 percent share of the RISC MPU marketplace. Among the suppliers of the mainstream R3000 device, Figure 5 reveals a five-way battle (in ascending order of ranking) among Performance Semiconductor, IDT, NEC, LSI Logic, and Siemens. BIT and Toshiba have also entered or will soon enter the marketplace.

ACE Initiative: Losing Momentum As a Key Player Departs?

The MIPS processor market had gained momentum during 1991 through the Advanced Computing Environment (ACE) initiative. The ACE/MIPS strategy was to compete against Intel's 80486/80586 family using the same NT-Windows operating system. The key alliance players (role) at that time were former MIPS Computer (architect); Microsoft (operating system); 75 system vendors—most notably DEC and Compaq Computer (users); and the MIPS MPU suppliers as shown in Figure 5.

The ACE/MIPS strategy confronts some challenging realities. In terms of market results, for 1991 MIPS processor platform sales—mainly workstations—totaled just over 100,000 units. Two users—DEC and Silicon Graphics—accounted for two-thirds of these platform units. Embedded applications accounted for 40 percent of shipments.

During the first half of 1992, the ACE/MIPS alliance encountered a series of momentum-draining events. First, DEC announced its ALPHA architecture, the result of a $1 billion R&D effort. Second, MIPS Computer—a key player—continued to lose money and was acquired by Silicon Graphics. The scenario here is akin to Intergraph's acquisition of Fairchild's Clipper architecture during the 1980s. The eventual result in that case was that the Clipper architecture became a good one-company processor—for Intergraph—with some prospective customers leery of using a processor owned by an actual or prospective competitor (that is, Intergraph). Some current and prospective users of the MIPS processor are uncomfortable with Silicon Graphics' acquisition of MIPS Computer.

Third—and perhaps most tellingly—Compaq Computer withdrew from the ACE consortium early in the second quarter of 1991. Compaq has delayed indefinitely workstation systems that were to use the MIPS processor. The news on Compaq's 80586-based system emerged shortly thereafter. Other systems manufacturers such as Convex and Groupe Bull have left the consortium in favor of other RISC alliances (Convex with Hewlett-Packard, Bull with IBM).

Nevertheless, the RISC market is quite young. Market players remain enthralled with the 64-bit R4000 processor. During the first half of 1992, Silicon Graphics and former MIPS Computer Systems kept performance pressure on competitors by introducing R4000-based systems that operate at speeds of 50 to 67 MHz.

MIPS Processor Supply Side

Performance Semiconductor and IDT maintained their leadership ranking of 1990 during 1991. These suppliers are not industry giants and earnings should continue to be uneven over time. For example, Performance Semiconductor—which announced a processor with on-board IU, FPU, and cache memory—to date depends largely on DEC in terms of its customer base. IDT has a more balanced customer base including workstation (Silicon Graphics), embedded, and system module (AT&T) applications. NEC jumped in ranking during 1991 by winning business from DEC. LSI Logic lost share. However, the supplier could rebound via an integrated processor that targets X Window terminal applications. Siemens gained 10 percent market share in its first year in the market. Recent entrants such as BIT and Toshiba aim for similar results.

In terms of embedded applications, the MIPS supplier base includes most of the suppliers shown in Figure 5—Performance Semiconductor, IDT, and Siemens. Macronix (Taiwan), NKK (Japan), Sony, and Toshiba have entered or likely will enter this segment during 1992. Macronix and NKK also have a flash memory alliance that uses NKK's new $1 billion 0.8-micron fab.

Of the MIPS suppliers shown in Figure 5, NEC might emerge as a long-term market leader. As shown in Table 4, this vertically integrated supplier should be positioned for success not only in Japan but also in North America and Europe. In the aggregate, the MIPS marketplace is fragmented in terms of the supplier base—with NEC a likely survivor in the event of eventual market consolidation.

For users in North America and Europe, the outlook regarding the viability of the MIPS architecture and the supplier base remains uncertain.

PowerPC Family

As noted in the analysis on Motorola, the PowerPC alliance links Apple Computer and

Motorola—which have had a long-term business relation—with IBM, Apple's long-term competitor. The RISC PowerPC family will advance IBM's RS/6000 POWER architecture. As shown in Figure 4, this processor represented 7.5 percent of the RISC MPU market as measured in unit shipments. These shipments were for IBM's captive consumption. To date, Motorola will be the only merchant market supplier. Bull and Thomson-CSF recently joined the alliance as users.

The strategy is as follows: the alliance participants will jointly develop the processor at the billion-dollar Somerset R&D center. Later IBM and Motorola will separately manufacture the processors. Intended applications include the entire platform market: notebooks, PCs, workstations, and servers. As noted earlier, development of the Taligent operating system appears on schedule for introduction during 1994.

One alliance participant—Apple Computer—publicly shares its vision of the role that the alliance will play in the company's market evolution. For Apple, the alliance is the key for establishing itself in the corporate client/server marketplace. The PowerPC MPU should become critical as Apple makes the transition from CISC MACs—which were based on Motorola's 680X0 family—to RISC MACs.

Precision Architecture RISC (PA-RISC)

Hewlett-Packard first shipped this family during 1987 and advanced the technology during 1989. As shown in Figure 4, HP's PA-RISC processor represents 3.3 percent of the RISC MPU market—which understates its potential impact. The PA-RISC processor ranks as one of the performance leaders in the performance-intensive RISC arena—creating a threat for other RISC processors such as SPARC products. In addition to HP's captive production, other suppliers/users include Japan-based Hitachi and Korea-based Samsung, a potentially powerful global alliance.

HP has steadily if quietly grown this market. Although small today, the PA-RISC architecture already shows sign of emergence as a long-term winner. For example, during the first half of 1992 HP struck an alliance with Convex, a former member of the ACE/MIPS consortium.

Section 4: MPU Design and Production Trends

This section highlights trends in MPU design and production. Table 5 summarizes information on leading-edge 32-bit and 64-bit RISC/CISC processors regarding the following factors: architecture, speed, process technology, power supply voltage, design rule, transistors, and chip size. The table includes information on two devices developed by DEC, including ALPHA and one from Sun/TI (SuperSPARC). No R4000 papers were presented at ISSCC 1992.

Trends from ISSCC 1992

At ISSCC 1992, all microprocessor papers were presented by computer/workstation companies. Digital's Alpha RISC architecture and MIPS R4000 architecture (not presented at ISSCC/1992) herald the arrival of 64-bit computing. Leading-edge microprocessors are using CMOS technology with minimum lithography design rules in the 0.5- to 0.8-micron range. Extra-wide field stepper lenses and other lithography innovations such as step-and-scan technology will be needed to print increasingly larger microprocessor chips. BiCMOS technology may be needed to implement the ECL-type low-level logic swings of high-speed microprocessors.

Microprocessors continue to drive multilevel interconnect technology. Three-level interconnect

Table 5
Key Features of Microprocessor Technology at ISSCC/1992*

Company	Architecture	Speed (MHz)	Technology	Power Supply Voltage	Design Rule (Microns)	Transistors (Millions)	Chip Size (cm * cm)	Package
DEC	32-Bit/CISC	100	CMOS	3.3V	0.75	1.30	1.62 * 1.46	CPGA-339
DEC	64-Bit/RISC	200	CMOS	3.3V	0.75	1.68	1.68 * 1.39	CPGA-431
Sun/TI	32-Bit/RISC	40	BiCMOS	5V	0.80	3.10	1.60 * 1.60	CPGA-293

*All use three layers of metallization
Source: Dataquest, ISSCC/1992 (May 1992)

technology is rapidly becoming the standard in advanced 32/64-bit microprocessors, with four-level interconnect implementations looming on the horizon. Metal linewidth/space and contact feature sizes in the range of 0.5 to 0.8 microns rival the traditional transistor gate-length as a technology driver. In response, microprocessor manufacturers will increase the proportion of the wafer fab equipment capital budget spent on planarization, plug, interconnect deposition, and etch applications, relative to lithography applications.

The Impact of RISC?

What is the potential MPU impact of the RISC technology? The semiconductor revolution is giving way to the semicomputer evolution. The design innovation pendulum is swinging away from traditional proprietary, merchant microprocessor houses such as Intel and Motorola toward system-knowledge intensive captive computer companies such as Digital Equipment Corporation, Hewlett-Packard, IBM, Sun, and Silicon Graphics. The evolution of RISC-based open-architecture computing and access to leading merchant CAD tools and global ASIC foundries has significantly leveled the silicon playing field between traditional merchant microprocessor companies and captive computer/workstation companies.

Section 5: MPU Life Cycle Pricing

This section extracts recently published work by SPS on forward-stage MPU pricing. The information can be used to generate estimates—based on MPU transistor counts and prior MPU price history—for next-generation parts. The example is Intel's 80586 processor.

There are two goals of this section: to explain the forward-pricing methodology, and to make clients aware that SPS can assist them via our inquiry service—along with published reports such as this article—on forward-pricing analysis.

Methodology behind MPU Life Cycle Pricing Analysis

A number of SPS clients have requested a structured framework as they make the transition from today's predominantly CISC world to tomorrow's CISC/RISC marketplace. The following analysis was first published April 20, 1992 in a Semiconductor Procurement *Dataquest Perspective* article entitled "Buyer's Headache: Will IC Prices Stay Low if the Economy Turns Up?". This analysis marks a move toward that goal.

Figure 6 shows pricing measured in dollar-per-transistor for the early, or forward, stages of the product life cycle for 80286-10, 80386DX-16, and 80486DX-25 devices, and 68000-8, 68020-16, and 68030-25 parts. To construct this MPU life cycle pricing curve, we used information dating as far back as 1979 and 1980 on pricing, product introduction dates, and transistor counts.

Figure 7—which is based on the information in Figure 6—shows the rate-of-price decline for the 80x86 and 680x0 devices relative to the family's prior generation part over the life cycle. Although the objective is to estimate the forward price of the 80586 device from Intel, Motorola MPU price history serves as an analytical "check."

The rates of decline shown in Figure 7 are quite similar for the forward life cycle stages regarding 80486DX-25 pricing vis-a-vis the prior-generation 80386DX-16 product; 68020-16 pricing vis-a-vis the 68000-8 device; and 68030-25 pricing versus the 68020-16 part.

The Assumptions behind the 80586 Price Estimate

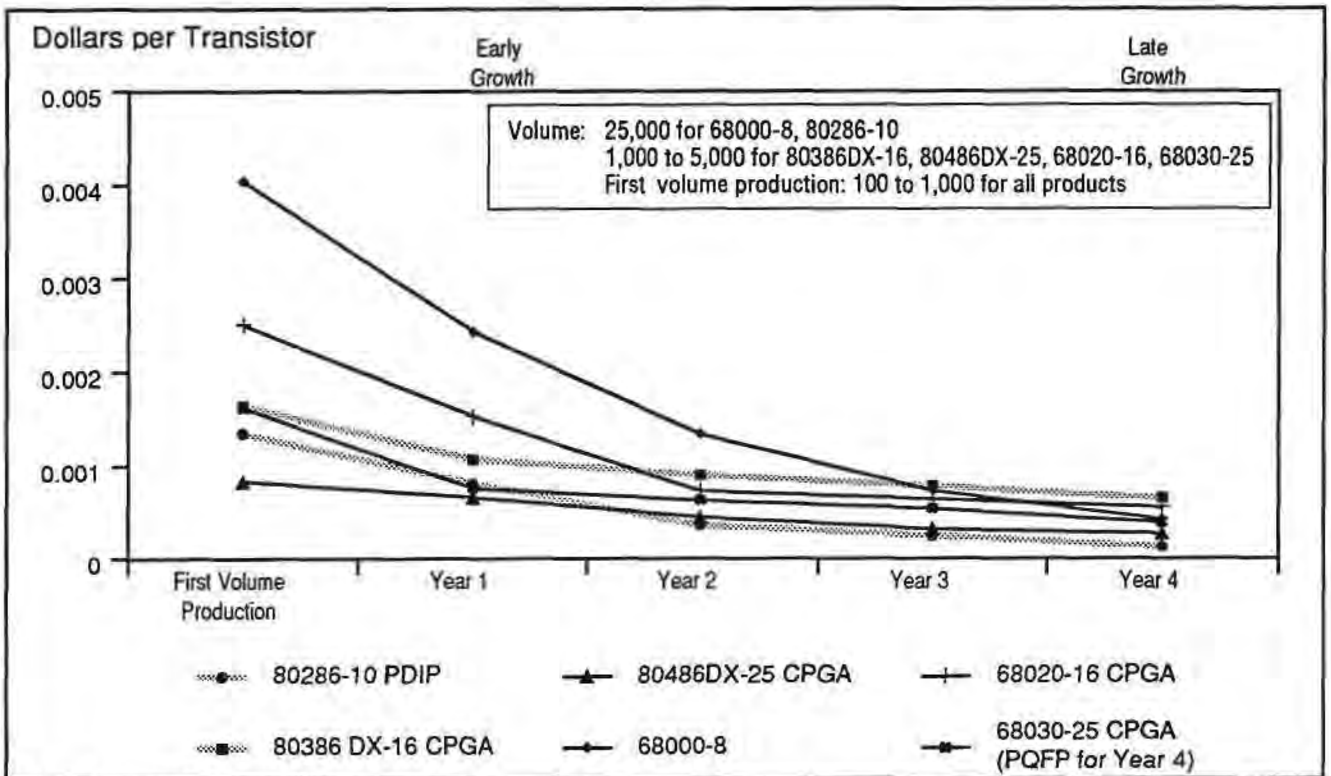
Dataquest clients require a statement of the assumptions for forward price estimates like the 80586 estimate shown in Table 6.

Table 6 states the critical assumptions. Clients who disagree with these assumptions can modify the estimated price in line with their differing assumption(s). The table shows several assumptions regarding specifications (for example, transistor count and package) but also an analytical assumption regarding the pricing environment/rates of price decline that Dataquest assumes. Again, clients may modify their estimate depending on the kind of competitive environment they assume.

Other Forward Prices

Dataquest also tracks forward-pricing via discussions with users and suppliers. For example, the DEC Alpha 21064 200-MHz device (see Table 5) should be available during the third quarter of 1992 at an estimated price of $1,650 (1,000-unit volume). Another device shown in Table 5, the Sun/TI SuperSPARC

Figure 6
North American MPU Pricing by Life Cycle Stage (Dollars per Transistor)



Source: Dataquest (May 1992)

G2000608

processor (33 MHz, CPGA-293) should be priced during the first quarter of 1993 at less than $400 at 10,000-unit volume.

Table 6
Estimated 80586 Pricing by Product Life Cycle Stage

Stage:	Price ($)
Introduction (Second Half 1992) First Volume Production[1]	1,268
Early Growth (1993) Price at First Full Year of Production[2]	788
Growth (1994) Price at Second Full Year of Production[2]	694

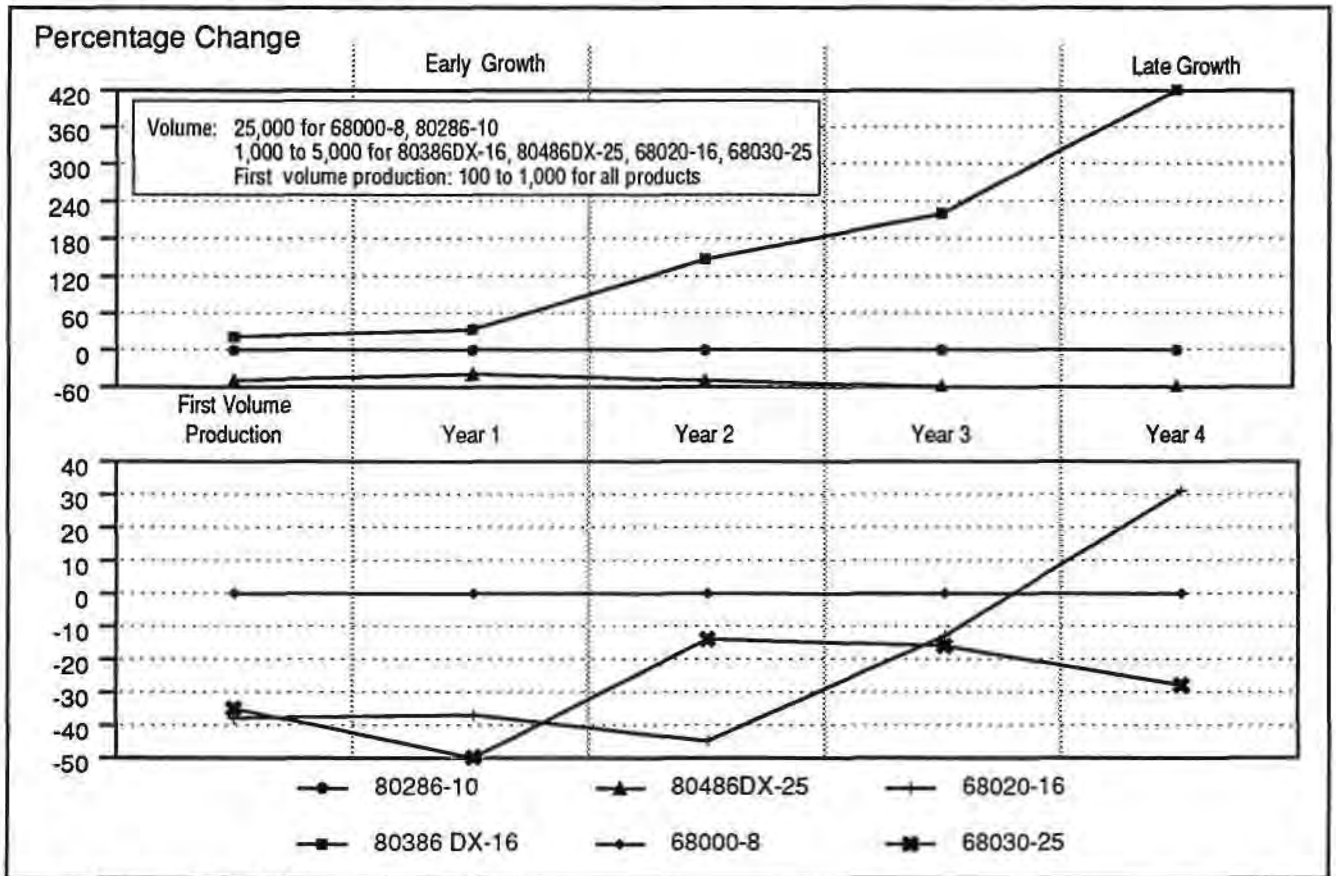
Assumptions: Specs: 3 million transistors; 50 MHz; CPGA (not multichip module). Intel's strategy: conforms more so with historic forward-pricing strategy associated with competitive market environment and less so with monopoly-pricing power. Life cycle: starts by fourth quarter of 1992
[1]Volume of 100-1,000 units
[2]Volume of 1,000-5,000 units
Source: Dataquest (May 1992)

Dataquest Perspective

The next two to three years should be especially challenging for users of MPUs. The rise of the RISC technology and AMD's entry to the 386 marketplace signal dramatic long-term market change. For example, as this report was being prepared, two RISC devices—TI's SuperSPARC and Cypress's HyperSPARC processor—hit the market, along with the CISC 486 device from Cyrix/TI.

For many users, the central MPU supply base issue is whether to maintain or break a long-standing buyer-seller bond with Intel. Regarding 80386 devices, not only is AMD a viable second source but AMD also has a stronger strategic interest than Intel in serving long-term demand for this part. Depending on legal results, AMD and Cyrix-TI stand poised to smash Intel's 80486 monopoly. Other would-be entrants aim to do the same, although their prospects for successful market penetration appear more cloudy.

Figure 7
MPU Pricing: Rate of Decline at Forward Stages in Life Cycle Relative to Prior Generation (80286-10 and 68000-8 = Base of 0)



Source: Dataquest (May 1992)

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However, the long-term action in this sexy MPU world—as indicated by this article's title and papers presented at ISSCC 1992—lies in the 32/64-bit CISC-versus-RISC battle that could completely reshape the IC business during this decade. Simply stated, systems houses such as Apple, Hewlett-Packard, and IBM could emerge as the key players in the MPU marketplace later this decade. But at press time—with news of Compaq systems that will be based on Intel's next-generation 80586 CISC processor—old ways seem never to change.

By Ronald Bohn

Inquiry of the Month

Q. What were the North American bookings price differences between the 4Mb×1 and 256K×18 and 256K×16 DRAMs for the first quarter of 1992 (contract volume, 80ns)?

A. See Table 1. Price premiums for the ×16 and ×18 organization are because of the number of suppliers and the corresponding level of demand. Pricing for 256K×16 devices runs 5 to 7 percent less than ×18 parts.

Table 1
Price Ranges for 4Mb×1 and 256K×18 and 256K×16 DRAMs, First Quarter of 1992

Product	Price Range ($)	Estimated Q1/1992 Price
4Mb×1 DRAM	12.40 to 14.55	13.26
256K×18 DRAM	17.00 to 19.00	17.07

Note: This information correlates to Dataquest's quarterly forecast dated March 1992.
Source: Dataquest (May 1992)

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- June Procurement Pulse
- Cost model update
- DRAM product update

CONFERENCE ANNOUNCEMENT

Dataquest's 11th Annual SEMICON/West Seminar: Status 1992
Wednesday, June 17, 1992

Wafer fab equipment and materials companies had a tough time in 1990 and 1991 as the industry faltered. Dataquest believes that 1992 will also be a difficult year because of the lack of capital investment in semiconductor facilities. Will this dismal scenario continue? We don't think so. This year's SEMICON/West seminar will explore some of the reasons why the equipment and materials industry slowed over the past several years and why we believe that the industry will pick up again to resume a more normal growth path.

Attendees will hear Dataquest speakers discuss the following topics, which will provide a cohesive picture of the wafer fab equipment and materials industry from both supply-side and demand-side perspectives:

- Wafer fab equipment market status and forecast
- Wafer fab equipment company trends
- Semiconductor fab overview
- Capital spending forecast
- Changing strategies for materials companies
- Is there a future for the 1Gb DRAM?
- Portable PCs: A hot demand-side application

The seminar covers a lot of ground but it is specifically designed to provide the kind of high-level status and trend information that semiconductor equipment and materials industry executives need to support their decision-making. Industry executives have full and hectic schedules during SEMICON/West, but we believe that attendance at our acclaimed annual seminar will be an excellent investment of your time that will pay dividends to you and your company.

Dataquest's Status 1992 Seminar will be held on Wednesday, June 17 at the ANA Hotel (formerly Le Meridien) in San Francisco, just a few minutes' walking distance from Moscone Center, site of the SEMICON/West trade show. The seminar will begin at 8:30 a.m. and conclude by 11:40 a.m. Registration and continental breakfast will commence at 7:30 a.m. The fee for this seminar is $145. Please contact Dataquest's Conference Department at (408) 437-8245 for further information.

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9204 April 20, 1992

In This Issue...

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File inside the *Dataquest Perspective* binder labeled
Semiconductor Procurement

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing*

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.17	0.15	0.17	0.18	0.14
74AC138	0.30	0.32	0.26	0.27	0.28	0.21
74AC244	0.44	0.44	0.35	0.39	0.42	0.36
74AC74	0.24	0.21	0.20	0.21	0.22	0.17
Lead Time: (Weeks)	4	3	4	4	5	5
4F00	0.11	0.12	0.09	0.10	0.10	0.09
4F138	0.15	0.19	0.15	0.17	0.19	0.14
4F244	0.22	0.26	0.21	0.24	0.27	0.23
4F74	0.11	0.13	0.12	0.13	0.13	0.11
Lead Time: (Weeks)	4	3	4	4	5	5
7805-TO92	0.10	0.18	0.11	0.12	0.13	0.11
CODEC-FLTR 1	1.80	2.25	2.50	1.90	2.00	1.35
CODEC-FLTR 2	4.15	4.35	5.00	4.80	5.00	
Lead Time: (Weeks)	6	3	6	3	4	
DRAM 1Mbx1-8	3.33	3.29	3.50	3.70	3.80	3.55
DRAM 1Mbx9-8	35.50	37.11	33.50	37.75	39.00	34.50
DRAM 256Kx1-8	1.10	1.54	1.60	1.20	1.29	1.10
DRAM 256Kx4-8	3.33	3.34	3.50	3.70	3.80	3.55
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	
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
Lead Time: (Weeks)	4	4	4	4	7	4
68020-16	27.50	37.85	26.00	37.50	35.50	
80286-16	9.50	10.39	10.00	11.30	11.70	9.70
80386DX-25	125.00	136.92	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			
Lead Time: (Weeks)	6	7	4			

*Prices in U.S. dollars
Source: Dataquest (April 1992)

Market Analysis

April Procurement Pulse: Semiconductor Availability, Inventory Levels Excellent As System Demand Slowly Grows

The Procurement Pulse is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This explains what inventory and order corrections mean to semiconductor users.

Semiconductor Order Rate Remains Unchanged

Figure 1 illustrates the relative flat order level expectations for April, compared with the past five months. The 1.1 percent increase in forecast order activity is by no means a go-go indicator. Rather it notes a balance of system sales activity with order rate levels. The overall six-month system sales outlook increased from last month's 7.5 percent to the current 8.0 percent, while the computer segment expects a slight contraction from last month's 8.8 percent to 8.3 percent sales growth. The lower revenue growth areas in computers relate to the commoditized low-end personal computer market, where price pressure continues unabated. There are bright spots in data processing, primarily in the higher-end file server and selected mainframe markets. Prices continue to slow in their rate of decline, going from February's negative 1.8 percent to March's negative 1.6 percent price erosion. This continued flattening of pricing is another sign of improved demand levels relative to the current supply base. Adequate capacity levels remain, waiting for consistent signs that demand will continue to grow beyond current levels.

Figure 1
Averaged Monthly Semiconductor Orders

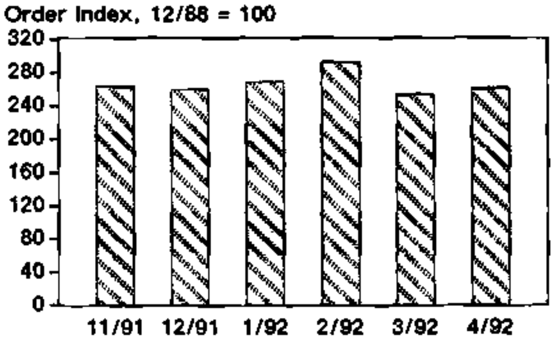


Figure 2
Averaged Semiconductor Lead Times

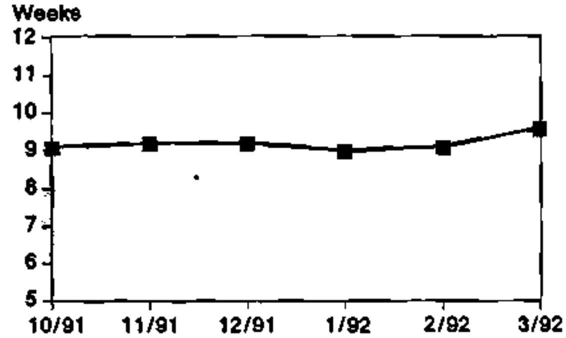


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

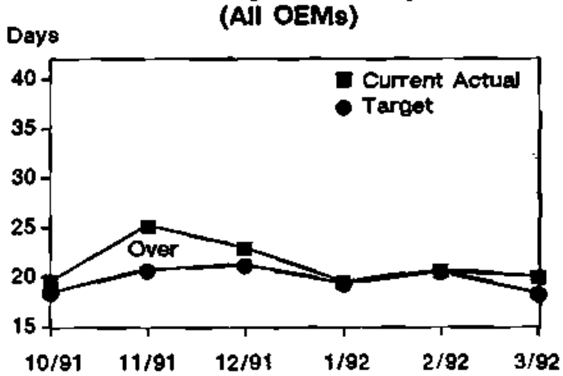
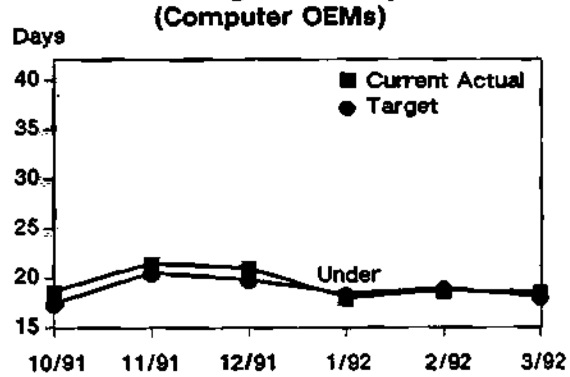


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (April 1992)

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Lead Times Increase By Two Days To 9.6 Weeks—Not A Big Deal

The incremental stretched lead time noted in Figure 2 basically reflects small increased delivery spans noted by only a few respondents to this month's survey. Ninety percent of our respondents saw no change in lead times, compared with last month. Although there are some signs of business picking up in certain markets, aggregated capacity levels are by no means being stretched and average lead times should soon return to the nine-week average noted in Figure 2. Aside from a continuing lone respondent having a problem with some ASIC products, no reported product problems are noted in this month's survey. Issues facing procurement continue to revolve around quality, cost reduction, and end-of-life buys. Quality and cost-reduction concerns coincide with the priorities noted in our annual procurement survey as those needing attention.

Inventories Remain Low And Under Control

Figures 3 and 4 show a relatively unchanged inventory situation, compared with the last two months. The overall inventory balancing act continues with targeted levels for the overall sample falling by two days from 20.6 to 18.4 days, while the actual level stabilized, going from a controlled 20.7 days to 20.1 days. The computer segment reported respective targeted and actual inventory levels of 19.0 and 18.7 days, going to a current comparable reduction of 18.1 and 18.6 days. Isolated areas of improved equipment business aside, inventory control and the requisites of good forecast communication continue to keep focus on basic cost control. The current unprecedented levels of inventory control will allow any change in demand levels to directly translate into changes in semiconductor demand shifts.

Dataquest Perspective

The continuing positive outlook for end equipment sales is slowly being realized in gradual, paced semiconductor order increases handily being absorbed by existing capacity levels. The ultracautious period for capital expenditure is being replaced by a reluctant approval mode because of existing equipment obsolescence or a long-overdue upgrade need that is more palatable now because of low interest rates and solid cost control programs. The current good availability of semiconductors is expected to continue, thus enabling any equipment growth trend to be unimpeded by component restraints. Dataquest continues to forecast double-digit growth in the semiconductor market that is based on demand improvements in the equipment industry now being seen.

By Mark Giudici

European Community Semiconductor Tariffs: An Executive Overview for Suppliers and Buyers

Exports of semiconductor devices to the European Community (EC) from third countries (non-EC countries) are subject to ad valorum import duties (that is, proportional to value). A weighty legislative document is released annually by the European Commission detailing the Common Customs Tariff (CCT) for the following calendar year. The complexity of this legislation, together with the high-profile coverage the media has given to other trade matters in the EC, has caused a certain amount of confusion in the international semiconductor community regarding the subject of EC semiconductor tariffs and related issues. This article, which is extracted from a larger, comprehensive special report, provides a concise and authoritative source of reference on this subject for semiconductor suppliers and buyers. Readers are recommended to use the references at the end for further information on areas of special interest.

Background

The European Community is the last major semiconductor market in the world that continues to apply conventional rates of import duty on semiconductor devices. In 1985, the United States, Canada, and Japan indefinitely suspended their conventional rates of import duty on semiconductor devices and computer printed circuit boards (PCBs). A number of Asia/Pacific countries have recently agreed to do the same.

The EC and other countries have progressively reduced tariff and nontariff barriers to international trade through various rounds of multilateral talks that began after the World War II. The General Agreement on Tariffs and Trade (GATT) came into force on January 1, 1948 following initial talks in 1947, and continues to be the only forum for multilateral trade talks. The current round of talks that began six years ago, known as the "Uruguay Round," is still in progress. The possible effect on EC semiconductor tariffs when these talks are concluded is discussed in the Dataquest Perspective section at the end of this article.

In 1968 the EC formally adopted the current system of the CCT for all forms of produce exported to the EC. However, the concept of the CCT was originally introduced when the European Economic Community was formed in 1957, and was based upon an arithmetic average of the import tariffs formerly applied in each member country.[1] The purpose of the CCT has been one of a set of measures "to promote the efficiency and competitive capacity of its industry on an international scale."[2] This has often been referred to in the European Community as "leveling the playing field" against external competition. In the context of the semiconductor industry, the European Electronic Component Manufacturers' Association (EECA) has determined that the manufacturing costs of European semiconductor suppliers are at least 20 percent higher than in the United States or Japan.[3]

The present CCT is based upon a 1987 European Commission Council Regulation,[4] which is republished by October 31 every year in the Legislation series of the *Official Journal of the European Communities*. This regulation serves to differentiate between 97 general product groups in order specify the rates of duty that are applied against exports from third countries. Semiconductor devices comprise a small subset of one of these groups.

Another purpose of this differentiation is to track the volume of imports and exports of different products between the EC and third countries. Every EC customs office records the shipment of products in and out of the EC by CCT code and submits this to a central point for consolidation of trade statistics. The European Commission uses this information to develop and support its policies for EC industries, including the tariff structure.

Product differentiation is more detailed in areas that are of strategic importance. Taking a particular example in the semiconductor sector, there was only 1 product code for all semiconductor memory devices in the 1987 regulation. In the current version there are 15 product codes for MOS memory devices and 1 code for other memory devices. This indicates the growing importance of MOS memory to the EC semiconductor industry.

Table 1 summarizes the major semiconductor device families covered by the CCT and the corresponding rates of import duty. Also included in this table are some of the key materials used in the manufacture of semiconductor devices, examples of electronic assemblies that use finished semiconductor devices, and some examples of completed electronic equipment. This draws the "big picture" of the European electronic products tariff structure, from raw materials to final end equipment. The rates of duty shown are based upon published legislation from the European Commission for the year 1992.[5] Note that there has been no change in the rates of duty on semiconductor devices between 1991 and 1992, although product differentiation has increased.

Terms of Reference

The European Commission adopted a system of classification for goods in its 1987 Council Regulation called the Combined Nomenclature, or CN for short, in which each single product is defined by an eight-digit code. This replaced the previous system of Nomenclature of Goods for External Trade Statistics of the Community and Statistics of Trade Between Member States, or NIMEXE for short, in which a six-digit code was used.

The CN system is used to unambiguously identify a product and apply the correct rate of import duty when it enters the European Community from a third country. The duty is applied as a percentage of the product's CIF value—or in other words, the sum of its cost, insurance, and freight. This is the general rule. In addition, each EC member country may apply its own national sales tax (such as, value-added tax) on top of this import duty. The rate of sales tax currently varies from one EC country to another. One of the goals of the unification of the EC market on January 1, 1993 is a standard rate of sales tax for all EC member countries.[6] However, this article is only concerned with EC import duties under the CCT.

Table 1
European Community Import Duties for Electronic Components and Products
(Based on Conventional Rates)

Code	Description	1992 Duty (%)
Silicon Ingots		
Not yet sliced into wafers		
28046100	Minimum purity 99.99%	6.0
28046900	Maximum purity 99.99%	6.0
Unprocessed Wafers		
Doped but not yet diffused		
38180010	Doped silicon	7.6
38180090	Other doped material	7.6
Processed Wafers		
Diffused but not yet cut into die		
85421101	Digital MOS IC die on wafer	9.0
85421188	Non-MOS digital IC die on wafer	9.0
85421910	Nondigital IC die on wafer	9.0
85412110	Transistor <1W die on wafer	9.0
85412910	Transistor >1W die on wafer	9.0
85411010	Diode die on wafer	9.0
86413010	Thyristor die on wafer	9.0
85415010	Other discrete/opto die on wafer	9.0
Die		
Cut from wafer but not yet packaged		
85421105	Digital MOS IC die	14.0
85421189	Non-MOS digital IC die	14.0
85421920	Nondigital IC die	14.0
85412190	Transistor <1W die	14.0
85412990	Transistor >1W die	14.0
8541109*	Diode die	14.0
85413090	Thyristor die	14.0
85415090	Other discrete die	14.0
85414010	LED die	14.0
85414091	Solar cell die	4.6
85414093	Photosensor die	4.6
85414099	Other opto die	4.6

(Continued)

Table 1 (Continued)
European Community Import Duties for Electronic Components and Products
(Based on Conventional Rates)

Code	Description	1992 Duty (%)
Assembled devices		
Packaged die not yet mounted on PCB		
85421105	Monolithic digital MOS IC device	14.0
85421189	Monolithic digital non-MOS IC device	14.0
85421920	Monolithic nondigital IC device	14.0
854220**	Hybrid (multidie) IC device	14.0
85412190	Transistor <1W device	14.0
85412990	Transistor >1W device	14.0
8541109*	Diode device	14.0
85413090	Thyristor device	14.0
85415090	Other discrete device	14.0
85414010	LED device	14.0
85312090	LED/LCD display	4.4
85414091	Solar cell device	4.6
85414093	Photosensor device	4.6
85414099	Other opto device	4.6
Passives not yet mounted on PCB		
85321100	Fixed tantalum capacitor	7.0
85322200	Fixed aluminium capacitor	7.0
85322300	Fixed ceramic single capacitor	4.9
853224**	Fixed ceramic multilayer capacitor	4.9
85322500	Fixed paper/plastic capacitor	4.9
853230**	Variable/adjustable capcitor	7.0
85331000	Fixed resistor	5.3
85333***	Variable wirewound resistor	5.3
85334***	Variable other resistor	5.3
PCBs		
PCB without diffused devices mounted		
85340011	With multicircuit contacts only	6.2

(Continued)

Table 1 (Continued)
European Community Import Duties for Electronic Components and Products
(Based on Conventional Rates)

Code	Description	1992 Duty (%)
85340019	With other circuit contacts only	6.2
85340090	With passive devices mounted	6.2
PCB with diffused devices mounted		
84731010	Used in typewriters and WP systems	4.0
84732110	Used in battery calculators	6.3
84732910	Used in mains-supply calculators	4.0
84733010	Used in other EDP systems (e.g. PC)	4.0
84734010	Used in other non-EDP office systems	4.0
90099010	Used in photocopier systems	7.2
85179081	Used in telephone systems	7.5
85179092	Used in telegraph systems	7.5
85179011	Used in other communications systems	4.6
85229091	Used in audio and video systems	5.8
85299070	Used in radio and TV systems	7.2
84159090	Used in air conditioning systems	5.3
84189990	Used in refrigerators and freezers	3.8
84229010	Used in dish washers	3.5
85099090	Used in food mixers	5.1
85169000	Used in microwave ovens	5.1
85389010	Used in electricity control systems	4.6
85309000	Used in public transport systems	4.4
870899**	Used in private transport systems	4.9
88033090	Used in private aircraft systems	4.9

(Continued)

Table 1 (Continued)
European Community Import Duties for Electronic Components and Products
(Based on Conventional Rates)

Code	Description	1992 Duty (%)
90069190	Used in photographic cameras	7.2
90330000	Used in medical/industrial systems	5.6
92099400	Used in musical instruments	5.0
Systems		
Equipment using PCBs and devices		
8469****	Typewriters and WP systems	4.6
84701000	Battery calculators	12.0
84703000	Mains-supply calculators	4.1
8471****	Other EDP systems (e.g., PC)	4.9
8472****	Other non-EDP office systems	4.4
9009****	Photocopier systems	7.2
8517****	Communications systems	7.5
8518***	Audio amplifiers	4.9
8519****	Audio reproduction systems	9.5
8520****	Audio recording systems	7.0
8521****	Video systems	14.0
85251090	Radio/TV transmission systems	4.9
85252090	Radio/TV transceiver systems	6.5
852530**	TV/Video cameras	4.9
9006****	Photographic cameras	7.2
85269290	Remote control systems	6.2
8527****	Radio receiver/recording systems	14.0
8528****	TV/video receiver/monitor systems	14.0
8415****	Air conditioning systems	5.3
8418****	Refrigerators and freezers	3.8
84221100	Domestic dish washers	4.9
85094000	Food mixers	5.1
85143010	Infrared ovens	4.1

(Continued)

Table 1 (Continued)
European Community Import Duties for Electronic Components and Products
(Based on Conventional Rates)

Code	Description	1992 Duty (%)
85165000	Microwave ovens	5.1
8530****	Public transport systems	4.4
870899**	Private transport systems	4.9
88033090	Private aircraft systems	4.9
8535****	>1KV electrical switching systems	4.6
8536****	<1KV electrical switching systems	4.6
8537****	Electrical switching display systems	4.1
9010****	Semiconductor lithography systems	4.9
9018****	Medical/diagnostic systems	5.3
9019****	Breathing and therapy systems	4.6
9022****	X-ray and radiography systems	4.6
90302090	Cathode-ray oscilloscopes	11.0
92071090	Electronic musical instruments	6.0

PCB = Printed circuit board, including SIMMs and SIPs
CN = Combined Nomenclature, used by EC to differentiate products
* Various codes, please refer to EC Council Regulation 2587/91
Source: Dataquest (April 1992)

Correctly identifying the product by its CN code so that the appropriate level of import duty can be applied is only the first stage in the customs process. The next important step is to identify the country of origin of the product, so that duty concessions or penalties may be applied, according to the trading status between the EC and that country. National sales taxes will normally remain in place, independent of any duty concessions.

Before discussing the subject of duty concessions, it would be useful at this point to define the countries that comprise the European Community. The EC member countries are Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. Trade between member countries is not subject to any import duty.

Duty Concessions

There are a great number of legislative documents concerning trade arrangements between the EC and individual third countries. Numerous revisions and amendments to these arrangements result in a complex web of mutual concessions. The duty concessions that currently exist between the EC and third countries are summarized in the following paragraphs.

The EC has a zero-duty arrangement with member countries of the European Free Trade Association (EFTA). The EFTA member countries are Austria, Finland, Iceland, Norway, Sweden and Switzerland. The tiny country of Liechtenstein is affiliated by protocol with EFTA, and is expected to become a full member in the near future. EC and EFTA countries are continuing discussions of mutual economic integration, creating what is known as the European Economic Area (EEA), but some institutional problems still have to be overcome. In parallel to these discussions, some EFTA countries have made independent applications to become members of the EC.

The EC also applies generalized tariff preferences on products from nearly 200 developing countries.[2] This is where the CCT (i.e., import duty) is fully suspended on exports of products to the EC from each developing country up to a ceiling of shipments per annum. The normal rate of import duty is applicable on any shipments above this ceiling. In the case of integrated circuits (ICs), this ceiling is ECU 5.513 million (or just under $7 million at current exchange rates). The purpose of the tariff preference arrangement, under the umbrella of the United Nations, is for "improving access for developing countries to the markets of the preference-giving countries." Examples of countries benefiting from this arrangement are Colombia, Brazil, Uruguay, Cyprus, Singapore, China, Malaysia and India. Rather interestingly, South Korea continues to be included in this list as a developing country. However, benefits have been temporarily suspended since 1987 until a mutually satisfactory agreement is reached on intellectual property rights between the EC and South Korea.

Those remaining countries that are not covered, and are Contracting Parties of the GATT, and/or have Most-Favored Nation (MFN) trading status with the EC are generally subject to "conventional" rates of duty on products exported to the EC. This covers the overwhelming majority of exports to the EC, and as such, is regarded as the normal rate of duty. Exports from the United States, Canada, and Japan are subject to this rate. It is also this rate of duty which forms the focus of this executive overview.

Any other countries not covered by any of the aforementioned are subject to an "autonomous" rate of duty on products exported to the EC. This rate of duty is generally much higher than the conventional rate. In theory, these are typically countries with no diplomatic relations with the EC, and so represent a negligible volume of potential exports to the EC. Also, in exceptional cases where the autonomous rate is lower than the conventional rate, the autonomous rate will apply. In practice, the autonomous rate is very rarely used.

Another rate of duty is applicable for very small consignments sent from one private individual to another or contained in a traveller's personal luggage up to a ceiling value of ECU 200 (or just under $250 at current exchange rates). This is called the "standard" rate of duty, and is a flat rate of 10 percent regardless of the product type. This rate is mentioned for information only.

Rules of Origin

Rules of origin define the method by which a product's origin is determined. This is important in order to apply the correct rate of duty, bearing in mind the concessions made to certain third countries, as discussed in the previous section. For lower-technology products such as tobacco or steel, this is a relatively trivial exercise, and reference to the European Commission 1968 *Regulation on the Common Definition of the the Concept of the Origin of Goods*[9] is sufficient guidance. This states that the origin of goods is defined as the country "in which the last substantial process or operation, that is economically justified, was performed." Where a number of processes have been performed in different countries, this is interpreted to mean the country where the most value was added to the goods.

In the manufacture of very large scale integrated (VLSI) circuits, various complex processes can occur in several different countries. Assigning a single country of origin to a VLSI semiconductor device can therefore be equally complex, and some clarification of the 1968 rule of origin is needed. The European Commission published an unambiguous rule of origin for the integrated circuit[10] in 1989. This regulation identifed the process of diffusion (or fabrication) as the last substantial operation to determine origin for an IC. In other words, diffusion was determined to be the highest contributor to added value. This results from the ever-increasing complexity of integrated circuits, some of which have as many as 4 million transistors diffused on a piece of silicon smaller than a postage stamp, and therefore the high value of the diffusion process compared with other stages in the manufacture of an IC. Dataquest published its analysis of the regulation at the time of its release.[11]

There are a small number of special exceptions to the IC origin rule, such as the preferential semiconductor origin rule for EFTA countries. Also note that discrete semiconductor devices, such as a single transistor or diode, generally have their origin determined by the assembly or packaging process. This is because assembly is usually the largest contributor to added value for these products.

The United States and Japan generally determine the origin of all types of semiconductor devices, including ICs, by the assembly or packaging process. There was strong opposition by the U.S. Semiconductor Industry Association (SIA) to the EC IC origin rule when it appeared. U.S. manufacturers with IC assembly facilities in the EC, but no diffusion, feared that because their products would no longer be regarded as European in origin they would be subject to greater import duty. This is a misunderstanding of the effect of the IC origin rule, which Table 2 should clarify. In fact, the major benefit of the IC origin rule is in the implemention of antidumping action. This allows the EC to apply antidumping duties dependent on where ICs are diffused rather than where they are assembled.

It is also relevant to discuss the case of the printed circuit board (PCB). The EC definition of a PCB includes Single In-line Memory Modules (SIMMs) and Single In-line Packages (SIPs) that are regarded by many semiconductor manufacturers as semiconductor devices. Indeed, SIMMs and SIPs are very much a standard product in the electronics industry, and are listed beside ICs in suppliers' product catalogs. However, they are not subject to the same rate of import duty as

Table 2
Effect of IC Origin Rule

Manufacturing Stage		Before IC Origin Rule		After IC Origin Rule		Change in Status	
Front-End Diffusion	Back-End Assembly	Origin Status	Duty Payable	Origin Status	Duty Payable	Origin Status	Duty Payable
EC	EC	EC	None	EC	None	No change	No change
EC	Non-EC	Non-EC	On package	EC	On package	Reversed	No change
Non-EC	EC	EC	On die	Non-EC	On die	Reversed	No change
Non-EC	Non-EC	Non-EC	On both	Non-EC	On both	No change	No change

Source: EECA

semiconductor devices. In many cases the rate is significantly lower, as shown in Table 1. Semiconductor memories are increasingly being exported to the EC in this format.

The European Commission considered the introduction of a rule of origin for PCBs. This was primarily to be used in context with antidumping proceedings against certain electronic equipment manufacturers from third countries with assembly operations within the EC.[12] The definition would have been related to the origin of the semiconductor devices mounted upon the PCB. This caused much consternation in the electronics industry, as it was feared this would lead to discrimination against import of SIMMs and SIPs based upon a new origin rule. However, a section of the regulation that dealt with the problem of circumvention of antidumping duty was regarded as inconsistent with GATT, and the PCB origin rule that was to have been employed in this context never appeared. This anticircumvention rule, which the media christened the local content rule, is now effectively defunct.

Dataquest Perspective

The issue of tariff and nontariff barriers to trade is a global one that has been addressed through the various rounds of GATT talks since the end of the World War II. The level of these barriers have been progressively reduced after each round by reciprocal concessions between all GATT contracting parties or countries. The preamble to the present text of the General Agreement on Tariffs and Trade states the goals of the Contracting Parties as follows: "Recognizing that their relations in the field of trade and economic endeavor should be conducted with a view to raising standards of living, ensuring full employment and a large and steadily growing volume of real income and effective demand, developing the full use of resources of the world and expanding the production and exchange of goods, being desirous of contributing to these objectives by entering into reciprocal and mutually advantageous arrangements directed to the substantial reduction of tariffs and other barriers to trade and to the elimination of discriminatory treatment in international commerce ..."

Whereas the EC continues to maintain a semiconductor tariff, it should be borne in mind that other countries also maintain tariff and nontariff barriers in this and other industries. Each country has certain strategic industries it wants to protect against external competition, and in the final analysis, the sum of any concessions made by one country to another should generally be reciprocated in equivalent value after each round of GATT talks. In other words, at the start of each round of talks, each contracting party begins negotiations as an equal. There are no scapegoats. Negotiations are multinational, multi-industrial, multilingual, and multiconcessional. No wonder each round of GATT talks stretches on for many years.

During the Uruguay Round of talks, the EC has offered to reduce its import tariff on integrated circuits by one-third (that is, from 14 percent to 9 percent) if other contracting parties can produce reductions in tariff or nontariff barriers in this or other industries to the same effective value. To date, the EC has not received satisfactory offers of reciprocal concessions.

In the case of Japan, the offer of improved market access would be a valuable concession in return for the EC tariff reduction. Table 3 shows estimated worldwide regional semiconductor market shares by worldwide regional suppliers for calendar year 1991. It is clear from this table that the Japanese semiconductor market

Table 3
Estimated Worldwide Regional Market Shares of Worldwide Regional Suppliers: Preliminary Estimates for 1991 (Percentage)

	Regional Suppliers				
Regional Markets	North America	Japan	Europe	Asia/ Pacific	World Total
North America	68.2	21.7	6.5	3.6	100.0
Japan	10.9	87.8	0.7	0.6	100.0
Europe	41.7	17.7	37.5	3.1	100.0
Asia/Pacific	34.7	37.7	9.9	17.8	100.0
World Total	35.9	49.7	10.1	4.4	100.0

Source: Dataquest (April 1992)

is dominated by Japanese suppliers, which control 87.8 percent of the total business, whereas European suppliers held a minority 0.7 percent share. Although this weak share is mainly a result of nontariff barriers, it should be recognized that market access is a two-edged sword, and European suppliers must also aggressively pursue business in this market.

Table 3 shows that the European semiconductor market is shared more equally than those of the United States and Japan. The market share of U.S. and European suppliers is about 40 percent each, with most of the remaining 20 percent share held by Japanese suppliers. In fact, even in their home market, European suppliers do not hold a majority share. Naturally, there is a fear that if semiconductor import tariffs are reduced or abolished, their domestic share will decline even further. The logic in this argument is that if non-EC suppliers are already competitive against European suppliers—and they clearly are—then any reduction in the tariff can only lead to an increase in their competitiveness with a consequential erosion in European suppliers' market share.

Figure 1 shows estimated worldwide semiconductor market share by worldwide regional suppliers over the last 13 years. European and U.S. market share has almost continuously declined over this period while Japanese and Asia/Pacific share has risen. European suppliers are concerned that their share will decline further, ultimately being overtaken by Asia/Pacific, to become the smallest supply base in the world. The European Commission's *Policy Statement on the Electronics and Information Technology Industries*[13, 14, 15] addresses these concerns and proposes an integrated course of action to reverse this trend.

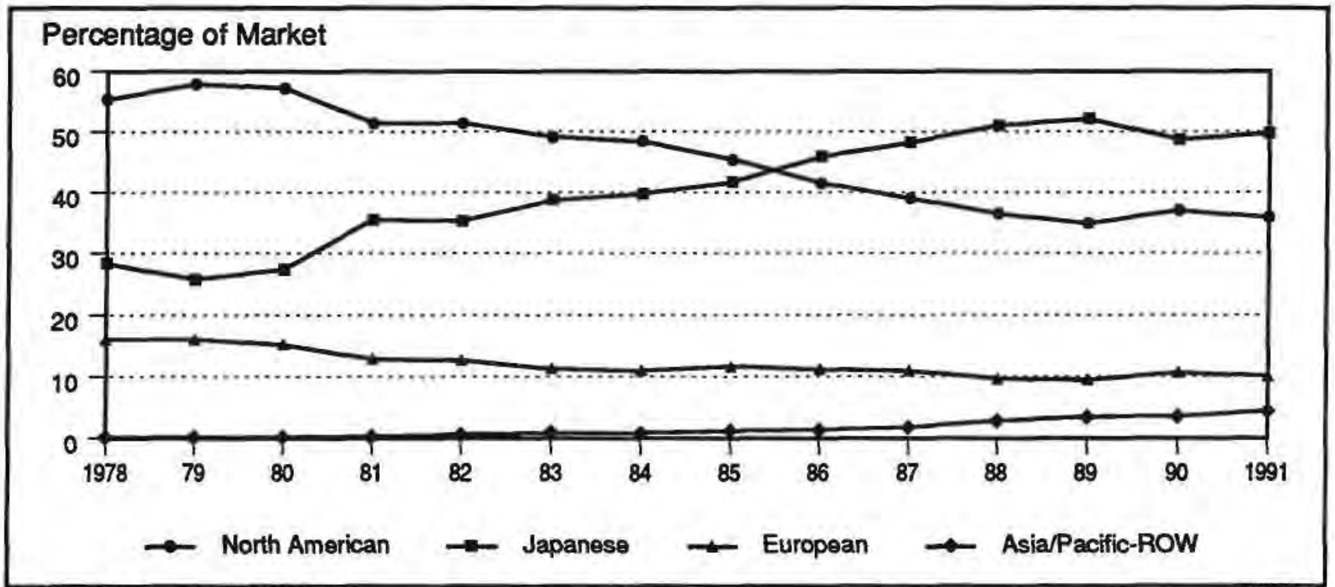
Figure 2 shows estimated European semiconductor market share by worldwide regional suppliers over the same period. Clearly the trend in the worldwide arena is reflected in the European market. As discussed earlier, a reduction in the tariff may accelerate this trend.

While the EC maintains its tariff barrier against third countries, it is interesting to note that prices for commodity ICs in Europe are very competitive against other world markets. For example, according to Dataquest's regional semiconductor pricing database,[16] European prices on standard memory devices are consistently lower than those in Japan, and are very similar to North American prices. This indicates that exporters of semiconductors may only be making marginal profits in the European market, while European manufacturers, with typically higher manufacturing costs, may not be making any profits at all.

Dataquest believes that an immediate reduction in, or the complete abolition of, the semiconductor tariff in the EC could have one of the following results:

- Exporters to the EC could increase their free on board (FOB) prices by the percentage savings made in the semiconductor tariff reduction. This would mean European market prices would remain unchanged, EC semiconductor manufacturers' profit margins (if any) would remain unchanged, and exporters profit margins would increase. This additional profit could be used toward investment in new products, thereby making them more competitive against EC semiconductor manufacturers.

Figure 1
Worldwide Semiconductor Market Share by Supplier Base Region



Source: Dataquest (April 1992)
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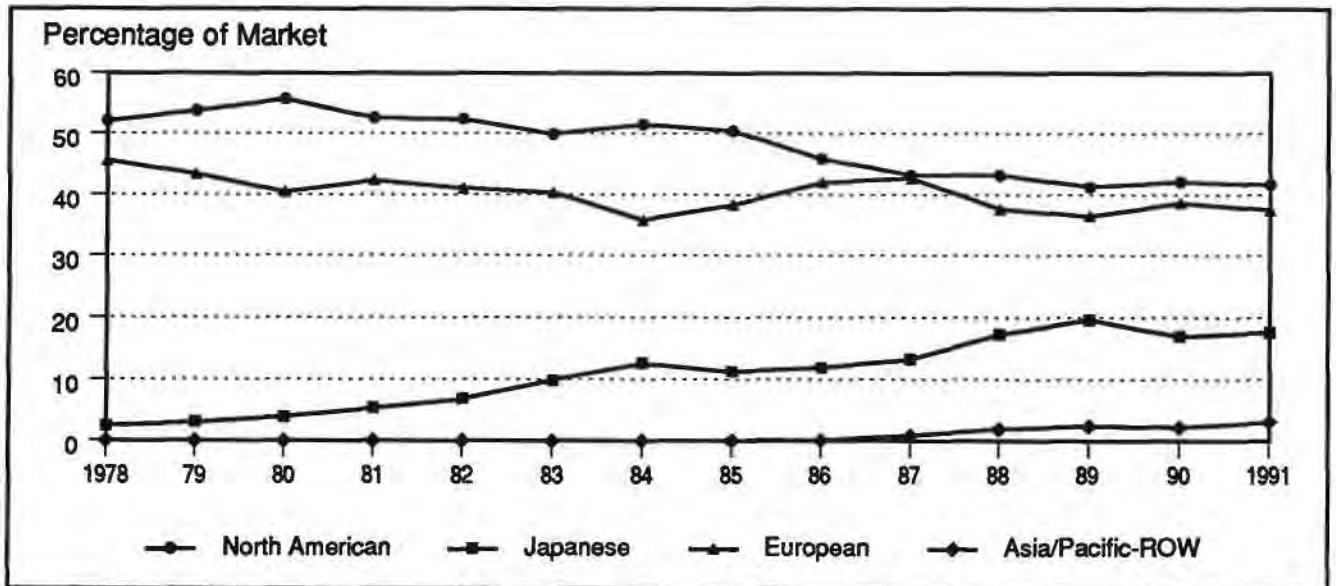
Figure 2
European Semiconductor Market Share by Supplier Base Region



Source: Dataquest (April 1992)
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- Exporters to the EC could maintain their FOB prices at a constant level. This would mean that European market prices would fall, EC semiconductor manufacturers' profit margins (if any) would fall, and exporters profit margins would remain unchanged. This could make the European market the cheapest in the world, and therefore the least profitable. The survival of EC semiconductor manufacturers would therefore depend mainly on export markets, in which they are currently relatively weak.
- Most likely, a combination of the above two extremes would occur, with a bias toward the first. This bias is likely because semiconductor manufacturers throughout the world are having difficulties making profits. As semiconductor prices in the European market are already competitive against other world markets, it is better business sense to make a return on sales than to further lower market prices.

The effect of a significant reduction, or total abolition, of the EC semiconductor tariff on EC semiconductor manufacturers would therefore be substantial. If it were achieved before these manufacturers had properly restructured to benefit from the unification of the EC market, it is likely to be disastrous.

The scenario seen by Dataquest, therefore, is that the EC semiconductor tariff will be reduced in easy hurdles leading into the 21st century through successive rounds of GATT talks. The target of a zero-rated EC semiconductor tariff should be realized within 20 years.

By Byron Harding

(This article is an extract from a larger, comprehensive special report that is available separately on request. This report, entitled *EC Semiconductor Tariffs and Related Issues: a Guide for Suppliers and Buyers,* clarifies the subjects of duty suspension, antidumping duty, anticircumvention, and local content. It also presents the perspectives of the European Commission and the major trade associations representing international semiconductor suppliers and buyers. This article is reprinted with the permission of Dataquest's Semiconductors Europe service.)

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By Byron Harding

Product Analysis

Buyer's Headache: Will IC Prices Stay Low if the Economy Turns Up?

At the start of the second quarter of 1992, some economic measurements signaled recovery in the North American economy—including the electronics and semiconductor sectors. By contrast, the weakening of Japan's economy has caused a call for Japanese government/business action. From this backdrop Table 1 presents key results from Dataquest's recent North American bookings price survey. To answer the question posed in this article's headline—barring an unexpectedly strong upturn—North American users can expect competitive pricing this year for IC products. In this article, Dataquest also uses historic life-cycle price analysis to assess the forward-stage pricing outlook for Intel's soon-to-be-introduced "80586" MPU.

(Please note that the pricing analysis presented in Table 1 correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement Service (SPS) clients on March 16. The survey information was collected by Dataquest's Research Operations. For SPS clients that use the SPS online service, the pricing presented here correlates with the quarterly and long-range price tables dated March 1992 in the SPS online service. The price tables are available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: Second Quarter 1992." For additional product coverage and more detailed product specifications, refer to those sources.)

Memory Trends

An ample supply of DRAMs—4Mb parts as well as 1Mb devices—means competitive pricing in North America during the first half of 1992. However, the recent pickup in IC demand causes some concern regarding the second-half 1992 supply-demand equation. Pricing for fast SRAMs remains competitive in this region. The splash over flash memory continues—causing more aggressive EPROM pricing. Government intervention translates into a flat price profile for North American users of 256K slow SRAMs (see Figure 1).

Dataquest added the following memory ICs to its quarterly survey of North American bookings pricing: 256Kx16 DRAM 70ns SOJ; 512Kx8 DRAM 70ns SOJ; 4Mbx9 SIMM 80ns; and 2Mbx8 ROM. Readers are invited to make other recommendations. For example, some users recommend the inclusion of 2Mb VRAMs. Let us know your recommendations on IC price survey coverage.

Adequate DRAM Capacity—But for How Long?

Table 1 and Figure 1 show a somewhat more aggressive price forecast during 1992 for 4Mb DRAM pricing in North America than prior forecast quarters. The reason is that a wide supplier base of 4Mb DRAMs has aggressively ramped up output since the second half of 1991. Suppliers now battle for 1992 orders. First-tier Japan suppliers say little now regarding fears of excess capacity—which was a publicly professed concern during the second half of last year. The new 1992 market concern is inadequate capacity should North American demand for 4Mb DRAM turn sharply upward this year.

Table 1 shows that contract-volume pricing from OEM buyers for 4Mbx1 DRAM should range from \$11.77 to \$14.05 during the second quarter of 1992. Some spot market orders are more aggressive (mid-\$11 range), with isolated reports of sub-\$10 pricing. By the fourth quarter, the range should run from \$10 to \$13. DRAM lead times remain manageable at a length of from one to eight weeks.

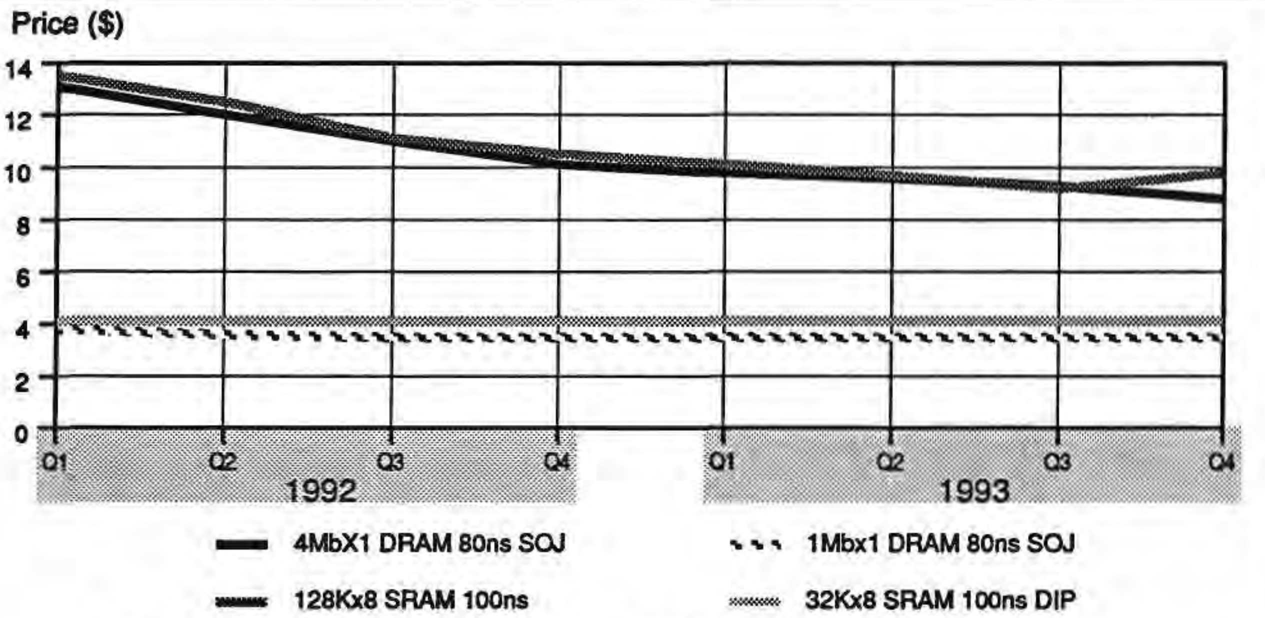
Pricing for 1Mb DRAMs collapsed again on some early 1992 spot market transactions as Japan-based suppliers cleared their books for a fiscal year that ended on March 31, 1992. The survey results shown in Table 1 reveal that the second quarter 1992 contract-volume bookings price for 1Mb DRAM should range from \$3.40 to \$3.85. However, a few users reported several

Table 1
Estimated Semiconductor Pricing and Lead-Time Trends
(North American Bookings, Volume Orders)

	1992 Pricing Trend (Dollars)			
Part	Estimated Second Quarter Price Range ($)	Forecast for Second Quarter ($)	Estimated Fourth Quarter Price Range ($)	Lead Times
1Mbx1 DRAM 80ns, DIP/SOJ	3.40 to 3.85	3.56	3.20 to 3.71	1 to 6 weeks
4Mbx1 DRAM 80ns, SOJ	11.77 to 14.05	12.02	10.00 to 13.05	1 to 8 weeks
256Kx16 DRAM 70ns, SOJ	NA	15.50	12.00 to 14.60	4 to 8 weeks
32Kx8 SRAM 35ns, PDIP	6.00 to 7.20	6.10	5.50 to 7.20	5 to 10 weeks
128Kx8 SRAM	12.75 to 15.50	12.50	11.10 to 15.50	2 to 10 weeks
"80586" (100-1000 units)	NA	NA	$1,250 to $1,300	NA

NA = Not available
Source: Dataquest (April 1992)

Figure 1
Estimated DRAM and Slow SRAM Price Trends (North American Bookings; Contract Volume)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated March 1992.

Source: Dataquest (April 1992)

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opportunities during the first quarter of 1991 to book at a price under $3. By the fourth quarter of 1992, the low-end OEM contract-volume pricing for 1Mb DRAMs should decline to a level of $3.20.

Will DRAM Prices Stay Low If the Demand Heats Up during 1992?

The global network of DRAM suppliers continue to try the impossible: to "manage" the unmanageable DRAM market. For example, in North America—which is in the midst of a presidential election year—some suppliers accuse foreign suppliers of dumping. In turn, most non-U.S.-based suppliers who serve demand in North America welcome any opportunity to charge North American users a higher price for DRAMs than is charged to users in suppliers' home markets or other world regions.

Protectionist sentiment aside, the market supply/demand pattern currently favors buyers, meaning 4Mb DRAM price erosion. Should this equation change dramatically during 1992, then the rate of 4Mb DRAM price decline would moderate somewhat but still continue downward. For example, Table 1 shows that pricing for less familiar 4Mb DRAMs such as the 256Kx16 DRAM 70ns SOJ device remains relatively high. As suppliers move into this market, pricing should drop aggressively this year. At this time, the wide 4Mb DRAM supplier base can handle expanding market demand—and continue to cut pricing in the process.

Key an Eye on 1Mb Slow SRAM Price Trends

Users concerned about the supply and pricing for 4Mb DRAMs should monitor 1Mb slow SRAM trends via Dataquest's Online Monday service. Japan-based suppliers can and—with a lag of one or two quarters—do switch capacity between these devices in line with demand patterns. During most of 1991, pricing for 1Mb slow SRAM was below the 4Mb DRAM price line. Demand for 4Mb DRAM during the first half of 1991 was unimpressive, so Japan-based suppliers focused more on the 1Mb slow SRAM—causing a lower price.

With 4Mb DRAM demand picking up, Japan-based suppliers are focusing more capacity on this part—and as shown in Figure 1, 4Mb DRAM pricing now trends beneath the 1Mb slow SRAM curve.

Changes in the price relation shown in Figure 1—and/or product lead times—typically mean changes in the DRAM marketplace. Dataquest's Online Monday service can provide early signals on this critical market dynamic.

DRAM Alliances: The Fifth Assumption to the Post-1992 Scenario

In a recent report we stated four key assumptions behind Dataquest's long-range DRAM price forecasts (see "Manufacturing Capacity and Cost Will Govern Long-Range DRAM Price Trends," in the February 17, 1992 Semiconductor Procurement *Dataquest Perspective*).

Those assumptions remain consistent and are as follows:

- Users can expect continued DRAM cost reductions because of suppliers' manufacturing technology improvements.
- DRAM capacity should adequately meet long-term demand.
- Non-Japanese Asian suppliers will increase DRAM market share.
- The legal jurisdiction of intellectual property law will expand across the globe and be more aggressively enforced at the local level.

Our fifth assumption should also be explicitly identified. In his recent book *Managing for the Future*, Peter F. Drucker identified "alliances" as a key factor that will shape the business environment and strategies during the rest of this decade. During the research process by which Dataquest articulated the four assumptions above, our worldwide network of DRAM analysts ranked key alliances involving DRAM suppliers as the fifth-most-significant assumption behind our long-range price forecast. In fact, Dataquest's analysts in London and Tokyo gave a top ranking to DRAM alliances as a long-term influence on worldwide and regional DRAM pricing trends.

(For a full listing and report on DRAM alliances, see "Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest," in the December 23, 1991 Semiconductor Procurement *Dataquest Perspective*).

Microprocessor Trends

Intel's ever-widening and endless battle to maintain its 80x86 hegemony continues to capture market spotlight. Figure 2 shows the price forecast for a host of x86 devices.

Reports of the impending legal/marketing death of Advanced Micro Devices at the hands of Intel have proved greatly exaggerated: AMD just reported record earnings and profits. Shipments of AMD's 386 device might have peaked, however, during the first quarter of 1992 at a level of nearly 1 million units.

Less familiar names wait in the wings to enter the 80486 market—Cyrix (United States) soon and UMC (Taiwan) later—while Intel's legal team waits in the foyers of the nearest state and U.S. federal courts. In turn, Texas Instruments backs Cyrix and Chips & Technologies with a powerful combination of manufacturing and legal strength in the battle to take market share from Intel—with TI's strategy apparently now leaning more strongly to Cyrix's 80486-type part.

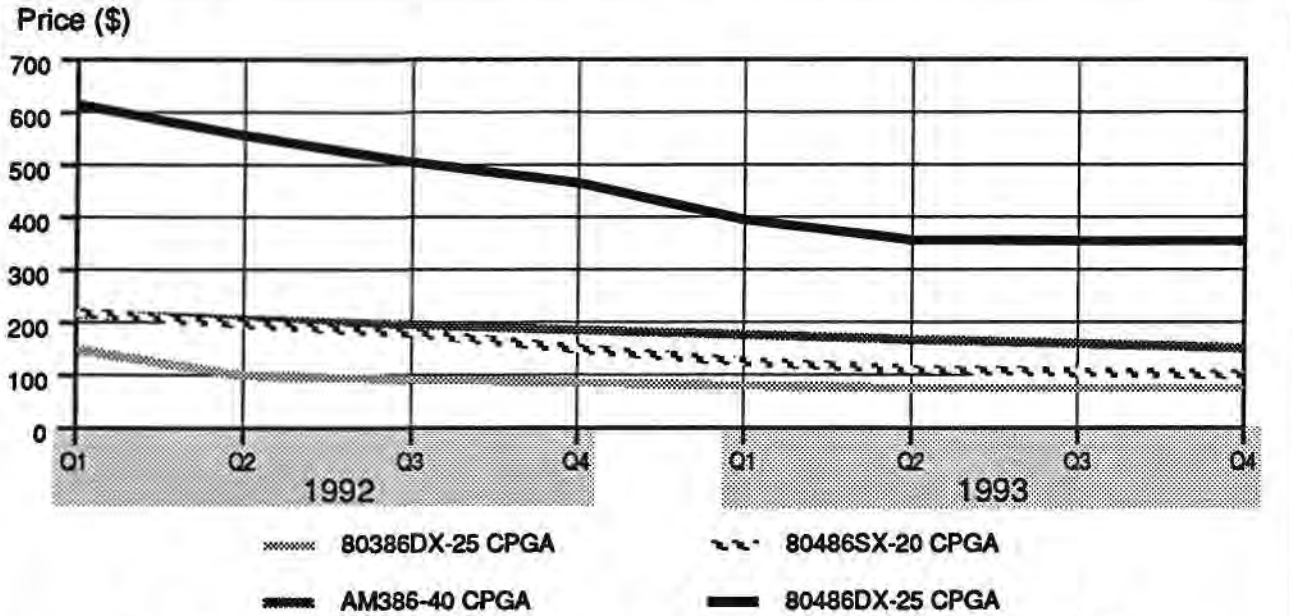
Meanwhile, Motorola—again Dataquest's "Semiconductor Supplier of the Year"—continues to pump out 68x00 devices in virtually whatever package, speed, or volume the market demands at attractive prices. Motorola makes steady R&D progress at the billion-dollar design center on the Apple-IBM-Motorola PowerPC IC, a RISC processor.

Synchronization with Intel's Migration Plan: Impossible for System Users?

The assumptions behind the Intel MPU price forecasts have been consistently stated in prior reports. The key assumption—that Intel will most favorably support users who coordinate system life cycles in line with Intel's migration schedule to higher-priced parts—manifests itself again with Intel's first-quarter 1992 introduction of the 80486DX2 (25/50-MHz) product. The product is priced—voila!—at a 30 percent premium over the 80486DX-25 device. The main point: Users must be prepared to migrate in line with Intel's product migration strategy, or else risk suffering severe market consequences.

Resistance to this trend or consternation by systems manufacturers who use Intel parts is understandable. In fact, even users at systems manufacturers who are willing to timely migrate with Intel are starting to lose their ability to do so. Why? The processor enhancement slot (PES)

Figure 2
1992 x86 Price Trends (North American Bookings; Volume: 1,000-5,000)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated March 1992.

Source: Dataquest (April 1992)

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in the 80486 device—as shown with the introduction of the 80486DX2—means the ultimate end user can now upgrade an old system and entirely bypass the original systems manufacturers.

For Intel, the migration strategy has become even more critical to its long-term success now that the 386 monopoly has been broken and the 80486 stronghold is being threatened. Some Intel customers, in fact, now clamor for a more rapid rate of new product introductions and upward system migration in order to thwart competitors who use AMD parts.

Intel: A Continuing Distaste for Pricing Competition

As stated in prior reports, Dataquest still expects over the long term that Intel will ignore to the best of its ability competitors' pricing for similar products. However, Intel's short-term strategy calls for response to competitors' pricing. Buyers report that AMD on some orders severely slashes pricing for AM386 parts. In turn, Intel now prices the 80386DX-25 device at $99 for orders of 1,000 pieces or more effective this second quarter.

Nevertheless, no final legal decision has yet been rendered in the AMD-Intel series of litigation. Ultimate legal vindication for Intel would mean a return to sole-sourced pricing. Intel still strives to avoid direct pricing wars with 80386/80486 competitors. For example, having lowered the 80386DX price curve, future decreases in this product's price should be manageable and incremental—with Intel focusing its real effort on migrating users to the higher-priced 80486 and 80586 families. Intel will avoid low-ball pricing for the 80386DX, which is defined here as a price near the estimated $35 to $40 cost of manufacture. Instead, as will be discussed, Intel more likely will exert pressure on suppliers of 386DX MPUs by cutting the price of Intel's higher-priced 80486SX device—remaining true to the migration strategy in the process.

A Turning Point for the 80486 Price Strategy?

With sub-$100 pricing for Intel's 80386DX-25 now hitting world markets, users can anticipate more competitive pricing for the 80486 family during 1992. A related issue is the timing of prospective 80486 price cuts. For example, users can expect that the price curve for the 80486DX-25 and 80486DX-33 devices will eventually take a step-function down—but likely not until after the introduction of the 80586 chip and/or a competitor's successful 80486DX market entry, which means the third or fourth quarters of this year. By contrast, pricing for the 80486DX-50-MHz could plunge sooner but would stay above the 80486DX-25/-33 price level.

At press time, Cyrix-TI were apparently on the verge of entering the 486SX market. Pricing for 80486SX devices could soon make a step-function down should Intel decide to wield a 80486SX price cut as a double-edge sword that would hit competitors below—in the 80386DX segment—as well as above—the 80486SX/DX arena. In effect, Intel appears poised during 1992 to collapse the 80486SX price curve onto the 80386DX curve.

MPU Life-Cycle Pricing

Multisourcing in the 386/486 arena means a lot of work during 1992 for purchasers and component engineers at systems manufacturers. Some SPS clients have requested a structured framework—something different and independent from this year's weekly or daily flurry of new product/price announcements—as they make the transition from today's 80386/80486 world to tomorrow's 80586 world.

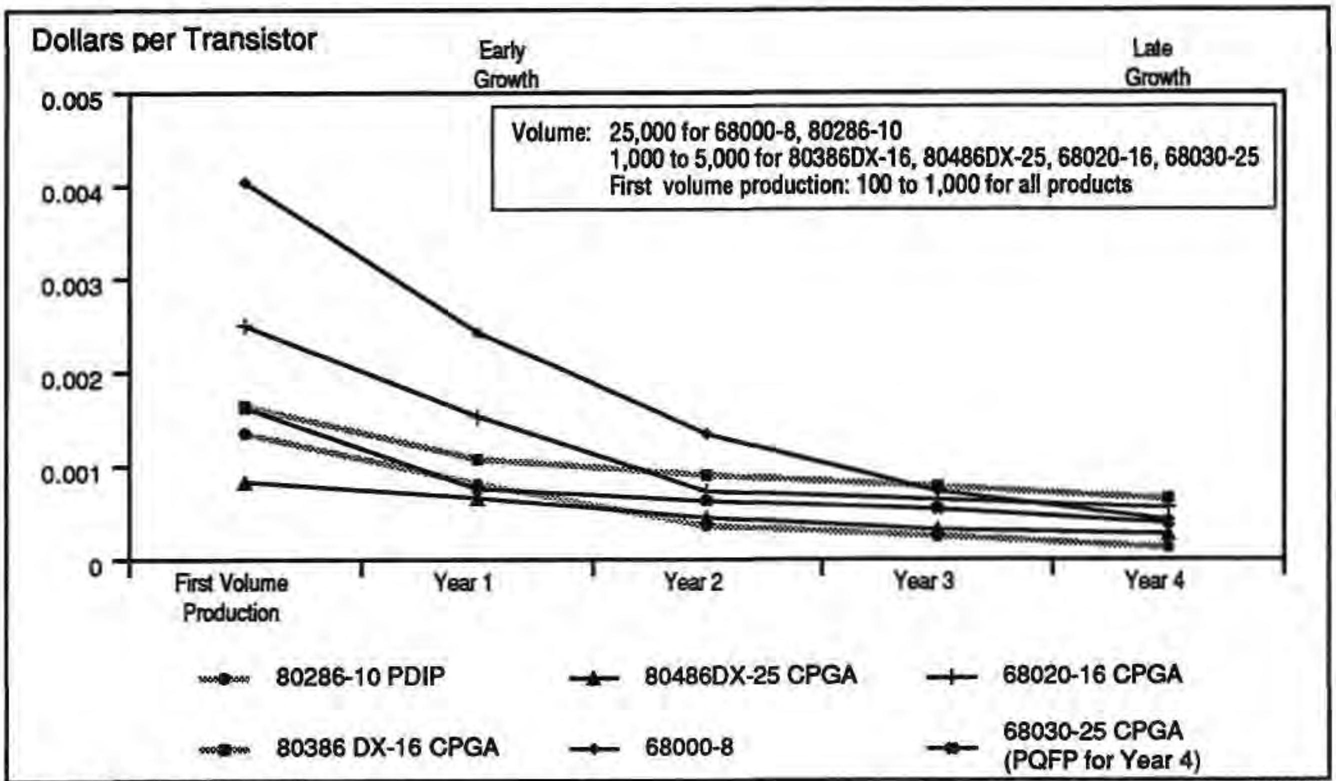
Toward this objective, Figure 3 shows pricing measured in dollar-per-transistor for the early, or forward, stages of the product life cycle for 80286-10, 80386DX-16, and 80486DX-25 devices and 68000-8, 68020-16, and 68030-25 parts.

Figure 4 is based on the information in Figure 3 and shows the rate-of-price decline for the 80x86 and 680x0 devices relative to the family's prior generation part over the life cycle.

A Rule of History

Historians say that those who ignore history are doomed to repeat it. The rates of decline shown in Figure 4 are quite similar for the forward life-cycle stages regarding 80486DX-25 pricing vis-a-vis the prior-generation 80386DX-16 product; 68020-16 pricing vis-a-vis the 68000-8 device; and 68030-25 pricing versus the 68020-16 part. Dataquest believes that these rates of decline

Figure 3
North American MPU Pricing by Life-Cycle Stage (Dollars per Transistor)



Source: Dataquest (April 1992)

reflect typical historic MPU price curves that—combined with a statement of assumptions—can serve as the basis for near-term price projections for next-generation devices such as the soon-to-be-introduced "80586" part.

An exception in Figure 4—the 80386DX-16 curve—can be explained. First, Intel—as the then sole source for this IC—refused to engage in a forward pricing battle during the 1986-1987 period with competitors such as AMD, even as a pricing plunged in the multisourced 80286 marketplace. Next, Intel's eventual strategy was to introduce a different part during 1988—the 80386SX device—as a would-be 80286 price/performance killer.

Don't Ignore These Historic Price Curves

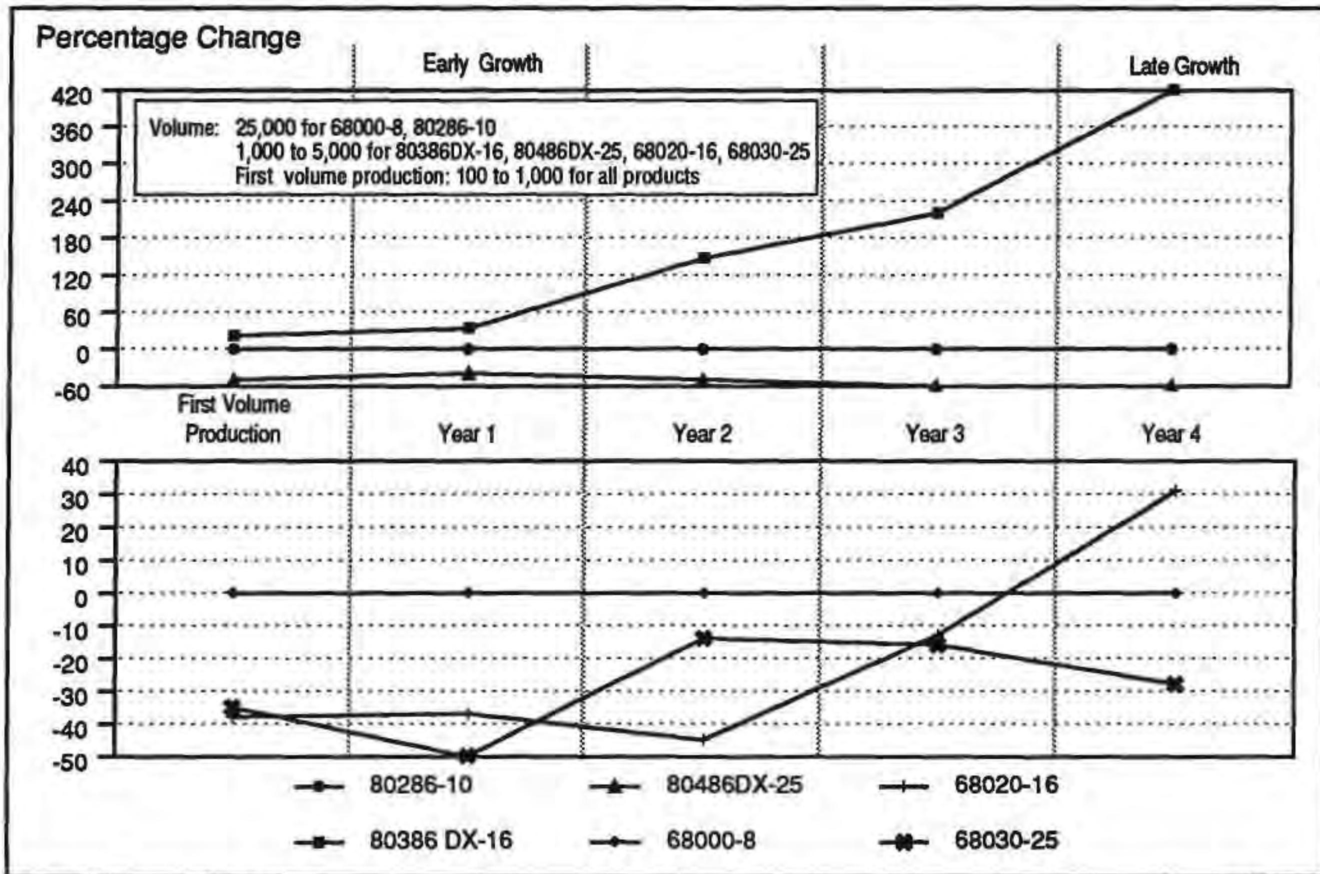
The historic price curves shown in Figures 3 and 4 may be seen in the market again—in the form of the 80586 price curve. Table 2 uses the life-cycle pricing information contained in these figures to generate a projection of 80586 prices for the early stages of the product's life cycle—which should start during the second half of 1992. The key assumptions are stated in the table.

Dataquest Perspective

With effects of the economic recession still being felt, IC pricing remains competitive in North America at the start of the second quarter of 1992. The North American electronics market appears to be turning upward, however, which for purchasing teams leads to the question in the title of this article. For this year, manufacturing strength should separate the supply-base winners from the losers—with ability to compete on price a key element of the success equation.

In the DRAM marketplace, adequate capacity currently exists to meet demand and should continue so for the rest of this year. For example, North American pricing for 4Mb DRAMs should continue to erode—with a likely year-end 1992 price of $10 or less. First-tier Japan-based companies do not appear united in terms of a market management strategy. North American and Korean suppliers are able and willing to

Figure 4
MPU Pricing: Rate of Decline at Forward Stages in Life Cycle Relative to Prior Generation
(80286-10 and 68000-8 = Base of 0)



Source: Dataquest (April 1992)

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compete on price in North America in order to keep or expand market share.

In the microprocessor arena, AMD shipped nearly 1 million units of the AM386 during the first quarter and plans to expand output at the fab in Austin, Texas. Intel adheres to a migration strategy—which is accelerating in pace—while responding with some defensive price cuts. The TI-Cyrix-Chips & Technologies movement to the 80486 marketplace indicates a lowering—perhaps abruptly—of the 80486SX or 80486DX price curves during this year.

In his landmark book *The Structure of Scientific Revolutions,* Thomas Kuhn asserted that shifts in how people view the world—which he called paradigm shifts—can be extremely difficult to make at the time of the shift, but extraordinarily

Table 2
Estimated 80586 Pricing by Product Life Cycle Stage

Stage:	Price ($)
Introduction (Second Half 1992) First Volume Production*	1,268
Early Growth (1993) Price at First Full Year of Production**	788
Growth (1994) Price at Second Full Year of Production**	694

Assumptions: Specs: 3 million transistors; 50 MHz; CPGA (not multichip module) Intel's strategy: conforms more so with historic forward-pricing strategy associated with competitive market environment and less so with monopoly-pricing power. Life cycle: starts by fourth quarter of 1992
*Volume of 100-1,000 units
**Volume of 1,000-5,000 units
Source: Dataquest (April 1992)

easy to understand later with the benefit of hindsight. Intel has had a monopolist's view in the 80386/80486 marketplace for the past half decade. With litigation continuing, the Intel mind-set has not really changed and the monopolist viewpoint still prevails. The soon-to-be-announced "80586" device could mark a juncture for Intel. As the MPU life-cycle pricing history shows, Intel can choose either to view the market as a sole-sourced CISC world—and price the "80586" in its forward stage like the 80386DX at this stage—or else as a multisourced RISC/CISC world with more competitive "80586" pricing akin to historic forward-stage pricing.

By Ronald Bohn

Semiconductor Capacity: How Much Is Too Much?

The semiconductor industry is one of the most capital-intensive in the world. Currently, 18 percent of semiconductor revenue is spent on equipment and facilities. To meet these huge costs, semiconductor companies do what people have always done when the burden gets too heavy: they get help. They are getting help from each other through joint ventures, and from governments in the form of financial incentives and lowered capital costs. The result of all this help is that there may be too much capacity today, particularly in DRAMs.

The semiconductor industry is well on the road to spending $1 billion for a new fab. Intel already has a capital spending budget of more than $900 million per year. Motorola spent more than $600 million on its newest fab at Oak Hill, Texas, which opened in 1991. Sharp reportedly will spend $800 million on a new fab to make flash memory for Intel.

These are staggering sums. On top of this, semiconductor companies also spend about 14 percent of their revenue on R&D. In other words, semiconductor companies each year must spend 33 percent—or one-third—of their revenue on technology development and capital.

No single semiconductor company can carry these costs alone. Intel, one of the industry's most profitable companies, recently announced the formation of a long-term partnership to jointly develop and manufacture future generations of flash memory with Sharp. Why has Intel participated in this partnership? Because it does not have the resources to simultaneously develop and capitalize its flash memory and microprocessor lines.

Even giants such as IBM, Siemens, AT&T, and NEC cannot afford to go it alone. IBM now has partnered with Siemens to produce 16Mb DRAMs, and AT&T and NEC have a joint development/production agreement to develop and produce 0.5-micron ASICs.

In addition to helping each other through joint development and production agreements, semiconductor companies have not been bashful about seeking and getting governmental help to build their fabs. The central government of Italy, as well as the local governments of that country, have provided financial inducements to both Texas Instruments and SGS-Thomson to build fabs in Italy. Ireland has provided Intel with financial incentives to locate its newest fab in Ireland. The Singapore Development Agency is a major backer of Tech Semiconductor, a joint venture involving Canon, Hewlett-Packard, the Singapore Development Agency, and Texas Instruments.

The list goes on and includes many local governments. Most recently, the People's Republic of China (PRC) announced a joint venture with NEC. We believe that both Motorola and VLSI Technology are also negotiating with the PRC to build fabs in China to support its potentially vast market for electronics.

Why are so many players investing so much money in semiconductors? Governments offer financial incentives to attract technology and jobs. Semiconductor companies invest so many millions because, ultimately, they hope to turn a profit.

Dataquest Perspective

But with so many players and so much capacity, how likely is it that a profit will be turned? The answer to that question depends on the balance of supply and demand for individual products. Currently, we believe that there is an overcapacity of facilities capable of making advanced DRAMs.

Dataquest estimates that demand for 4Mb DRAMs and 16Mb DRAMs in 1992 will be 415 million units and that this demand will rise to 782 million units in 1993. The 415 million units are equivalent to 12 DRAM fabs with a monthly capacity of 20,000 6-inch wafers starts (assuming reasonable, state-of-the-art yields and factory use rates). Currently 50 fabs are capable of producing either 4Mb DRAMs or 16Mb DRAMs—a ratio of actual fabs to needed fabs of 4.2 to 1.

We do note, however, that because some of these fabs are capable of producing SRAMs, ASICs, or other submicron products, the ratio of 4.2 to 1 is somewhat overstated. Still, even assuming that half the capacity of these existing DRAM-capable fabs is devoted to non-DRAM products, the ratio of actual DRAM fab capacity to DRAM fab demand is still 2.1 to 1.

Because of this overcapacity, some DRAM manufacturers have scaled back or delayed DRAM capacity additions. For example, Japanese companies had originally planned to have a total of 11 200mm fabs with a combined monthly capacity of 57,000 wafers online by the end of 1992. However, production start dates have been pushed back, and now only 7 facilities will be online by the end of the year. These facilities will have a monthly combined capacity of 22,000 wafers—a mere 38 percent of what had been originally planned.

However, as Japanese companies cut back their capacity expansion plans, South Korean companies are going ahead with additional 4Mb DRAM and 16Mb DRAM fabs. South Korean companies will spend $1.5 billion for DRAM capacity in 1992.

Thus, all this help may be too much help. Even with joint ventures and governments sharing the costs of new fabs, the bottom-line question—is it profitable?—will be answered in the negative, at least for the short term. Companies and governments have increased the number of DRAM fabs beyond the current demand for DRAM fabs. DRAM suppliers that also have broad product lines may be able to switch some excess capacity into production for other (and perhaps higher-margin) leading-edge devices. However, companies that do not have broad product lines will have huge investments producing submicron profits in addition to submicron semiconductor devices.

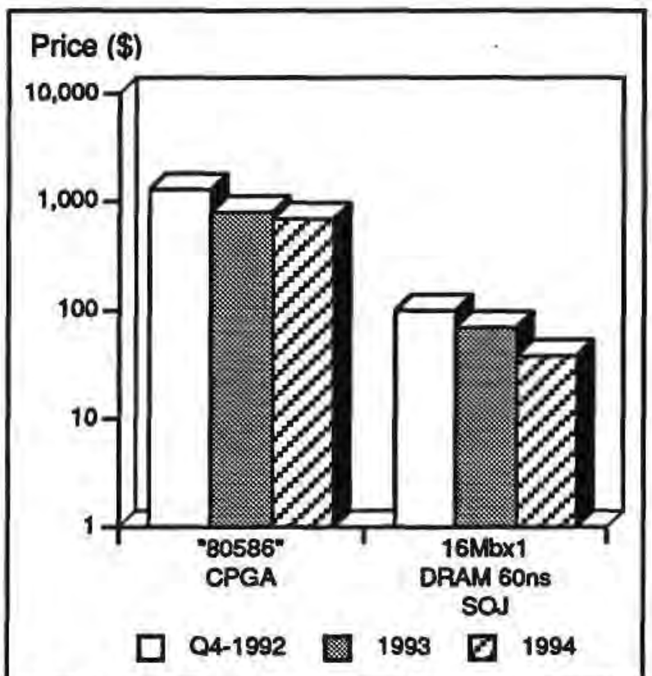
By George Burns

News and Views

Procurement Pop

Figure 1 shows Dataquest's estimate for the North American bookings price for two key components during the forward stages of their life cycle: Intel's "80586" microprocessor and 16Mbx1 DRAM 60ns SOJ. A host of suppliers have been sampling the 16Mb DRAM as they move toward early volume production and other suppliers approach market entry. The 16Mb DRAM crossover should occur in 1994. The "80586" should move into early volume production by year-end. Eventually this part should be available in a multichip module. (For more detailed analysis of the "80586" price outlook, see "Buyer's Headache: Will IC Prices Stay Low if the Economy Turns Up?" elsewhere in this issue).

Figure 1
Forward-Stage Pricing: "80586" and 16Mb DRAM (North American Bookings)



Source: Dataquest (April 1992) G2000607

Inquiry of the Month

Q. What are the historical Quarterly Price Trends for the 64K 256K, 1Mb, and 4Mb DRAMs from 1985 to the present?

A. See Table 1.

Table 1
Historical DRAM Price Estimates (North American Bookings Price in U.S.$; Volume = 100,000-Plus Units)

64K DRAM Year	Q1	Q2	Q3	Q4
1985	1.70	1.40	1.00	1.00
1986	1.10	1.05	1.05	0.90
1987	0.90	0.92	1.00	1.15
1988	2.00	2.10	2.20	2.20
1989	2.20	2.20	2.00	1.89
1990	1.65	1.55	1.52	1.37
1991	NA	NA	NA	NA
256K DRAM	Q1	Q2	Q3	Q4
1985	9.00	7.00	2.80	2.20
1986	2.25	2.30	2.85	2.85
1987	2.15	2.37	2.50	2.56
1988	2.90	3.00	3.35	3.50
1989	3.71	3.78	3.40	2.25
1990	2.15	2.00	1.85	1.73
1991	1.77	1.77	1.77	1.68
1992	1.60			
1Mb DRAM	Q1	Q2	Q3	Q4
1985	NA	NA	160.00	125.00
1986	50.00	34.00	52.00	25.00
1987	20.00	18.00	15.50	16.50
1988	18.00	18.50	19.00	17.80
1989	17.75	16.22	12.50	10.10
1990	7.25	6.37	5.99	4.63
1991	4.55	4.50	4.33	4.18
1992	3.80			
4Mb DRAM	Q1	Q2	Q3	Q4
1985	NA	NA	NA	NA
1986	NA	NA	NA	NA
1987	NA	NA	NA	NA
1988	NA	NA	NA	NA
1989	360.00	250.00	159.00	95.00
1990	53.51	37.50	31.00	23.43
1991	19.99	17.55	16.00	14.75
1992	13.13			

Source: Dataquest (April 1992)

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- May Procurement Pulse
- Microprocessor update
- Cost model update

For More Information . . .

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9203 March 23, 1992

In This Issue...

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Table 1
Regional Pricing Update

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.17	0.14	0.17	0.18	0.14
74AC138	0.31	0.34	0.25	0.27	0.30	0.21
74AC244	0.45	0.45	0.34	0.39	0.42	0.36
74AC74	0.24	0.22	0.19	0.21	0.22	0.17
Lead Time (Weeks)	4	3	4	4	5	5
4F00	0.11	0.12	0.09	0.10	0.10	0.09
4F138	0.15	0.20	0.16	0.17	0.19	0.14
4F244	0.22	0.28	0.21	0.25	0.27	0.23
4F74	0.12	0.13	0.12	0.13	0.13	0.11
Lead Time (Weeks)	4	3	4	4	5	5
7805-TO92	0.11	0.18	0.11	0.13	0.13	0.11
CODEC-FLTR 1	1.83	2.35	2.50	2.10	2.00	1.35
CODEC-FLTR 2	4.25	4.61	5.00	4.75	5.00	NA
Lead Time (Weeks)	6	3	6	3	4	NA
DRAM 1Mbx1-8	3.45	3.80	3.65	3.90	4.00	3.60
DRAM 1Mbx9-8	35.50	40.44	35.00	38.75	39.00	35.50
DRAM 256Kx1-8	1.10	1.61	1.58	1.35	1.30	1.10
DRAM 256Kx4-8	3.45	3.84	3.65	3.90	4.00	3.60
DRAM 4Mbx1-8	13.25	12.98	14.85	15.00	16.00	12.70
EPROM 1Mb 170ns	3.63	4.26	3.20	3.95	3.90	2.90
EPROM 2Mb 170ns	7.35	7.86	6.10	7.85	7.90	5.70
SRAM 1MB 128KX8	13.40	13.56	10.00	16.55	15.30	NA
SRAM 256K 32Kx8	3.80	3.99	3.50	4.08	4.00	3.30
SRAM 64K 8Kx8	1.95	1.59	1.75	1.55	1.40	1.30
Lead Time (Weeks)	4	4	4	4	7	4
68020-16	27.50	37.61	26.00	42.50	36.10	NA
80286-16	9.50	11.23	10.00	11.75	11.50	9.70
80386DX-25	140.00	152.60	144.00	172.50	160.00	98.00
80386SX-16	46.00	58.10	53.00	54.00	55.10	48.00
R3000-25	120.00	137.88	110.00	NA	NA	NA
Lead Time (Weeks)	4	7	4	NA	NA	NA

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (March 1992)

Market Analysis

March Procurement Pulse: Balance Pervades Market As Orders, Lead Times, and Inventories Hold Steady

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to semiconductor users.

Semiconductor Order Index Slides Slightly

The semiconductor order level declined by 12.3 percent from last month's indexed level (see Figure 1) primarily because of some respondents' cutting back to keep very lean inventory levels intact. The overall six-month outlook for equipment sales remains a positive 7.5 percent relative to last month's 7.6 percent forecast. Computer industry respondents expect an 8.2 percent rise in sales compared with last month's 8.0 percent forecast. The above-average growth areas are in the higher-end systems and lower-priced value-added newer systems where price is not the differentiator. Availability remains very good yet the rate of price decline has dropped to 1.8 percent from last month's negative 2.6 percent and January's negative 3.3 percent. The overall flattening of prices is also being seen in Dataquest's *DQ Monday Report* research and is because of the balancing of overall supply with demand levels of many key commodities. Capacity levels of suppliers are far from being maximized. If sustained increased demand occurs, more than adequate supplies will come online, providing continued price declines and ready availability for users.

Lead Times Stay Steady at 9.1 Weeks

As seen in Figure 2, the flat lead-time situation continues with an incremental half-day increase noted since last month's survey. This lead time increase, combined with the flattening of prices,

Figure 1
Averaged Monthly Semiconductor Orders

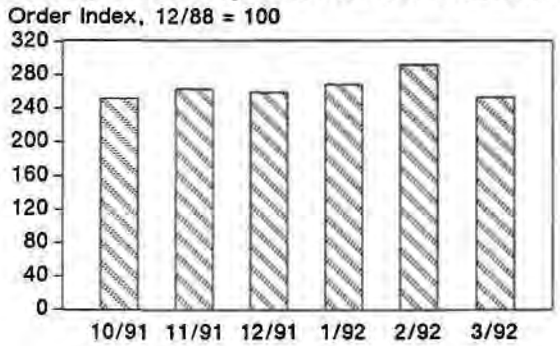


Figure 2
Averaged Semiconductor Lead Times

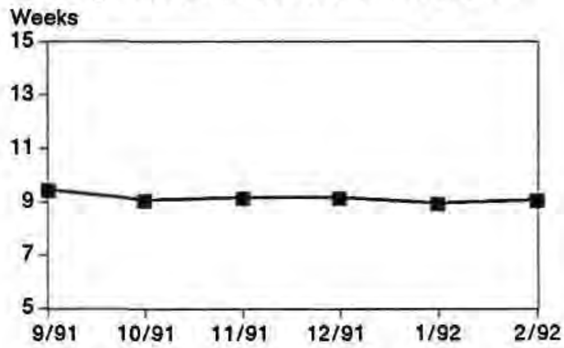


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

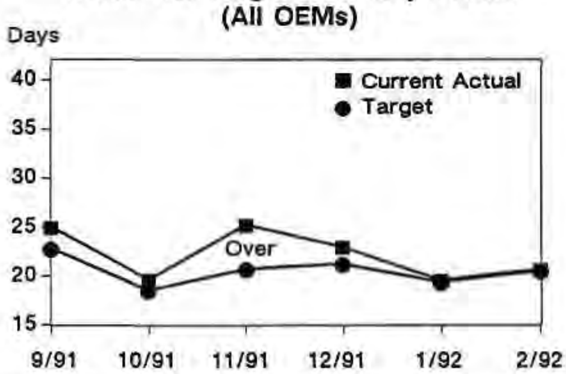
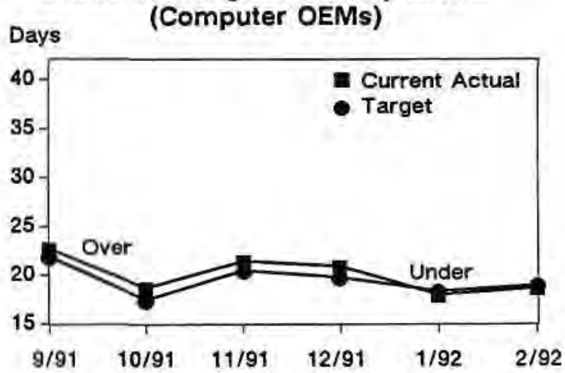


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (March 1992)

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could be seen as the beginning of the long-awaited turnaround in business. The overall demand situation remains relatively unchanged, however, with above-average sales going to isolated pockets of high-end, ease-of-use systems while applications that use embedded semiconductors are not seeing much improvement. The majority of respondents are not having any problems with product availability, yet there still are concerns with the availability of x9 memory modules and some mature gate array sourcing. The overall issues of cost reduction and end-of-life buys still remains predominant with many of the respondents.

Inventories at Historical Balancing Point; Computers Again under Target!

Figure 4 highlights the second month running now that the computer segment's actual inventories were below the average target level. The overall inventory balance also continued with the overall target and actual levels (respectively 20.6 and 20.7 days) relatively flat with last month's 19.4- and 19.6-day target and actual levels (see Figure 3). The focus on cost reduction continues, with inventories acting as the litmus test for many companies to tangibly gauge how well matters are under control. As mentioned in past articles, low inventory levels go hand in hand with good communication, both within companies and between supplier and user. The current unparalleled level of inventory management reflects basic changes in forecasting methods helped by a relatively slow economy. The communications improvements gained over the past years will be tested once the aggregate market returns to an expansion mode—of which we currently see some areas improving.

Dataquest Perspective

Although order levels of semiconductors are expected to slip this month, the overall basics of cost control and solid communications links will keep inventories in line with end-use sales levels. The current situation can be compared to the beginning of a horse race: the horses are waiting for the gates to open while maintaining composure so as not to stumble out early or have a slow start by being unaware when the gate opens. The steady progression of cost control measures and forecast improvements is keeping companies ready for any improvement in business activity. The current balanced situation took a long time to achieve and requires constant monitoring to maintain. Business improvements adequately communicated in advance will work their way through the current market relatively well.

By Mark Giudici

Inventory Control Optimization: Don't Overlook This Competitive Tool in a Market Turnaround

The "Total Cost" or "Cost of Ownership" concept that emphasizes looking at all the variables of material cost (such as quality, adherence to delivery schedules, customer support, and price) often employs stringent inventory control measures in conjunction with high quality to keep material costs manageable. This article examines where inventory levels have come from and where they are now relative to the past three years of business activity, and how the ongoing trend of inventory control of semiconductors will affect business patterns.

Historically, the Trend Is Good

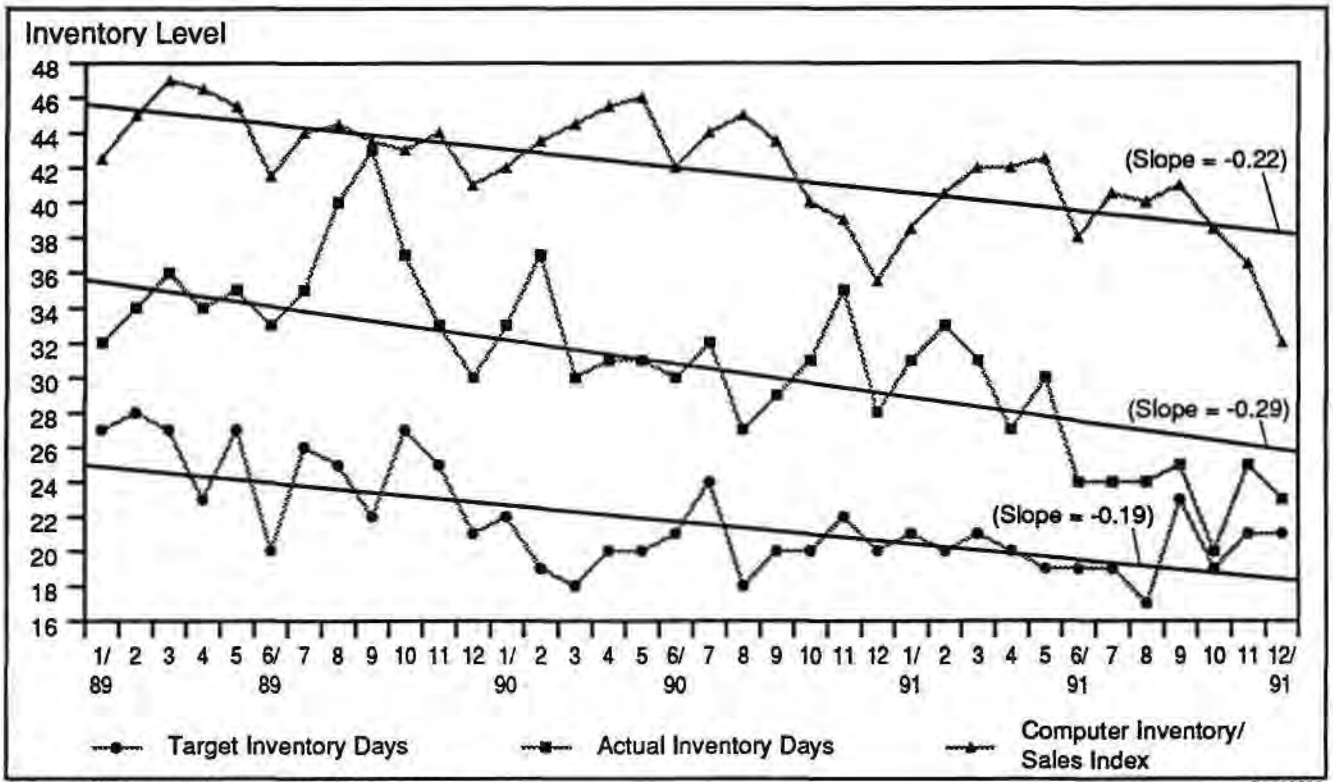
Figure 1 highlights the close correlation of inventory levels at both the component semiconductor (Dataquest Procurement Pulse) and finished goods (Department of Commerce, or DOC, Computers and Office Equipment) level over the past three years. The targeted and actual data for semiconductor inventory levels are an aggregate that Dataquest has gathered monthly from system company procurement managers. The computer inventory level is an index based upon the ratio of the dollar level of sales to the dollar level of inventory over the past three years taken from the DOC. The slope correlation of the actual semiconductor (negative 0.29) and finished goods (negative 0.22) inventory reductions in days cements the notion that real inventory gains have been made during the last three years of lackluster growth.

What Are the Options?

The question many in the industry are asking is: What will happen to inventory levels (and the corresponding cost savings) once system shipments rise substantially? Dataquest sees three scenarios that could develop as the system industry rebounds from the current doldrums:

- 1. Inventory dollar levels remain at current low levels dependent on good user forecasting

Figure 1
Semiconductor Inventory Levels, Overall Electrical Sample



Source: Dataquest, Department of Commerce G2000535

- 2. Inventory dollar levels decline further, similar to the Just-In-Time kanban delivery system found in Japan (again extremely dependent on forecasting accuracy and excellent communication between supplier and user)
- 3. Inventory dollar levels float with shipment rates, providing a cushion against forecasting or inventory control shortcomings

Option 1 would result in a reduction in days of inventory on hand while the actual dollar level remained static. Option 2 results in a reduction of both days of inventory and dollars on hand, while option 3 results in rising levels of inventory dollars on hand but a flat level of inventory days.

Table 1 shows how going from one level of sales to another can directly impact inventory (cost) levels. Companies A, B, and C have system sales of $100 million per year each, which translates into about $10 million of semiconductors purchased for that year. Assuming 250 working days in a year, that $10 million of annual semiconductor use implies $40,000 of semiconductors used daily on average. As we will see, when sales increase to $125 million, that same ratio of semiconductor use results in $50,000 of semiconductors used daily.

If Company A currently has 26 days of semiconductor inventory on hand, that is equivalent to $1.04 million of inventory cost on the books. If sales rise for Company A to $125 million and the directive is to keep the inventory levels unchanged at about $1 million, the actual level of inventory days will naturally decline to 21 days (refer to Table 1 for actual trend).

If Company B saw an equal rise in sales from $100 million to $125 million but the directive was to cut the amount of inventory dollars on hand, the resulting cut in inventory days would be dramatic—inventory levels going from $1.04 million to $720,000 drops the inventory days on hand of 26 days of inventory at $100 million to 14 days at $125 million in sales.

If Company C saw an equivalent 20 percent rise in sales from $100 million and orders were to keep the level of inventory days unchanged, the

Table 1
Inventory/Sales Analysis

	System Sales/Year	Semiconductors(S/C) Bought	I/O Ratio
1.	$100 million	$10 million	10:1
	$10 million/250 working days/year = $40,000 S/Cs used/day		
2.	$125 million	$12.5 million	10:1
	$12.5 million/250 working days/year = $50,000 S/Cs used/day		

S/C Inventory on Hand		S/C Used/Day	S/C Inventory/Year
Year 1 Companies A, B, C			
18 days	×	40,000	= $720,000
26 days	×	40,000	= $1,040,000
38 days	×	40,000	= $1,520,000
Year 2 Companies A or B			
14 days	×	50,000	= $720K
21 days	×	50,000	= $1,040K
30 days	×	50,000	= $1,520K
Year 2 Company C			
18 days	×	50,000	= $900,000
26 days	×	50,000	= $1.3 million
38 days	×	50,000	= $1.9 million

Source: Dataquest (March 1992)

net effect would naturally see inventory dollars rise equally with sales (in this case from $1.04 million to $1.3 million).

Optimizing—Not Minimizing—Is Key

What we have seen over the past three years in a generally unrobust electronics market is a cumulative effect of a Company C scenario—letting inventory levels follow the sales rate, combined with some Company B activity of cutting actual inventory dollar levels. What usually occurs in a growing market is what Company C did, keeping inventory level growth even or lower than the sales level increase. What Company A accomplished, keeping inventory dollars unchanged, may be the best course to follow when business improves, as it can involve selectively increasing strategic component inventory while continuing to reduce noncritical, multi-sourced parts.

Company A's strategy is highly recommended if a company is already at its optimal inventory level, which Dataquest views as 15 inventory turns a year or better. If a company's inventory (cost) position is high above average, a strategy closer to that of Company B would show dramatic improvement while still allowing for realistic and attainable goals. Company C's traditional method of inventory management may prove efficient for some industries where profit margins are not as slim as in electronics. The additional costs of additional inventory often outweigh the perceived benefits of safety stock because of unforeseen product mix shifts or demand swings in a market upturn.

Dataquest Perspective

The function of inventory control has in the past been used as a quick and tangible—yet blunt—tool for keeping costs of manufacturing under control, often at the expense of the supplier. The past slow market has provided impetus to cut inventory to historic low levels and has proven that inventory can be well managed if adequate communications/forecasting information is relayed to a company's supply base. In order to maintain the gains made in inventory control and still remain flexible to market fluctuations inherent in any market upturn, a list of core strategic components must be made or updated depending on an individual company's specific market application.

A strategic component is one or more of the following:

- Sole-sourced
- An emerging technology not yet in full production by many suppliers
- Also a strategic part for competitors
- Mandatory for production (that is, some 32-bit microprocessors, 3.3V DRAMs, and gate array products, to name a few)

Once a strategic list is compiled, priorities of resource allocation are easier to assign. Then the focus quickly turns to where the biggest bang for the buck can be made. The overused term "strategic alliance" had its roots in the concept of focusing efforts on assuring adequate supplies of critical components for a buyer's company's survival. This does not imply that inventory responsibility has shifted to the supplier, but rather that regular forecast communication be made as far in advance as possible to prevent under- or overordering.

Although the overall electronics market continues to muddle along, there are some signs of increased demand in selected high-end markets that may be the beginning of improved overall capital equipment expenditure. Once the market turns around, the function of optimized inventory management can add to profitability and be a finely honed competitive tool that is often overlooked by the thundering herd.

By Mark Giudici

Product Analysis

Is IC Life Cycle Pricing Creative Destruction or Industry Suicide?

Joseph Schumpeter stated that "There is inherent in the capitalist system a tendency toward self-destruction" (*Capitalism, Socialism and Democracy,* 1942). He viewed the tendency as creative and positive—creative destruction—because growth in the form of new companies and industries ultimately springs from the destruction—through competition—of inefficient businesses. In response to clients' inquiries, this article examines DRAM pricing trends over the product life cycle, keeping Schumpeter's perspective in mind. This article also sets the stage for future Semiconductor Procurement service reports on life cycle pricing analysis.

Creative Destruction in the IC Industry

Figure 1 shows DRAM pricing plotted over the product life cycle for devices in densities of 64K, 256K, 1Mb, and 4Mb.

The background history to Figure 1 is the tendency of DRAM suppliers to put an aggressive downward thrust on the price curve. The historic result is periodic market volatility—and heartburn for suppliers, investors, and even some buyers.

Figure 1 illustrates creative destruction in action—a process that has fueled IC industry growth for the past three decades. As enunciated by Intel, the industry aims to double IC integration levels every two or three years. The historic pricing trend as enunciated by Intel in the 1970s? DRAM pricing as measured in terms of price-per-bit would be cut in half every two or three years.

Figure 2 is based on the information in Figure 1 and shows the rate of price decline at each new density of DRAM relative to the prior generation over the life cycle. The rates of decline are aggressive. The anomalies associated with the early years of the 1Mb DRAM life cycle derive from the United States-Japan fair market value (FMV) system of pricing that went into effect during 1986.

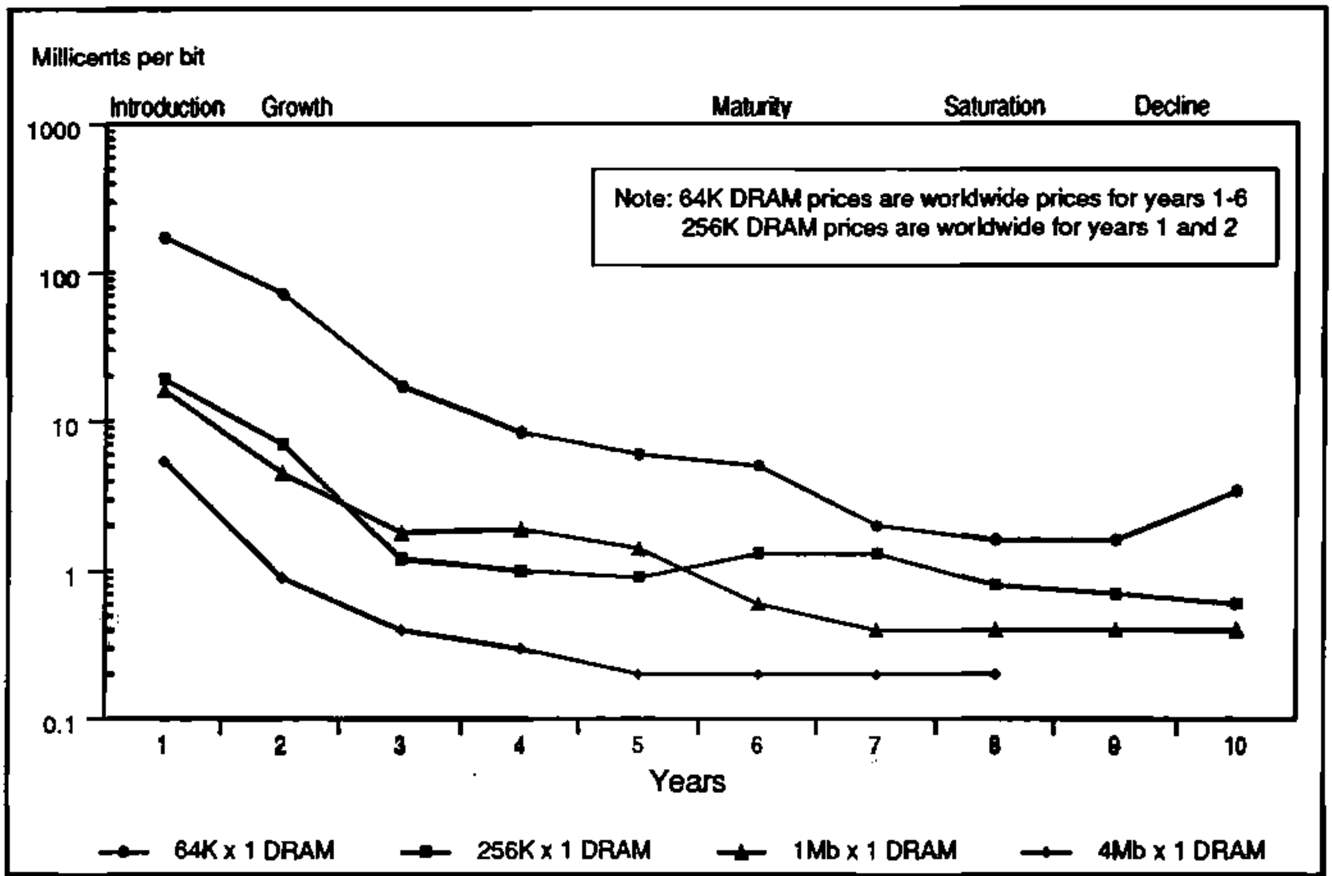
DRAM users have translated the information in Figures 1 and 2 into the following rule of thumb: Buyers expect two or three years hence *either* to receive twice as much memory as measured in bits consumed for today's price *or,* from a different angle, to pay half of today's price for the same quantity of bits consumed.

Forward-Stage Life Cycle Pricing: Industry Boon or Bane?

Forward-stage life cycle pricing is a strategy that calls for aggressive cuts in the early, or forward, stages of an IC's life cycle. The strategic goal is to win system design-ins early, drive competitors from the market, and establish ultimate market leadership. Suppliers of multisourced ICs such as memory devices and standard logic have been more likely to use this strategy.

By contrast, suppliers of sole-sourced devices such as the Motorola 680X0 series and the Intel i80386 family have been less likely to employ the approach. (Readers should note that second sourcing for the latter part occurred after the early stages of the life cycle). Sole-sourced IC

Figure 1
North American DRAM Pricing by Life Cycle Stage (Millicents per Bit; Volume: 100,000 Units)



Source: Dataquest (March 1992)

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markets are not always immune to forward-pricing practices. For example, at a Montgomery Securities conference in Silicon Valley in late January, LSI Chairman and CEO Wilf Corrigan, in response to a question from the author on gate array pricing trends, bluntly stated that today's IC buyers are only interested in low-cost pricing. By contrast, during the 1980s suppliers of ASICs such as gate arrays were unlikely to use this pricing strategy. The current battle among suppliers to win orders for 0.8-micron gate array or cell-based ICs in effect exemplifies forward-stage life cycle pricing in action.

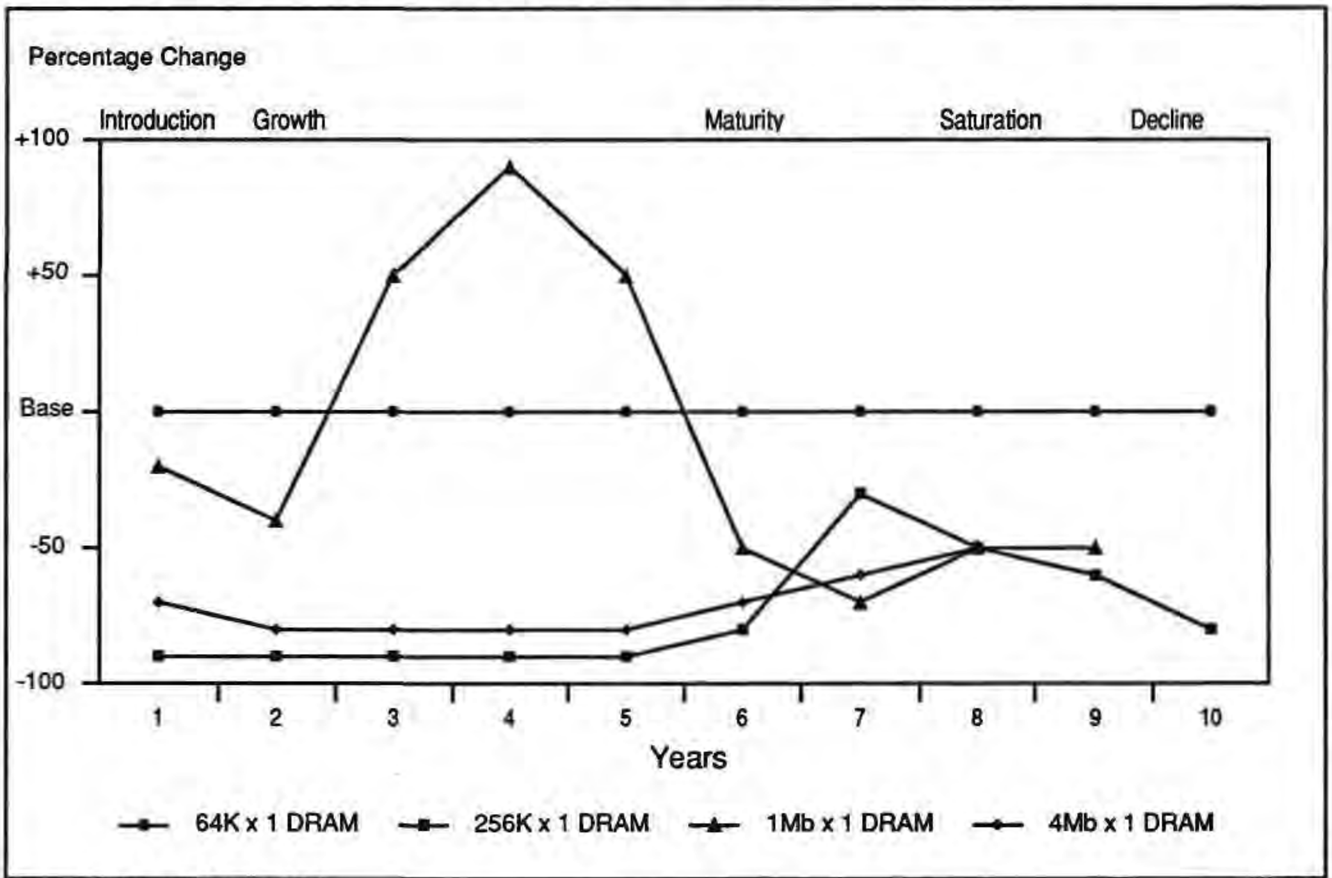
Understandably, forward-pricing represents a boon for buyers and a bane for most suppliers. For many suppliers, the forward-pricing strategy pushes creative destruction one step too far; the market result may be low-level pricing, which is akin to below-cost dumping of product. For example, the rates of price decline shown in Figure 2 for 256K DRAM during the introduction and growth stages of the life cycle illustrate forward-pricing results, which led to United States-Japan trade acrimony and the FMV system.

Dataquest Perspective

Figure 2 is the key graphic in this article because it not only shows when the forward-pricing strategy was used in North America—at the 256K density—but also raises the question of whether, and when, any supplier will ever again pursue this strategy. The FMV system negated the strategy in North America at the 1Mb density. Figure 2 shows that the price curve for 4Mb DRAMs was less aggressive than the 256K DRAM curve. The FMV system—assisted by suppliers' "market management" strategy—moderated to some extent the rate of 4Mb DRAM price declines during the forward stages of the 4Mb life cycle vis-a-vis 256K DRAM pricing at the same stages.

IBM just introduced the first systems that incorporate 16Mb DRAMs, and a host of suppliers

Figure 2
DRAM Pricing: Rate of Decline at Each Stage in Life Cycle Relative to Prior Density (64K DRAM = Base)



Source: Dataquest (March 1992)

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are either sampling or preparing for early volume production of this next-generation device. An obvious question is the likelihood of suppliers using a forward-pricing strategy on 16Mb DRAMs during 1992 and 1993. Rising trade tension in North America throws a spotlight on this issue.

Samsung does not lag far behind the early Japan-based and U.S.-based leaders in the 16Mb segment, which would signal an aggressive price curve. Goldstar will add market/pricing pressure. Japan- and U.S.-based suppliers will certainly squawk and fight to thwart the trend, with the IBM-Siemens alliance in Europe likely to be a conservative pricer. Some industry participants, however, view Samsung as a "follow the leader" on DRAM pricing—and no longer as a price leader. Goldstar has a strategic alliance on 1Mb and 4Mb DRAMs with Hitachi, and the risk of preserving that key alliance might require following the leaders at the 16Mb density.

Even so, under current market conditions as of first quarter 1992, users in North America should expect the 16Mb DRAM price curve for the early stages of the life cycle to mirror the 256K curve more than the 4Mb curve. However, signals are unclear at this time as to whether users should expect an impending return of forward pricing in the 16Mb DRAM segment.

The DRAM life cycle pricing curves shown in this article exemplify Schumpeter's theory of creative destruction in action over time. Schumpeter would probably argue that aggressive pricing strategies ultimately offer the IC industry its best protection against eventual destruction through competition from more economically efficient industries—whether or not we can imagine such competitive industries at this time.

Semiconductor Procurement reports will use the information in Figures 1 and 2 to examine the likely pricing scenarios for DRAM densities of 16Mb and greater. For example, a recent Semiconductor Procurement report on ULSI DRAMs noted that the DRAM's role as process-technology driver should become accentuated as the market moves beyond the 16Mb density.

Based on client recommendations, this article sets the stage for future SPS reports on life cycle pricing analysis. Future analyses will reflect the other side of Schumpeter's creative destruction process: the enormous financial burden that suppliers will confront in order to develop and manufacture 64Mb, 256Mb, and 1Gb DRAMs.

By Ronald Bohn

Inquiries of the Month

We heard the following two inquiries from many clients in the wake of the continued presence of AMD and others in the 32-bit microprocessor market.

Q. What is the historical microprocessor pricing for Intel's 80286, 80386, 80386SX, and 80486 parts, and for Motorola's 68000, 68020, 68030, and 68040 parts from introduction to present?

A. See Table 1 for the pricing history for these parts.

Q. Starting from the time of introduction, what is the pricing history over the life cycle for the following microprocessors: 80386-25, 80486-25, 68020-25, 68030-25, and 68040-25?

A. See Table 2 for the pricing history of the microprocessors.

Table 1
North American Microprocessor Price History, 1985-1991
(16-Bit Volume = 25K, 32-Bit Volume = 1K to 5K)

Year	Product	MHz	Price ($)
1985	80286	8	72.00
1986		8	48.00
1987		10	47.00
1988		10	32.00
1989		10	16.37
1990		10	9.37
1991		10	6.54
1988		12	48.64
1989		12	25.75

(Continued)

Table 1 (Continued)
North American Microprocessor Price History, 1985-1991
(16-Bit Volume = 25K, 32-Bit Volume = 1K to 5K)

Year	Product	MHz	Price ($)
1990		12	12.00
1991		12	6.87
1991		16	13.5
1986	80386	16	295.00
1987		16	246.25
1988		16	215.00
1989		25	252.23
1990		25	184.21
1991		25	157.61
1988	80386-SX	16	156.00
1989		16	81.08
1990		16	62.73
1991		16	57.74
1991		25	89.21
1989	80486	25	975.00
1990		25	790.39
1991		25	533.75
1991		33	560.96
1985	68000		10.40
1986			9.50
1987		8	5.25
1988		8	4.30
1989		8	3.24
1990		8	3.32
1991		8	3.81
1988		12	7.74
1989		12	5.83
1990		12	5.98
1991		12	5.58
1986	68020	16	184.00
1987		16	125.00
1988		16	106.5
1991		16	92.60
1988		25	188.51
1989		25	163.84
1990		25	131.20
1988	68030	16	168.00
1990		16	138.00
1989		25	227.00
1990		25	189.28
1991		25	161.00
1990	68040	25	730.38
1991		25	538.85

Source: Dataquest (March 1992)

Table 2
Pricing History for Selected Microprocessors

Product	Price 1st Volume Run and Year) (100-1,000 pc)	Price (1st Full Year of Production and Year) (1K-5K pc)	Price (2nd Full Year of Production and Year) (1K-5K pc)	Price (3rd Full Year of Production and Year) (1K-5K pc)	Price (4th Full Year of Production and Year) (1K-5K pc)	Price (5th Full Year of Production and Year) (1K-5K pc)	Price (6th Full Year of Production and Year) (1K- 5K pc)	Price (7th Full Year of Production and Year) (1K-5K pc)	Price (8th Full Year of Production and Year) (1K-5K pc)
80386-25	Q3-88	1989	1990	1991	1992	1993	1994	1995	1996
CPGA	$380	$252	$184	$157	$105.50	$70	$67	$67	$67
	CPGA	CPGA	CPGA	CPGA	CPGA	PQFP	PQFP	PQFP	PQFP
80486-25	Q4-1989	1990	1991	1992	1993	1994	1995	1996	1997
CPGA	$975	$790	$533.75	$382.50	$325	$305	$275	$250	$250
	CPGA	CPGA	CPGA	CPGA	CPGA	CPGA	CPGA	CPGA	CPGA
68020-25	Q3-87	1988	1989	1990	1991	1992	1993	1994	1995
CPGA	$699	$188.50	$163.80	$131	$105	35.13	$33	$31	$3
	CPGA	CPGA	CPGA	CPGA	CPGA	PQFP	PQFP	PQFP	PQFP
68030-25	Q2-88	1989	1990	1991	1992	1993	1994	1995	1996
CPGA	$485	$227	$189	$161	$118	$107	$97	$94	$93
	CPGA	CPGA	CPGA	CQFP	PQFP	PQFP	PQFP	PQFP	PQFP
68040-25	Q4-90	1991	1992	1993	1994	1995	1996	1997	1998
CPGA	$730	$538.80	$425	$370	$332	$325	NA	NA	NA
	CPGA	CPGA	CPGA	CPGA	CPGA	CPGA	NA	NA	NA

Note: 68040-25 will shift during 1993/94 to become 68EC040-20 for embedded control.
NA = Not available
Source: Dataquest (March 1992)

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- April *Procurement Pulse*
- The 1992 Semiconductor Supplier of the Year Award winner
- Semiconductor capacity level review

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9202 February 17, 1992

In This Issue...

Inquiry of the Month

Semiconductor Procurement Inquiry Highlights

What are the current and future industry trends relative to programming voltage (12V versus 5V) and supply voltage (5V versus 3V) for flash memory, and what is the 1991 market ranking for flash memory?

Subject: Flash Memory Trends

There are two types of flash memory: EPROM-based (12V), or EEPROM-based (5V and lower). The overall market trend is to go to the low voltage product due the main application (laptop computers) that requires low power usage. However, due to its lower manufacturing costs, the 12V EPROM-based flash memory will be very cost competitive with the lower voltage product lines. By the year 2000 a 3V programming voltage and 3V supply voltage family of parts will be available. The mainstream PC market most likely will go for the lower voltage devices, yet other applications will provide steady demand on the more economical 12V parts now and on through the year 2000.

Table 1 lists 1991 flash memory market rankings.

Table 1
1991 Flash Memory Company Rankings

Rank	Company	Units (K)	Market Share (%)
1	Intel	11,137	85
2	AMD	1,115	7.2
3	Toshiba	415	2.7
4	ATMEL	351	2.3
5	SGS-Thomson	203	1.3
6	SEEQ	100	0.6
7	Hitachi	65	0.4
8	Mitsubishi	30	0.2
9	Catalyst	10	0.1
	Total	15,426	

Source: Dataquest (February 1992)

Regional Pricing Update

DQ Monday Report: Volume Mean Pricing*

Table 1
Regional Pricing Update Table

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.19	0.15	0.17	0.16	0.14
74AC138	0.36	0.35	0.26	0.29	0.28	0.21
74AC244	0.46	0.47	0.36	0.40	0.40	0.36
74AC74	0.25	0.27	0.20	0.21	0.20	0.17
Lead Time (Weeks)	2	3	4	4	5	5
4F00	0.11	0.13	0.09	0.10	0.09	0.09
4F138	0.15	0.20	0.16	0.17	0.17	0.14
4F244	0.22	0.28	0.21	0.25	0.25	0.23
4F74	0.12	0.14	0.12	0.13	0.12	0.11
Lead Time (Weeks)	2	3	4	4	5	5
7805-TO92	0.11	0.19	0.11	0.13	0.13	0.11
CODEC-FLTR 1	1.85	2.43	2.50	2.10	2.12	1.35
CODEC-FLTR 2	4.33	4.77	5.00	4.75	4.70	NA
Lead Time (Weeks)	4	3	6	3	4	NA
DRAM 1Mb×1-8	3.60	3.98	3.85	3.95	4.00	3.70
DRAM 1Mb×9-8	36.50	43.72	36.00	39.00	39.00	35.50
DRAM 256K×1-8	1.35	1.67	1.60	1.43	1.30	1.10
DRAM 256K×4-8	3.60	4.04	3.85	4.00	4.00	3.70
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
Lead Time (Weeks)	2	4	4	4	7	4
68020-16	29.00	44.52	26.00	45.50	40.80	NA
80286-16	10.00	11.73	10.001	2.00	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
Lead Time (Weeks)	4	6	4	NA	NA	NA

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (February 1992)

Market Analysis

February Procurement Pulse: Orders, Sales Outlook Up; Inventories Under Control

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to semiconductor users.

Semiconductor Order Levels Gain in Line with Improved Sales Outlook

The semiconductor order level for this month is expected to improve by about 9 percent (9.2 percent) over last month despite the continued flat overall electronics market (see Figure 1). Signs of a pickup in demand from selected areas of the market (primarily high-end workstations and servers) may be precursors of a general trend. The overall six-month sales outlook again rose this month from a positive 6.0 percent level to the current 7.6 percent, while the computer subset increased from positive 6.8 percent to the current 8.0 percent level. Reflecting ready availability, semiconductor prices are expected to decline an average 2.6 percent from last month. Further checking into the price decline situation reveals that, even though some areas of semiconductors are in higher demand, overall supplies continue to meet or surpass market needs. Dataquest maintains that current overall capacity levels are more than adequate to meet rational increases in semiconductor demand now and for the rest of the year.

Lead Times Average Sub-9 Weeks and Steady

The average lead time declined from 9.2 weeks to 9.0 weeks (see Figure 2). Lead time remains

Figure 1
Averaged Monthly Semiconductor Orders

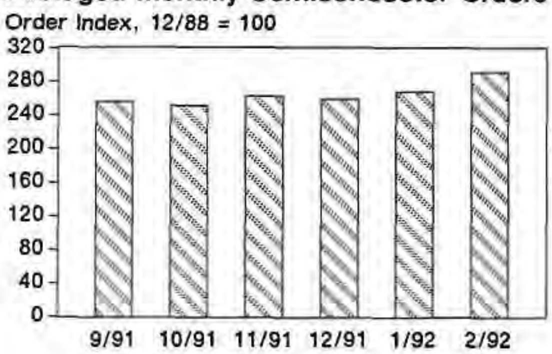


Figure 2
Averaged Semiconductor Lead Times

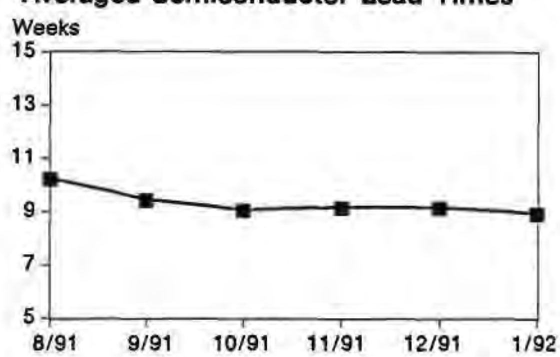


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

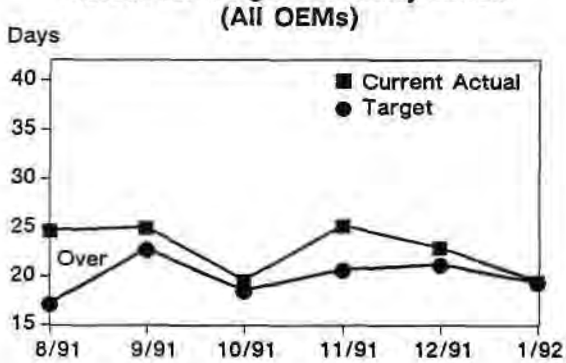
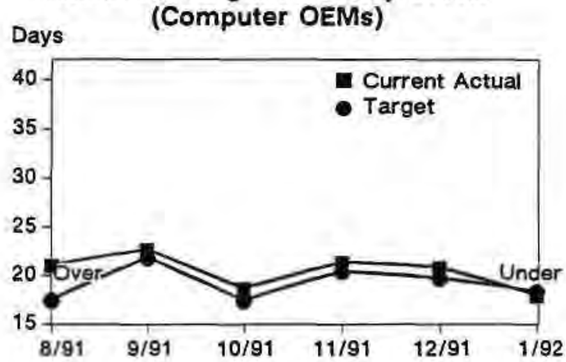


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (February 1992)

relatively static, as mentioned last month, at about 1.5 months even though many buyers continue to take advantage of off-the-shelf spot market product. The majority of respondents had no problem products to report, yet reports continue of problems with end-of-life (EOL) buys for mature ASICs and some discrete product availability. The main procurement issues revolve around EOL buys and quality versus cost. The EOL problem often is preventable with adequate forecast information while the quality issue remains one of seeing quality as a part of total cost and not as an external variable to the cost of ownership. Quality may not be totally free, but no or low quality is very expensive in the long run.

Wowsers! Average Actual Inventories Below Target for Computers

For the first time since October 1988, the average actual semiconductor inventory levels fell below targeted levels for the computer segment of our survey—18.0 actual days vs. 18.4 targeted days (see Figure 4). The overall sample targeted and actual inventories fell from 21.3 and 23.0 days to a respective 19.4 and 19.6 days, which highlights excellent control of inventory (see Figure 3). Exceptional in this month's response was the overall sub-20-day average for all inventory indexes combined with expectations of increased semiconductor order activity. Procurement managers and production control groups have not lost focus on cost control and continue to communicate well internally with marketing as well as externally with their suppliers. Dataquest continues to foresee aggressive commoditylike price pressure in the main line personal computer market providing added impetus for cost control. We are closely watching developments in demand shifts now occurring in selected high-end markets. Increases in overall demand will test the good communication now keeping costs under control.

Dataquest Perspective

Order levels for semiconductors are an upward slope, while inventories and lead times reflect good, solid cost control. All that is needed now is an overall increase in electronic product demand to complete a healthy economic picture. The Dun & Bradstreet Corporation expects the overall economy to improve moderately this year. With it will come moderate increases in capital equipment expenditure. Price-cutting aside, as capital expenditure rises, strains on the current market stasis may surface, resulting in possible component shortages or price inflexibility. The forecast horizon must be kept in focus and quickly communicated on through the supply network. The delivery system is working well now and preventative maintenance will keep it running under more stressful conditions.

By Mark Giudici

Product Analysis

Manufacturing Capacity and Cost Will Govern Long-Range DRAM Price Trends

Sluggish demand during early 1992 should mean competitive memory pricing during the first half of 1992 for most North American and European buyers. For the long-term outlook, Table 1 provides a summary of Dataquest's Semiconductor Procurement service forecast of North American bookings pricing for select DRAMs and SRAMs through the year 1995. Tables 2 and 3 outline the assumptions that govern the long-range price forecasts. Dataquest views capacity and cost as the critical factors that should shape long-term DRAM price trends.

Long-Range DRAM Price Trends

Table 2 lists the key assumptions that guide Dataquest's 1992 to 1996 North American DRAM bookings price forecast. The table includes a ranking on the significance of each assumption from the perspective of Dataquest's worldwide network of DRAM analysts in London, San Jose, Seoul, and Tokyo. The assumptions and conclusions in this article pertain most directly to the North American bookings price forecast. However, key differences in regional perspective will be noted.

DRAM Cost Reductions

As shown in Table 2, Dataquest analysts view continued DRAM cost reductions as a critical factor associated with long-range DRAM pricing trends, not only in North America but also in rest of world (ROW), Asia, and Europe (that is, 4Mb DRAMs). Users can expect the average DRAM price-per-bit to decrease by an estimated 20 percent per year during this decade. For example, Table 1 shows that the low end of the

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Semiconductor Procurement

February 24, 1992

Errata

In the article entitled "Manufacturing Capacity and Cost Will Govern Long-Range DRAM Price Trends" in Semiconductor Procurement *Dataquest Perspective* issue 9202, which was dated February 17, 1992, Table 1 had alignment problems in its column headings. We apologize for any confusion this may have caused and reprint the table here with corrected headings.

Table 1
Long-Range Memory Pricing Trends* (North American Bookings, Volume Order)

Part	Price Range Expected for Q1 1992 ($)	Price Range Expected for Q4 1993 ($)	1995 Price Forecast ($)
1Mbx1 DRAM 80ns, SOJ	3.50 to 4.09	3.00 and 3.85	3.80
4Mbx1 DRAM 80ns, SOJ	13.50 to 14.55	7.50 to 11.00	7.90
8Kx8 SRAM PDIP, 25ns	3.04 to 3.35	2.75 to 3.30	3.00
64Kx4 SRAM PDIP, 25ns	8.75 to 7.20	6.60 to 6.50	5.41
128Kx8 SRAM PDIP, 25ns	48.40 to 52.06	21.00 to 29.25	12.26

*These prices correlate with the SPS forecast dated December 1991.
Source: Dataquest (February 1992)

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1Mb DRAM price range in North America should decline to a level approaching $3 by the end of 1993. Some additional 1Mb DRAM technology improvements are possible (for example, another die shrink).

Additional 4Mb DRAM technology improvements are virtually certain. For example, the low end of 4Mb DRAM pricing in North America could decline to $5.50 or lower by the 1995 to 1996 time frame. Dataquest's cost model says DRAM pricing in North America could fall to these low levels over the long term, although some other market factors to be discussed should keep the market price somewhat above these levels.

Adequate DRAM Capacity

Dataquest believes that worldwide DRAM capacity should be adequate to meet anticipated long-term demand (see Table 2). This assumption ranks second—just behind the cost model assumption—in terms of its significance to Dataquest's global network of DRAM analysts regarding long-range DRAM price trends. For analysts in North American and Japan, this assumption marks the key factor that should influence long-range DRAM price trends. The capacity assumption indicates competitive long-term DRAM pricing trends.

The blunt issue for DRAM users and suppliers is: Will long-term DRAM capacity more likely be

Table 1
Memory Pricing Trends* (North American Bookings, Volume Order)
Long-Range Pricing Trend (Dollars)

Part Expected for Q1 1992	Price Range Expected for Q4 1993	Price Range and Forecast	1995 Price
1Mbx1 DRAM	3.50 to 4.09	3.00 and 3.85	3.80
80ns, SOJ			
4Mbx1 DRAM	13.50 to 14.55	7.50 to 11.00	7.90
80ns, SOJ			
8Kx8 SRAM	3.04 to 3.35	2.75 to 3.30	3.00
PDIP, 25ns			
64Kx4 SRAM	8.75 to 7.20	6.60 to 6.50	5.41
PDIP, 25ns			
128Kx8 SRAM	48.40 to 52.06	21.00 to 29.25	12.26
PDIP, 25ns			

*These prices correlate with the SPS forecast dated December 1991.
Source: Dataquest (February 1992)

Table 2
Key Assumptions for the Long-Range North American DRAM Price Forecast
(In Order of Ranking by Dataquest DRAM Analysts)

Dataquest Ranking	Assumption
1	Users can expect continued DRAM cost reductions because of suppliers' manufacturing technology improvements.
2	DRAM capacity should adequately meet long-term demand.
3	Non-Japanese Asian suppliers will increase DRAM market share.
4	The legal jurisdiction of intellectual property law will expand across the globe *and* be more aggressively enforced at the local level.

Source: Dataquest (February 1992)

insufficient or excessive for meeting demand? For suppliers who have been in the DRAM business since the early 1980s, the history of the 1985 to 1986 period says that the risk of overcapacity far outweighs the risk of undercapacity. Furthermore, the capital markets in Japan and North America during the 1990s likely will provide more limited funding for DRAM fab construction versus the less prudent pattern of the 1980s.

A key DRAM pricing assumption—that DRAM capacity should adequately meet long-term demand—undergoes scrutiny now to test its validity.

A related critical point on the 0.8-micron fabs required to produce 4Mb DRAMs is that suppliers—especially Japan-based companies—have cut year-end 1992 capacity goals by 20 percent versus their plans of less than two years ago. In addition, the risk of periodic regional spot shortages remains ever present in the volatile DRAM marketplace. For example, the market transition to next-generation DRAMs—as suppliers shift capacity between prior-generation DRAMs to the next-generation device or to slow SRAMs in periods of slower DRAM demand—often occurs in an uneven fashion, which can result in DRAM spot shortages. As indicated earlier, Japan's Ministry of International Trade and Industry (MITI) projects that 4Mb production will increase by 13.5 percent between the second half of 1991 and the first half of 1992, with worldwide 4Mb DRAM demand forecast to grow by 75 percent during this period. The spectre always lurks of short-term DRAM allocation.

Nevertheless, to date rather telling Dataquest analysis shows that adequate DRAM capacity exists to meet demand and should continue to do so. For example, excluding demand from IBM, worldwide demand for 4Mb DRAM during 1992 could theoretically be met by just one dozen 0.8-micron fabs that produce 20,000 6-inch wafers per month. The scenario for future years is similar. The example is extreme—by choice—to make this point: Dataquest assumes that long-range DRAM capacity will be adequate to meet demand.

Readers should note that Dataquest analysts are currently comparing the DRAM fab capacity outlook against DRAM demand forecasts. The results of that assessment will published in a Semiconductor Procurement *Dataquest Perspective* article during the second quarter of 1992.

Non-Japanese Asia Suppliers Will Increase DRAM Market Share

The assumption ranked third is as follows: Following the path broken by Korea-based supplier Samsung, suppliers from the Asian "Tiger" nations will increase global DRAM market share with concomitant downward effect on pricing. Dataquest views two Korean suppliers—Goldstar and Hyundai—as two key wild cards in the long-range DRAM pricing equation. For example, Goldstar, a huge vertically integrated supplier, has become quite adept at successfully adapting its business practices—despite rising trade friction—in overseas markets such as North America. This supplier has formed a key alliance with Hitachi of Japan on DRAMs that continues to expand—with a time lag—as new generations of DRAMs are introduced.

Hyundai, another vertically integrated giant, along with Goldstar could become one of the world's future low-cost DRAM producers. Hyundai's management in alliance with the Korean government and financial community continually ponders the company's future role in the IC business, which remains subject to change (that is, potential withdrawal). Long-term success in other global business enterprises such as automobile, ship, and steel manufacturing could enable this Korean supplier to grow into a giant of the DRAM business.

In terms of the DRAM supplier base, Dataquest also views other suppliers such as IBM, Matsushita, Oki, and Siemens as prospective DRAM wild cards. For example, for users in North America and especially Europe, the IBM/Siemens alliance on DRAMs carries an enormous long-term potential effect on the DRAM market outlook. Even so, from Dataquest's perspective, the rise of DRAM suppliers in Korea, Singapore, and other Asian countries should have the strongest impact—being downward—on DRAM pricing for the next half-decade.

International Expansion of Intellectual Property Law

Dataquest analysts rank the global expansion of intellectual property law and more aggressive local enforcement as the fourth most significant factor affecting the long-range DRAM price scenario. North American manufacturers such as Texas Instruments—joined by other regional suppliers such as SGS-Thomson of Europe via its Mostek-based patents—will drive more vigorous global respect for patent and related intellectual property laws. An additional cost element, royalties of several percent, must be factored into the long-range DRAM pricing equation—especially for regions such as Europe and ROW/Asia.

For example, Wang's lawsuits against alleged nonlicensed sellers and users of the Wang patent on the "30-pin ×9" single in-line memory modules (SIMMs) have thrown a global spotlight on the potential impact on DRAM pricing. Wang currently is settling with unauthorized users and suppliers for an estimated 4 percent royalty charge. Legal uncertainty often translates into market uncertainty. Hitachi's recent agreement with TI on the Kilby patent and the intellectual property agreement between the People's Republic of China and the United States highlight the trend.

Other Key Assumptions

Other assumptions that did not make Table 2 should be significant to users and suppliers in Europe, Japan, and Asia.

Alliances

The evolving global network of DRAM alliances should have some long-term impact on North American pricing trends. However, market players in Europe and Japan should expect a stronger degree of alliance-related pricing effects. For example, as noted before the IBM/Siemens alliance on DRAMs carries an enormous long-term potential effect on the Europe DRAM price scenario. For a detailed look at worldwide DRAM technology alliances, see "Worldwide DRAM Technology Alliances: Global Evolution Motivated by Survival of the Fittest," in the Semiconductor Procurement *Dataquest Perspective*, Vol. 1, No. 17.

Increased Trade Friction

Dataquest analysts in Europe and ROW/Asia expect global trade friction to increase although the effects on pricing should vary by world region. For example, Europe's Reference Pricing system in part has caused 4Mb DRAM pricing during early 1992 to be higher vis-á-vis other world regions. The European pricing reality will continue until Japan-based suppliers complete new European fabs. By contrast, Japan/United States trade friction likely will have little impact on DRAM pricing because of intense North American user disdain with the now-terminated foreign market value system. Asian suppliers—whether from Korea, Japan, or other countries—continue to walk a very closely monitored line between competitive pricing practices and allegations of dumping in regions such as Europe.

Table 3
Key Assumptions for the Long-Range North American SRAM Price Forecast

Ranking	Assumption
Slow SRAMs	
1	Low-cost suppliers from ROW/Asia will compete against Japan-based suppliers for slow SRAM market share.
Fast SRAMs	
1	The trend in the fast SRAM market is toward commoditization although some micromarket opportunities should remain available.
2	The trend to commoditize should cause some compression of fast SRAM pricing, meaning fast SRAM cost-reductions will drive pricing trends a la DRAMs and slow SRAMs.
3	The global fast SRAM supplier base will continue to shift and not contract dramatically.

Source: Dataquest (February 1992)

Long-Range SRAM Price Trends

Table 3 contains the assumptions that guide Dataquest's 1992 to 1996 North American SRAM bookings price forecast.

Non-Japanese Asian Suppliers Will Increase Slow SRAM Market Share

The key assumption for the long-range North American slow SRAM bookings price forecast, which assumes that non-Japanese Asian suppliers will increase market share and keep pricing competitive, parallels the third-ranked assumption on DRAM price trends. As identified over the years by Dataquest, the reason relates to the manufacturing trade-off that can be made between slow SRAMs and DRAMs. Most suppliers of slow SRAMs are vertically integrated suppliers from Japan or Korea. These companies can produce either DRAMs or slow SRAMs from the same manufacturing line, allowing for a time lag of several quarters to make the switch. In times of stronger demand, suppliers focus on the potentially more lucrative DRAM device. During periods of slow DRAM demand or aggressive pricing, the slow SRAM serves as a product alternative (or fab filler).

As vertically integrated Korean suppliers such as Samsung and still unproven Hyundai flex their DRAM manufacturing strength, their impact on global slow SRAM pricing trends should also increase. To date, these suppliers have focused on establishing their brand name at the 64K density, now positioning Korea as the world's low-cost 64K slow SRAM source. Samsung, perhaps joined by Hyundai and/or Goldstar, will make a long-term migration to higher density devices and ultimately shape North American pricing trends.

Fast SRAM Assumptions: Commoditization, Price Compression, Supplier Shifts

Tabe 3 lists the three critical assumptions that guide Dataquest's long-term outlook on fast SRAM pricing trends in North America. First, the market trend is toward commoditization, although some micromarket opportunities should remain available. Second, for the global network of fast SRAM suppliers and users the commoditization trend connects directly to the next assumption: commoditization should cause long-term compression—or lowering—of fast SRAM pricing. During the 1980s, the fast SRAM business was in part a series of micromarkets such that the limited number of suppliers in each niche could command wide profit margins. Dataquest assumes that future fast SRAM cost reductions will govern pricing trends a la the DRAM/slow SRAMs scenario. This trend should result in more competitive pricing for users, more narrow margins for suppliers, and perhaps ultimately a more narrow supplier base. For users in North America and Europe, the prospect of more competitive pricing, however, will require—as indicated in the third assumption—more active management of a shifting global fast SRAM supplier base.

The Future Scenario

The pricing forecasts for three fast SRAMs in Table 1 illustrate the interplay between the assumptions on the market forces that guide Dataquest's North American price outlook.

64K Fast SRAM

Because of unimpressive growth prospects, the supplier base for some fast 64K SRAMs (for example, 64K×1 SRAM 25ns, 16K×4 SRAM 35ns, and 8K×8 SRAM 45ns) will decline. Suppliers will shift to more vibrant market segments such as 8K×8 SRAM 25ns or 16K×4 SRAM 25ns or else migrate to higher-density devices, although in a few cases suppliers from other regions (for example, Taiwan) will enter maturing segments such as the 8K×8 SRAM 45ns arena in order to establish market presence and reputation. Suppliers from around the globe aim to meet North American and European demand for 8K×8 SRAM 25ns and 16K×4 SRAM 25ns.

> ***DRAM and SRAM pricing should be competitive, although not predatory, now and over the long term.***

In addition, new entrants will target these vibrant segments. A main point is that users can expect continuing shifts in the fast SRAM supplier base—and more competitive long-term pricing trends. For example, over the long term North American users can expect less familiar suppliers from North America such as AT&T and Taiwan (for example, ISSI, UMC, and Winbond) to have considerable effect on pricing for devices such as 8Kx8 SRAM 25ns. Demand from PC clone manufacturers in part explains the trend.

Before this year, Japan's MITI informally established $3 as the lowest price to be charged by Japan-based suppliers for 64K fast SRAMs. As shown in Table 1, for North American users recent shifts in the supplier base for 8Kx8 SRAM 25ns mean that the low end of the price range for this device should fall below $3—and already approaches $2 in Taiwan. Users in Europe should expect only low-cost suppliers to survive over the long term.

256K Fast SRAM

For North American and European users of 256K fast SRAMs, the influence of Japan's MITI on the pricing strategy of familiar Japan-based suppliers such as Fujitsu and Hitachi should decrease somewhat—meaning more competitive long-term pricing. Non-Japanese suppliers such as Cypress, IDT, Motorola, and Micron aim to increase market share within defined product segments although the targeted segments, as noted, should shift in response to evolving application/demand trends. In addition, other Japan-based suppliers such as Sharp and Sony clearly aim to increase share in North America and Europe. In Europe, SGS-Thomson (including Inmos) remains a force although Matra-MHS continues to expand.

The long-term upshot for users is that compressed pricing will be linked—most simply—to the cost of manufacturing. For example, Table 1 shows the outlook on pricing for 64Kx4 SRAM 25ns. The low end of the price range is currently at $7.25 in North America. For year-end 1993, Dataquest projects a price level of $6.50 in North America, dropping under $5.50 for 1995. North American and European users should view this forecast as conservative, given the intense level of supplier competition in the growing 256K fast SRAM marketplace.

1Mb Fast SRAM

The three assumptions that guide the 64K/256K fast SRAM price forecast for North America apply in general to the 1Mb fast SRAM forecast shown in Table 1—with a caveat. The caveat: Through informal advisories to leading edge Japan-based suppliers, Japan's MITI should exert influence on the rate of price declines in regions such as North America and Europe, essentially applying the brakes against a rapid tumble in pricing during the forward (or earlier) stages of the product life cycle. As noted, North American users can look forward to increased pricing competition from non-Japanese suppliers (for example, Motorola). However, vertically integrated suppliers from Japan will continue to wield market power in this segment of the fast SRAM business—with an agenda that calls for a steady and manageable long-term decline in pricing.

Dataquest Perspective

At press time, Dataquest's Research Operations team (field interviewing) had just begun the February-March 1992 survey of North American users and suppliers of ICs including DRAMs and SRAMs. This report identifies the assumptions and assesses the market factors that guide the long-range North American DRAM and SRAM price forecasts. In effect, this article lays out the thinking that will guide the long-range forecasts to be generated during March 1992. Users can compare these assumptions with their long-range views and modify Dataquest forecasts or their in-house forecasts for strategic planning purposes.

These assumptions are not set in stone. Dataquest's worldwide network of memory analysts identify them now in order to allow our thinking to change during 1992 and beyond, in line with changing memory market realities. A key DRAM pricing assumption—that DRAM capacity should adequately meet long-term demand—undergoes scrutiny now to test its validity.

For now, users in North America can expect an ample supply of 1Mb and 4Mb DRAMs, which will be carefully managed and monitored by the global supplier base. DRAM and SRAM pricing should be competitive, although not predatory, now and over the long term. In maturing product areas such as 64K slow SRAMs and 256K DRAMs today—and 1Mb DRAMs and 64K fast SRAMs in the next year or two—users must carefully manage the selection of the supplier base.

By Ronald Bohn

Technology Analysis

Substrate Market Trends: What Will Become of the Traditional PCB?

As clock rates continue to spiral upward beyond 50 MHz, circuit delays from interconnect technologies can become the limiting factor for increasing system performance. The marketplace wants faster operating speeds, quicker access times, and smaller printer circuit board (PCB) real estate.

The answer to this problem is the latest buzzword in electronic packaging: multichip modules (MCMs). Simply stated, multichip modules are a collection of bare dice whose I/Os are connected on a substrate that functions similarly to a PCB. Conceptually, the MCM is a higher-level, hybrid IC. It resembles a large ASIC (die) made up of several small pieces (dice).

An MCM could include an assortment of bare dice such as a microprocessor, cache memory, controller, and peripheral logic, all mounted to one common substrate. These dice are connected with traces narrower and more closely routed than the traditional PCB, which results in increased performance over conventional mounting techniques. This performance increase is shown in Table 1.

Types of MCMs

Because the definition of multichip modules encompasses a variety of technologies, MCMs have been classified according to substrate interconnect technology, as follows:

- MCM-L is a module that uses PCB laminate as a substrate.
- MCM-C is a module that has multiple layers of interconnect separated by multiple layers of cofired ceramic material. This could include both cofired and thin-film multilayer technology.
- MCM-D is a module that has interconnect conductor widths less than 5 mils; the substrate is manufactured using semiconductor processing techniques.
- Hybrid is a module with one layer of ceramic material having conductor widths greater than 5 mils.

All of these approaches have one goal in mind: to provide a higher ratio of silicon to substrate area, thus resulting in faster system operation.

How will this affect the traditional PCB?

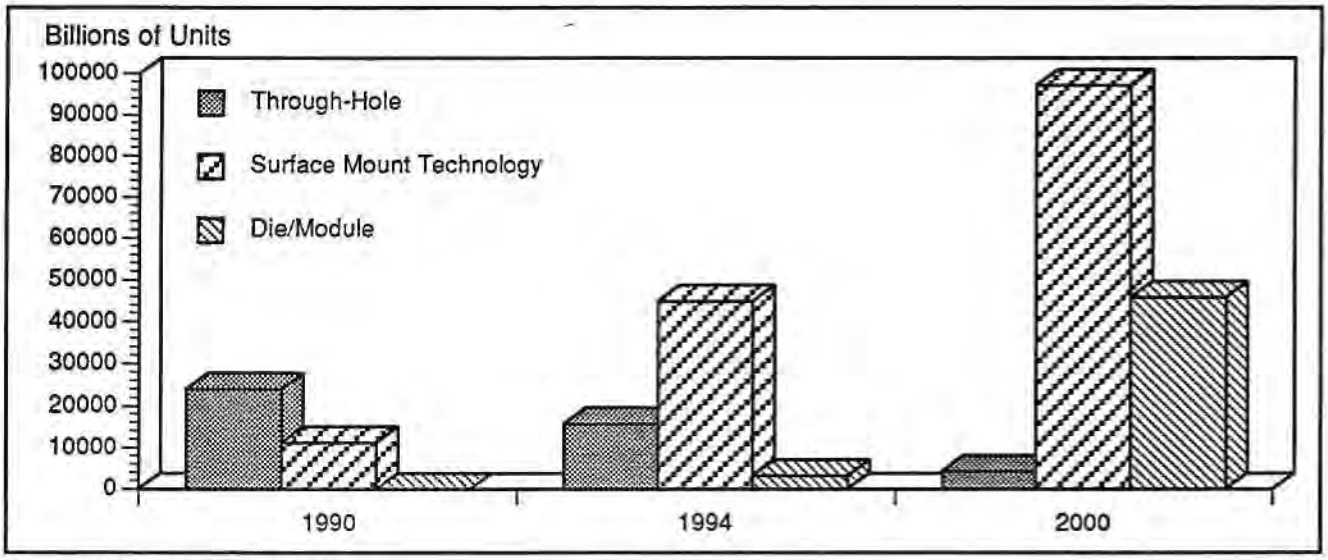
Because MCMs are a combination of substrate and IC technology, both PCB and semiconductor markets will be affected (see Figure 1, which compares the estimated worldwide package production in relation to the potential MCM market). Traditional PCBs as we know them will still be used, but in a more supporting role. The need for backplanes and motherboards will continue. Not all high-pin count ICs will require interconnection on a corresponding high-density substrate. Only when the entire board consists of predominantly high lead-count devices will it need to provide dense interconnection capability. Cost pressures and mature products will still dictate PCB usage over newer, emerging systems. But even here, an advanced level of sophistication will be required.

Table 1
Interconnect Technologies: Performance Comparison*

Ranking Assumption	PCB/PTH	PCB/SMT	MCM
Board area	91 sq. in.	49 sq. in.	16 sq. in.
Package delay	6.9 ns	4.6 ns	2.0 ns
Total delay	16.9 ns	14.6 ns	12.0 ns
Package system delay (%)	41	31.5	16.7
System clock frequency	59 MHz	68 MHz	83 MHz
Performance improvement (%)	—	15.7	40.8

*Assumes a 100-MHz microprocessor clock frequency
Source: Dataquest (February 1992)

Figure 1
Estimated Worldwide Package Production Potential MCM Market



Source: Dataquest (February 1992)

The Role of PCBs

The PCB industry is one of the most mature yet most underdeveloped (in technology) areas of the electronics industry. For many years, the PCB used traditional through-hole mounting techniques, with signal traces/spaces commonly in the 8- to 12-mil range. As very large scale integration (VLSI) semiconductor technology on the die level developed, it began pushing the PCB interconnect from the simple single- and double-sided PCB to multiple layers, or multilayer substrates. With the advent of surface mount demanding increased density and performance, multilayer technology blossomed in recent years, pushing conductor widths down to 5 mils and below. At this level, PCB state-of- the-art is being pushed to its maximum limits.

The increasing speed of the ICs demands that the PCB not delay the chip-to-chip interconnect (system delay). Because of increased speed, more heat is generated. The traditional FR-4 type PCB can no longer manage the thermal and mechanical stresses generated and maintain a desired level of reliability. The simple, cost-effective manufacturing techniques of PCBs can no longer adequately meet these stringent demands. New processes, materials, and equipment must be developed to meet the challenges of high-density interconnects. Table 2 lists some of the relevant issues facing PCB and MCM implementation.

This challenge, however, can be and is being met by the PCB industry in some areas. Referring to the definitions provided earlier, the majority of MCMs today are based upon MCM-L technology, which is largely based upon consumer markets. Videogame modules, memory modules, smart cards, watches, and many other multiple chip-on-board applications can be included in this category. These products meet the demand for smaller, lower-cost systems, achieved by pushing the limits in PCB technology. However, as system demands continue to increase, it becomes apparent that the traditional PCB cannot solve one growing problem: speed.

Because we know that the fastest system speeds are attainable at wafer (die) level, it becomes clear that we need to put more and more functions on a die. One method that has been tried is wafer scale integration (WSI). Most all-monolithic WSI efforts to date have been disappointing, because this technology is still unproven and yet to be developed. The alternative is to try to place die as close as possible to each other on a common substrate that minimizes system delays. Thus the need for high-density multichip modules.

Table 2
Comparison of PCB and MCM Issues

PCB	MCM
Mature technology	Unproven interconnect techniques
Easy to use	Difficult to design
Worldwide standards	Lack of standardization
Proven reliability	Limited characterization
Low substrate cost	High substrate cost
Large infrastructure	Limited die availability
Proven interconnect technologies	Unproven processes
Limited power capabilities	Improved power capabilities
Slower system speeds	Faster system speeds
Laminate/layer limits	Higher density
Routing limitations	Reduced number of interconnects
Large package footprints	Die-level densities
Easy to test	Variable test methods

Source: Dataquest (February 1992)

MCM manufacturers order wafers or die with the desired interconnects from foundries and then mount ASIC and peripheral chips directly on the substrate. The chips can be mixed from many manufacturers—if they can be obtained.

Effect of MCMs on PCB Marketplace

Many issues must be addressed before each level of MCM technologies is developed. The major issue is MCM substrate selection. MCM-Ls are being used because of their low cost, but technical issues limit the wiring density to 50 to 150 cm/cm^2 and speed capability to 100 to 150 MHz. But, they have the potential for being extended to compete with the next levels, MCM-C and MCM-D. For this to occur, materials will need to be developed that yield thinner laminates for the fabrication of high-density vias while providing a lower dielectric constant (note that the dielectric constant is the biggest determining factor in the speed of signals from chip to chip within an MCM). IBM's Surface Laminar Circuit and Cherry Semiconductor's chip-on-flex are two examples of an extended MCM-L application.

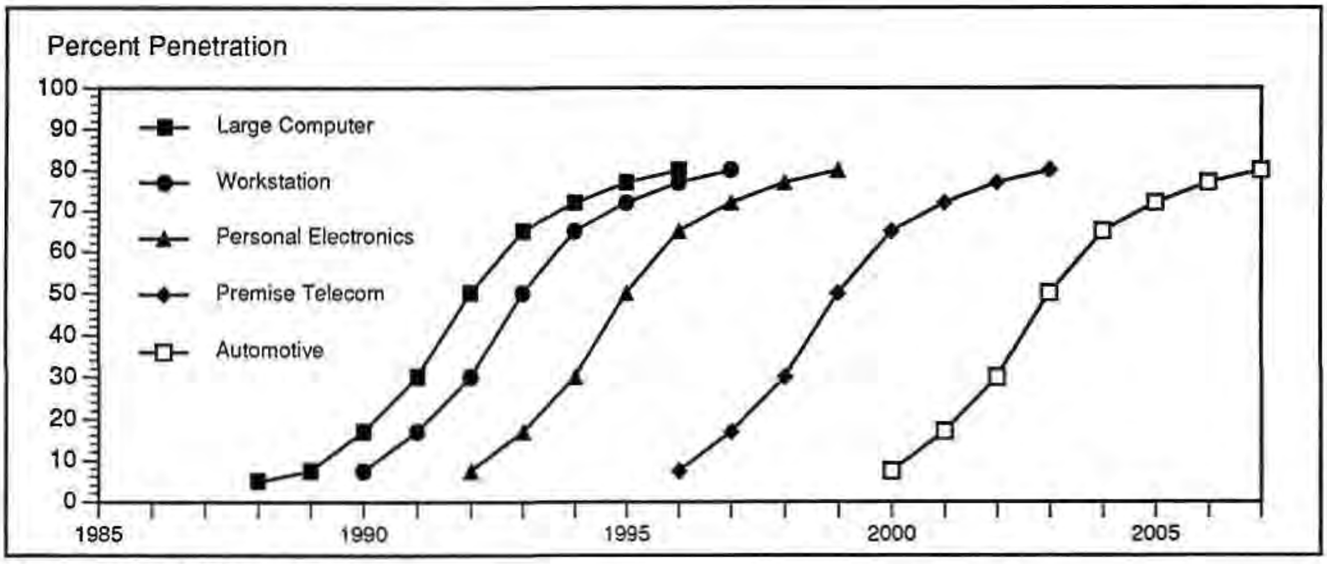
Currently, only high-cost, low-volume, mainframe computer systems afford high-level MCM technology (MCM-D). The long development cycles and higher manufacturing costs can only be justified in high-end systems. Cost and time-to-market must be reduced to make MCM technology viable for lower-end applications. The key to this will be new design tools. These tools must provide high-level design verification, synthesis, and partitioning, and multilevel physical design that will equally combine the IC, MCM substrate, and board level in a homogeneous environment.

Assembly technologies will also change. Flip chip assembly, used mainly by IBM for the last 10 years, shows increasing promise. This technology, where the die is directly attached to the substrate (unlike wire or TAB bonding, where the chip is bonded to the wire, or tape, and the wire is subsequently bonded to the substrate), eliminates one level of interconnect, thereby increasing speed, density, and reliability. Used primarily in the past on ceramic substrates, it is now seeing promise on lower-cost flex and rigid-flex substrates.

Dataquest Perspective

OEMs know more about building systems. IC manufacturers specialize in semiconductor design and manufacturing. The challenge is to combine or bridge the gap between these two. Vertically integrated companies such as IBM and AT&T have been meeting this challenge internally for years and have solved many of the difficulties associated with MCMs. This has

Figure 2
MCM Application Penetration



Source: Dataquest (February 1992)

given them the distinct advantage, but only for internal use.

The system design companies of the 1990s are not vertically integrated and have no fab or assembly capabilities. They must rely on outside services to meet their product and system goals. This need has given rise to a new class of company: the contract multichip module manufacturer. Unlike the OEM, the MCM maker is a partner with a system design house and the IC maker. All three companies must share in the exchange of ideas to achieve the common goal of system performance optimization.

An example of this partnering of chip supplier and system house is Cypress Semiconductor and Sun Microsystems. Sun desired to develop its Galaxy multitask, multiprocessor-based network. Cypress is a supplier of SPARC microprocessors. Multichip Technology, a subsidiary of Cypress specializing in advanced packing technology, designed a dual-CPU module that solved the complicated cache memory interface problems found in multiprocessor systems. This increased performance from 10 to 15 percent over a traditional PCB design.

Figure 2 shows Dataquest's forecast for MCM applications. These curves represent the extent, based upon economic feasibility, to which each market segment becomes potentially committed to modules. The driving forces behind the acceptance of MCMs will be the telecommunications, automotive, computer, and consumer markets, which require high chip-to-chip interconnects and minimum board space with reduced costs. The multichip module will become the next high-performance ASIC package.

By Jim Walker
Mark Giudici

(This article was written by Jim Walker in conjunction with Mark Giudici. For further information, please contact Mark Giudici.)

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- March *Procurement Pulse*
- Semiconductor cost model update
- Supplier of the Year Award announcement

For More Information . . .

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Dataquest Perspective

Semiconductor Procurement

SPWW-SVC-DP-9201 January 20, 1992

In This Issue...

Regional Pricing Update

*DQ Monday Report: Volume Mean Pricing**

Family	United States	Japan	Europe	Taiwan	Hong Kong	Korea
74AC00	0.18	0.19	0.15	0.17	0.18	0.14
74AC138	0.32	0.34	0.26	0.30	0.31	0.21
74AC244	0.46	0.45	0.36	0.40	0.42	0.36
74AC74	0.25	0.26	0.20	0.21	0.22	0.17
Lead Time (Weeks)	2	3	4	4	5	5
4F00	0.11	0.12	0.09	0.10	0.10	0.09
4F138	0.15	0.20	0.16	0.17	0.19	0.14
4F244	0.22	0.27	0.21	0.25	0.27	0.23
4F74	0.12	0.13	0.12	0.13	0.13	0.11
Lead Time (Weeks)	2	3	4	4	5	5
7805-TO92	0.12	0.18	0.11	0.13	0.14	0.11
CODEC-FLTR 1	1.95	2.43	2.50	2.10	2.15	1.35
CODEC-FLTR 2	4.50	4.79	5.00	4.75	5.00	NA
Lead Time (Weeks)	4	3	6	3	4	NA
DRAM 1Mbx1-8	3.70	4.00	3.80	4.25	4.10	3.75
DRAM 1Mbx9-8	38.25	45.53	37.00	39.00	40.20	35.50
DRAM 256Kx1-8	1.65	1.66	1.70	1.43	1.40	1.10
DRAM 256Kx4-8	3.70	4.01	3.80	4.40	4.10	3.75
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	17.00	NA
SRAM 256K 32Kx8	3.93	4.13	3.60	4.25	4.80	3.30
SRAM 64K 8Kx8	2.13	1.59	1.85	1.60	1.50	1.30
Lead Time (Weeks)	2	4	4	4	7	4
68020-16	31.00	48.24	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
Lead Time (Weeks)	6	6	4	NA	NA	NA

*Prices in U.S. dollars
NA = Not available
Source: Dataquest (January 1992)

Market Analysis

January Procurement Pulse: Order Rates Expected to Inch Up while Lead Times and Inventories Remain Static

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. This article explains what inventory and order corrections mean to semiconductor users.

Semiconductor Order Levels to Creep Up Despite Current Soft Market

Although the overall electronics market remains sluggish, this month's respondents expect to order slightly more than 3 percent (3.7 percent) more semiconductors than last December (see Figure 1). The order rate continues to hover around the 250 index range as buyers match order levels with system shipments. The six-month overall system sales outlook also improved slightly, going from a positive 5.5 percent to the current 6.0 percent forecast, while the computer subset of our sample dipped below the previous positive 7.2 percent to a 6.8 percent sales outlook.

Semiconductor prices are expected to continue their decline this month by an average of negative 3.3 percent. Current availability and slack demand remain the main forces behind the steady drop in price. There is talk by some Japanese DRAM suppliers of permanently curtailing production of some DRAMs because of the sustained low-demand situation that is not filling fab capacity as expected. Although these

Figure 1
Averaged Monthly Semiconductor Orders

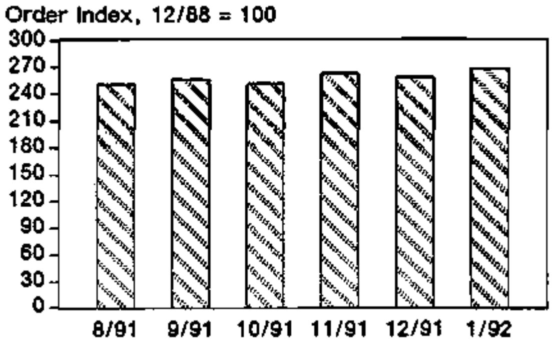


Figure 2
Averaged Semiconductor Lead Times

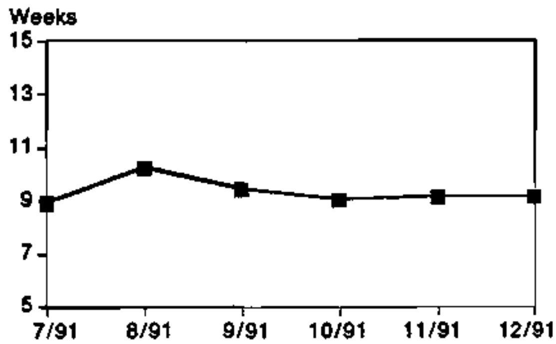


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

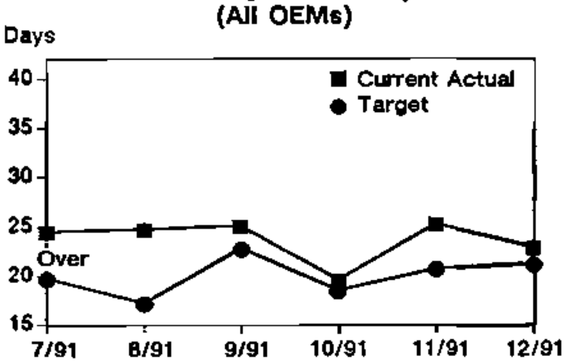
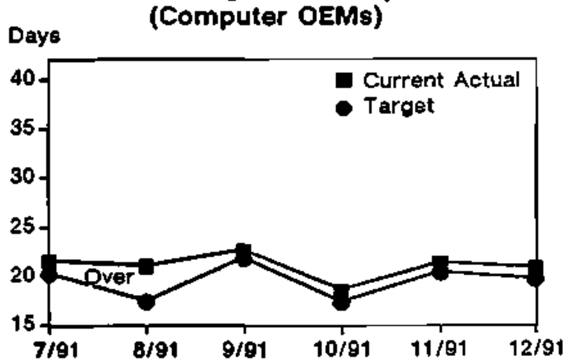


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (January 1992)

suppliers are market leaders in this commodity, any reduction in Japanese capacity will be easily accommodated by other suppliers in the current market.

Lead Times Flat at 9.2 Weeks; No Change in Sight

The comfort zone of a month-and-a-half lead time between order and delivery remains while buyers on the spot market still get off-the-shelf delivery on most parts if needed. Although urgent needs can be quickly met, Figure 2 shows that the controlled pace of the market tied in with the low inventory situation balanced lead times at a current 9.2 weeks (unchanged) for this month. Although the majority of this month's respondents had no problems, questions about the status of x9 SIMMs persist, and some ASIC design-out problems remain a product-based issue with some users.

Inventories, prices, lead times, and order levels all show signs of being well under control and in tune with current demand levels.

Regarding obsolete products, a third of the respondents were having problems with end-of-life (EOL) buys (ensuring deliveries of older parts while new designs ramped up in volume). Regular product forecasting often prevents EOL supply problems as suppliers inform users of phaseouts with enough time to shift suppliers or phase in new parts.

Semiconductor Inventories Stabilize, for Now

The targeted and actual inventory levels for the overall and computer respondents as seen in Figures 3 and 4 have remained relatively unchanged since the slight decline noted in October. The overall target and actual levels for December were 21.3 and 23.0 days, respectively, compared with like numbers of 20.8 and 25.3 days noted for November for the whole sample. The computer subset saw both indices drop from a targeted and actual level of 20.5 and 21.5 days to a current 19.8 and 21.0 days, respectively. The relative stability of inventories, both targeted and actual, confirms the strength of inventory control now in place. Dataquest continues to foresee semiconductor inventory levels remaining at a 20- to 25-day actual range because of the ready availability of components and the static level of ongoing business.

Dataquest Perspective

Inventories, prices, lead times, and order levels all show signs of being well under control and in tune with current demand levels. What is being discussed lately is what happens if/when demand increases (the worst case: a sharp increase)?

For users with solid communication with their supply base, the short-term dislocation of capacity (as suppliers adjust to higher demand levels) will be minimized, while those that benefited largely from spot-market pricing will be most negatively affected by product availability. A prudent mix of procurement from both sources where applicable/appropriate often can minimize availability exposure while garnering the advantages of ready delivery and low spot prices.

The outlook for 1992 is for demand levels to begin increasing in the late second quarter to early third quarter.

The outlook for 1992 is for demand levels to begin increasing in the late second quarter to early third quarter. Although not a current problem, the balancing of future supplies at optimal cost will require better than average communication with suppliers as the volume of orders picks up.

By Mark Giudici

Product Analysis

IC Pricing Pressure Mounts as Recession Persists

Global economies are in recession at the start of 1992, and downward pressure is mounting on IC pricing in North America. The results of Dataquest's recent North American bookings price survey reveal that users should expect competitive pricing for memory ICs and ASICs. Intel Corporation's pricing strategy has taken a turn and the company is adjusting to new 1992 market realities.

Table 1 shows estimated semiconductor pricing and lead-time trends.

(Note: The pricing analysis in this article correlates with the quarterly and long-range price tables mailed to Semiconductor Procurement service (SPS) clients on December 20, 1991. The survey information was collected by Dataquest's Research Operations team. For SPS clients that use the SPS online service, the pricing correlates with the quarterly and long-range price tables dated December 1991 in the SPS online service. The price tables will be available in the *Source: Dataquest* document entitled "North American Semiconductor Price Outlook: First Quarter 1992." For additional product coverage and more detailed product specifications, refer to those sources.)

Memory Trends

The market awaits clear signals on 4Mb DRAM supply/demand trends and specifically on 4Mb DRAM capacity allocation. Pricing for SRAMs has become more competitive in North America, Europe, and parts of Asia. Users of flash memory can expect a premium of 7 to 15 percent for the thin small-outline package (TSOP) versus the PDIP choice.

Dataquest added the following memory ICs to its quarterly forecast/survey of North American bookings pricing: 256Kx18 DRAM 80ns SOJ; 512Kx36 SIMM; BiCMOS 64Kx4 SRAM 10ns PDIP; 32Kx8 SRAM 12ns PDIP; 256Kx4 SRAM 20ns PDIP; 128Kx8 SRAM 20ns PDIP; 1Mbx8 ROM 150ns SOP (32-pin); 128Kx16 EPROM 150ns CERDIP; 512Kx8 EPROM 150ns CERDIP; 256Kx16 EPROM 150ns CERDIP; 64Kx8 Flash Memory 150ns PDIP (12V); and 128Kx8 Flash Memory 150ns PDIP (12V).

Table 1
Estimated Semiconductor Pricing and Lead-Time Trends
(North American Bookings; Volume Orders)

	1992 Pricing Trend (Dollars)			
Part	Estimated First Quarter Price Range ($)	Forecast for First Quarter ($)	Estimated Fourth Quarter Price Range ($)	Lead Times (Weeks)
1Mbx1 DRAM 80ns, DIP/SOJ	3.50 to 4.09	3.90	3.20 to 3.97	1 to 8
4Mbx1 DRAM 80ns, SOJ	13.50 to 14.55	13.72	10.10 to 13.05	1 to 8
512Kx36 SIMM 80ns	79.00 to 86.30	81.00	74.00 to 84.20	4 to 8
32Kx8 SRAM 35ns, PDIP	7.17 to 7.77	6.75	6.63 to 7.06	5 to 10
128Kx8 SRAM 100ns SOJ	13.60 to 15.40	13.75	12.20 to 12.55	2 to 10
80486 33 MHz CPGA	405 to 415	405	360	6 to 8

Source: Dataquest (January 1992)

DRAM: Market Uncertainty

Figure 1 depicts the North American pricing outlook for DRAM and slow SRAM.

Suppliers of 4Mb DRAM remain concerned about demand for this part. Some players again wonder if there will be a shortened life cycle. A key issue in the supply/demand-pricing equation is capacity allocation by first-tier suppliers in Japan and North America. As noted last quarter, the market effect of a DRAM capacity shift typically occurs with a lag of two quarters. DRAM lead times remain manageable as of early 1992.

Pricing for 4Mb DRAM continues to erode steadily if not spectacularly. Pricing for 4Mbx1 DRAM should range from $13.50 to $14.55 during the first quarter of 1992. The range should erode to a range of $10 to $13 by the fourth quarter.

Pricing for 1Mb DRAMs collapsed on some year-end 1991 spot-market transactions. The survey shows that the first quarter 1992 contract-volume bookings price for 1Mb DRAM—on the low side of the range—should fall to $3.50. By year-end 1992, pricing for 1Mb DRAM should become more aggressive. Pricing likely will range from a low of $3.20 to nearly $4.

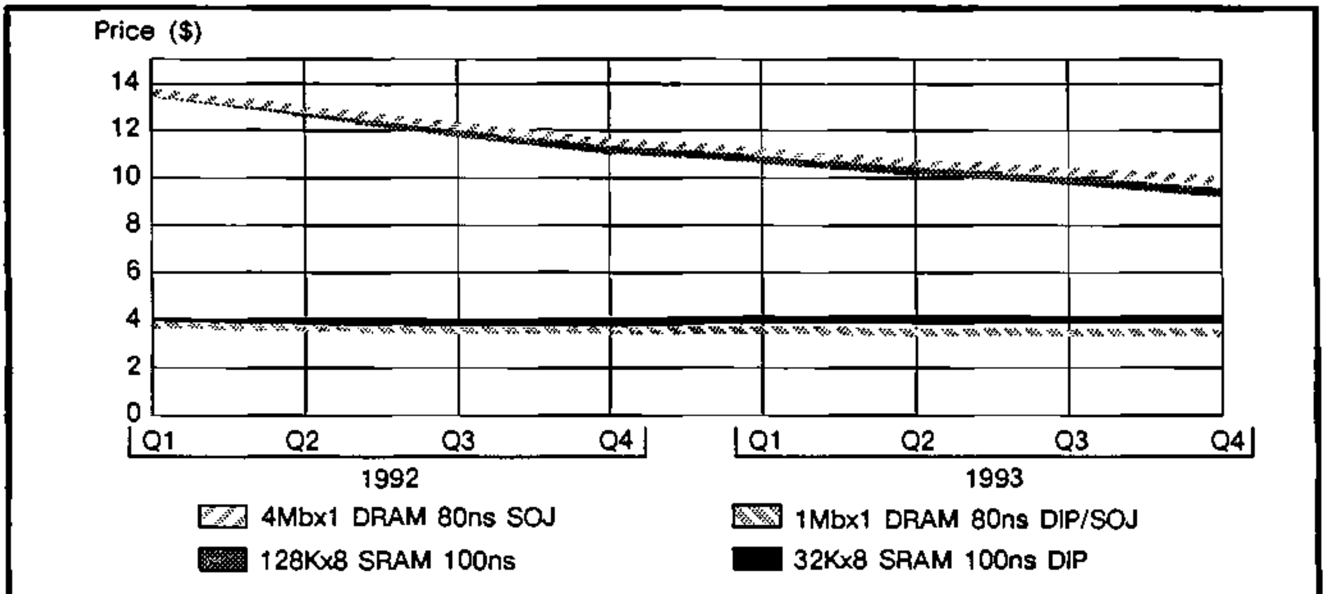
DRAM Market Management

DRAM suppliers continue to implement 1992 capacity plans. However, the market effects are not yet fully known. Suppliers are uncertain regarding the 4Mb DRAM market. Some suppliers aim to manage the market.

Other suppliers instead turn ahead to the 16Mb market or else backward to the 1Mb arena, which still enjoys resilient demand. Many suppliers are moving to less familiar DRAMs such as the 512Kx36 SIMM, VRAM, and specialty memory in face of uncertain demand trends (see Table 1). Dataquest assumes at this time that most suppliers will ease 4Mb DRAM and 1Mb DRAM pricing.

Dataquest will examine the assumptions behind and conclusions from its long-range DRAM and SRAM price forecasts in the next Semiconductor Procurement *Dataquest Perspective*.

Figure 1
Estimated DRAM and Slow SRAM Price Trends
(North American Bookings; Contract Volume)



Note: This information coordinates with Dataquest's quarterly forecast for 1992-1993, dated December 1991.

Source: Dataquest (January 1992)

SRAM: Shifting Market Trends

SRAM market demand is shifting to densities of 256K and above, although the 64K segment remains significant for new market entrants such as AT&T.

Pricing for 256K fast SRAM continues to decline (see Table 1). Pricing for 32Kx8 SRAM 35ns fell below Dataquest's forecast North American pricing during 1991. Pricing for this device could erode seriously by year-end 1992. The pricing scenario regarding 64Kx4 SRAMs 25ns is similar, if not more aggressive, because first-tier Japan-based companies aim—despite increased global competition—to hold share until the 1Mb fast SRAM market develops.

In the 64K fast SRAM arena, some suppliers from regions such as North America, Europe, and Asia have broken the informal $3 minimum-price level. For example, the competitive supplier base in Taiwan has brought pricing for 64K fast SRAMs (x4, x8 configurations; 20ns, 25ns) to $2. Users in North America and Europe should expect the entry of Taiwan-based suppliers such as UMC and Winbond to increase pricing competition.

Nonvolatile Memory

Dataquest's outlook for pricing of nonvolatile memory remains consistent with prior expectations. User interest as reflected by inquiries has shifted to EPROM devices of density of 1Mb or greater and ROM devices of 2Mb density and greater, including 8Mb and 16Mb devices.

Users are quite interested in flash memory, including Intel's strategy, the premium for TSOP, and EPROM-market effects. Dataquest currently sees a premium of at least 7 or 8 percent for TSOP, but as much as 20 percent is possible, depending on the supplier.

Microprocessor Trends

The fourth quarter of each year marks a key period of business decision-making, while the first quarter marks the implementation of new strategies. We noted in October that "Intel's strategic response in the next several months to market competitive forces could well determine whether or not Intel remains long-term king of the worldwide microprocessor market" and that all signals would "appear to augur a turning point in Intel's aversion to low-ball competition."

A Turning Point for the Intel MPU Price Strategy?

The competitive reality of 1992 and beyond—meaning, multiple sources/pricing competition for the 80386 family—apparently has prompted Intel to compete more aggressively on price. Dataquest learned at press time that Intel plans to cut 80386/80386SX pricing at the start of second quarter 1992—with 80486 price cuts expected to follow. Intel had issued no press release or price sheet at press time.

Users now can start to anticipate a turning point in the 80386/80486 pricing strategy.

Intel's pricing strategy and tactics appear to be changing. The assumptions behind Dataquest's forecast on Intel MPUs—and recent changes in these assumptions—shed light for users regarding the supplier's direction should Intel cut pricing during the second quarter of 1992. Based on current reports, Intel will slash by nearly half 80386/80386SX devices' pricing during the second quarter of 1992.

Intel MPU Price Forecast Assumptions

First Assumption: Synchronization with Intel's MPU Plans

The first assumption behind the Intel MPU price forecasts—that Intel will most favorably support users that coordinate system life cycles in line with Intel's migration schedule—appears to be bending under the heavy weight of market forces. Intel wants to pursue this strategy over the long term. However, for 1992 Intel must respond to continuing market demand for low-cost 386/386SX machines by lowering 80386/80386SX pricing. The life cycle for 80386/80386SX-based PCs is extending into 1992 and 1993—longer than Intel originally expected. Intel still intends during 1992 and 1993 to migrate users to the higher-priced

80486 family and away from the lower-priced 80386 family. Intel will not easily cede the 80386 market to competitors such as Advanced Micro Devices Inc. (AMD) or Chips & Technology Inc. (C&T).

Second Assumption: 1992 Means Multisourcing Plus the FTC Investigation

Intel now operates in a new competitive environment that threatens to reshape the company during 1992 and over the long term. Both the complex-instruction-set computing (CISC) and reduced-instruction-set computing (RISC) markets mean a trend toward multiple sources for users of MPUs—a break with the sole-sourced Intel/Motorola world of the not too distant past. Barring a major legal reversal, the 80386 marketplace has become a multisourced arena for Intel.

The DRAM market remains potentially volatile.

Even if Intel maintains its patent-based monopoly, the ongoing investigation by the U.S. Federal Trade Commission (FTC) could force—or perhaps already has forced—Intel to change its way of doing business and treating customers, especially in North America. As Dataquest has noted before, the FTC investigation—even more so than other widely publicized legal cases—might be the wild card that alters Intel's long-term product/pricing strategy.

Third Assumption: Intel's Resistance to Pricing Competition

Last quarter, we noted that another key assumption behind Dataquest's 80486 price forecast—Intel's intention to be relatively impervious to external pricing competition—seemed likely to change given year-end 1991 competitive realities. Dataquest anticipates that Intel over the long term will ignore to the best of its ability competitors' pricing for similar products. Even so, competitive multisourced pricing likely will become the predominant trend in the MPU business of the 1990s.

Intel's short-term strategy, however, calls for response to competitors' pricing. Dataquest's current forecast expects drops in 80486 pricing during 1992 that will set the stage for user migration to the 80586 device. A key point is that pricing for the 80486/80486SX device could take a step function downward by midyear 1992 if competitive pressure does not abate.

Fourth Assumption: No Intel Pricing Wars

Dataquest continues to assume that Intel will avoid a pricing war with AMD, C&T, or any other 80386/80486 market competitor. The price slashing for the 80386/80386SX devices—if they hold—to some extent is old news for major buyers (that were paying the lower prices during 1991) or else long overdue for smaller customers that had anticipated such pricing since the first half of last year. For example, AMD does not want a pricing war at this time because a pricing war could threaten its recent string of profitable quarterly results.

Dataquest Perspective

The first quarter of each year marks a time of implementation of new plans. The recession continues. Under these market conditions, IC pricing pressure mounts.

Users now can start to anticipate a turning point in the 80386/80486 pricing strategy. At press time, the spectre of a demand slowdown during 1992 and the evolution of a multisourced marketplace apparently has motivated Intel to fundamentally change its product pricing strategy—at least for 1992.

The DRAM market remains potentially volatile. Prices for 4Mb DRAMs are being booked during January 1992 at a sub-$14 level. Pricing for 1Mb DRAMs remains below $4 and approaches $3.50. The likely DRAM scenario remains the same: Suppliers of 1Mb DRAMs that usually demonstrate a willingness to compete on price will engage in aggressive pricing that may abruptly end. Suppliers of 4Mb DRAM will price conservatively until the effect of capacity allocation becomes known.

By Ronald Bohn

Memory Cards: An Emerging and Potentially Explosive Market

What Are Memory Cards?

A memory card is a portable semiconductor storage device that contains memory ICs. It resembles a thick credit card (3.3mm) with an edge connector at one end (see Figure 1).

Figure 1
Example of Memory Card

Source: Panasonic Industrial Company

Memory cards perform a function similar to that of a floppy disk. They store binary data.

As program or data storage media, memory cards are not new. They have been used in computer games, point-of-sale (POS) systems, photocopiers, and laser printers. More recently, electronic organizers such as the Casio BOSS and the Sharp Wizard along with palmtop PCs such as the Poqet and the HP 95LX have begun using memory cards for data storage. Figure 2 shows their application in portable PCs.

The memory card form factor has not changed much over time, but the type of edge connector and the electrical/mechanical interface have. The edge connector of a memory card is the conduit that allows data to move to and from the card's memory ICs. It defines the card's capabilities. To date, we have seen cards with a variety of connectors including 38-, 40-, 50-, and 60-pin.

Memory Card Varieties

Memory cards contain mostly semiconductor memory ICs that belong to one of the following families: mask ROM, EPROM, OTP, SRAM, DRAM, EEPROM, and flash. DRAM memory cards are relative newcomers and are meant to be used as "extended/expanded" memory with no need for battery backup. SRAM cards with

Figure 2
Memory Card Usage in a Portable PC

Source: Intel Corporation

battery backup have been used as solid-state "floppies" in the current generation of electronic organizers. Until recently, SRAM cards (with battery backup) were the only nonvolatile memory cards. Flash memory cards today provide a promising alternative. Items such as language translating software and dictionaries typically come in mask ROM cards, as they are the most dense and least expensive. Functionally, they are huge look-up data tables that need no change. Table 1 lists the various memory card alternatives.

Memory Card Applications

Memory card applications include the following:

- Personal computers
- Factory automation
- Instrumentation and testing
- Avionics
- POS terminals
- Musical equipment
- Medical instrumentation

On Standards

What inhibited memory card growth in the past was the lack of standards. In June 1989, the Personal Computer Memory Card Industry Association (PCMCIA) was formed in the United States, with a broad-based membership that included semiconductor companies along with software and hardware vendors. The PCMCIA's originally stated goal was to establish a standard for memory cards used with DOS-based PCs. It succeeded rather quickly as standards go. The first revision of a memory card standard was published in August 1990.

Table 1
Memory Card Alternatives

Type	Density
ROM	128KB—16MB
EPROM/OTP	128KB—8MB
DRAM	64KB—12MB
SRAM	32KB—4MB
EEPROM	8KB—512KB
Flash	128KB—4MB

Source: Dataquest (January 1992)

Revision 1.0 of the PCMCIA/Japan Electronic Industry Development Association (JEIDA) standard defined the following:

- The form factor—a device the size of a credit card, 3.3mm thick with a 68-pin socket connector
- The interface—parallel type bus, 8-bit/16-bit
- The address space—64Mb

The PCMCIA worked closely with the JEIDA and JEDEC. This close cooperation enabled the prompt international acceptance of the standard. Revision 2.0, as announced in September, addresses XIP (eXecute-In-Place) and I/O functions such as modems and LANs for PCMCIA bus cards. Intel Corporation also announced the Exchangeable Card Architecture (ExCA), a hardware and software implementation of the PCMCIA Revision 2.0 system interface. It is Intel's stated intention to make ExCA an industry standard so that different types of cards (memory, LAN, modem, and wireless communications) from different manufacturers will be interoperable.

Do Memory Cards Replace Hard Disks?

Strictly speaking, memory cards are not hard disk replacements. Rotating media have not been terribly successful with removable hard disks. A number of companies have tried that approach, but technology and costs kept it out of the mainstream. Thus, after a decade of using PCs, we are conditioned to think of hard disks as storage devices that belong inside the PC enclosure. This idea is a technology-dependent perception, and there is no reason why it should be so. On the other hand, memory cards, being a solid-state storage medium, are removable and portable. At a density of 20Mb, is a memory card acting like a "removable hard disk"? We believe that it is.

Memory cards have the following advantages over floppy/hard disks:

- Faster access and transfer rates
- Space, power, and weight reduction
- More ruggedness

However, they do have the following disadvantages:

- Expensiveness
- Lower capacity

The Cost Issue—How Important Is It?

In 1991, the average selling price (ASP) of a 2.5-inch 40MB hard disk drive was $250.00, which translates to $6.25 per megabyte. The 3.5-inch floppy cost is close to $1.00 per megabyte. By comparison, a 1MB flash card costs approximately $300.00 or $300.00 per megabyte—a substantial disparity! Semiconductor memory certainly costs more.

The question is, "Can you put a floppy disk drive in a palmtop PC to take advantage of that cost disparity?" The answer is, "No." There is not enough power (or space). *The issue, then, is not cost.* Here the removable storage medium dictates the product's capabilities and its success or failure in the marketplace. Without a memory card, a palmtop is nothing more than an electronic organizer. It is the memory card that transforms a palmtop into a full-fledged personal computer.

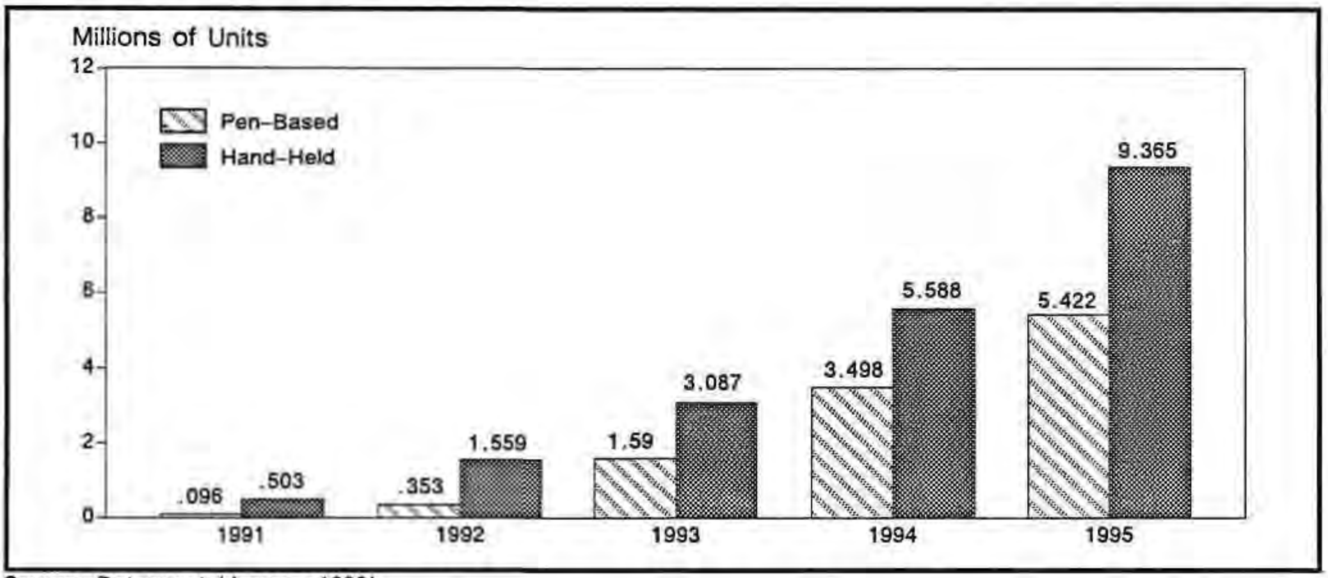
The Memory Card Market

As with any emerging technology, market size projections are difficult at best. The following assumptions may be used to gauge a portion of the total available market:

- The majority of hand-held PCs will use memory cards (80 to 95 percent).
- A portion of pen-based PCs will use memory cards (50 to 80 percent).
- Notebook PCs are forecast to grow from 686,000 units in 1991 to 7 million by 1995. A portion will use memory cards (10 to 20 percent).

Figure 3 provides some useful boundary conditions. Dataquest expects worldwide shipments of

Figure 3
Pen-Based and Hand-Held PC Forecast



Source: Dataquest (January 1992)

pen-based PCs to grow at a compound annual growth rate (CAGR) of 174 percent, from 96,000 units in 1991 to nearly 5.5 million units in 1995. At the same time, hand-held PC shipments will grow at a 108 percent CAGR from 503,000 units in 1991 to approximately 9.4 million in 1995. Together they amount to approximately 600,000 units in 1991, growing to almost 15 million by 1995. Some simple assumptions on memory card ASPs indicate that this could easily become a billion-dollar-plus market by 1995.

Flash memory cards hold the promise for becoming the least expensive form of solid-state storage.

Memory cards used in non-PC applications (which may account for as high as 90 percent of total memory card shipments in 1991 and 40 to 60 percent by 1995) are not included in this discussion. Electronic still photography alone may provide an explosive market for memory cards.

What Are the Key Developments Needed for Memory Cards to Succeed?

Three developments are necessary for the success of memory cards. These developments and the applications where they are needed are as follows:

- Cost reduction—all applications
- Development of data-compression ICs—electronic "filmless" still photography and PCs
- XIP—palmtop PCs

Cost Reduction

Flash memory cards hold the promise for becoming the least expensive form of solid-state storage. From a cell standpoint, flash rivals that of DRAM. Unlike DRAM or SRAM, it is nonvolatile, which means there is no need for battery backup. The need for bulk erasing of current-generation flash ICs creates a problem that requires clever solutions. With SRAM or DRAM cards, a single byte can be erased; EPROM-derived flash most often can be erased at the chip level (i.e., the whole chip). Recently, some vendors have announced products that allow erasure of particular memory segments. A prime example is the Intel 28F001BX 1Mb flash memory, which is segmented into areas of one 8KB, two 4KB, and one 112KB—all of which can be independently erased and programmed. EEPROM-derived flash is far more flexible at a cost premium (larger die). Flash EEPROM cells are larger than flash EPROM. Mask ROM memory cards will be the least expensive for the foreseeable future.

Data Compression ICs

Data compression ICs represent a key development for the electronic photography market and, to a lesser extent, for palmtop and pen-based PCs. Data compression ICs will be the subenabling technology devices. Without them, the future of electronic photography is in doubt. Thirty-six exposures (pictures) can be stored in a 2MB flash memory card in compressed form. If no compression were used, 40MB would be needed!

XIP

Simply stated, XIP allows a memory card to "plug-and-play." That is, once the card is plugged into the PC, program execution begins much in the way a program runs after one types in the program name and hits carriage return. That procedure is in contrast with current-generation PC architectures that need to copy the program code from secondary storage (hard disk or floppy) to main memory (DRAM) before execution. A palmtop PC with XIP capability needs just a single copy of a program, usually stored in the memory card, thus freeing up main memory.

The Players—Solid-State Disks

A number of companies are working on solid-state disk (SSD) replacement—a challenging task, to say the least. SunDisk Incorporated, located in Santa Clara, California, chose to focus primarily on hard disk replacement (solid-state disk) with a proprietary flash memory technology and architecture. The venture-capital-funded start-up launched three SSD products recently, all aimed at pen-based and palmtop PCs. The 2.5/5/10MB SSD plug-and-play subsystems come with an IDE industry-standard interface. The company is producing a 20MB solid-state disk subsystem on two PCMCIA form factor cards and expects to offer 40MB capacity shortly.

Toshiba announced a 4MB 5V EEPROM IC (TC58400) that is aimed at the SSD market. This device is by far the most dense EEPROM introduced to date. Architecturally, it is organized in a way that should facilitate SSD implementations. Toshiba uses a NAND cell structure that is 70 percent of its 4Mb DRAM cell; it is manufactured using a 0.7-micron double-poly CMOS process. The die size is $58.55mm^2$.

The bulk of the memory card growth will not come at the expense of rotating media. Growth will come from the creation of new markets.

Hitachi announced a 5.25-inch form factor SSD based on 4Mb DRAM technology. This product is targeted at CAD/CAM, imaging, and graphics systems that demand a higher I/O throughput than what hard disk drives provide. The Hitachi SSD has access time of 0.35ns, incorporates an SCSI interface, and comes in 32MB or 64MB PC boards. The SSDs may be expanded to a capacity of 320MB. The data can be protected from power failures by using an optional battery-powered backup hard disk drive.

The Players—Memory Cards

Table 2 lists some of the companies active in the memory card market and their products. Other companies include Datakey and ITT-Cannon.

Alternate Technologies—FRAM, novRAM

At least two different technologies may be used in future SSD and memory card implementations, assuming that they become cost competitive. Both of those technologies are nonvolatile (that is, need no battery to retain data) and are easily reprogrammable. FRAM

Table 2
Memory Card Offerings

Company	Density	Type
Toshiba	128KB to 1MB	Flash
	256KB to 2MB	SRAM
	256KB to 8MB	OTP
	128KB to 4MB	Mask ROM*
Intel	1MB to 4MB	Flash
Mitsubishi	256KB to 2MB	Flash
	64KB to 512KB	SRAM
	128KB to 192KB	EEPROM
	512KB to 16MB	Mask ROM
Fujitsu	256KB to 4MB	Flash
	64KB to 512KB	SRAM
	16KB to 128KB	EEPROM
	256KB to 1MB	EPROM
	256KB to 2MB	OTP
	512KB to 16MB	Mask ROM
Oki	256KB to 2MB	Flash
	64KB to 2MB	SRAM
	512KB to 4MB	OTP
	1MB to 8MB	Mask ROM
Rohm	128KB to 4MB	Flash
	32KB to 1MB	SRAM
	512KB to 3MB	OTP
	512KB to 6MB	Mask ROM
Epson	128KB to 2MB	Flash*
	32KB to 1MB	SRAM*
	8KB to 64KB	EEPROM*
	128KB to 1MB	OTP*
	128KB to 4MB	Mask ROM*
Maxell	64KB to 512KB	SRAM*
	64KB to 256KB	EEPROM*
	256KB to 1MB	EPROM*
	128KB to 1MB	OTP*
	1Mb to 8MB	Mask ROM*
Fujisoku	64KB to 1MB	SRAM
	256KB to 1MB	EPROM
	256KB to 2MB	OTP
	1MB to 4MB	Mask ROM
Panasonic	to 4MB	Flash
	512KB to 4MB	SRAM
	to 512KB	EEPROM
	to 4MB	OTP
	to 8MB	Mask ROM
Du Pont	256KB to 2MB	SRAM

*x16 organization
Source: Dataquest (January 1992)

(Ferroelectric RAM) devices are now becoming available from Ramtron International Corporation of Colorado Springs, Colorado. At this point, the 4Kb and 16Kb production offerings may find only limited use in memory cards and SSDs. However, Ramtron is working on 64Kb and 256Kb devices and hopes to offer 4Mb densities by 1995. From a technology standpoint, ferroelectric devices have the potential of reaching densities similar to those of DRAM.

The other alternative—novRAM—was, until recently, available in low densities (256 bits to 8Kb). However, Simtek Corporation, also of Colorado Springs, has demonstrated that it is possible to substantially increase novRAM densities. The company offers 64Kb devices now and plans to introduce 256Kb and 1Mb products in the future. A novRAM is essentially a combination of SRAM and EEPROM. Every SRAM bit has a corresponding EEPROM bit that is used to store the information when power is removed. Because the SRAM section of the device is used during normal operation, high-speed (30ns) read/write is available. However, the resulting die is larger than either an SRAM or an EEPROM device of the same density.

Some Thoughts on the Future of Memory Cards and PCs

In the past, the computer was the expensive component and the storage medium (floppy disk) the inexpensive one. We've become accustomed to that oddity and do not seem to question it. However, the computer is just a machine that manipulates information. It is the information that is important and valuable, not the machine that manipulates it. So perhaps it is fitting that the information carrier, a memory card, may cost more than the computer it is attached to. In the future, we will be using platforms (palmtop PCs) that cost much less than the storage media (memory cards) they use. Imagine a $50 PC attached to a $100 memory card. At least losing the PC will not be a problem anymore!

Dataquest Perspective

Dataquest believes that memory cards represent an important enabling technology. They have the potential to transform still photography and to make the 35mm film and cameras that use it obsolete. In the process, they will change that industry and provide tremendous opportunities for growth in the consumer electronics market.

Ultimately, we believe, memory cards may revolutionize portable PCs by enabling them to become smaller, more rugged, lighter, faster, and perhaps user-friendly in a way that appeals to the vast majority of people who at present have no use for them.

Memory cards will not eliminate rotating magnetic media any time soon. Instead, they will selectively replace them only when and where it makes sense. The bulk of the memory card growth will not come at the expense of rotating media. Growth will come from the creation of new markets. This should be good news for the semiconductor memory industry.

Ultimately, we believe, memory cards may revolutionize portable PCs by enabling them to become smaller, more rugged, lighter, faster, and perhaps user-friendly in a way that appeals to the vast majority of people who at present have no use for them. In doing so, memory cards may be the enabling technology that will make the PC of the future a true consumer item.

By Nicolas Samaras

In Future Issues

The following topics will be addressed in future issues of Semiconductor Procurement *Dataquest Perspective:*

- February *Procurement Pulse*
- Long-range DRAM/SRAM pricing
- Semiconductor Supplier of the Year Award and 1992 procurement issues
- Semiconductor cost model update

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User Wants and Needs

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Chapter 1
Executive Summary

Introduction

The market requirements of the semiconductor user, whether in procurement or component engineering, continue to be a moving target because of the shifting nature of the overall electronics industry. This study focuses on the what, where, when, and how of semiconductor users' main concerns, now and for the upcoming year.

How well an electronics company translates an end-user need into a finished product that meets that need often depends on how well the raw materials that comprise the finished product are sourced and then procured. The variety of electronic market segments—each of which has specific supplier requirements—at best makes the semiconductor supplier's task of meeting customer needs a challenge. But, as an industry, the electronics market also has some consensus semiconductor needs being met to varying degrees, depending on the specific industry segment. This report does the following:

- Highlights the overall electronics market's semiconductor user requirements
- Breaks the industry into eight specific segments to better understand where certain user requirements differ from the norm
- Segments the electronics market by semiconductor product category to note differences of need, by selected product type

Study Objectives

This document reports the findings of Dataquest's seventh annual Semiconductor User and Application Needs survey. This survey assesses the current status and future needs of the semiconductor user community and is presented in an impartial, third-party format that allows both users and suppliers of semiconductors to gain better insight into respective competitor and customer needs in the upcoming months.

The survey was designed to gather detailed information on the current status of semiconductor users and of their needs for 1993. The specific objectives were as follows:

- Highlight both the top user issues needing focus, along with areas now being met but that if neglected would cause supplier review/removal

- Provide a 1992 benchmark of key indexes for eight key electronic industry segments
- Provide a succinct list of supplier selection criteria, down to the semiconductor product level

Methodology

The overall goal of the project was to gain an understanding of semiconductor procurement logistics, service and product requirements, and issues for OEMs headquartered in North America. To this end, in October we surveyed 95 separate companies out of the sample population of the *Electronic Business Magazine* top 200 electronic companies (also known as the EB 200).

We were successful at accounting for $3.7 billion in semiconductor purchasing power, which represents 6 percent of the worldwide and 18 percent of North American semiconductor markets. A survey of about 50 questions was used in telephone and face-to-face contacts with predominantly senior procurement management officials with corporate overview.

Key Findings of This Study

Top User Issues and Supplier "Cardinal Sins"

According to the study, the three main issues that will receive top attention in the upcoming months are price, availability, and lead time. Areas now being done well (primarily high quality and on-time delivery) need to be maintained by suppliers in order to keep existing customers. Table 1-1 shows how top issues have changed (remain unchanged?) over the past six years. Tangible issues such as price, quality, and lead time generally take top priority, but it is often the intangibles, if neglected, that can rapidly turn into visible tangible costs (good supplier relations and supplier flexibility, among others). Quality levels now meet market requirements, and the next hurdle to face is lowering a tangible (and very visible) cost variable as much as practically possible. The current systems market is forcing semiconductor users to require the highest level of quality yet simultaneously cut and control costs. It is up to prudent management to decide what the total cost level must be for a system (integrating quality, price, and delivery, among others) and work toward that goal, rather than solely focus on isolated issues of price, lead time, and the like.

Semiconductor User Future Needs, by Industry

As a result of this survey, the respondents noted that the U.S. electronics industry designs and assembles the majority of its own circuit boards and predominantly assembles them in the United States, with the Far East as the runner-up for assembly location. It was found that the "latest" trend to use contract manufacturers or "outsource" is not new at all to the respondents of this survey. The vast majority of the respondents have a formal quality program in place and for the most part see the results at worst as being beneficial; many see the programs as critical to their ongoing

Table 1-1
Historical Procurement Issues

Issue	1993	1992	1991	1990	1989	1988
Pricing	1	1		2	2	2
Availability/Allocation	2	4	2	4	1	1
Lead Times	3	-	-	-	-	-
Quality/Reliability	4	2	5	6	4	6
On-Time Delivery	5	3	6	1	3	3
Cost Control	6	6	3	3	7	4
Flexibility/Service	7	-	-	-	-	-
JIT/Inventory Control	8	7	4	5	6	9
Developing Supplier Relations	9	10	-	-	-	-
New/Obsolete Products	10	5	7	7	8	8

Source: Dataquest (December 1992)

business. The small difference in average parts per million of rejected incoming semiconductors by product family and the overall low level of rejects attest to the effectiveness of these programs (see Figure 1-1). It appears that strategic supplier programs have gotten much attention and many companies have programs under way. It was found that the definition of "on-time delivery" had almost as many ranges as the number of respondents, with the most common delivery schedule being +0,-5 days to delivery date (see Figure 1-2). Although the 15.2 percent average electronics 1993 growth forecast given by our respondents is a bit aggressive, based on our research (Dataquest's 1993 U.S. electronics market forecast is 4.4 percent), it does reflect the positive outlook for next year of the economy pulling itself out of the current slowdown.

Semiconductor Supplier Selection Criteria

On average, quality and delivery performance remain the most stringently employed supplier selection criteria. Microcomponents (MPUs, among others) was the only product category where pricing was a serious contender as a selection criteria. This perception is probably because of the relative higher prices of these parts and the limiting sourcing options in some cases.

Quality performance across-the-board was clearly a prerequisite to doing business. All four surveyed product areas had average minimum acceptable quality levels of about 60 parts per million (ppm). The higher-volume businesses such as PCs required even more restrictive quality performance.

The high ranking of delivery performance, especially in ASICs, seemed to underscore the importance of timing in today's global market. With product life cycles running under two years in some volume segments, even a week slippage can hurt an OEM's market positioning.

Approved supplier lists are slated to shrink next year for almost all industries and for all semiconductor products. OEMs on average maintained eight microcomponent, six standard logic and analog, five ASIC, and five memory suppliers during 1992. High-volume users tended to keep the number smaller, whereas military/ aerospace users had nearly double the amount in some cases.

Structure of the Report

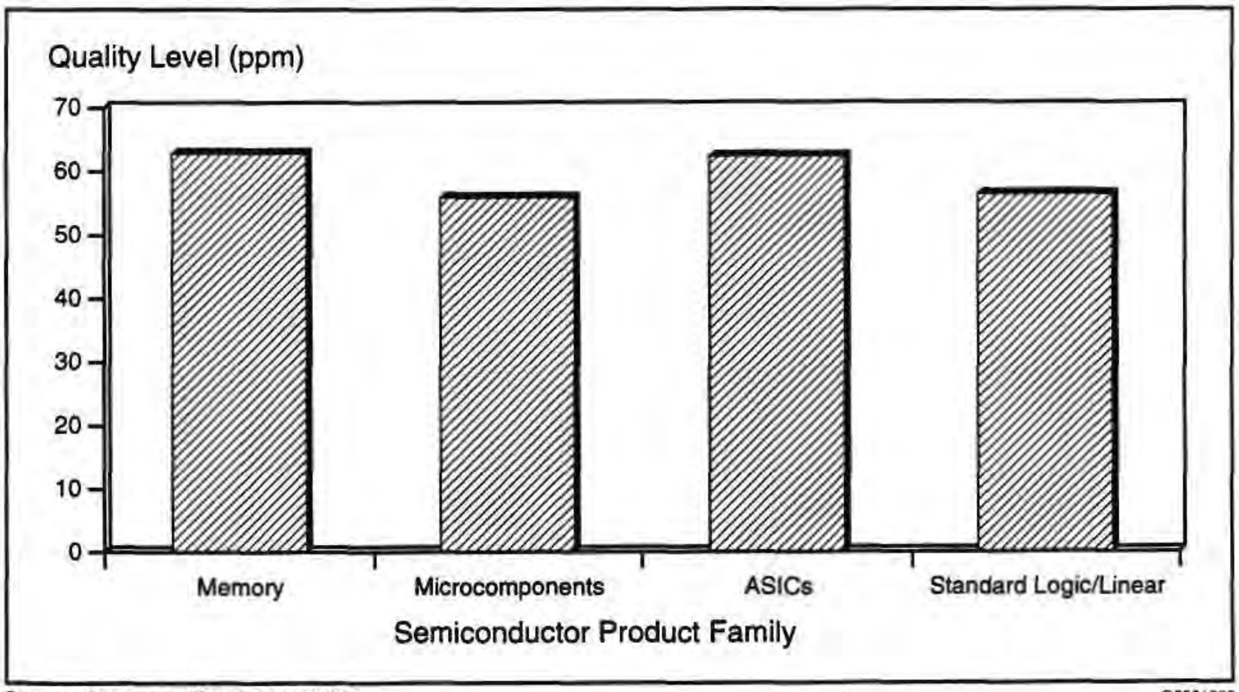
The remainder of this report is divided into five sections, deriving detail on procurement data, logistics, and issues by electronic industry (data processing, for example) and by semiconductor product category (memory ICs, for example). The report relies heavily on graphical analysis, facilitating quick assessment by the reader. The other chapters of the report include the following:

- Respondent Demographics—This chapter assesses the type of companies and decision makers surveyed for this report.
- 1993 Semiconductor User Issues and Supplier Cardinal Sins—This chapter addresses questions about what is most important to semiconductor users in various industries. The supplier "cardinal sins" or disqualification factors are brought to the surface and analyzed as well.
- Semiconductor User Status and Future Needs, by Industry—Key logistical and procurement information is spotlighted in this chapter. Information about regional board assembly, contract manufacturing, on-time delivery definitions (±days), and the usage of quality and supplier partnering programs is highlighted as well.
- Semiconductor User Needs, by Product Category—Organized by semiconductor product category, this chapter of the report assesses the supplier selection criteria used by OEMs. Criteria such as pricing consistency, delivery and quality performance, market flexibility, and product portfolio and plans are ranked by respondents. OEM definitions of quality on a ppm basis are uncovered, along with plans for reducing qualified supplier lists.
- Recommendations—This chapter provides twin assessments about how OEMs and chip companies can work with each other profitably in the competitive 1990s.

Project analysts: Mark Giudici and Gregory Sheppard

Research support: Mario Morales and Rick Shigemoto

Figure 1-1
Electronics Industry Average Quality Level, by Semiconductor Product Family (ppm)



Source: Dataquest (December 1992)

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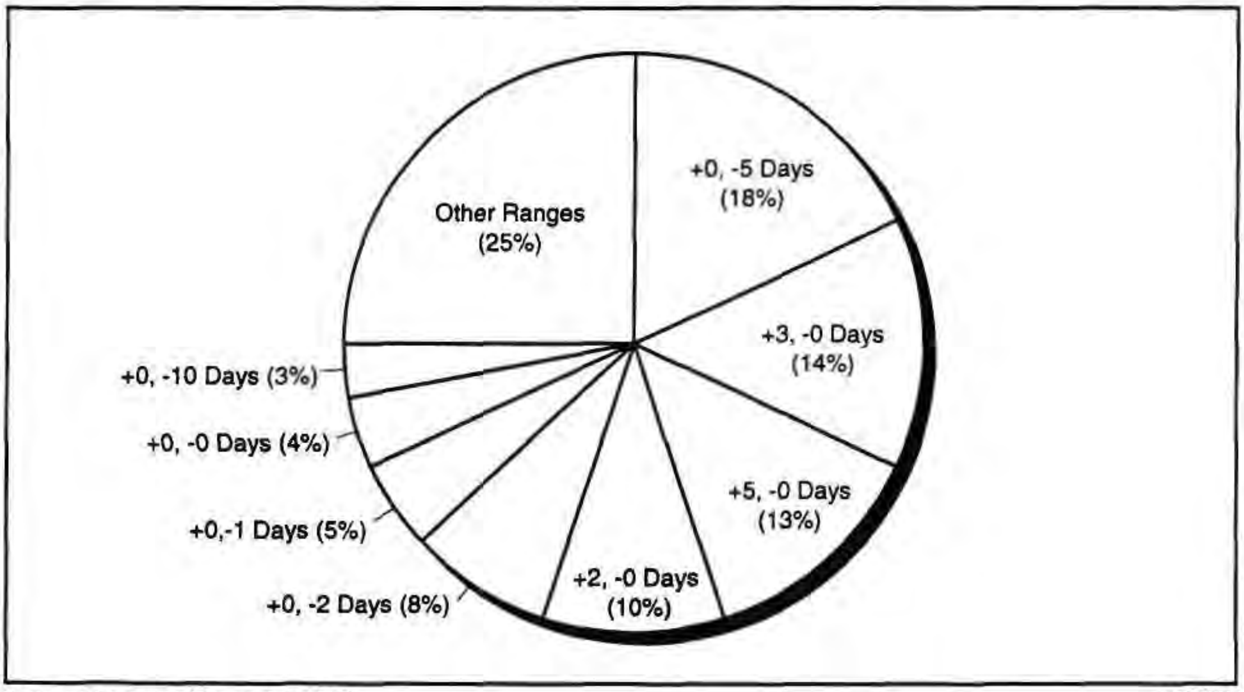
Figure 1-2
Electronics Industry On-Time Delivery Definitions (Delta to Delivery Date)



Source: Dataquest (December 1992)
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Chapter 2
Respondent Demographics

Introduction

The survey population was *Electronic Business Magazine's* top 200 North American electronic companies. Of these 200, 168 were contacted for this survey. The remainder were deemed ineligible because they were not system/subsystem OEMs. One goal of this survey was to capture responses from decision makers responsible for at least 10 percent of the North American market for semiconductors. The surveyed purchase value more than exceeded that, accounting for almost 18 percent of the North American market and 6 percent of the worldwide market. Another goal was to capture a valid sample of the market with representation from the various industries proportional to their mix of the market. Likewise, a substantial number of small companies were surveyed as well to give balance to their viewpoints.

Respondents' Role

Figure 2-1 presents the type of people we surveyed, by organizational title. About a third were of managerial status and another 40 percent were senior buyers.

Purchasing Power

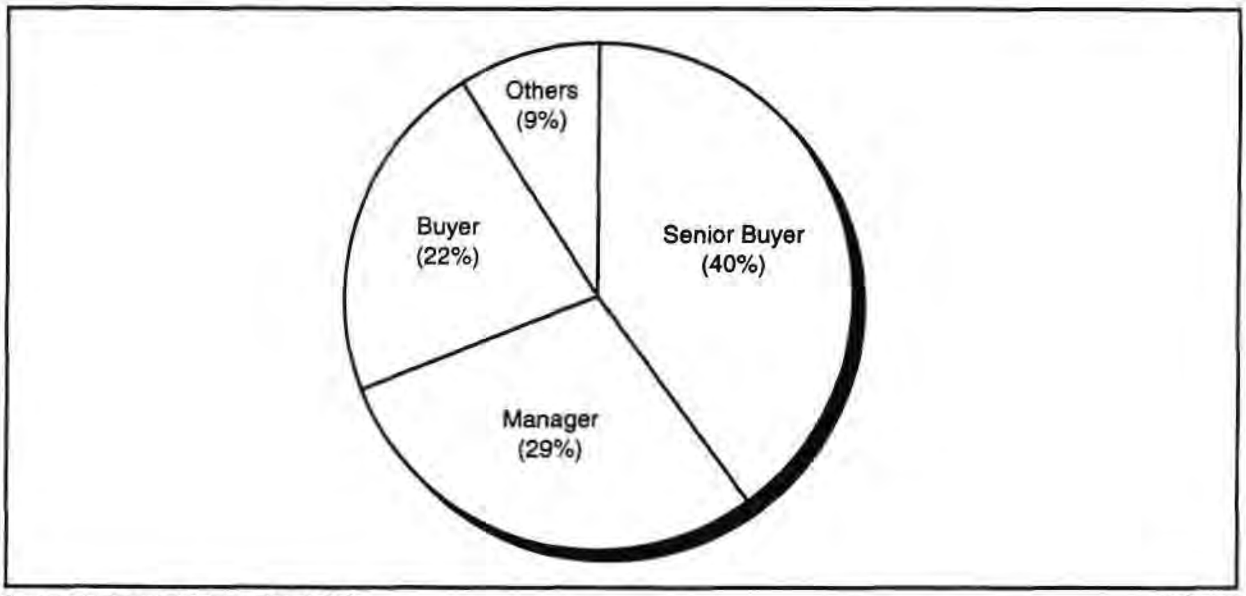
The overall semiconductor purchasing value of the respondents was $3.7 billion in 1992. This was spread among about 95 companies and 101 separate interviews. The intent was to approximate the actual distribution of the market. Figure 2-2 presents the weighted average distribution of semiconductor purchasing value covered in the survey. Data processing comprises more than 60 percent of the value, about 15 percent higher than what Dataquest estimates as the actual percentage it represents of the whole market.

Figure 2-3 indicates the purchasing power distribution captured in the survey. As happens in the marketplace, the predominant number of OEMs surveyed (including some divisions of large OEMs) purchase less than $10 million of semiconductors per year. The larger OEMs, however, account for a significant percentage of the overall market.

Summary

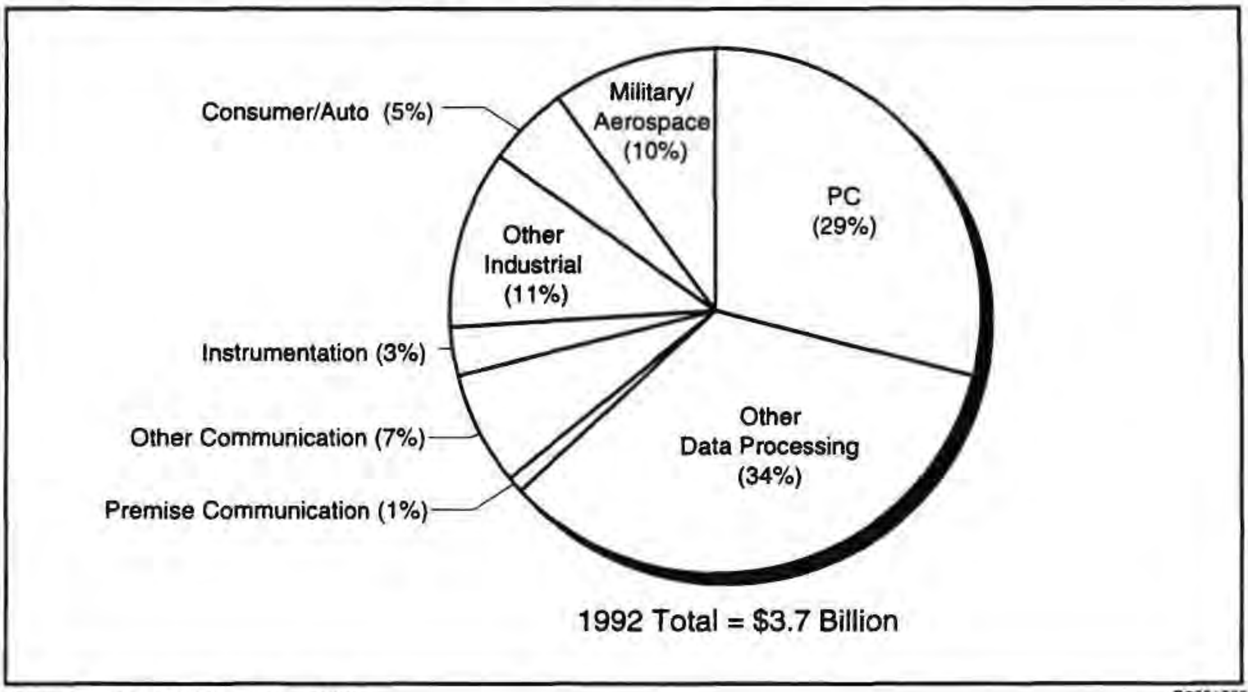
We believe that the survey demographics were representative of the market mix. Nearly 60 percent of the eligible EB 200 companies were surveyed by phone, and they accounted for 6 percent of the worldwide semiconductor market. Furthermore, surveys were conducted with primarily high-level decision makers knowledgeable of procurement practices and plans.

Figure 2-1
Respondents' Title



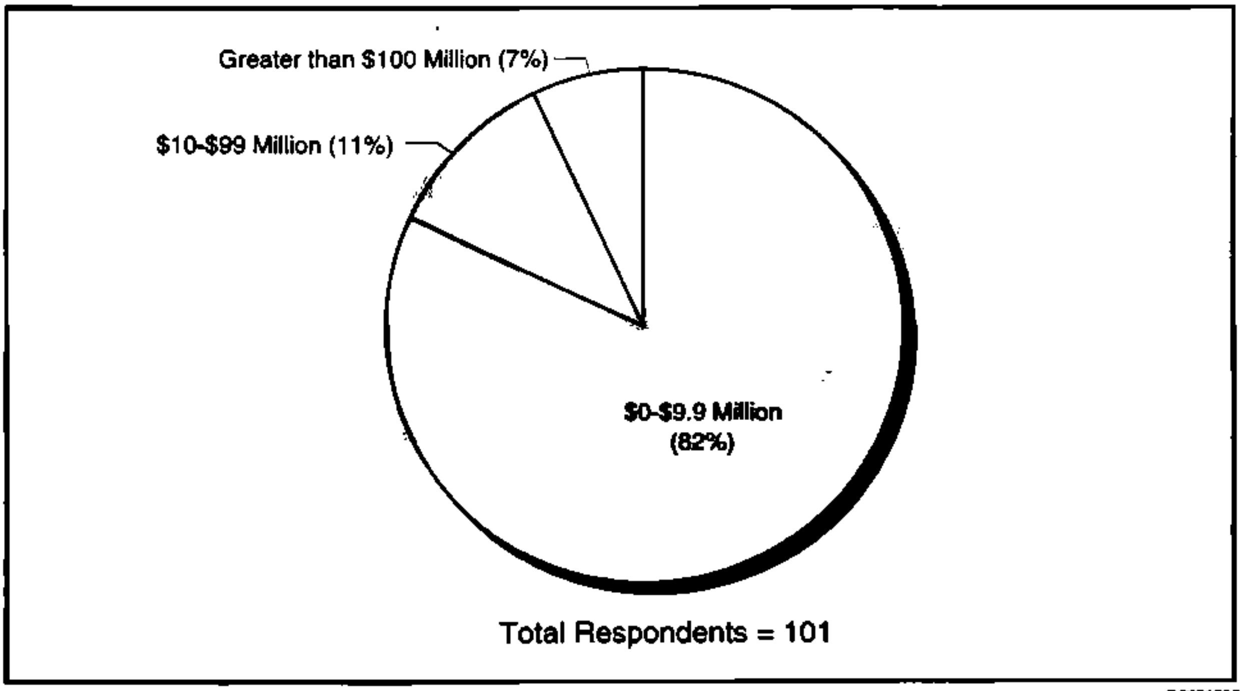
Source: Dataquest (December 1992) G2001284

Figure 2-2
Respondents' Semiconductor Purchasing Power, by Industry



Source: Dataquest (December 1992) G2001285

Figure 2-3
Respondents' Purchasing Power Segmentation



Source: Dataquest (December 1992)
G2001286

Chapter 3
1993 Semiconductor User Issues and Supplier Cardinal Sins

This chapter focuses on the key issues that need attention in 1993 (supplier opportunity) and, on a more negative note, on behavior by a semiconductor supplier that warrants review and its potential dropping (supplier cardinal sins). The overall sample clearly noted that price, availability, and lead time are the three key issues for 1993 (see Figures 3-1 and 3-2). Concern over semiconductor capacity levels and overall costs remain in the forefront.

The current business environment in general is growing at a moderate rate, with some companies in the data processing segment being constrained by lack of capacity. Behind all this growth, a top concern of most electronics companies remains overall cost control, often gauged in the most tangible of ways—price and inventory levels. Although these areas can be easily measured and benchmarked, the other variables of adherence to delivery schedules, world class quality, and market flexibility came out in this survey as other key areas that require attention in the upcoming months. The following paragraphs summarize each industry's key issues. Figures detail each grouping.

Key Issues

Data Processing

Availability and price appear to be the data processing market's key concerns, while poor quality ranks No. 1 as a reason to review or drop a supplier for this segment (see Figures 3-3 through 3-6).

Telecommunications

Figures 3-7 through 3-10 highlight that price and lead time are the telecommunications industry's key 1993 concerns. Continual missed delivery schedules, followed by poor quality, will warrant supplier review or removal in this industry.

Industrial Equipment

In the industrial equipment market, the instrumentation segment has distinct differences regarding key issues of price and availability. The rest of the industrial segment's focuses is on-time delivery and quality as key issues in the upcoming year (see Figures 3-11 through 3-14). There is concurrence in the industrial equipment industry that poor quality and missed delivery schedules warrant supplier review or removal.

Consumer/Automotive

Figures 3-15 and 3-16 show that the combined consumer and automotive industry category notes lead time and price as key 1993 issues, and that poor quality will cause immediate supplier review.

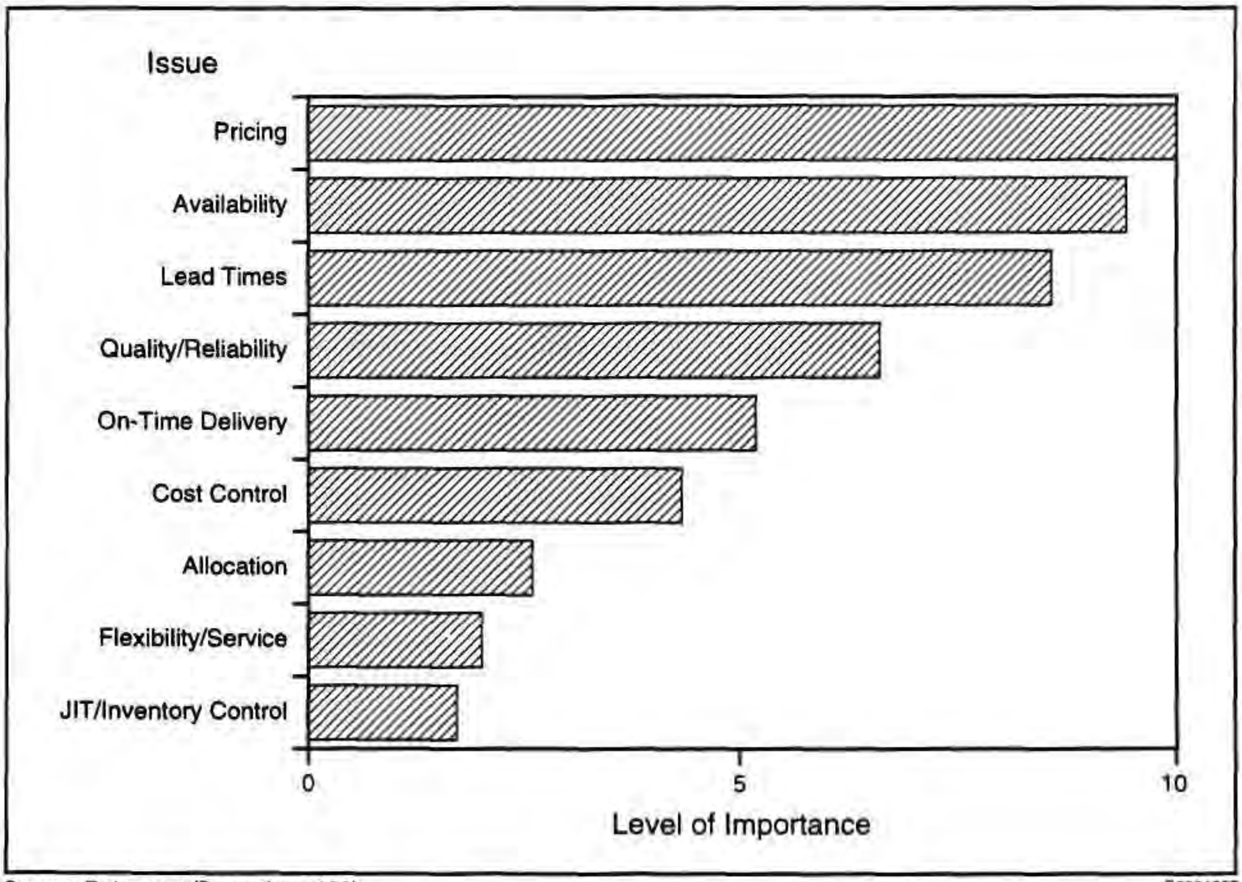
Military/Aerospace

The military/aerospace industry will focus on availability and a combination of quality and price in 1993. Missed delivery schedules and quality that is not up to specifications are reasons to drop a supplier (see Figures 3-17 and 3-18).

Summary

The three main issues that surfaced in this study were that price, availability, and lead time will receive top attention in the upcoming months. Areas now done well (primarily high quality and on-time delivery) need to be maintained by suppliers in order to keep existing customers. On the surface, the paradox of quality ranking as the overall reason for dropping a supplier and of price being the No. 1 cost-cutting issue for next year appears at odds with the concept of total cost management. Quality levels now meet market requirements and the next hurdle to face is lowering a tangible (and very visible) cost variable as much as practically possible. The current systems market is forcing semiconductor users to require the highest level of quality, yet simultaneously cut and control costs. To some extent this can be achieved, but generally only for a limited time. It is up to prudent management to decide what the total cost level must be for a system (integrating quality, price, and delivery, among others) and work toward that goal, rather than solely focus on isolated issues of price, lead time, and the like.

Figure 3-1
Electronics Industry 1993 Top Procurement Issues

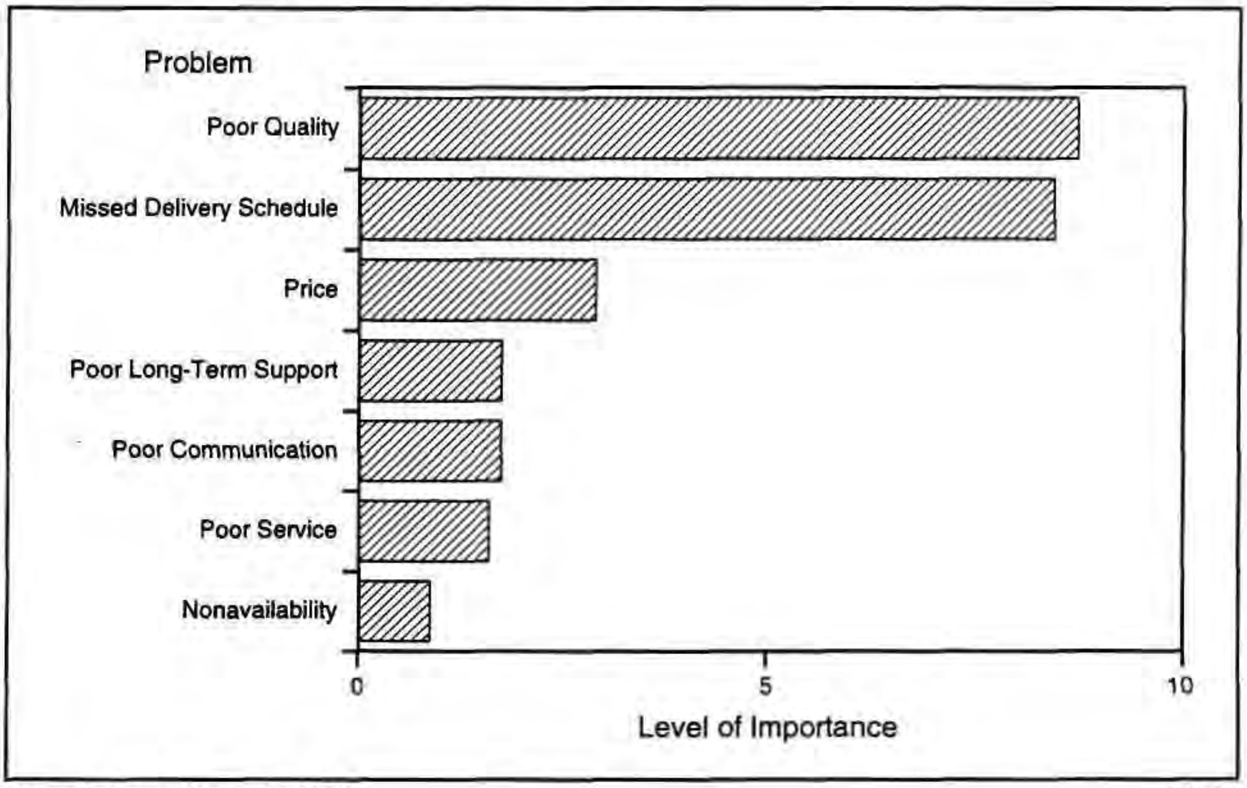


Source: Dataquest (December 1992)

G2001287

- *Concerns over semiconductor availability, lead time, allocation, and the like are again being raised as suppliers stretch existing capacity to meet demand growth.*
- *Quality and on-time delivery are significant issues, but are considered prerequisites for suppliers today.*

Figure 3-2
Electronics Industry Ranking of Supplier Cardinal Sins

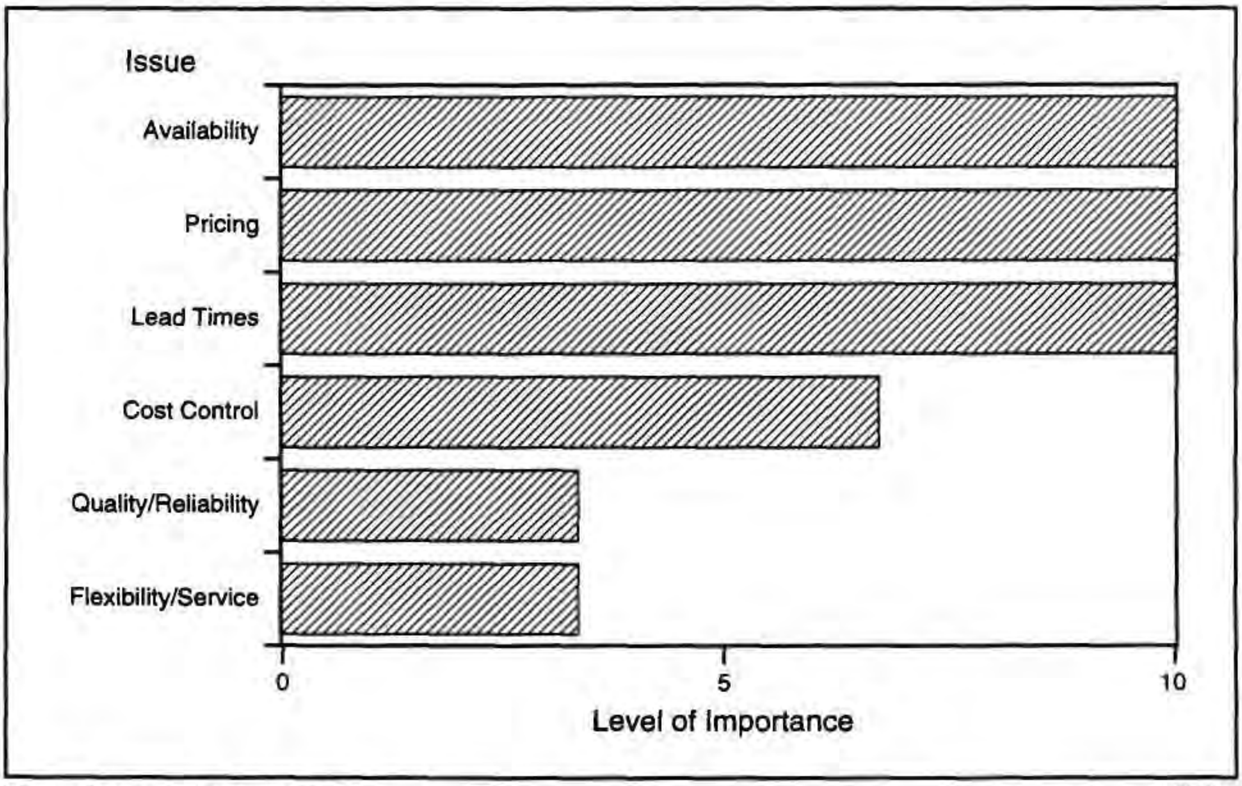


Source: Dataquest (December 1992)

G2001288

The top two actions/conditions that warrant supplier review or removal tie in directly with the total cost concept that relies on top quality and on-time delivery.

Figure 3-3
PC Industry 1993 Top Procurement Issues

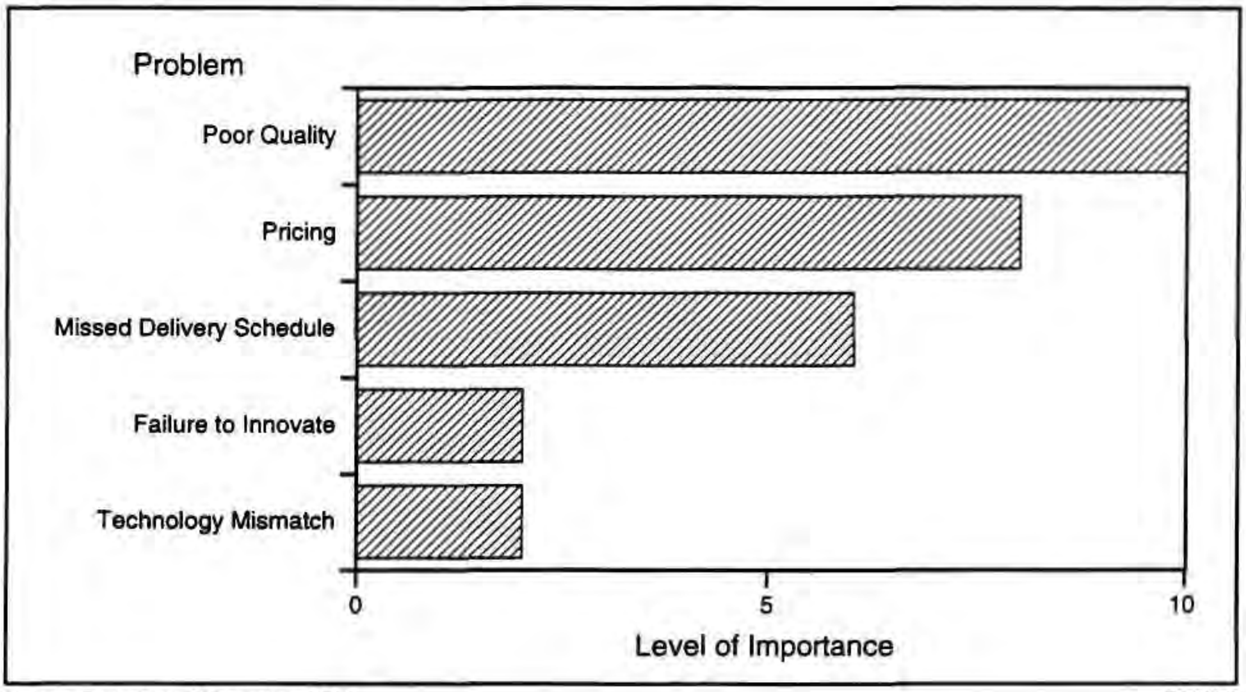


Source: Dataquest (December 1992)

G2001289

Three issues tie for the top spot in this segment, and all are interrelated. As capacity levels of suppliers fill, availability often takes precedence over price.

Figure 3-4
PC Industry Ranking of Supplier Cardinal Sins

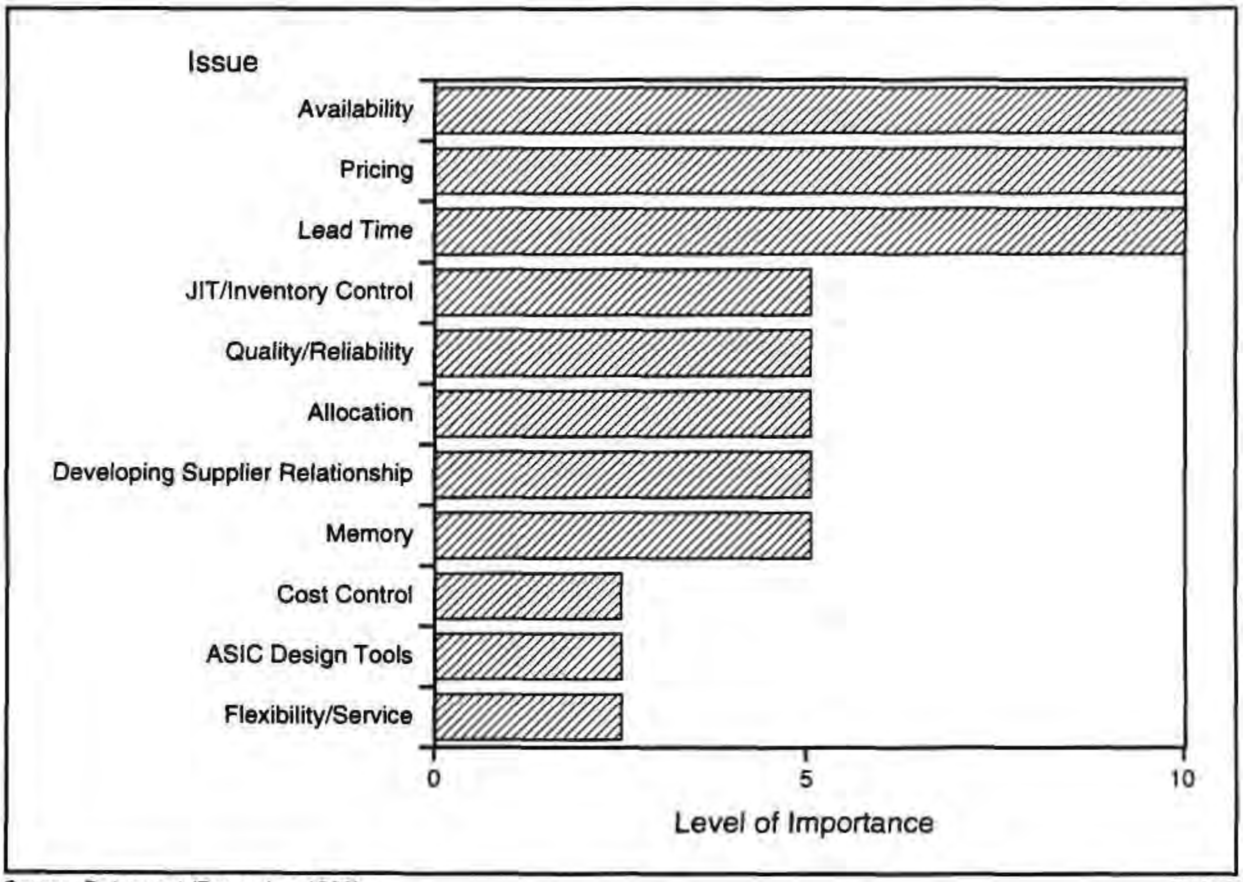


Source: Dataquest (December 1992)

G2001290

Suppliers that want to avoid review by their personal computer customers should provide top quality, competitively priced parts, and on-time delivery.

Figure 3-5
Other Data Processing Industry 1993 Top Procurement Issues

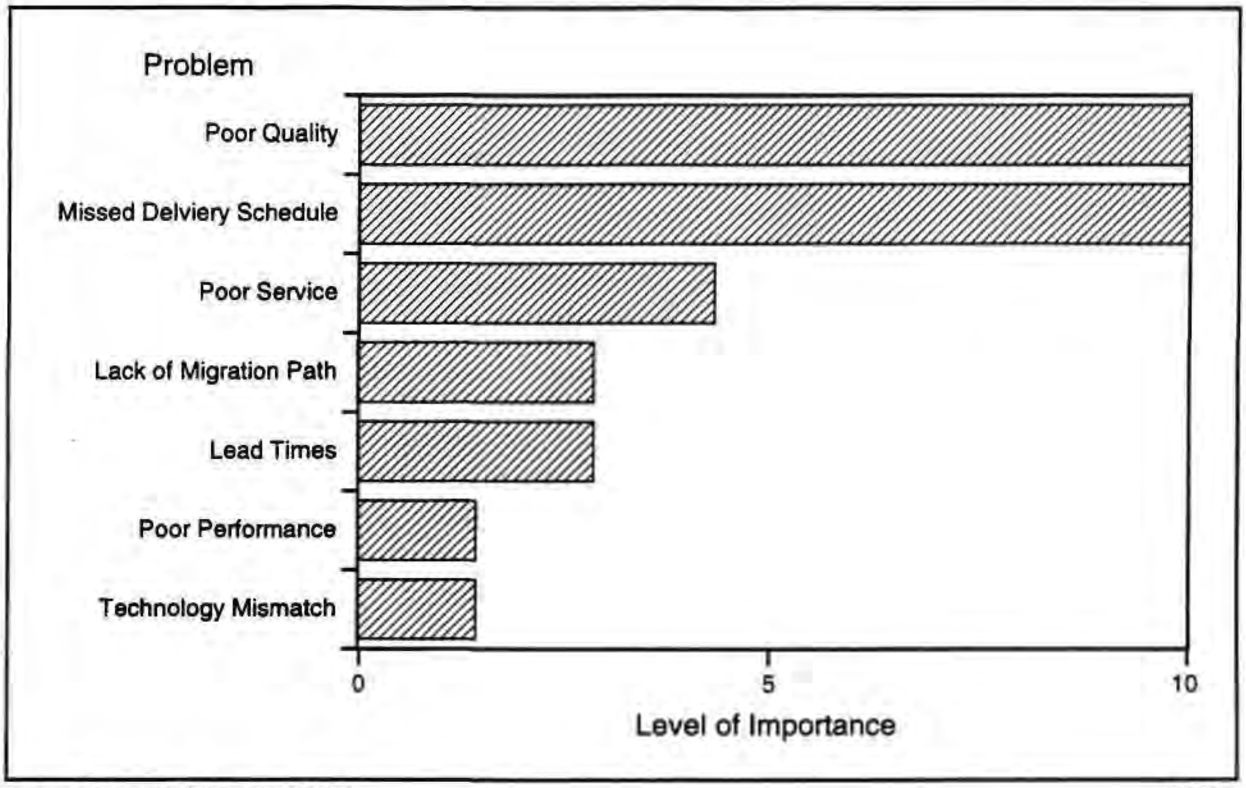


Source: Dataquest (December 1992)

G2001291

For the rest of the data processing companies, availability, pricing, and lead time tie as the key issues needing attention in 1993.

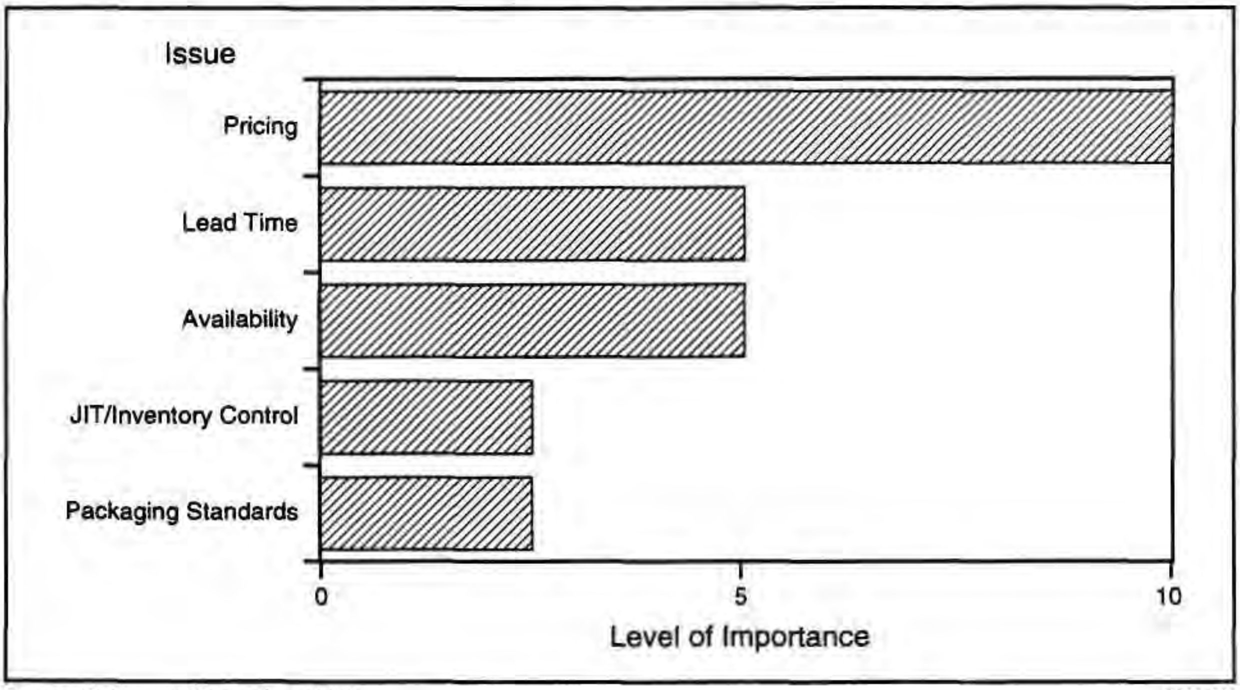
Figure 3-6
Other Data Processing Industry Ranking of Supplier Cardinal Sins



Source: Dataquest (December 1992)
G2001292

The two main taboos for semiconductor suppliers—poor quality and missed delivery windows—rank as the top problems that would warrant supplier review.

Figure 3-7
Premise Communications Industry 1993 Top Procurement Issues

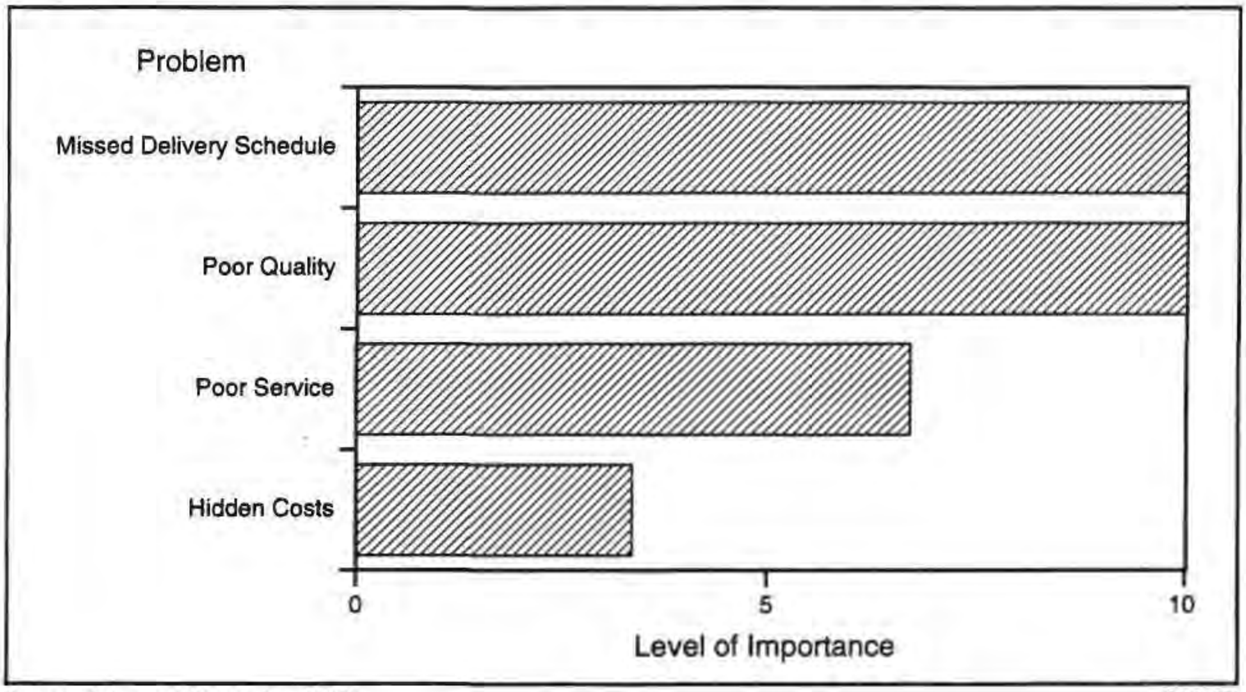


Source: Dataquest (December 1992)

G2001293

For the premise communications segment, pricing is the most important issue for next year, followed by concern over lead time and availability.

Figure 3-8
Premise Communications Industry Ranking of Supplier Cardinal Sins

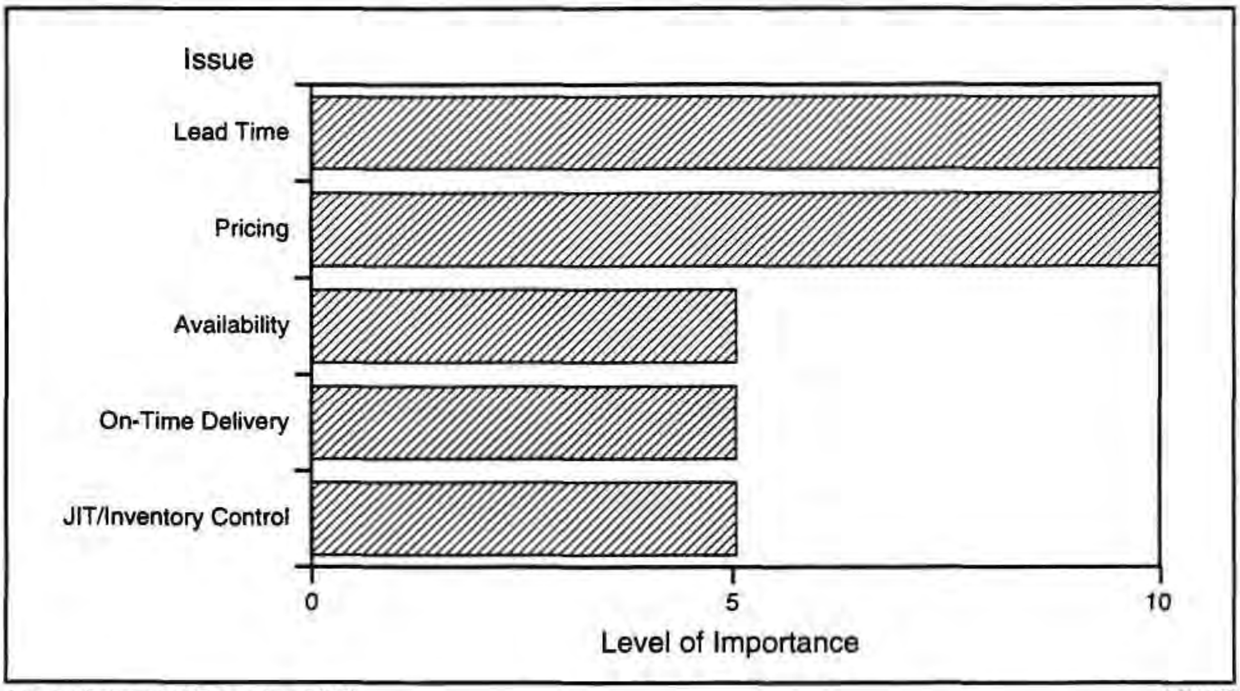


Source: Dataquest (December 1992)

G2001294

The big two problem areas—poor quality and missed delivery schedule—tie for the top of what suppliers should not do for this segment of customers.

Figure 3-9
Other Communications Industry 1993 Top Procurement Issues

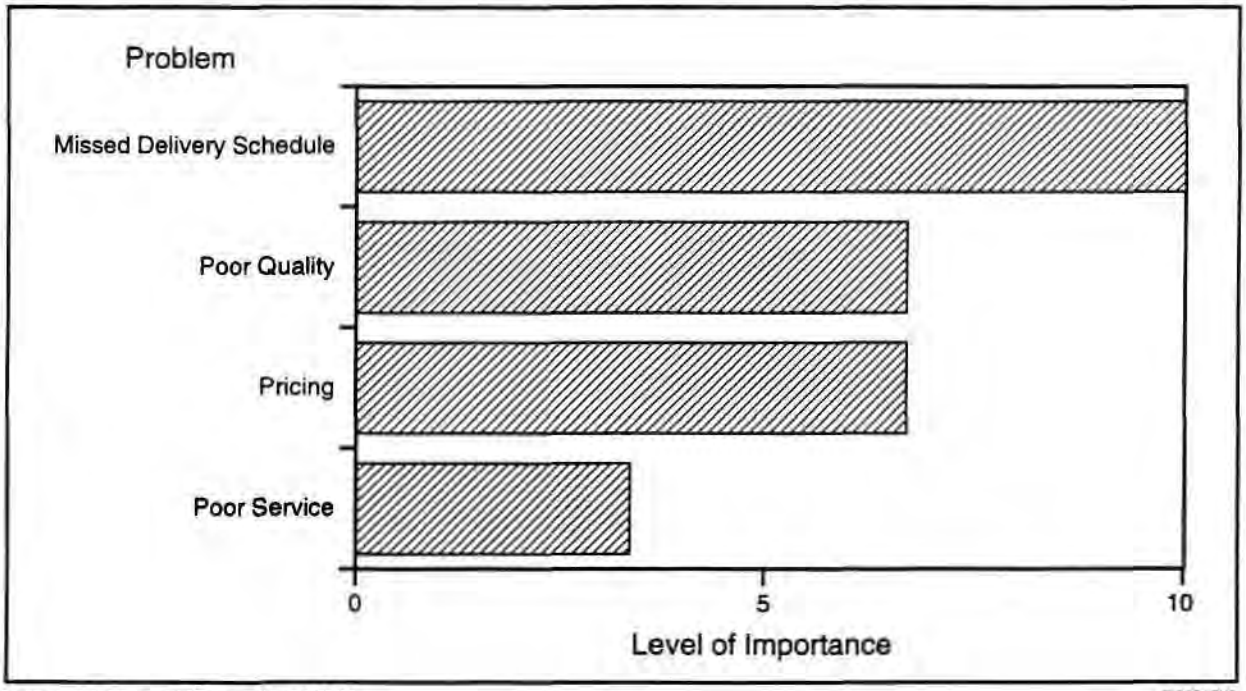


Source: Dataquest (December 1992)

G2001295

For this segment of the communications industry, lead time and pricing both take top honors as the key concerns for 1993.

Figure 3-10
Other Communications Industry Ranking of Supplier Cardinal Sins

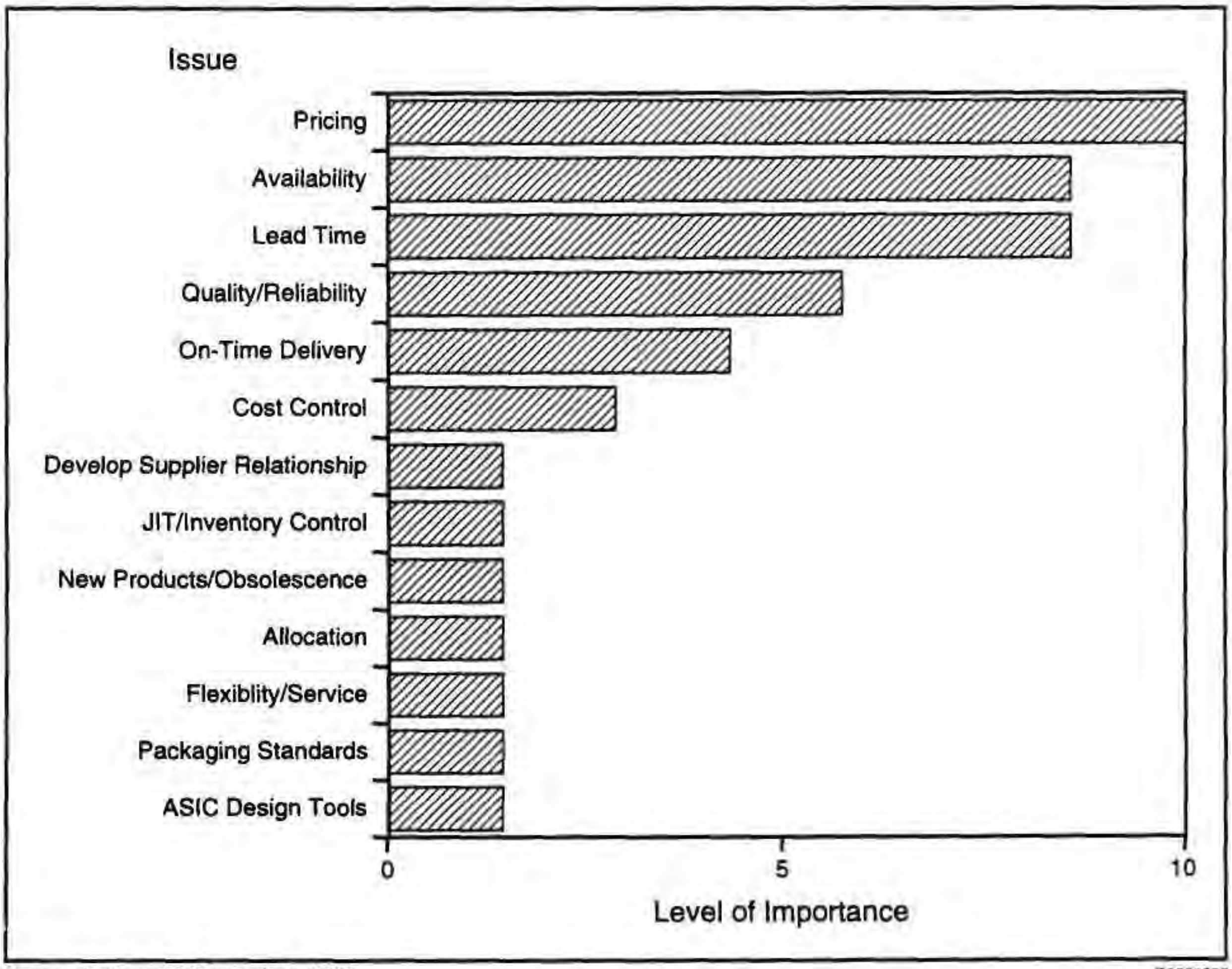


Source: Dataquest (December 1992)

G2001296

Missed delivery schedules is the top area warranting supplier review as inventory levels now remain at target levels (see Chapter 4).

Figure 3-11
Instrumentation Industry 1993 Top Procurement Issues

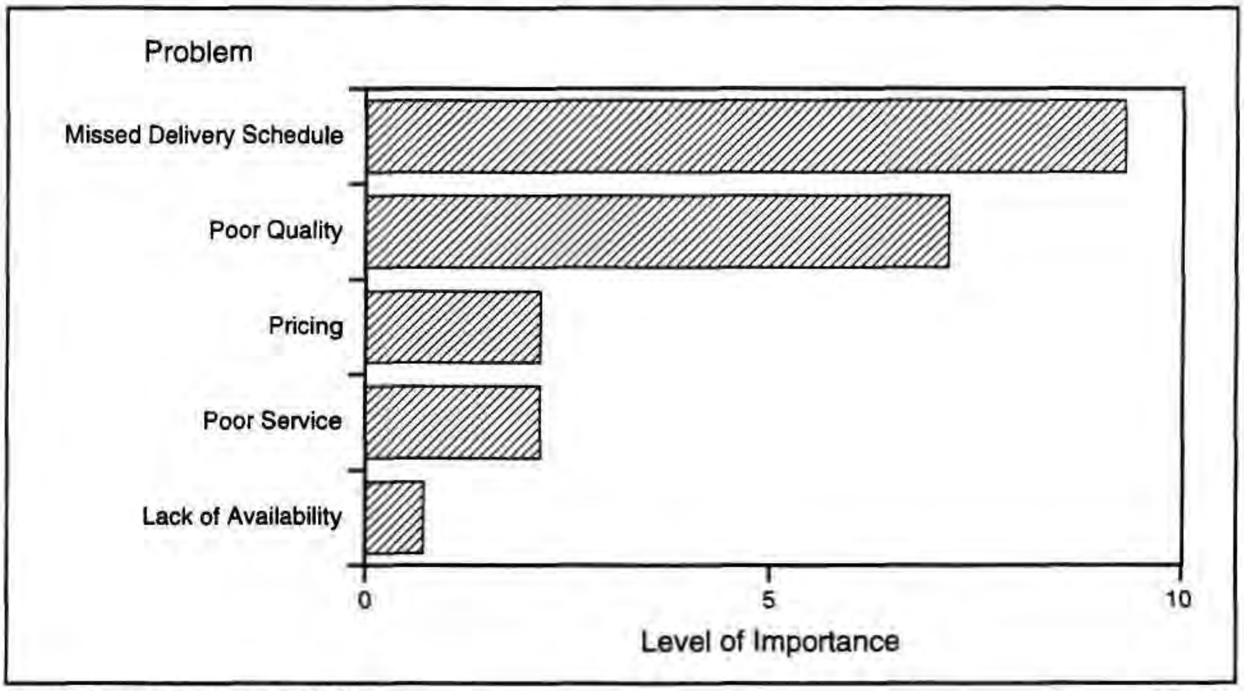


Source: Dataquest (December 1992)

G2001297

This segment sees pricing, availability, and lead time as the top three issues needing focus next year.

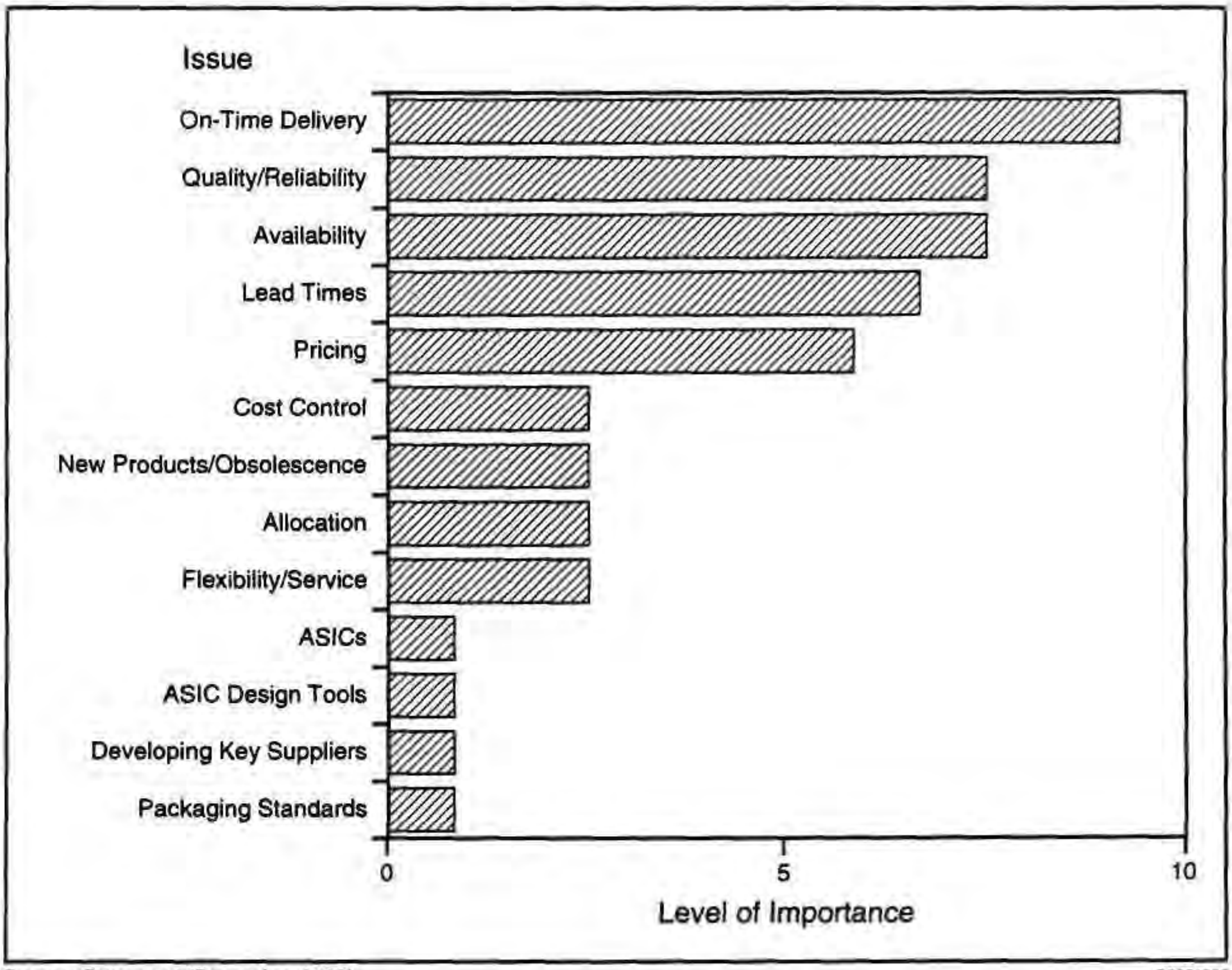
Figure 3-12
Instrumentation Industry Ranking of Supplier Cardinal Sins



Source: Dataquest (December 1992)
G2001298

Missed delivery windows, followed by poor quality, far and away are the top two areas that warrant supplier review or removal for this segment of the market.

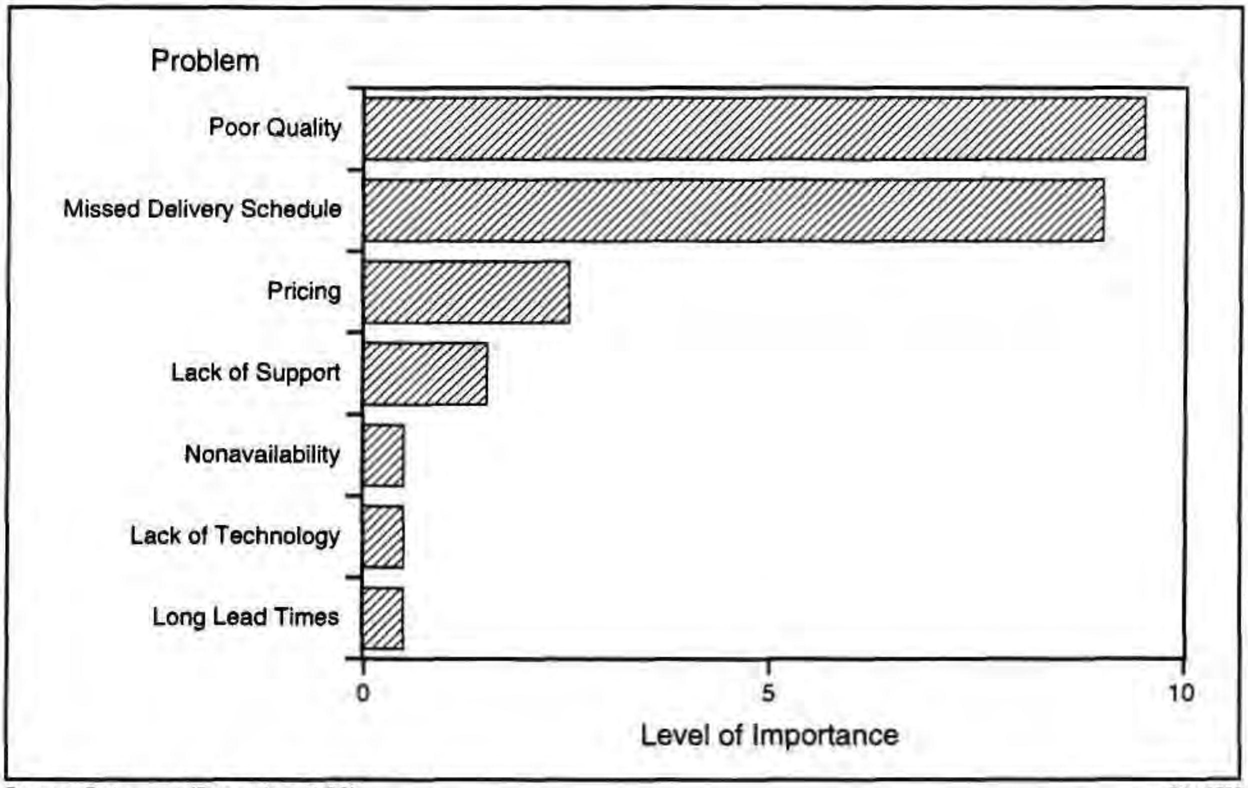
Figure 3-13
Other Industrial Companies' 1993 Top Procurement Issues



Source: Dataquest (December 1992) G2001299

- *For the rest of the industrial respondents, on-time delivery is seen as the top issue for 1993.*
- *The top five issues for this group cover the key variables of total cost and all are considered important issues in the upcoming year.*

Figure 3-14
Other Industrial Companies' Ranking of Supplier Cardinal Sins

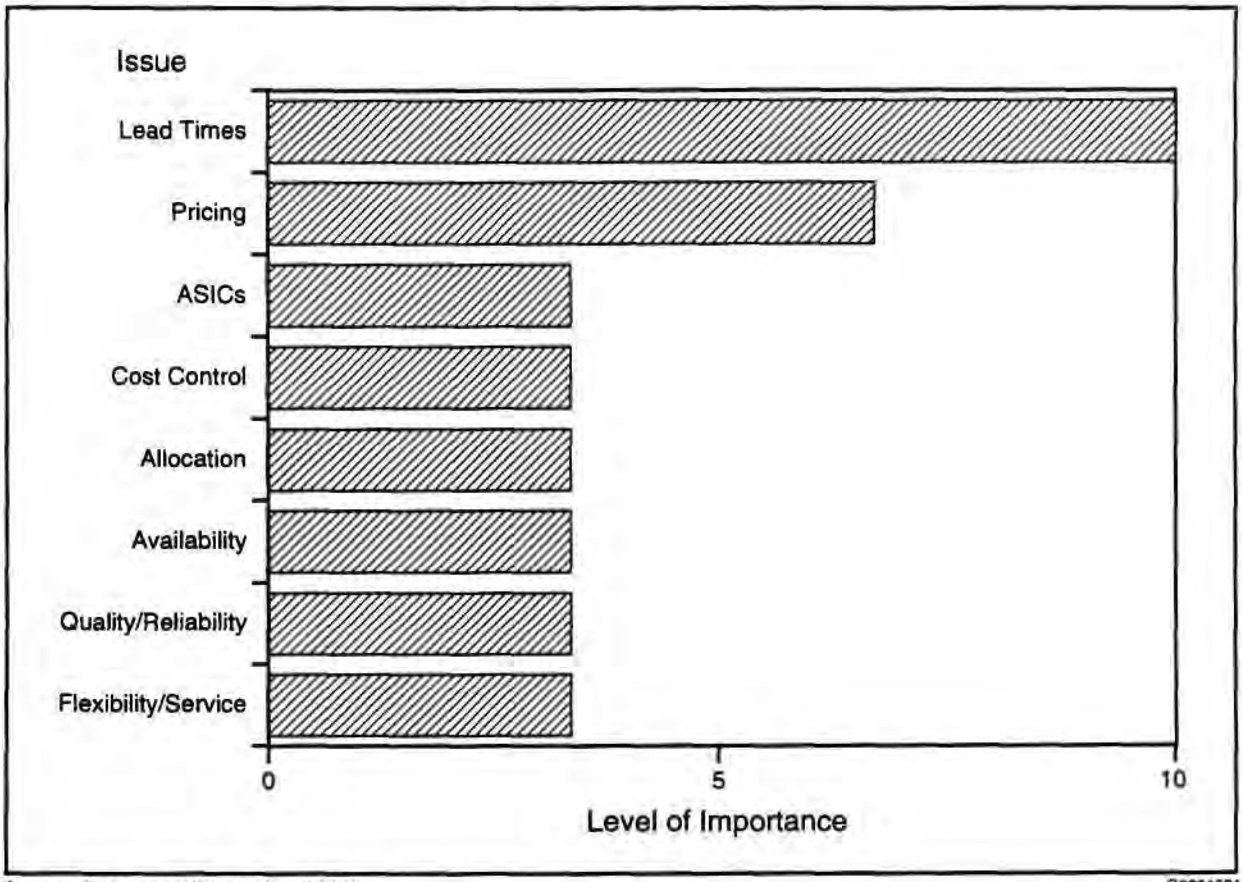


Source: Dataquest (December 1992)

G2001300

The big two user issues—poor quality, followed closely by poor delivery performance—are the main areas that companies in this market segment cannot condone.

Figure 3-15
Consumer/Automotive Industry 1993 Top Procurement Issues

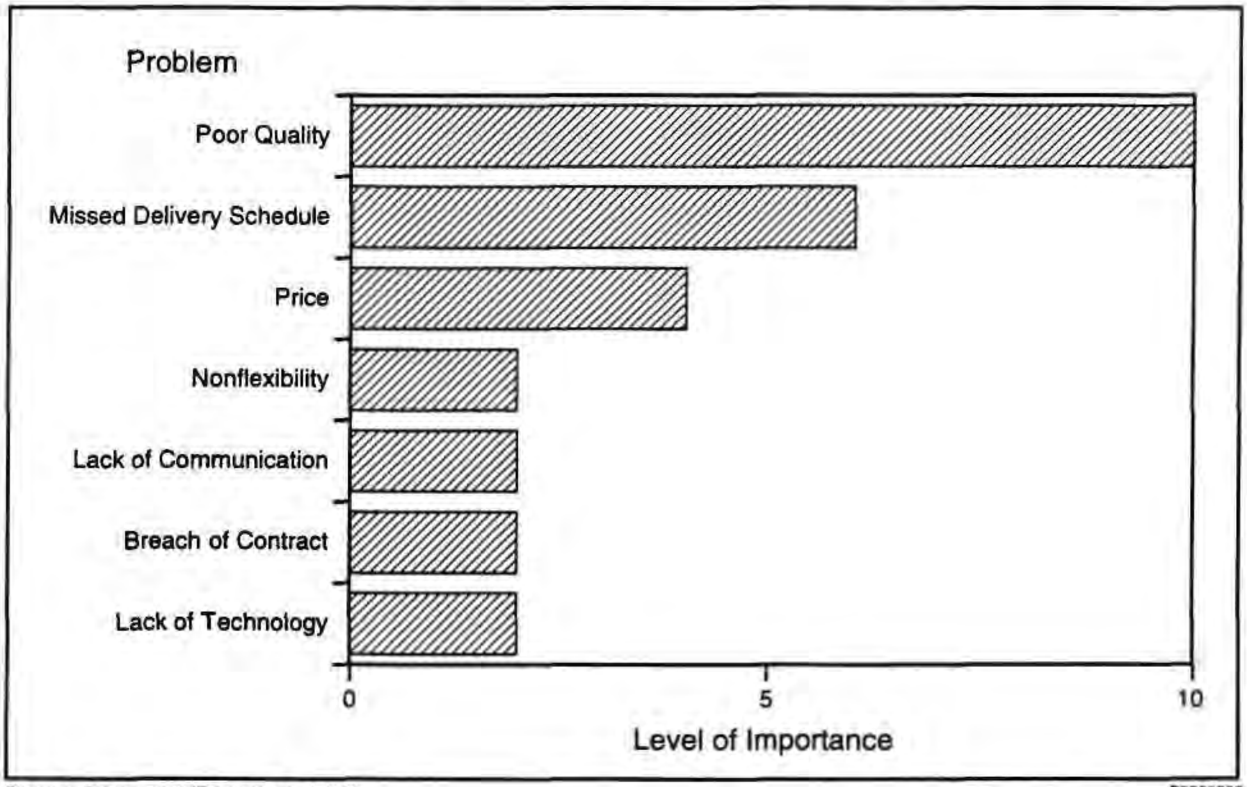


Source: Dataquest (December 1992)

G2001301

Lead time and pricing are the two main issues arising for this segment in 1993.

Figure 3-16
Consumer/Automotive Industry Ranking of Supplier Cardinal Sins

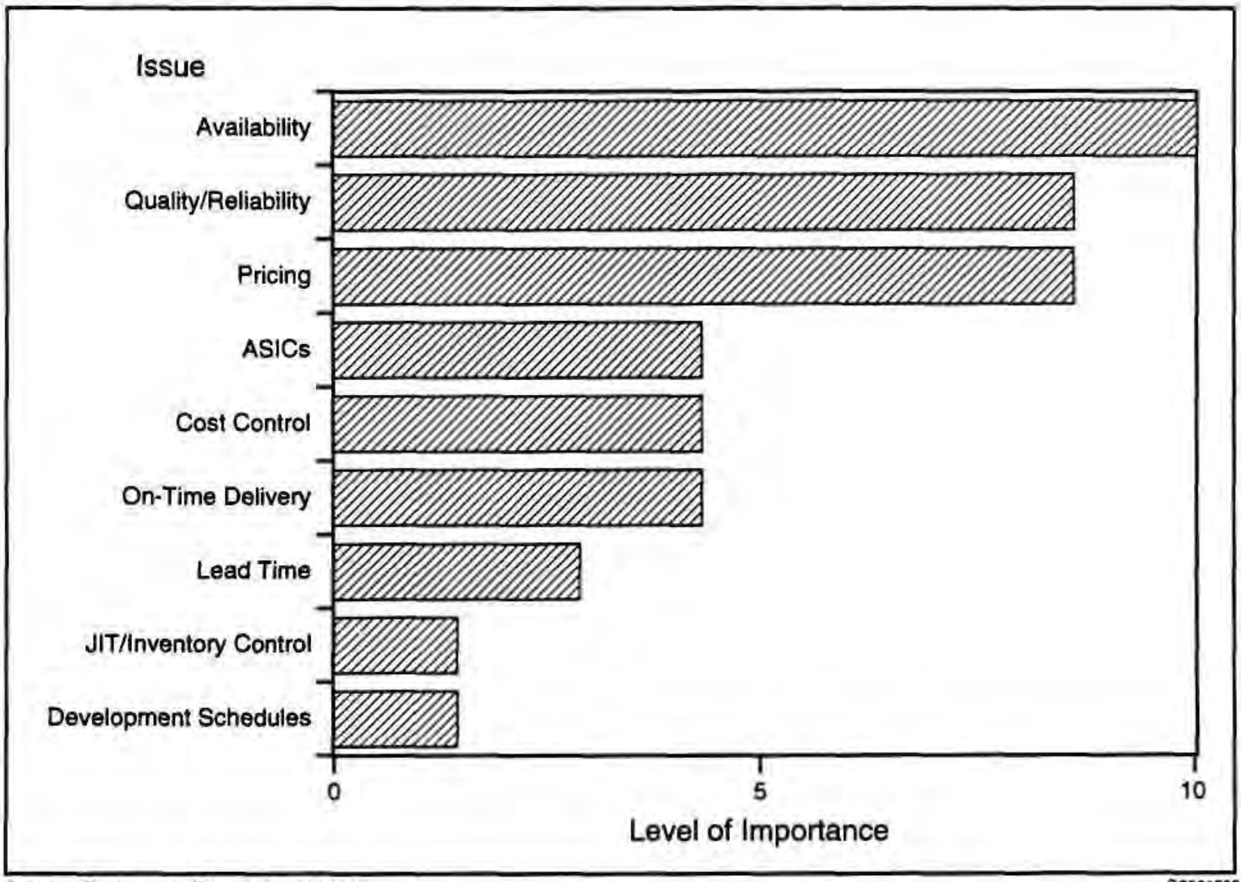


Source: Dataquest (December 1992)

G2001302

Because of the high reliability requirements of the automotive industry, poor quality is deemed the top issue warranting supplier review or disqualification.

Figure 3-17
Military/Aerospace Industry 1993 Top Procurement Issues

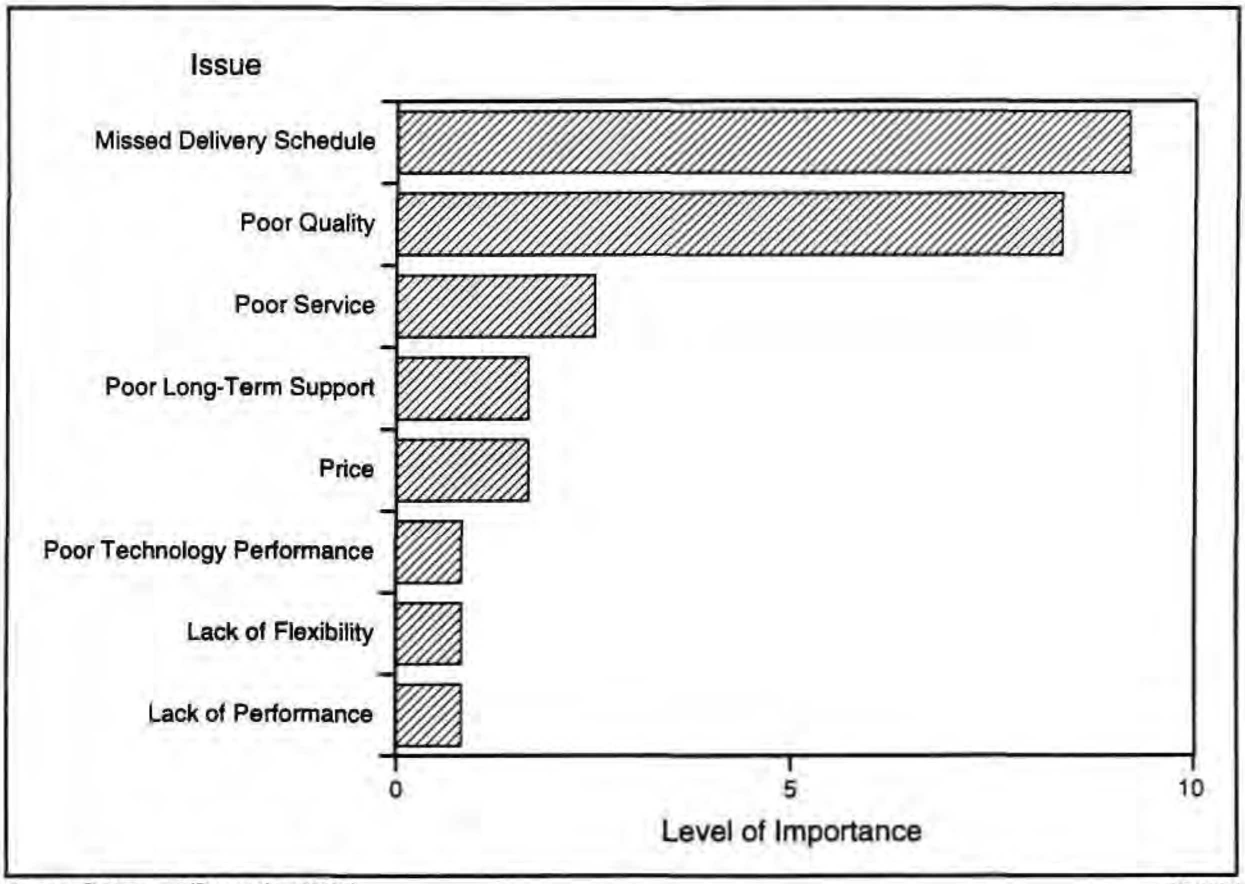


Source: Dataquest (December 1992)

G2001303

The top three concerns for this segment—availability, quality, and price—all will take center stage in 1993 as more cost-effective ways to procure semiconductors continue to be explored.

Figure 3-18
Military/Aerospace Industry Ranking of Supplier Cardinal Sins



Source: Dataquest (December 1992)

G2001304

Missed deliveries and poor quality are anathema for this group, because government contracts often mandate parameters. Suppliers to this market generally are well aware of these requirements.

Chapter 4
Semiconductor User Status and Future Needs, by Industry

This chapter focuses on what the overall electronics industry and each electronic industry subcategory is now doing and what is needed to remain competitive. Areas covered are the type of semiconductor family used by the industry grouping, the percentage of the industry that manufactures its own semiconductors, the extent each industry designs and assembles its own circuit boards, and where those circuit boards are assembled. Next reviewed are the status and plans for the number of semiconductor suppliers, and the level of contract manufacturing and semiconductor distributors used. Then we provide a spot check on semiconductor inventory levels by industry and analysis on the status of industry quality and strategic supplier programs, followed by a 1993 survey forecast for each industry. An analysis of average semiconductor quality levels (by ppm) by major product family and on-time-delivery definitions for the overall electronics industry is also presented. After each industry group summary, reference is made to figures that support the analysis.

Overall Electronics Industry

For the overall electronics industry sample, 93.1 percent designed their own circuit boards, but a third (33 percent) of this aggregate did not assemble them because of contract manufacturing use. Of the overall grouping, 84.4 percent physically assembled their products in the United States, but as noted later in this report, some industries were more homebound than others. The overall trend to reduce the supply base has been achieved, with minor reshuffling of the remaining key supply base of the respondents. As a whole, 61 percent of the respondents used contract manufacturing and were outsourcing an average of 9.6 years. An overall electronics industry definition for on-time delivery ranged from the highest response of +0,-5 days to schedule to the third highest response of +5,-0 days, highlighting the need yet not showing a consensus for one standard definition at this time. Although 14.9 percent of the respondents noted no formal quality program in place at their company, close to two-thirds (58.4 percent) did have a strategic supplier program in place, confirming a trend to lower overall costs via preventative measures. On average, a standard quality-level benchmark ranged from a low of 55.9 ppm (microprocessors/ASSPs), to a high of 69.2 ppm (memory products) for this sample. Based on the aggregate survey results, the overall electronics industry was expected to grow by 15.2 percent in 1993 (see Figures 4-1 through 4-14).

Personal Computer Industry

Three-quarters (75 percent) of the PC industry sample designed its own circuit boards and more than 80 percent (83.3 percent) continued to assemble them in-house. Although 71.4 percent of the sample assembled its boards in the United States, more than a quarter (25.7 percent) utilized offshore assembly in the Far East. The supply base for the PC industry appeared relatively stable, compared with other electronics industry subsets. Nearly two-thirds (62.5 percent) of the PC group used contract manufacturing, on average for 4.8 years. Although all respondents had a strategic supplier program in place, only 75 percent had a formal quality program utilized. Of those with a quality program, 16.7 percent found it only "nice to have." Per this sample, the PC market for 1993 was expected to grow by 10 percent (see Figures 4-15 through 4-25).

Other Data Processing Industries

A full 100 percent of this response segment both designed and assembled its own circuit boards, and 85.4 percent were assembled in the United States. Aside from memory suppliers, the other supply bases were expected to shrink in 1993 relative to this year for this subset. Although slightly more than half (53.8 percent) of the sample used contract manufacturing, the average use was for nearly 10 (9.9) years, highlighting that this "new" trend has been tried and tested for some time. Although 23.1 percent of the respondents' companies did not have a formal quality program in place, 60 percent of those companies that did found it "critical" in their cost-cutting goals. Nearly half (46.2 percent) of this group did not have a strategic supplier program in place. The 1993 outlook per this market sample was expected to grow by 15 percent (see Figures 4-26 through 4-36).

Premise Communications Industry

Although 100 percent of the respondents designed their own circuit boards, a solid 40 percent outsourced their assembly. More than three-fourths (78 percent) of the boards were physically assembled in the United States, with the large majority of the rest (21 percent) assembled in the Far East. The overall semiconductor supply base for this segment was expected to remain static next year. This subset is another strong user of contract manufacturing: 60 percent used outside contractors and had been for an average of 10.7 years. For the 60 percent of the sample that has a formal quality program in place all found the program "critical" to their ongoing operations. Although all respondents had a strategic supplier program in place, 20 percent noted that it was only "nice to have," highlighting an area that may need attention to maximize the return on this investment in time and money (see Figures 4-37 through 4-44).

Other Communications Industries

This segment of the industry wholly (100 percent) designed and assembled its own circuit boards; 97.5 percent of this sample physically assembled them in the United States. Aside from the ASIC supply base, all other semiconductor supplier levels were expected to shrink in 1993, per this group's response. Half (50 percent) of the sample used contract manufacturers, yet the average usage was only 3.0 years, the lowest average noted in this survey. Three-fourths (75 percent) of the respondents have a quality program in place, and all (100 percent) noted that it is "critical" to their operation. Likewise, 75 percent of the group had a strategic supplier program, and all (100 percent) of these participants found the program "critical" in sourcing components. The survey response industry outlook for 1993 was for an average 15.0 percent growth (see Figures 4-45 through 4-55).

Instrumentation Industry

About four-fifths (83.3 percent) of the respondents of this segment of the industrial equipment industry designed their own circuit boards, yet a third (33 percent) outsourced their assembly. This grouping is another strong user of domestic assemblers; 94 percent physically assembled their boards in the United States. Aside from the general-purpose microprocessor/ASSP supply base, all other supplier levels were expected to be marginally trimmed in 1993. Comparing closely with the overall electronics industry, 61.1 percent of this sample used contract manufacturers and had done so on average for 7.2 years. Nearly 90 percent (88.9 percent) of the respondents had a formal quality program in place, of whom 62.5 percent found the program "critical" to operations. Nearly 40 percent (38.9 percent) did not have a strategic supplier program formulated. This area of the industrial market was expected, per this sample, to grow an aggressive 25 percent in 1993 (see Figures 4-56 through 4-66).

All Other Industrial Companies

For all of the other industrial companies in our sample, 96.3 percent designed their own circuit boards and outsourced an average 36 percent of them for assembly by contract manufacturers. More than three-fourths (79.8 percent) of the boards are physically assembled in the United States, with 13.2 percent assembled in the Far East. Like the public/radio communications segment, this grouping was expected to marginally reduce its semiconductor supply base in the next year, except for the ASIC area. Contract manufacturers were used by 74.1 percent of the respondents and had been used an average 9.7 years, again highlighting the long usage of this extension of manufacturing. More than 90 percent (92.6 percent) of this sample had a formal quality program in place, with more than half (56 percent) noting it was "critical" to their business' success. Although 51.9 percent of this group had a strategic supplier program working, those participating generally were positive with the results thus far. On average, the survey respondents expected 1993 growth for this segment to be 11.5 percent (see Figures 4-67 through 4-77).

Consumer/Automotive Industries

All (100 percent) of this market segment designed its own circuit boards and 42.9 percent outsourced its assembly. Nearly two-thirds

(64.3 percent) physically assembled their boards in the United States, with the remainder assembled either in Japan or other areas in the Far East. The supply base level for this subset was expected to change, with memory and ASIC suppliers expected to rise, and the microprocessor/ASSP and logic supply base expected to shrink. Although more than half (57.1 percent) of the sample did not use a contract manufacturer, those that had on average used one (or more) for 7.3 years. More than 85 percent (85.7 percent) of the respondents had a formal quality program in place, and 83.3 percent saw it as a "critical" aspect of their business. A similar 85.7 percent of the sample had a strategic supplier program, of which a minority (16.7 percent) saw it as only "nice to have." Per these respondents' outlook, this segment of the industry was expected to grow 7.5 percent in 1993 (see Figures 4-78 through 4-88).

Military/Aerospace Industries

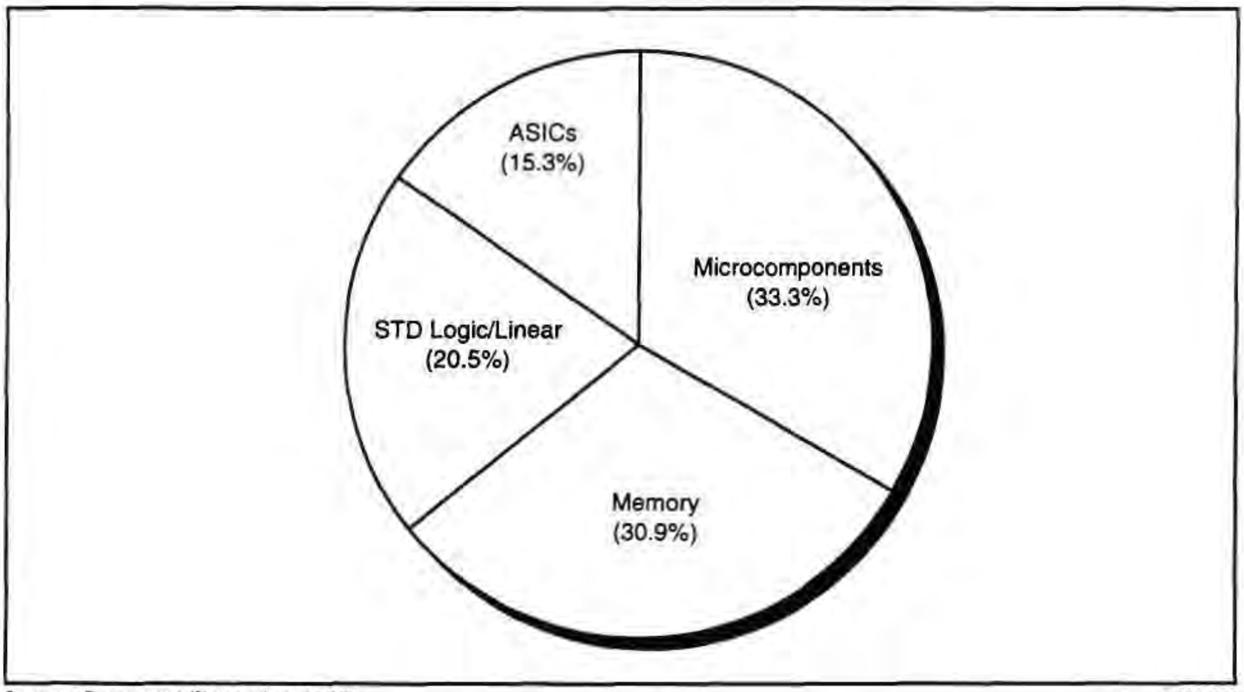
A strong majority of 94.4 percent of the respondents in this market designed their own circuit boards, and a like majority of 62.5 percent outsourced their assembly. Again the majority (93.4 percent) assembled their boards in the United States, with the balance spread evenly between Japan and the rest of Asia. As a result of restructuring in the defense industry, the overall supply base for this segment was expected to decline in 1993. This segment was by far the longest users of contract manufacturing; 55.6 percent of the respondents used outside contractors and had done so for an average of 16 years. Although quality specifications are often written into military contracts, the strong showing of 88.9 percent of the respondents having a formal quality program in place was not surprising. What was interesting was that only 37.5 percent of the respondents saw the program as "critical" to ongoing business. Although only 33.3 percent of the respondents had a strategic supplier program in place, 83.3 percent saw the program being either "beneficial" or "critical" to their companies (see Figures 4-89 through 4-99).

Summary

Based on our survey results, the U.S. electronics industry designs and assembles the majority of its own circuit boards and predominantly assembles them in the United States, with the Far East as the runner-up for assembly location. Although the majority of supplier reductions have occurred over the past few years, some fine-tuning remains where users continue to improve the balance of what they need/require versus what their supply base can deliver. The "latest" trend to use contract manufacturers or "outsource" is not new at all to the respondents of this survey. There is a positive correlation, however, to the amount of contract manufacturing used relative to the amount of time a company has used outside contractors. This bodes well for the contract manufacturing industry and for user companies weighing the pros and cons of whether to use outside contractors.

The vast majority of the respondents have a formal quality program in place and for the most part see the results at worst beneficial; many see the programs as critical to their ongoing business. It appears that, although strategic supplier programs have gotten much lip service and many companies have programs under way, more of the response was that the program is nice to have rather than critical or beneficial to business. This is an area where suppliers have an opportunity to differentiate themselves or solidify an ongoing program by addressing user requirements noted in Chapters 3 and 5. The 15.2 percent average electronics 1993 growth forecast given by our respondents is a bit aggressive, based on our research (Dataquest's 1993 U.S. electronics market forecast is 4.4 percent), but it does reflect positive outlook for next year as the economy pulls itself out of the current slowdown.

Figure 4-1
Electronics Industry Survey IC Purchases

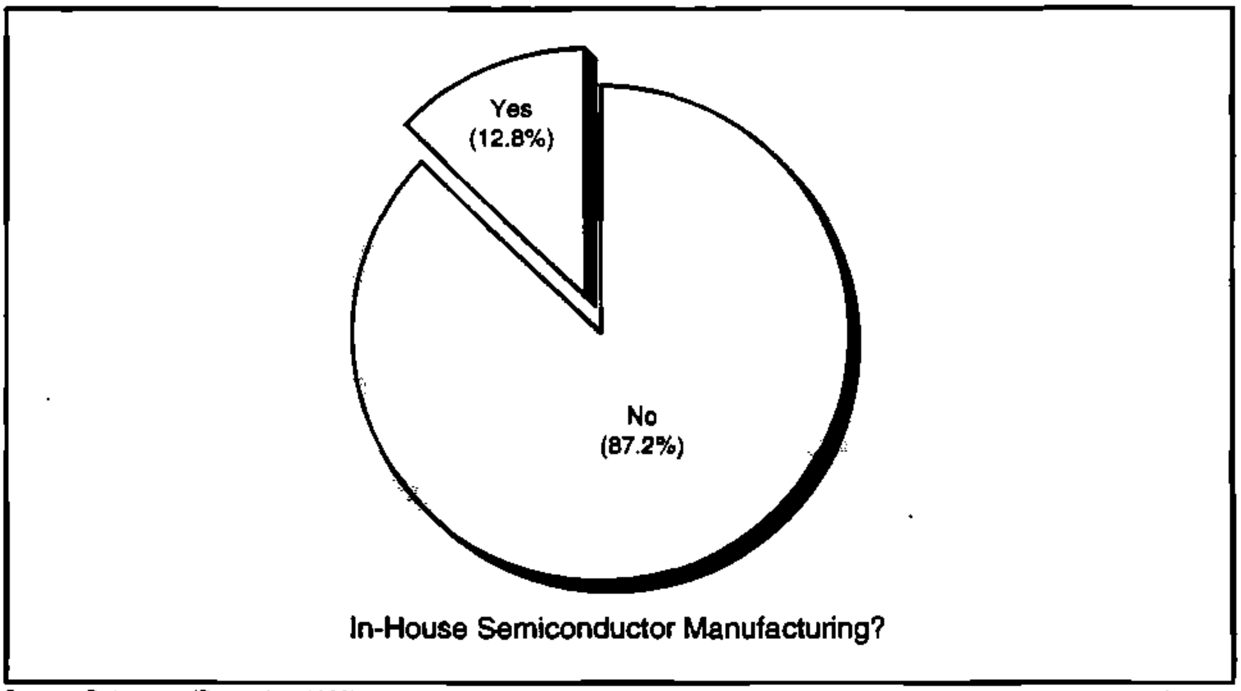


Source: Dataquest (December 1992)

G2001305

Nearly two-thirds (63.2 percent) of the overall electronics industry's IC purchases go to memory or microcomponent products.

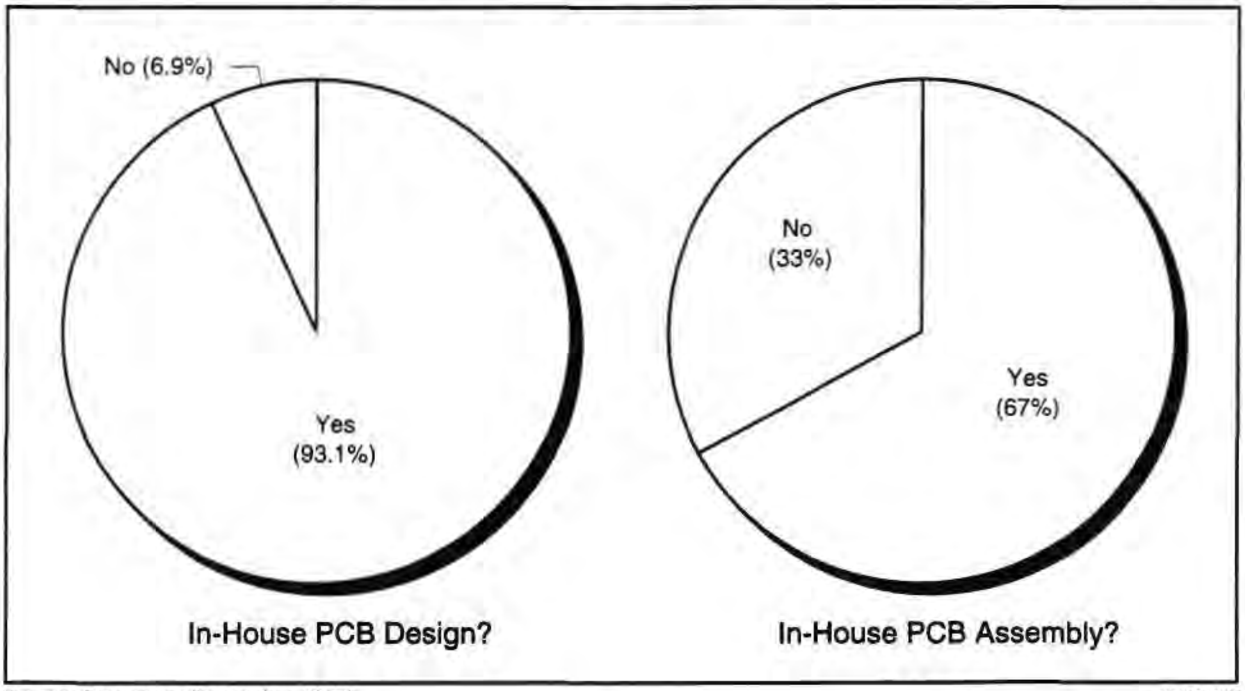
Figure 4-2
Electronics Industry Captive Semiconductor Production



Source: Dataquest (December 1992) G2001306

A minority of overall respondents (12.8 percent) have internal semiconductor production capability.

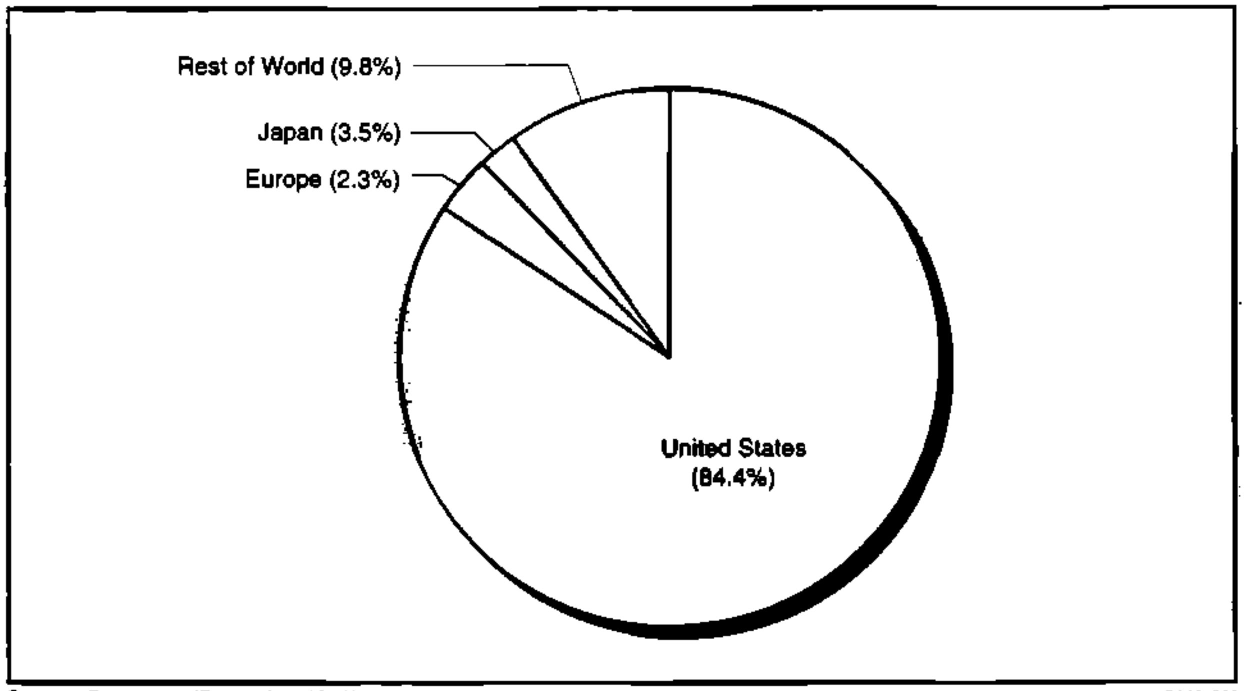
Figure 4-3
Electronics Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992) G2001307

Although the majority of the electronics industry designs its own circuit boards, a full one-third of the respondents subcontract their board assembly.

Figure 4-4
Electronics Industry Physical Circuit Board Assembly Region

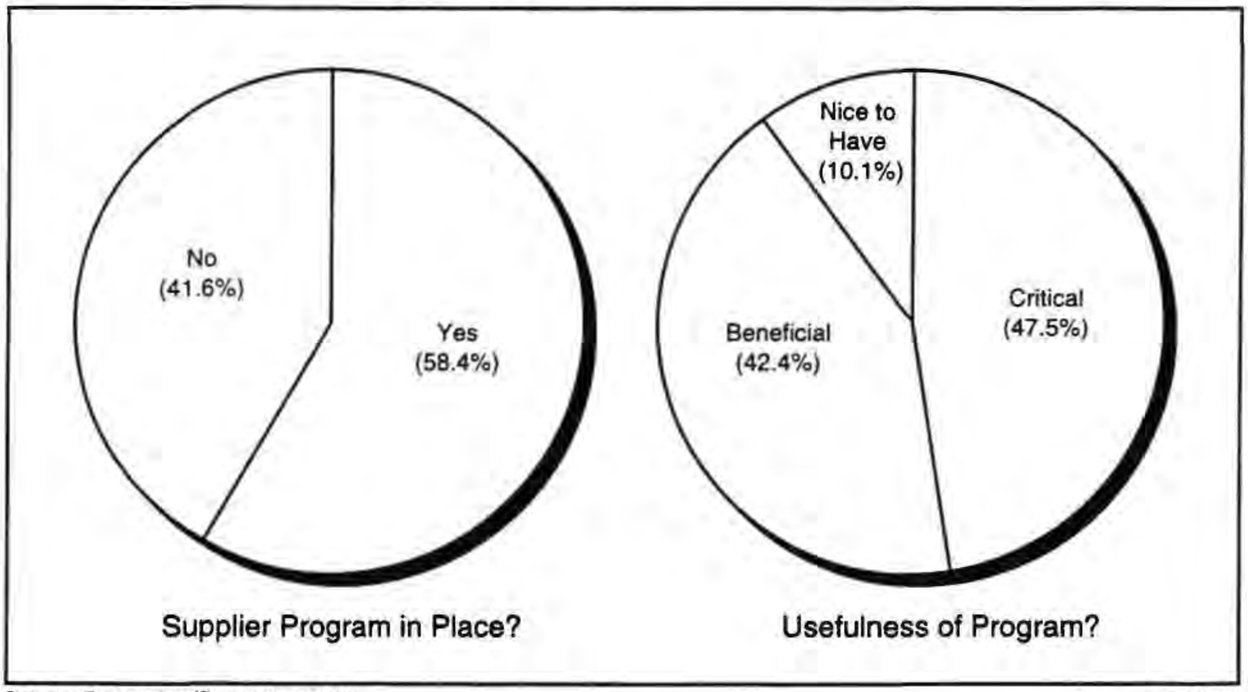


Source: Dataquest (December 1992)

G2001308

More than 80 percent of all circuit boards assembled are in the physical United States, with nearly 10 percent in Asia outside of Japan.

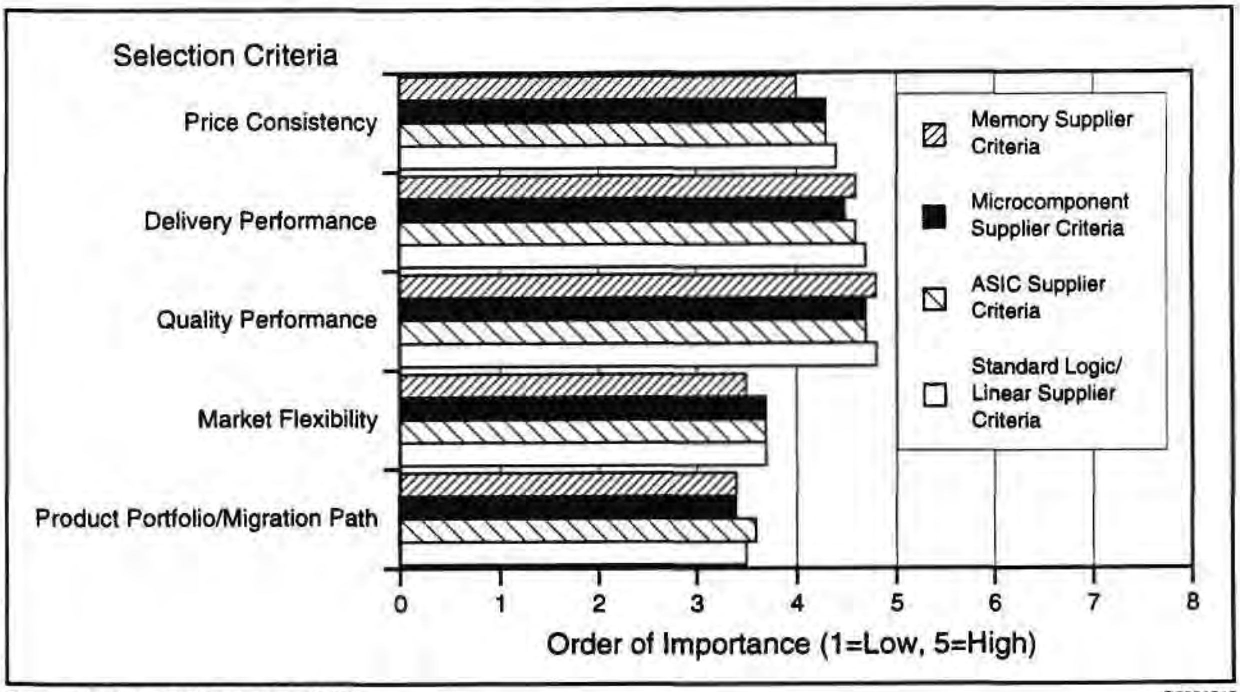
Figure 4-5
Electronics Industry Strategic Supplier Status



Source: Dataquest (December 1992) G2001309

Although more than half the respondents have a strategic supplier program in place, less than half see it as critical to their business; 10.1 percent see such programs as merely "nice to have."

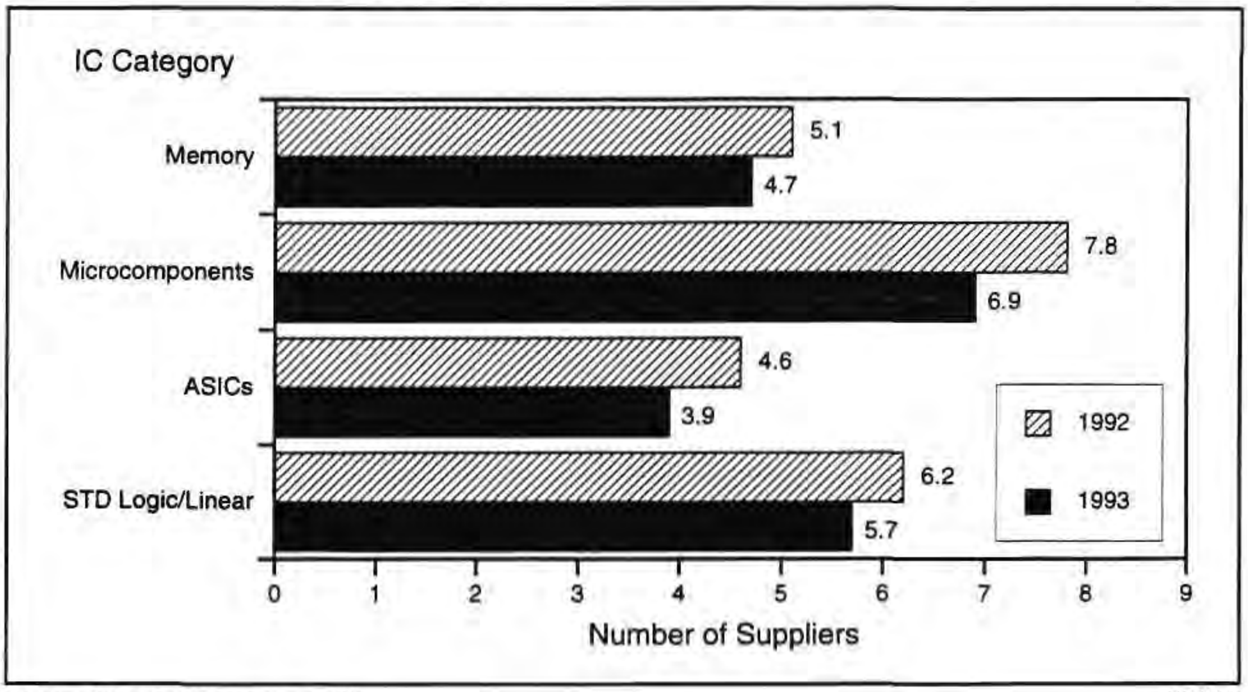
Figure 4-6
Electronics Industry Semiconductor Supplier Selection Criteria



Source: Dataquest (December 1992) G2001310

The top criteria used by the aggregate sample in selecting prospective semiconductor suppliers are quality and meeting delivery schedules.

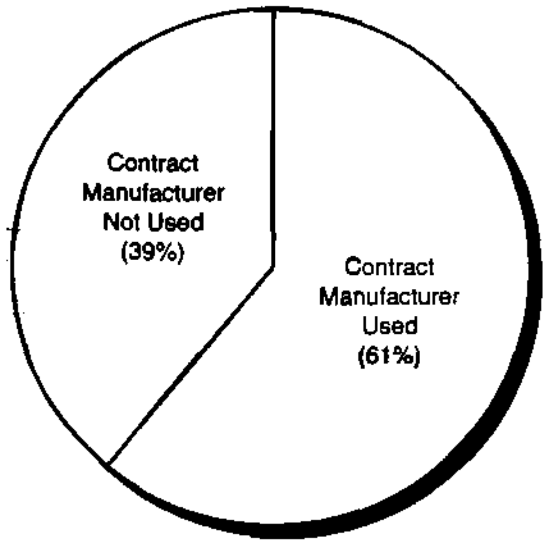
Figure 4-7
Electronics Industry Supply Base Trend



Source: Dataquest (December 1992) G2001311

The overall trend is to reduce the number of suppliers, but for the most part the survey respondents are fine-tuning existing low supply base levels.

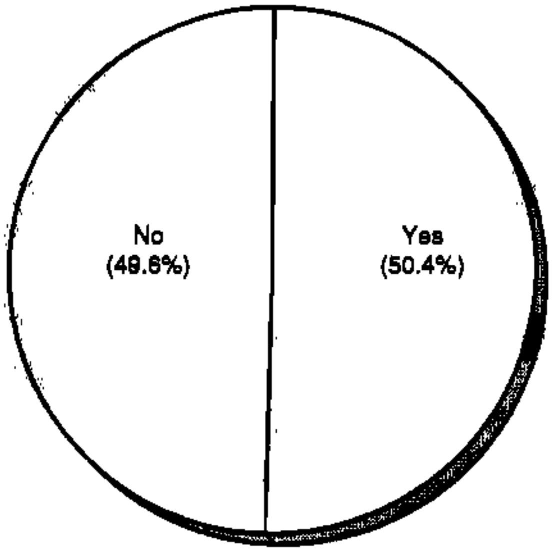
Figure 4-8
Electronics Industry Contract Manufacturer Use



Source: Dataquest (December 1992)
G2001312

- *More than 60 percent of respondents use contract manufacturers and have used them an average of more than nine years.*
- *The growing contract manufacturing market has long been a resource used by these large companies.*

Figure 4-9
Electronics Industry Semiconductor Distributor Use

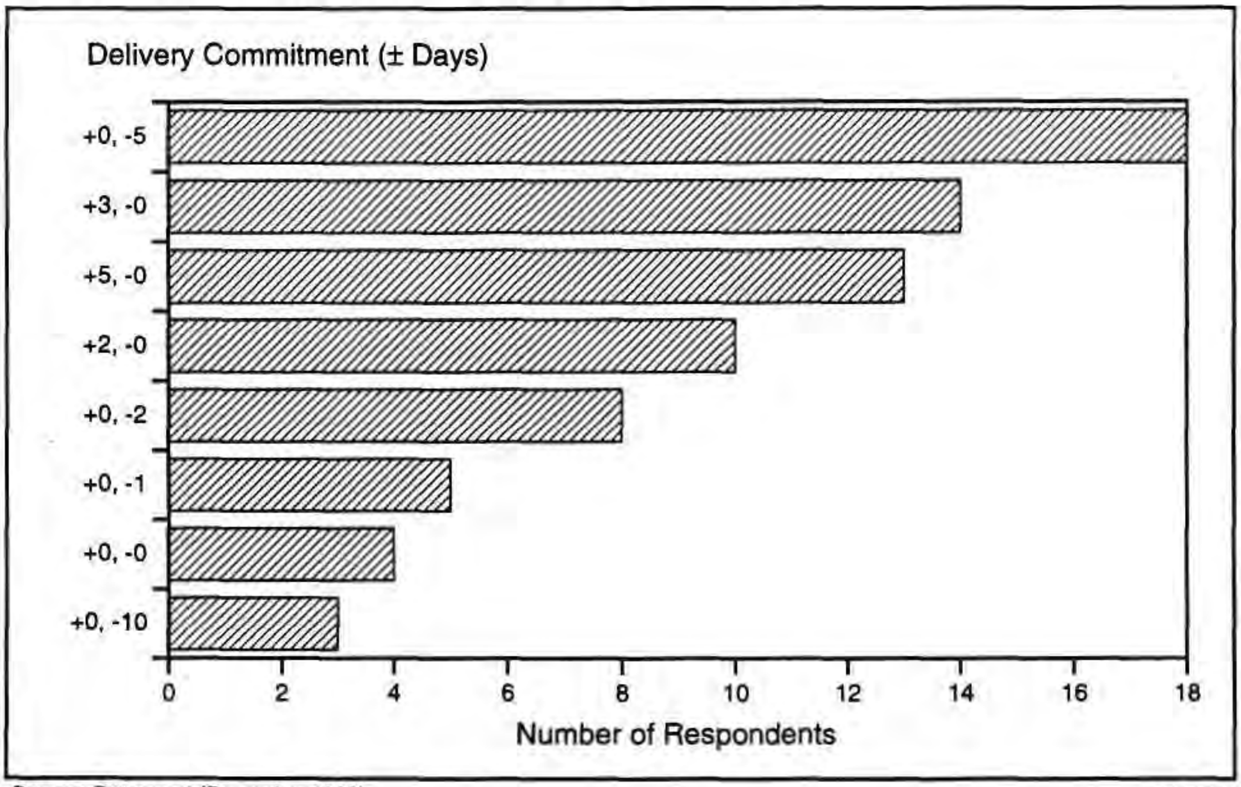


Source: Dataquest (December 1992)

G2001313

- *Slightly more than half of the sample uses semiconductor distribution.*
- *Distribution is not being used just by small to midsize semiconductor users.*

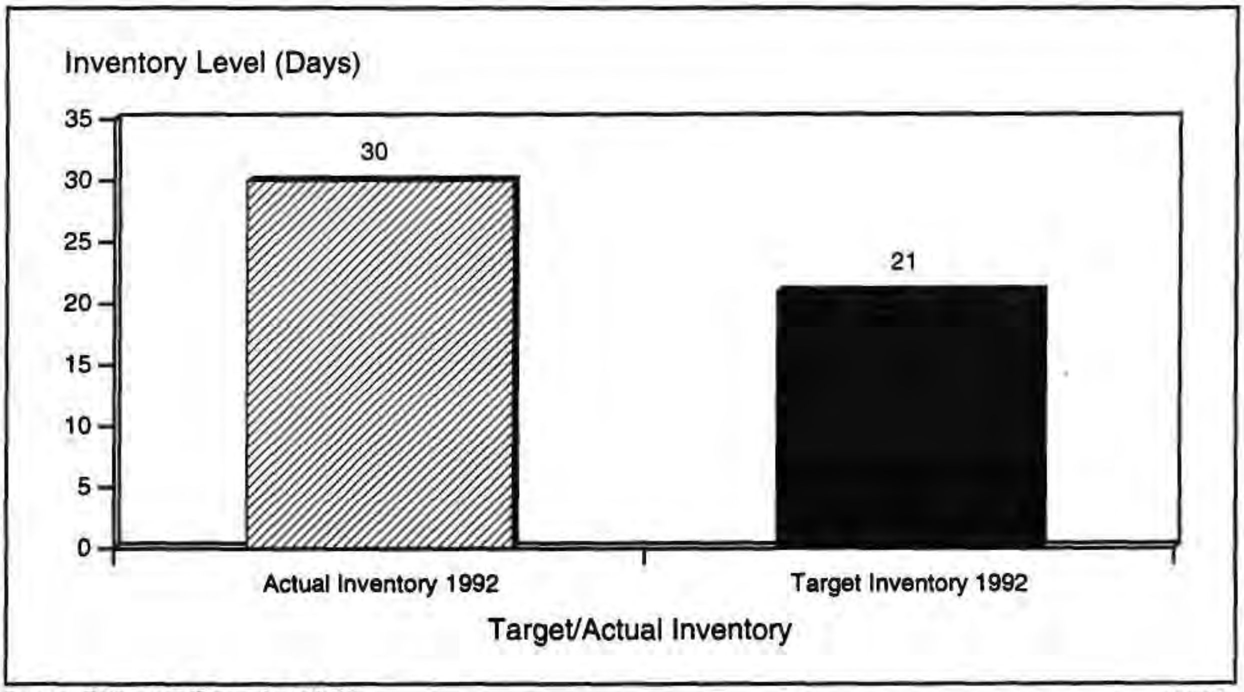
Figure 4-10
Electronics Industry On-Time Delivery Definitions



Source: Dataquest (December 1992) G2001314

- *Nearly half (45 percent) of the respondents favor between +0,-5 days; +3,-0 days; or +5,-0 days as a standard on-time delivery window.*
- *Taken together, this 10-day (+5,-0 and -0,+5) window has room for improvement.*

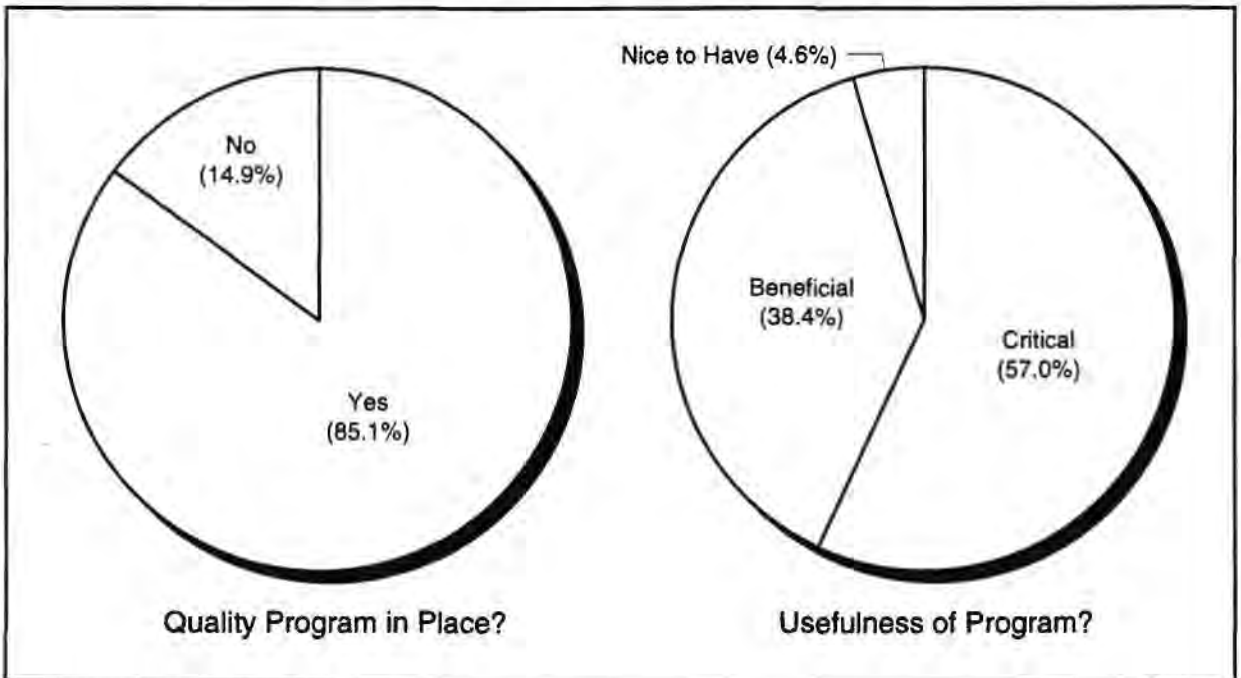
Figure 4-11
Electronics Industry Semiconductor Inventory Status



Source: Dataquest (December 1992) G2001315

Actual semiconductor inventory levels of 30 days for the overall electronics industry highlights that cost control is being focused on in this very tangible area.

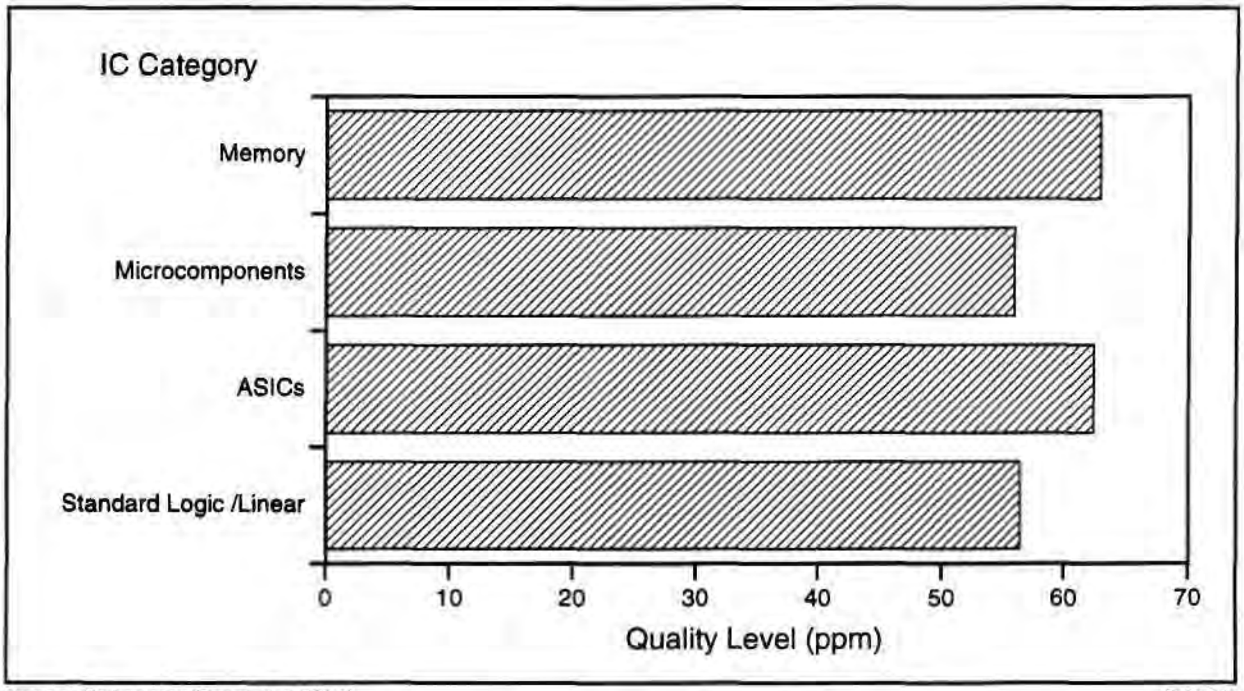
Figure 4-12
Electronics Industry Quality Improvement Program Status



Source: Dataquest (December 1992) G2001316

More than 85 percent of the respondents have a formal quality program in place; 95.3 percent of those that have one find the program either critical or beneficial to their business.

Figure 4-13
Electronics Industry Average Quality Level, by Major Semiconductor Product Family (ppm)

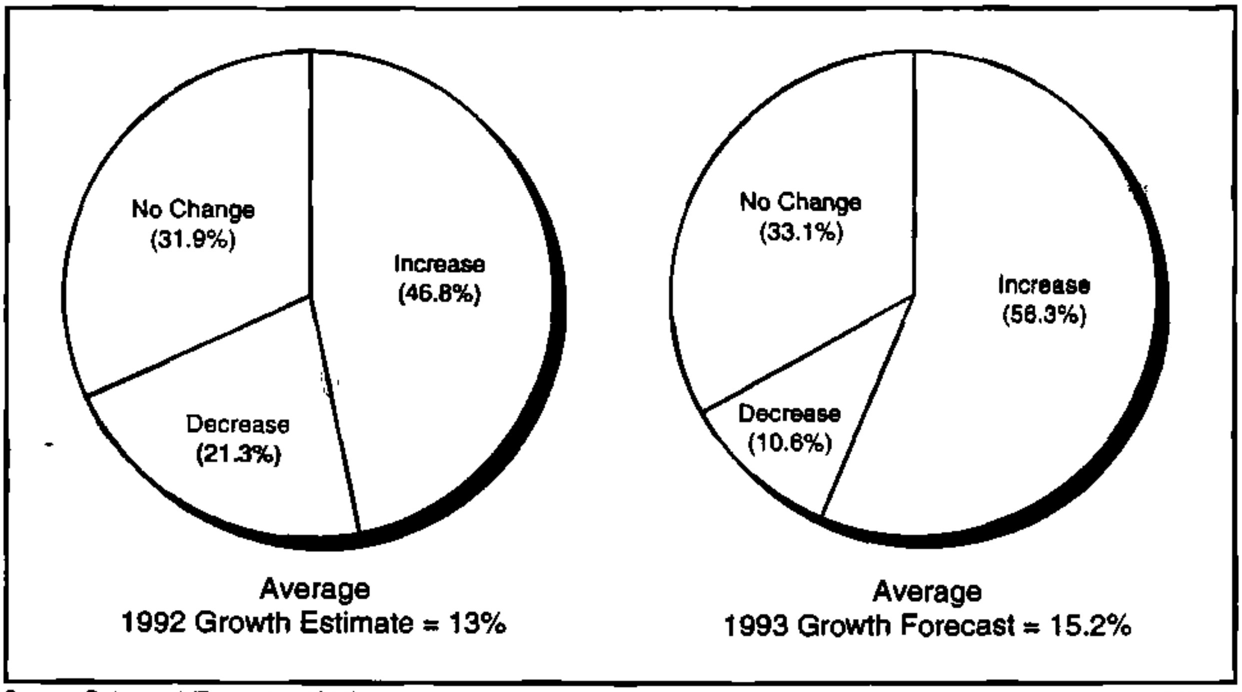


Source: Dataquest (December 1992)

G2001317

- *Quality improvement programs are reflected in the high overall average quality standard, ranging from 55 to 69 ppm.*
- *Improvements in quality programs should continue to result in lower ppm levels.*

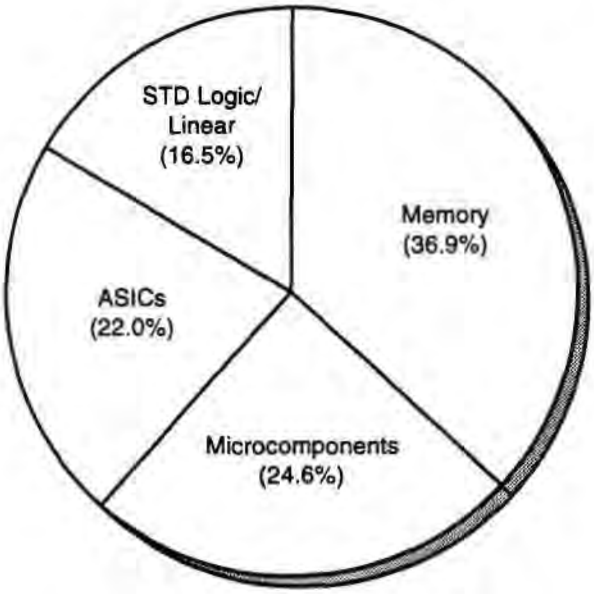
Figure 4-14
Electronics Industry Surveyed Growth Outlook



Source: Dataquest (December 1992) G2001318

- *The percentage of respondents expecting business to improve rose from less than half to more than half.*
- *Those expecting business to decline went from 21.3 percent in 1992 to 10.6 percent in 1993.*
- *This level of optimism, though a bit aggressive, underlies the overall trend for a positive growth year in 1993.*

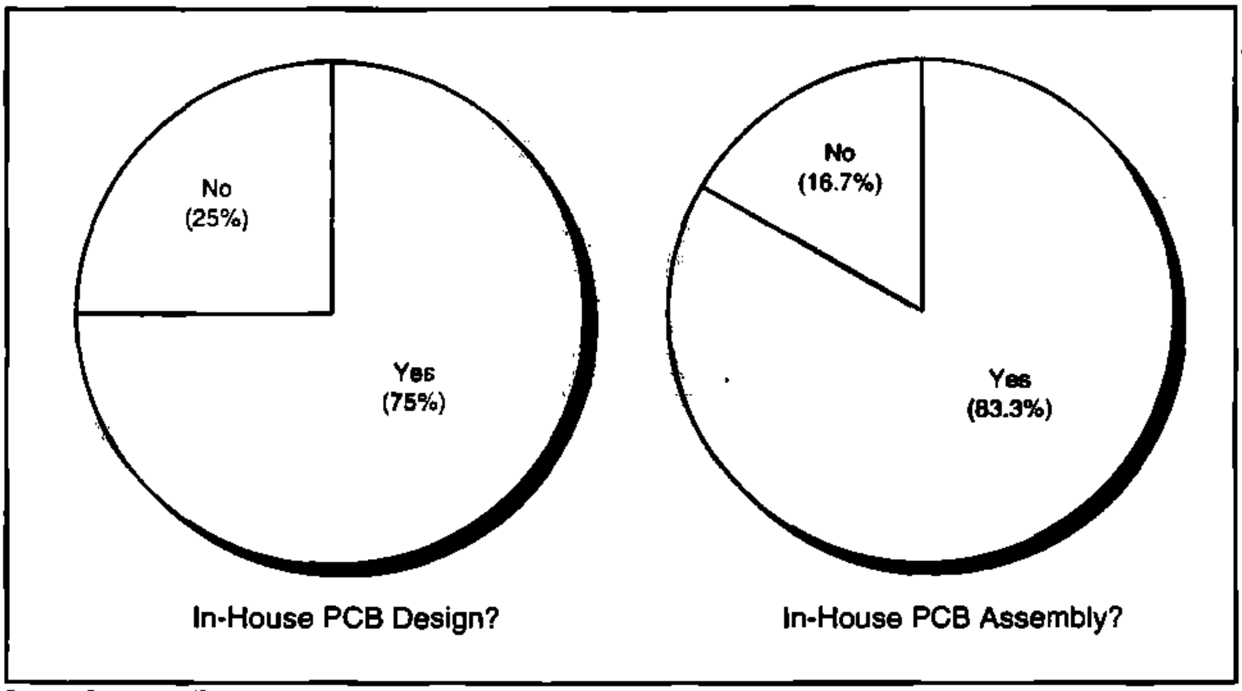
Figure 4-15
PC Industry Survey IC Purchases



Source: Dataquest (December 1992) G2001319

- *Because of the high memory content of PC systems, it is not surprising to see more than 36 percent of all semiconductor purchases going to memory.*
- *Combined with microprocessing purchases, more than 60 percent (61.5 percent) of semiconductor buys for this PC industry sample go to microprocessor and memory products.*

Figure 4-16
PC Industry Circuit Board Design and Assembly

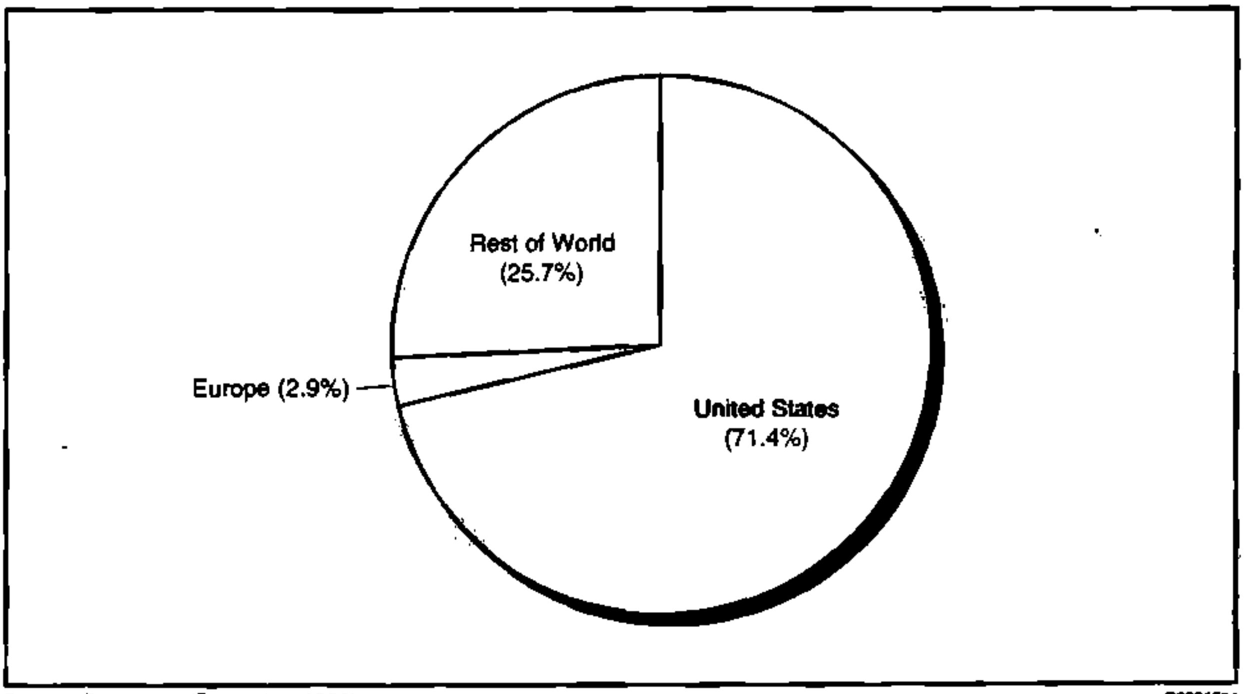


Source: Dataquest (December 1992)

G2001320

As the PC market continues to become commoditized, it is interesting to note the percentages of respondents that do not design or assemble their own circuit boards.

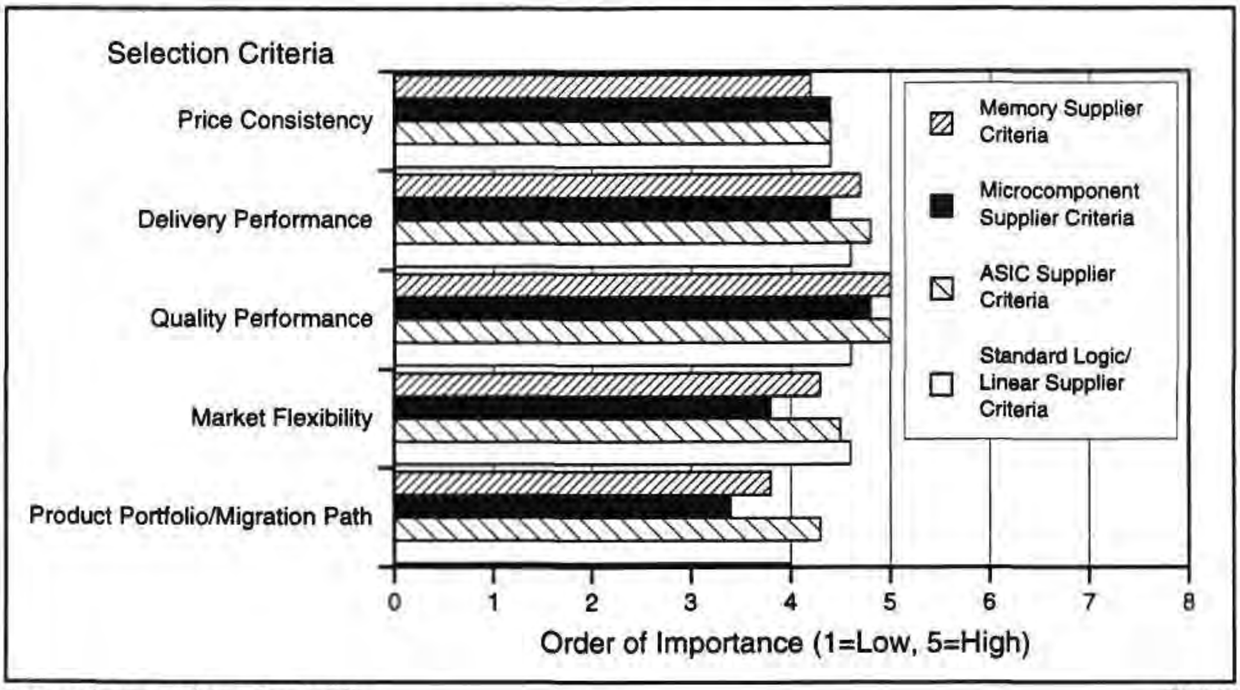
Figure 4-17
PC Industry Physical Circuit Board Assembly Region



Source: Dataquest (December 1992) G2001321

Although a great majority of U.S. company PC assembly is still done onshore, more than 25 percent of it is done in Asia outside of Japan.

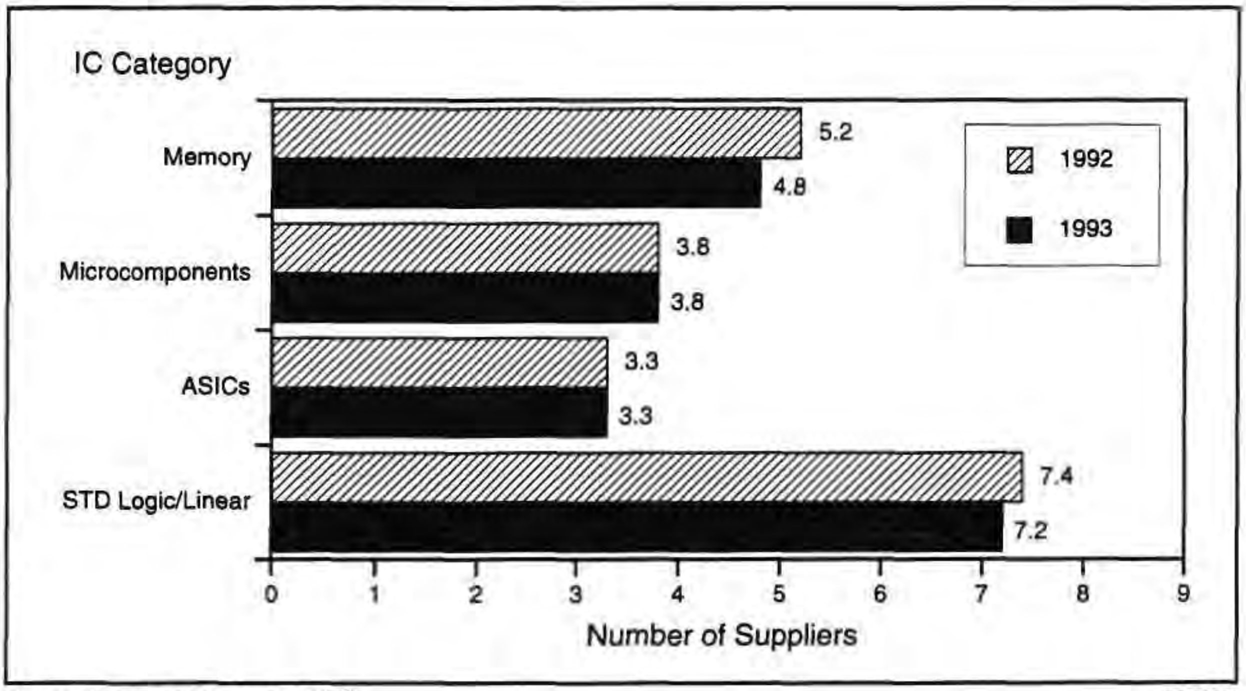
Figure 4-18
PC Industry Semiconductor Supplier Selection Criteria



Source: Dataquest (December 1992) G2001322

The PC industry requires absolute quality adherence when selecting memory and ASIC suppliers.

Figure 4-19
PC Industry Supply Base Trend

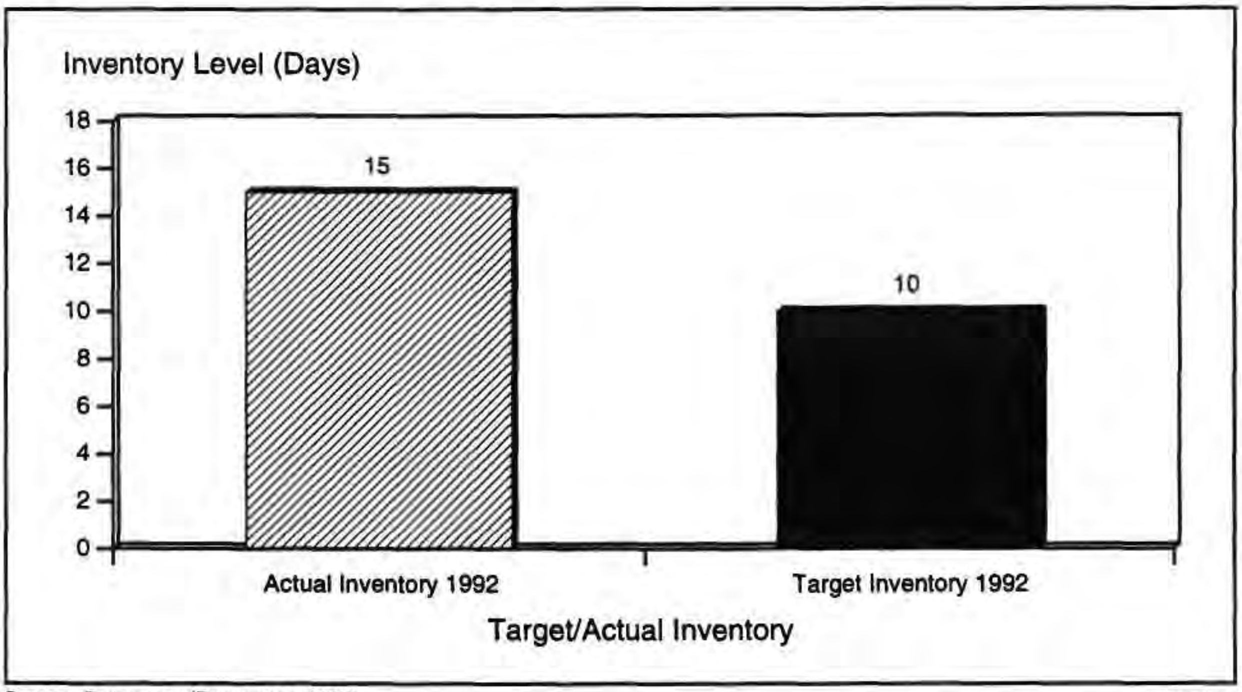


Source: Dataquest (December 1992)

G2001323

The PC semiconductor supply base is being well managed, as evidenced by the small amount of proposed change and the current low level of suppliers.

Figure 4-20
PC Industry Semiconductor Inventory Status

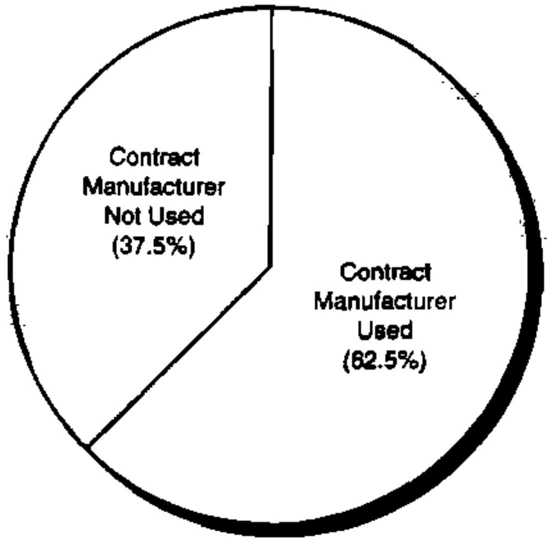


Source: Dataquest (December 1992)

G2001324

Because of the ultracompetitive PC market, targeted actual semiconductor inventory levels are half that of the overall electronics industry.

Figure 4-21
PC Industry Contract Manufacturer Use

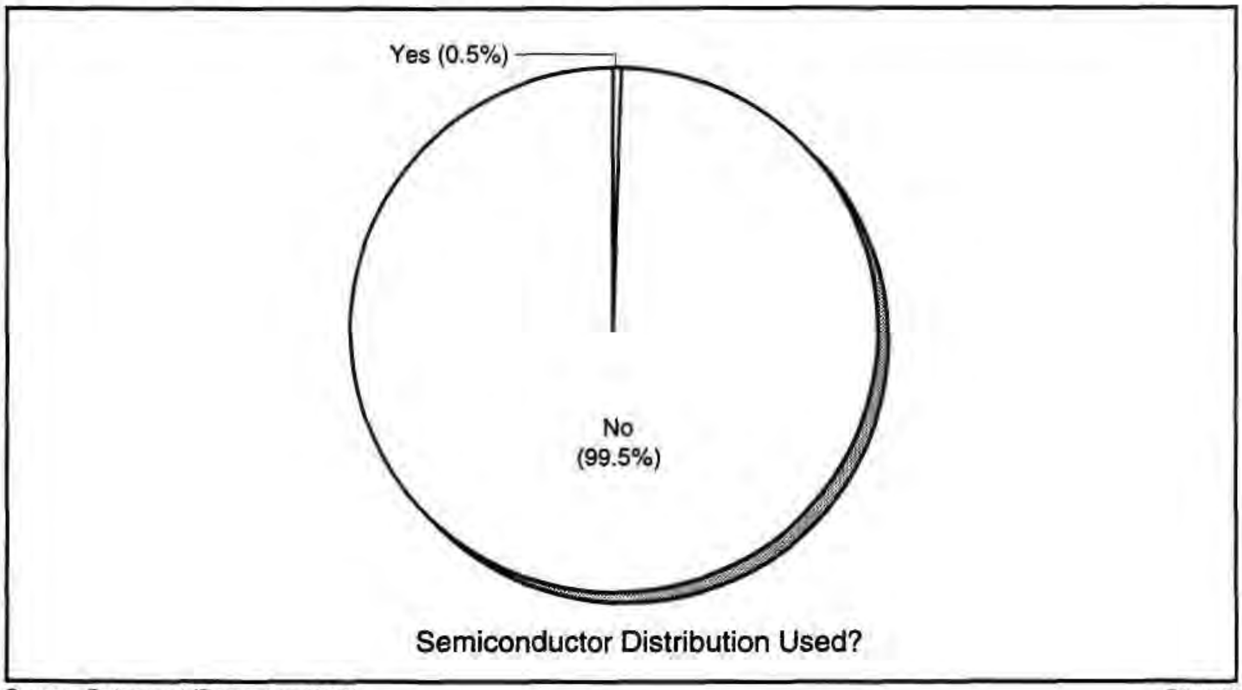


Source: Dataquest (December 1992)

G2001325

Although 62.5 percent of the respondents use contract manufacturing, it has not been until recently that they have been strategically used. This reflects the relatively short 4.8-year average time contract manufacturers have been used.

Figure 4-22
PC Industry Semiconductor Distributor Use

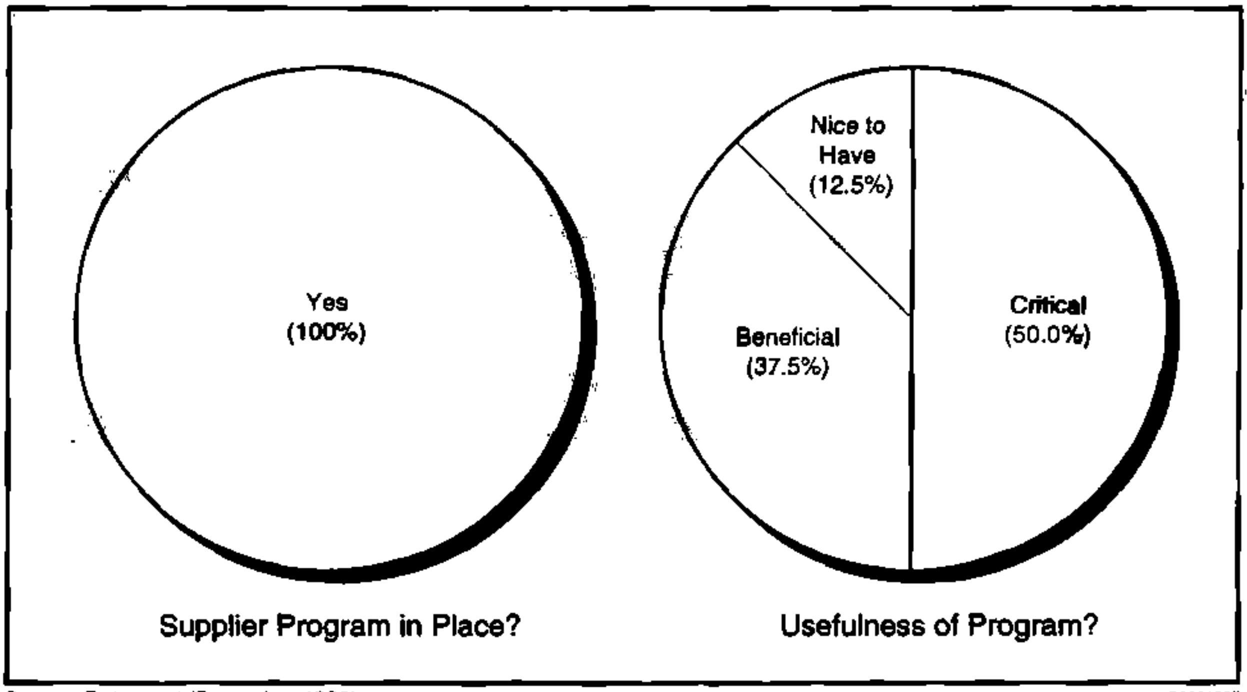


Source: Dataquest (December 1992)

G2001326

- *Less than 1 percent of this sample of PC companies use semiconductor distributors.*
- *Because of the large volumes and required low prices, most large PC manufacturers work directly with OEM semiconductor suppliers.*

Figure 4-23
PC Industry Strategic Supplier Status

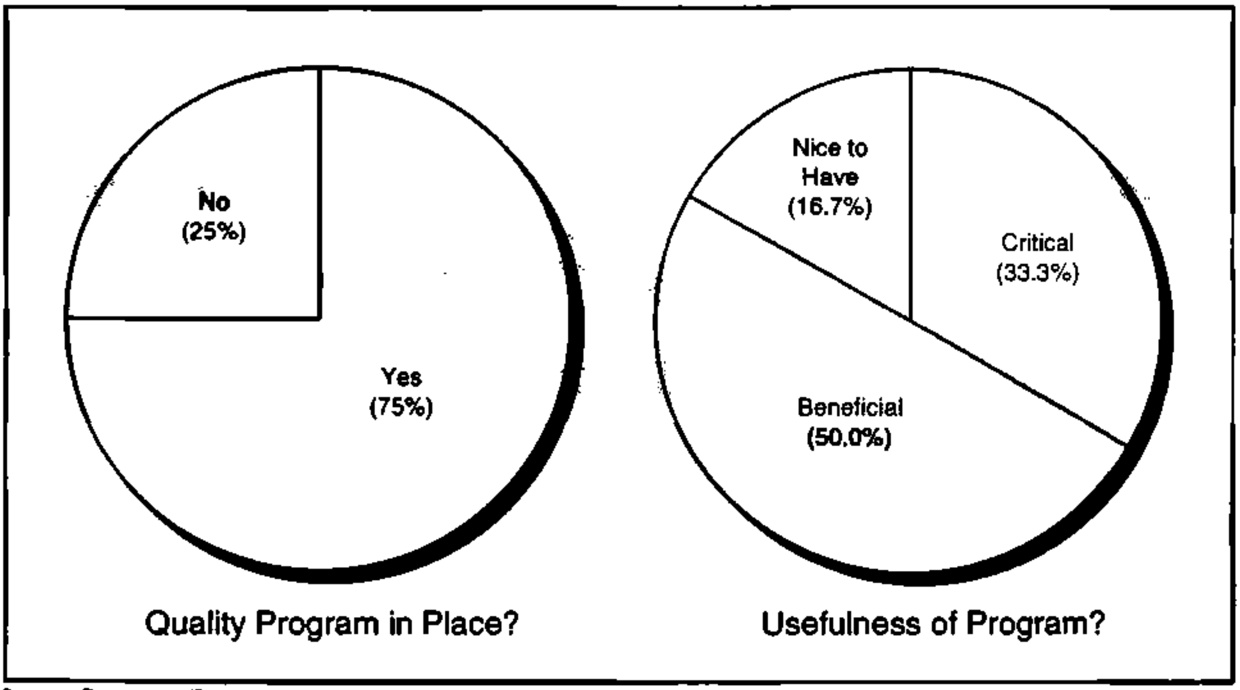


Source: Dataquest (December 1992)

G2001327

- *Tied in with the low use of semiconductor distributors, 100 percent of the respondents have strategic supplier programs in place.*
- *Nearly 90 percent of the respondents find the supplier programs either beneficial or critical for their business.*

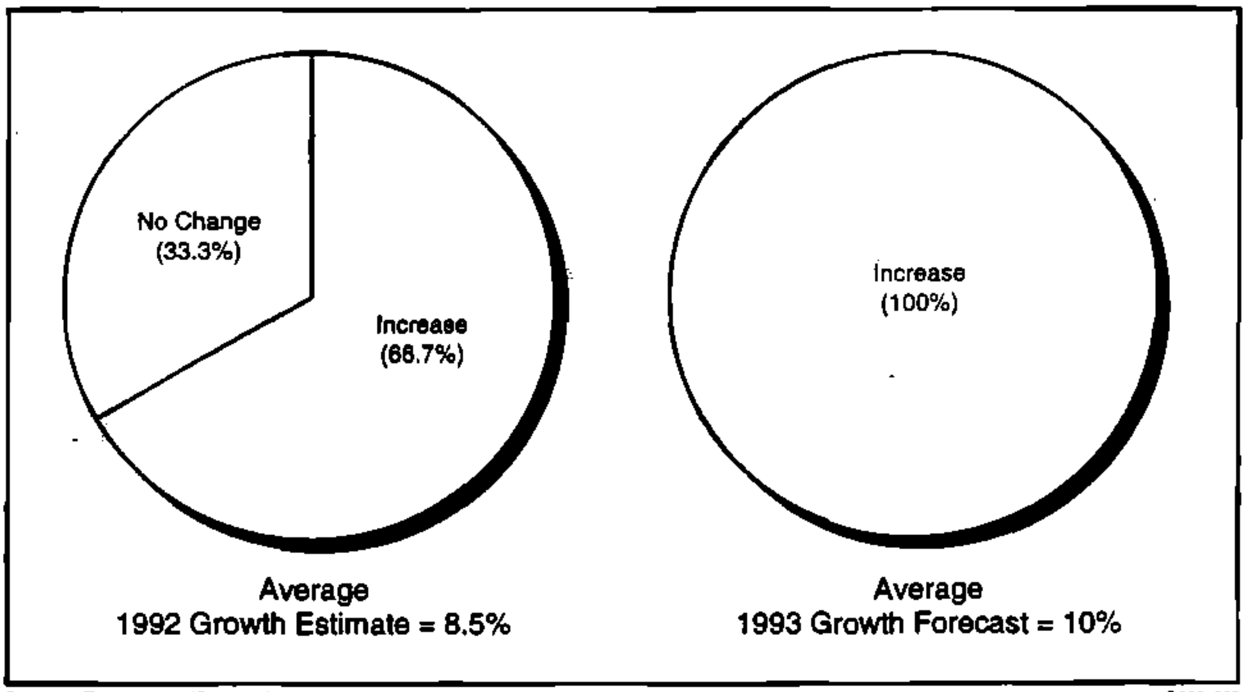
Figure 4-24
PC Industry Quality Improvement Program Status



Source: Dataquest (December 1992) G2001328

With 75 percent of the PC industry respondents utilizing quality improvement programs, more than 80 percent find them beneficial or critical to their business.

Figure 4-25
PC Industry Surveyed Growth Outlook

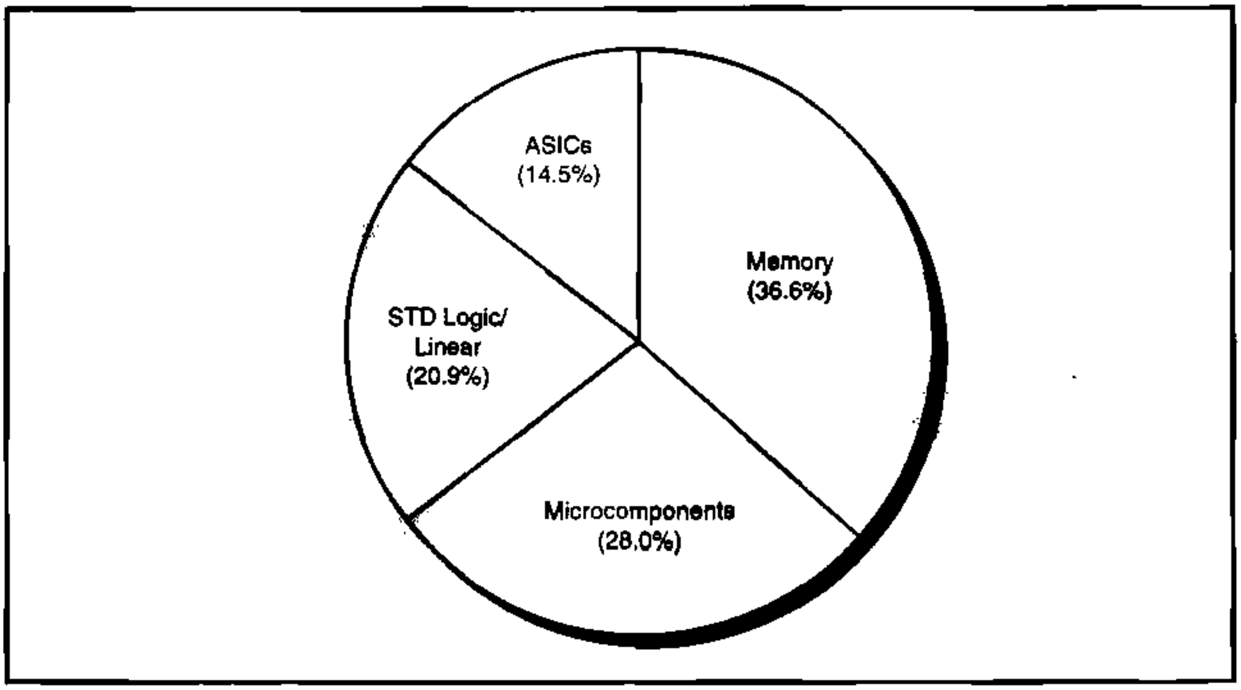


Source: Dataquest (December 1992)

G2001329

- *Despite the PC price wars, two-thirds of the respondents expect to see growth in 1992 averaging 8.5 percent.*
- *An optimistic sample, all expect to see business expand in 1993 an average 10 percent.*

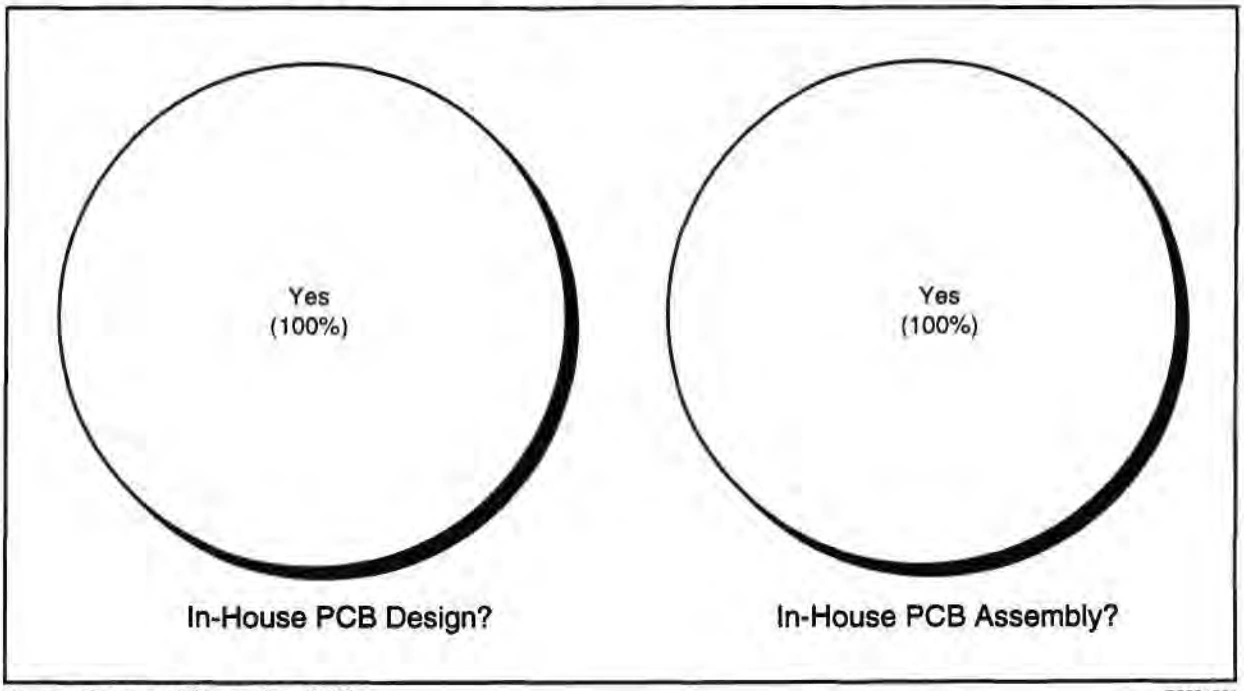
Figure 4-26
Other Data Processing Industry Survey IC Purchases



Source: Dataquest (December 1992)
G2001330

Nearly 65 percent of all the data processing (except PC) respondents' semiconductor dollar goes to memory and microcomponent devices.

Figure 4-27
Other Data Processing Industry Circuit Board Design and Assembly

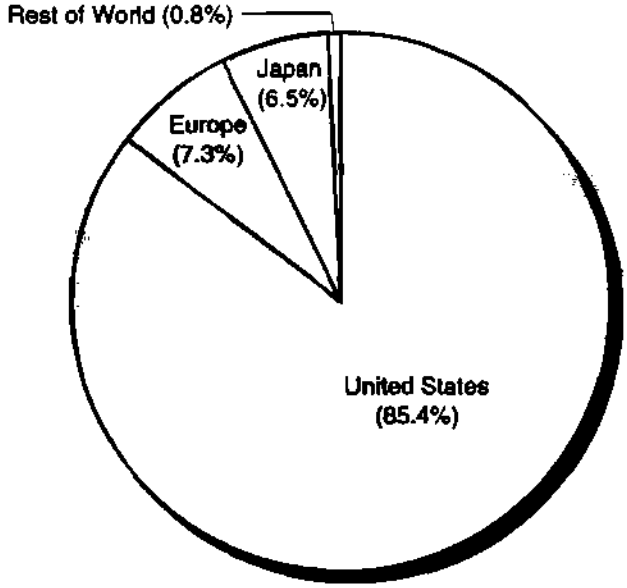


Source: Dataquest (December 1992)

G2001331

The nature of this market segment requires proprietary designs, which is a main reason all the respondents both design and assemble all of their circuit boards.

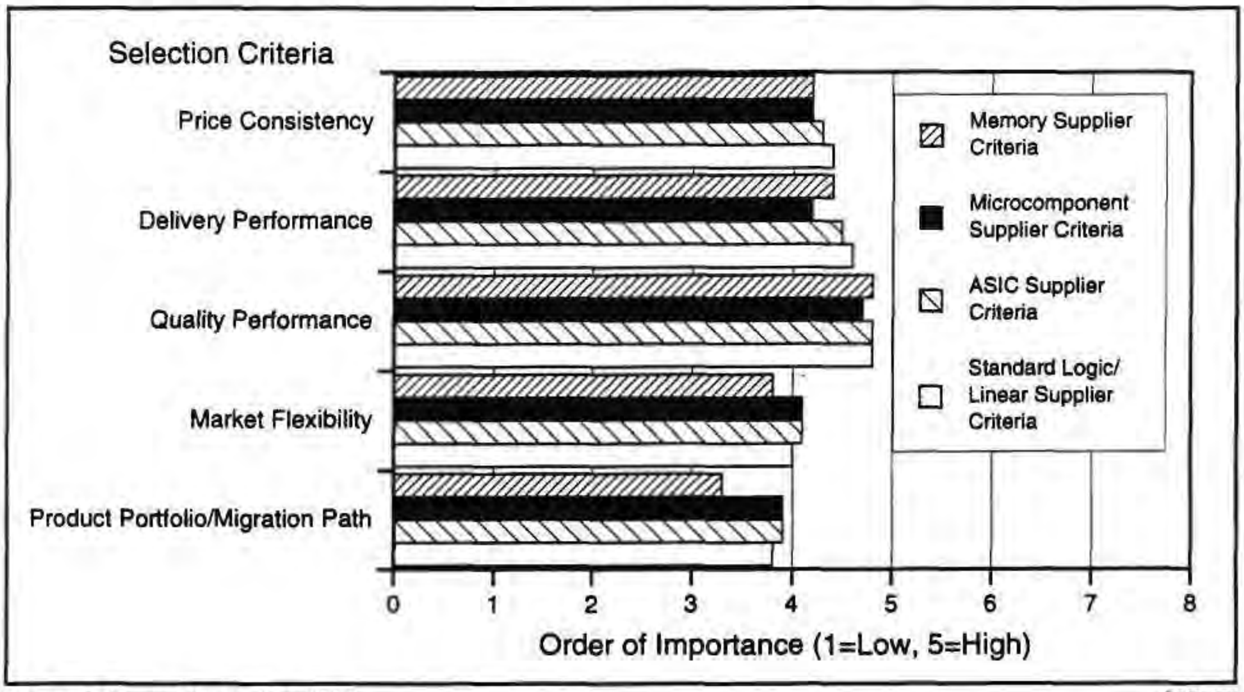
Figure 4-28
Other Data Processing Industry Physical Circuit Board Assembly Region



Source: Dataquest (December 1992)
G2001332

- *The United States remains the region where most assembly is done, followed by Europe, Japan, and the rest of Asia a distant fourth.*
- *Proprietary designs and local market content heavily influence assembly region decisions for this market.*

Figure 4-29
Other Data Processing Industry Semiconductor Supplier Selection Criteria

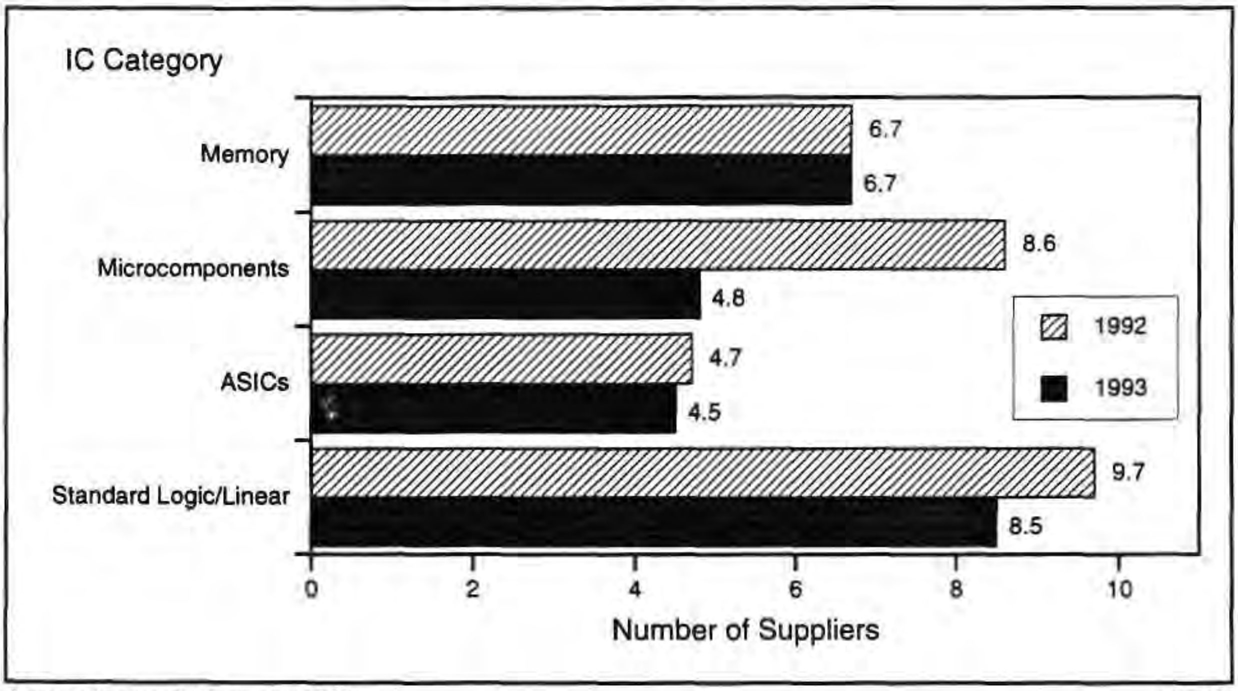


Source: Dataquest (December 1992)

G2001333

- *Across the supplier categories, quality performance is the key criterion for selecting a semiconductor supplier.*
- *The breadth and plans of a supplier universally was seen as not as important.*

Figure 4-30
Other Data Processing Industry Supply Base Trend

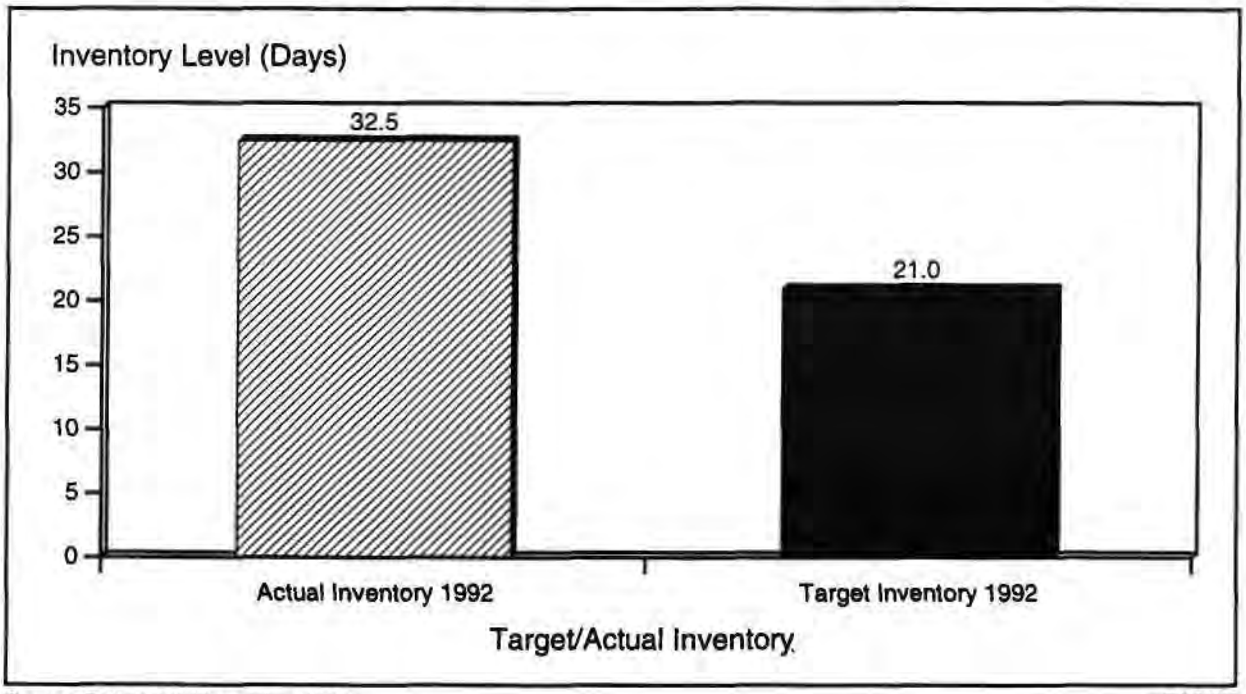


Source: Dataquest (December 1992)

G2001334

- *Aside from the microcomponent supply base, most supplier levels are expected to remain the same.*
- *Because of extreme competition in the ASSP market, respondents are consolidating their supplier list, focusing on long-term viable companies.*

Figure 4-31
Other Data Processing Industry Semiconductor Inventory Status

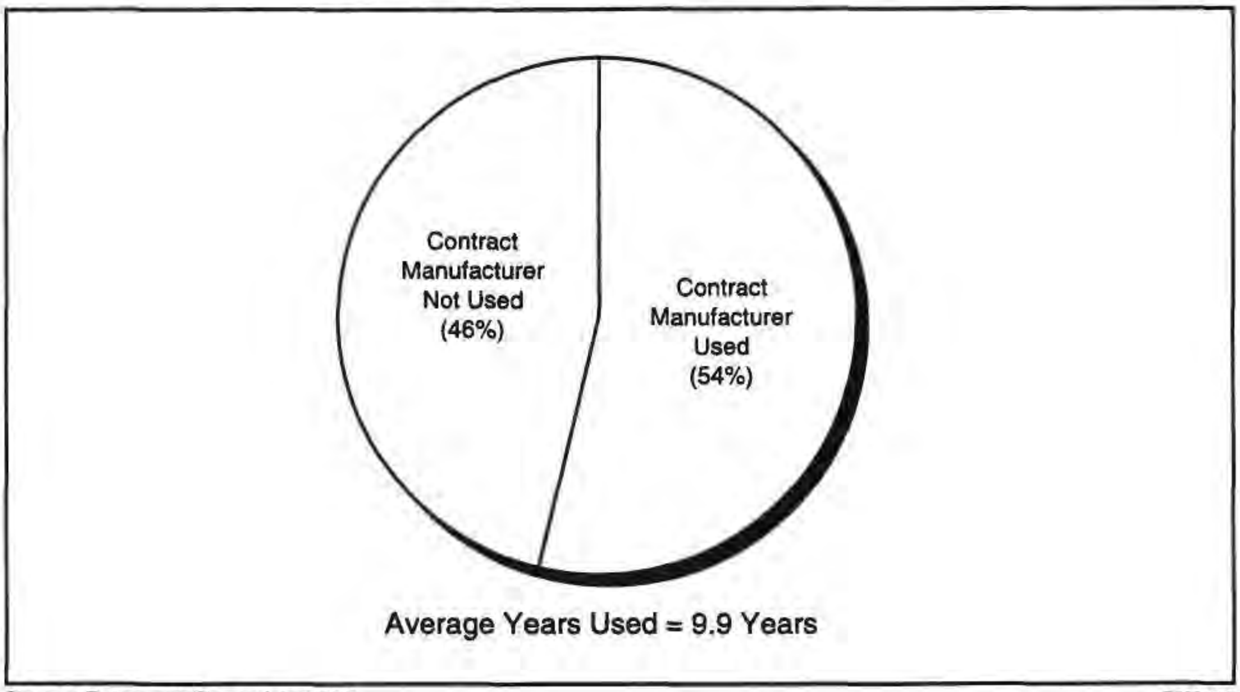


Source: Dataquest (December 1992)

G2001335

- *This segment of the industry closely tracks the overall electronics market in average target and actual semiconductor inventory levels.*
- *Despite the higher use of contract manufacturing and distribution, higher levels of inventory are kept relative to the PC market because of the diverse needs of the other segments of data processing.*

Figure 4-32
Other Data Processing Industry Contract Manufacturer Use

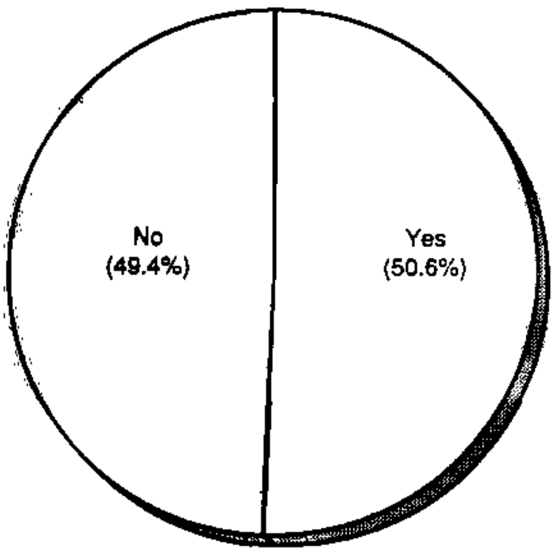


Source: Dataquest (December 1992)

G2001336

More than half the respondents use contract manufacturers, with the length of time a contract manufacturer was used averaging nearly 10 years.

Figure 4-33
Other Data Processing Industry Semiconductor Distributor Use

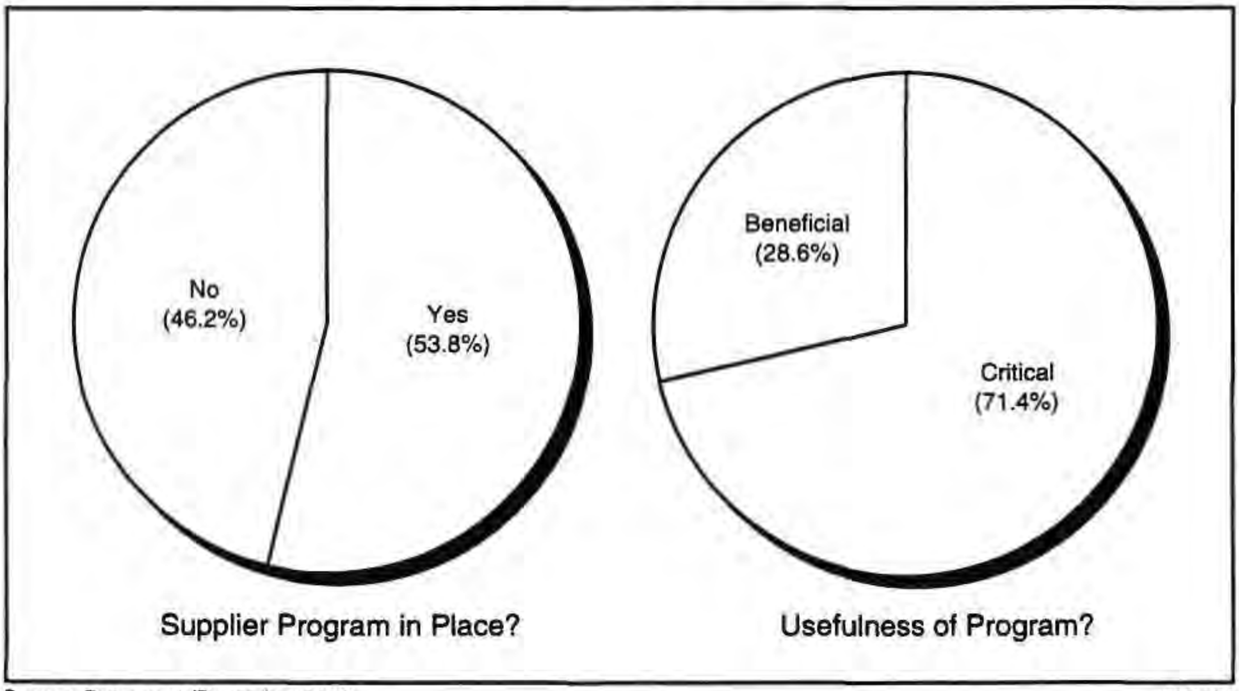


Source: Dataquest (December 1992)

G2001337

- *Slightly more than half the data processing respondents use semiconductor distributors.*
- *Distribution often is used to lower overhead costs of low-usage components or high-service-level items such as subassembly kits.*

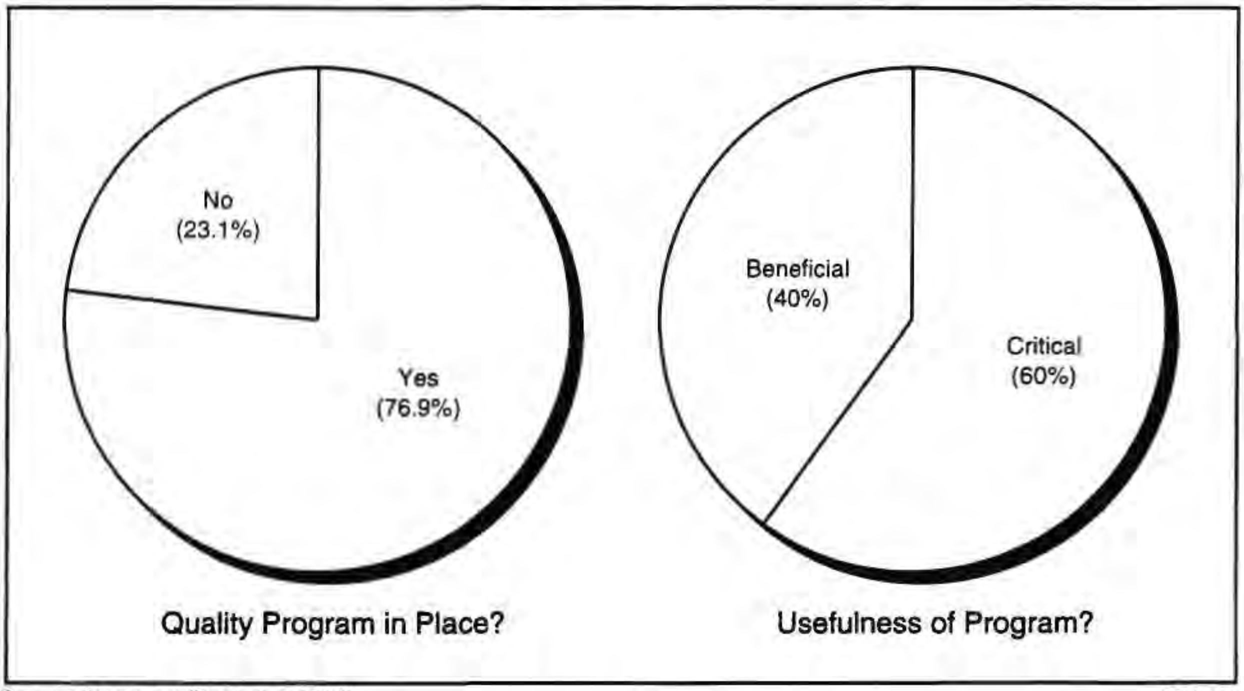
Figure 4-34
Other Data Processing Industry Strategic Supplier Status



Source: Dataquest (December 1992)
G2001338

For the 54 percent of respondents using a strategic supplier program, more than 70 percent found the program critical to their operation.

Figure 4-35
Other Data Processing Industry Quality Improvement Program Status

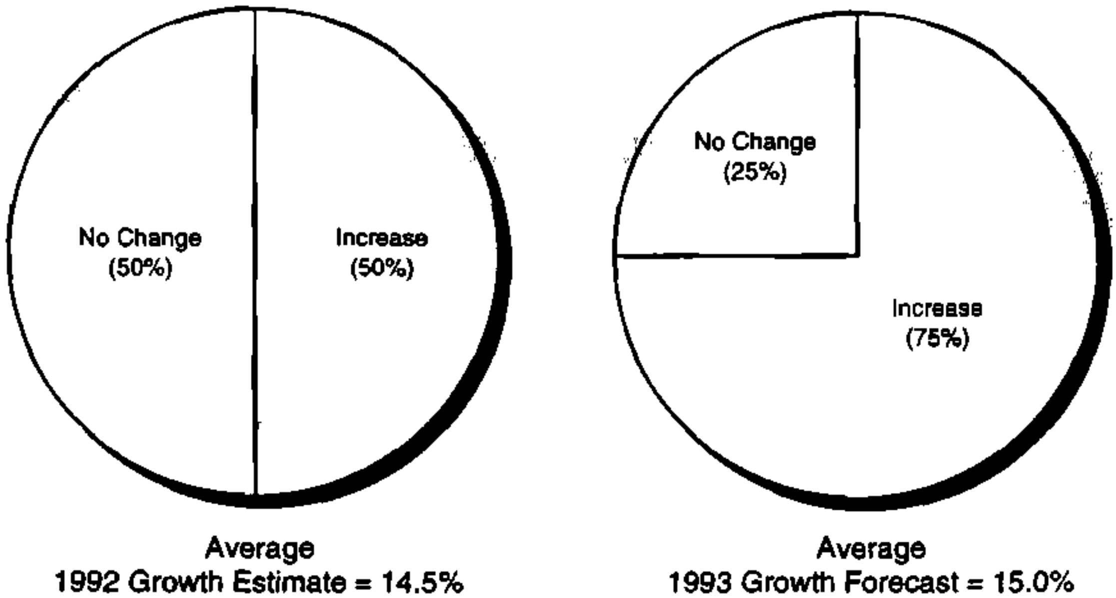


Source: Dataquest (December 1992)

G2001339

More than three-fourths (76.9 percent) of the sample has a formal quality improvement program in place, and 60 percent of the users find the program critical to their business.

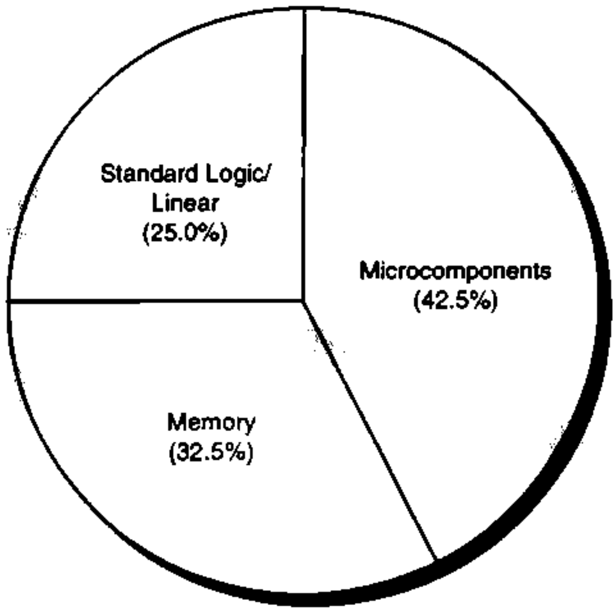
Figure 4-36
Other Data Processing Industry Surveyed Growth Outlook



Source: Dataquest (December 1992) G2001340

- *Although none of the respondents expects to see a decline in system sales, the results are evenly mixed on a flat to growing market for 1992.*
- *Seventy-five percent of the respondents expect growth to be an average 15 percent in 1993.*

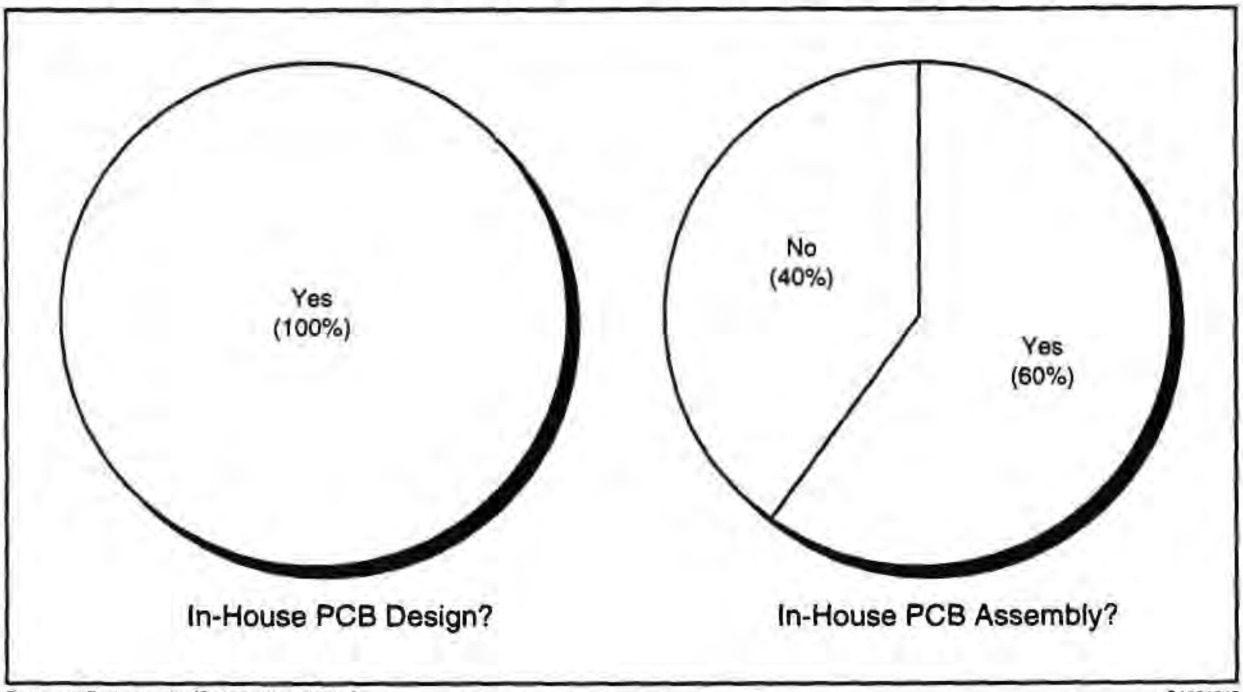
Figure 4-37
Premise Communications Industry Survey IC Purchases



Source: Dataquest (December 1992) G2001341

The respondents in this market segment spend 75 percent of their semiconductor procurement dollar on microcomponent devices.

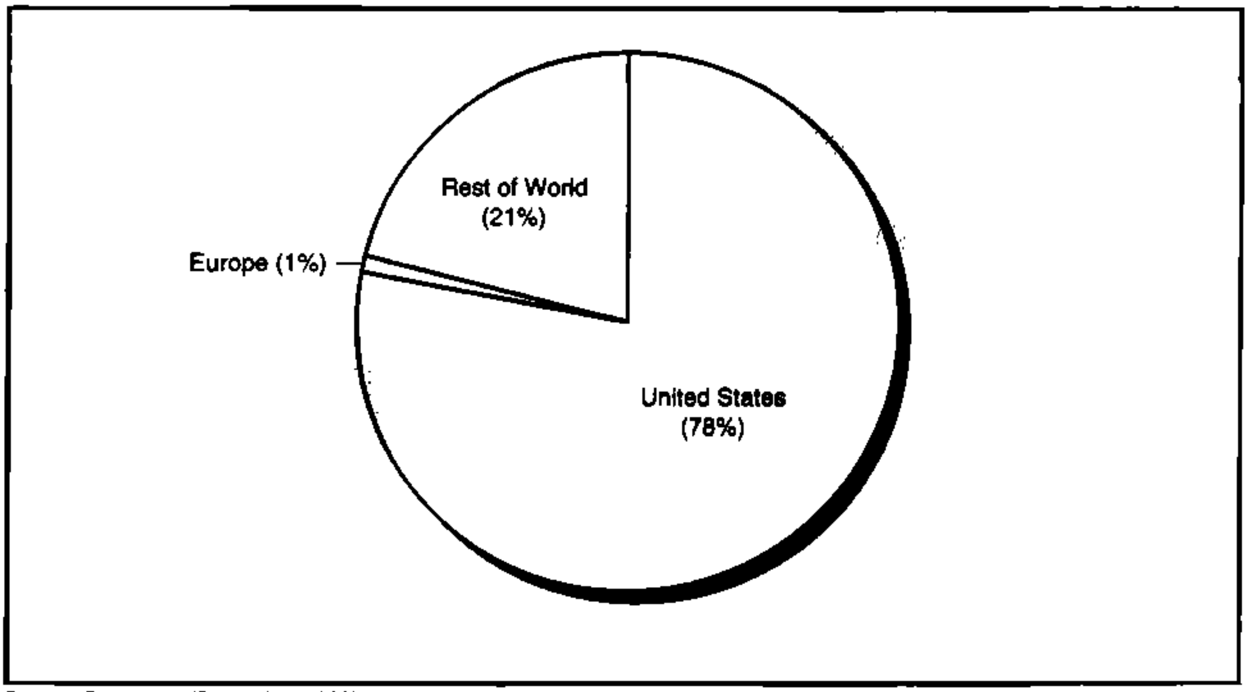
Figure 4-38
Premise Communications Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992)
G2001342

Although all respondents design their own circuit boards, 40 percent outsource their assembly.

Figure 4-39
Premise Communications Industry Physical Circuit Board Assembly Region

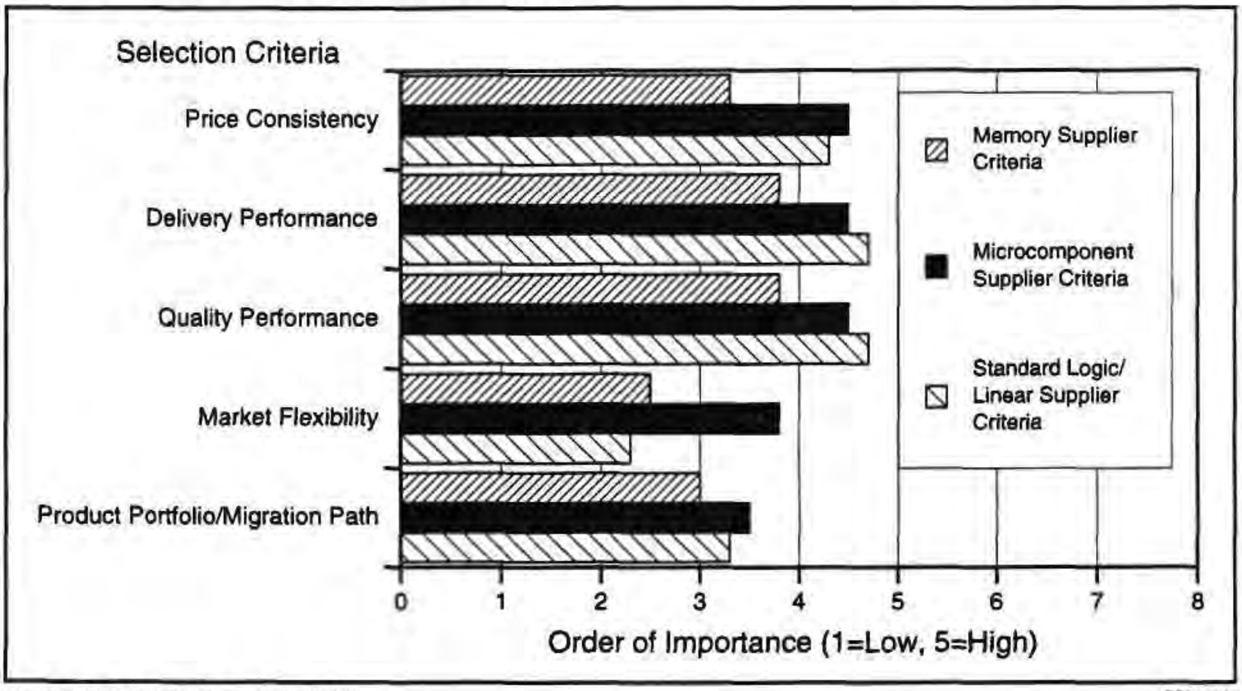


Source: Dataquest (December 1992)

G2001343

Assembly is predominantly done in the United States, followed by the Asian region outside Japan.

Figure 4-40
Premise Communications Industry Semiconductor Supplier Selection Criteria

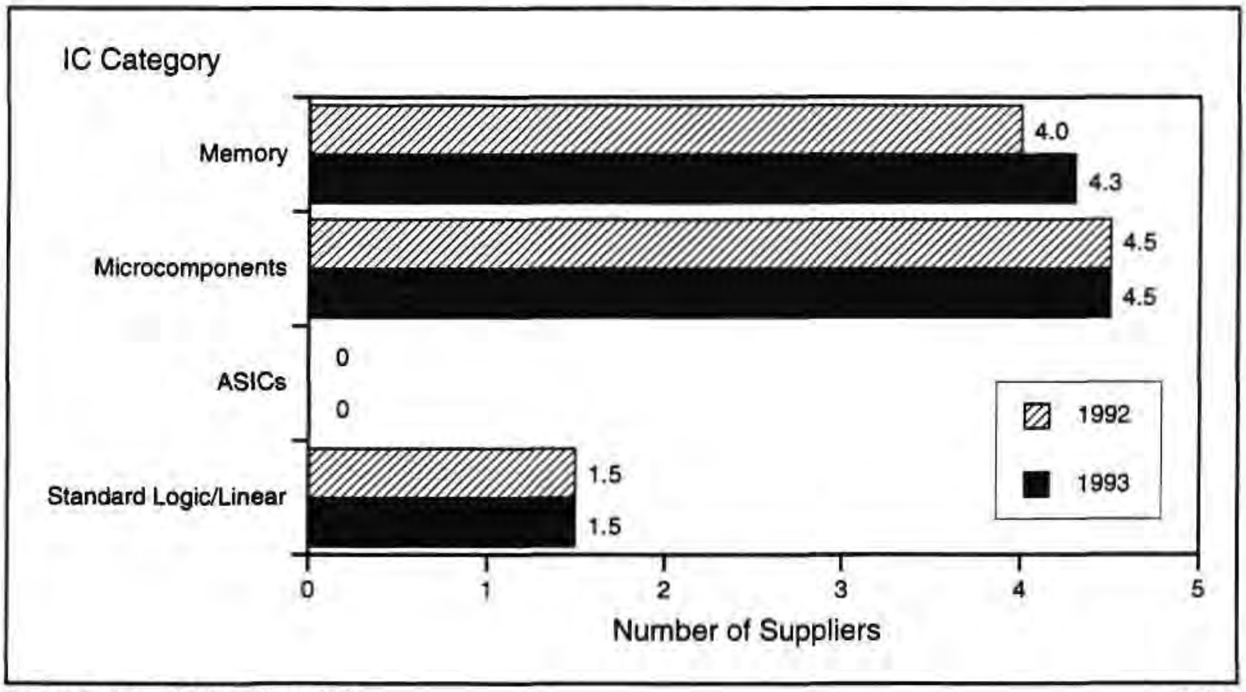


Source: Dataquest (December 1992)

G2001344

Because of the larger level of microcomponents consumed, this segment has higher criteria set for these suppliers, when compared to the rest of the industry.

Figure 4-41
Premise Communications Industry Supply Base Trend

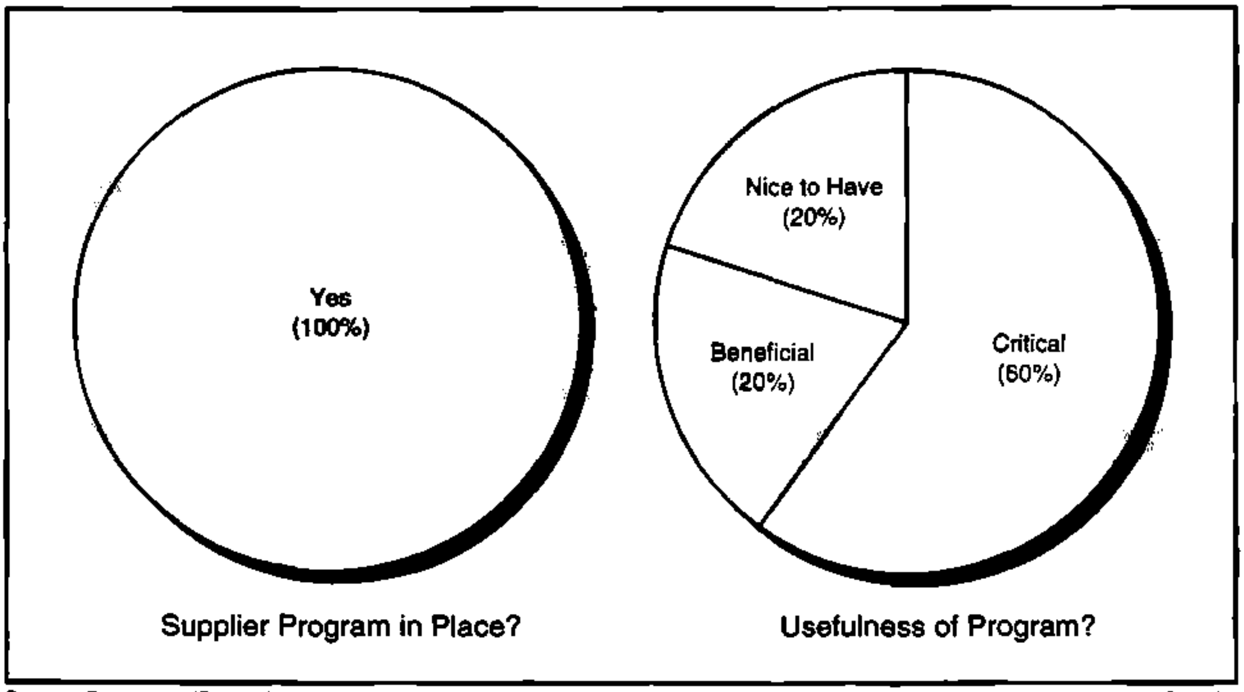


Source: Dataquest (December 1992)

G2001345

Aside from a slight adjustment in memory supply, all other suppliers are expected to remain the same.

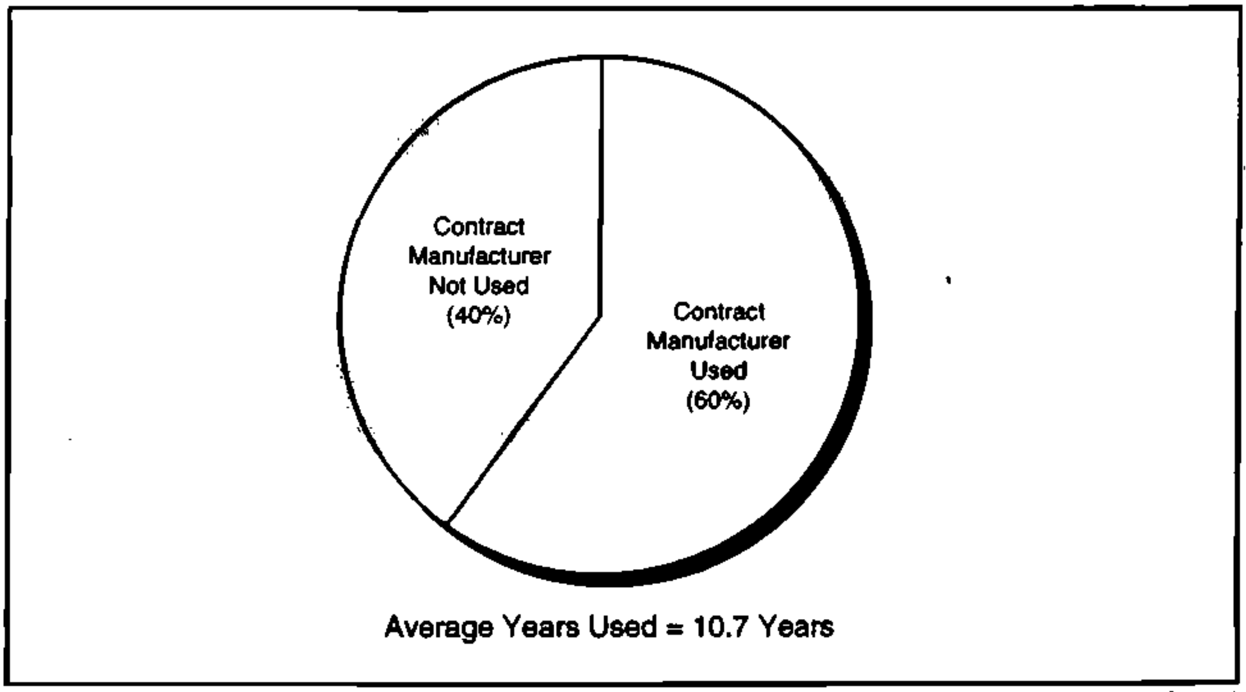
Figure 4-42
Premise Communications Industry Strategic Supplier Status



Source: Dataquest (December 1992) G2001346

All respondents have strategic supplier programs in place. Although 80 percent of the sample found the program beneficial to critical for their business, 20 percent saw the program as merely "nice to have."

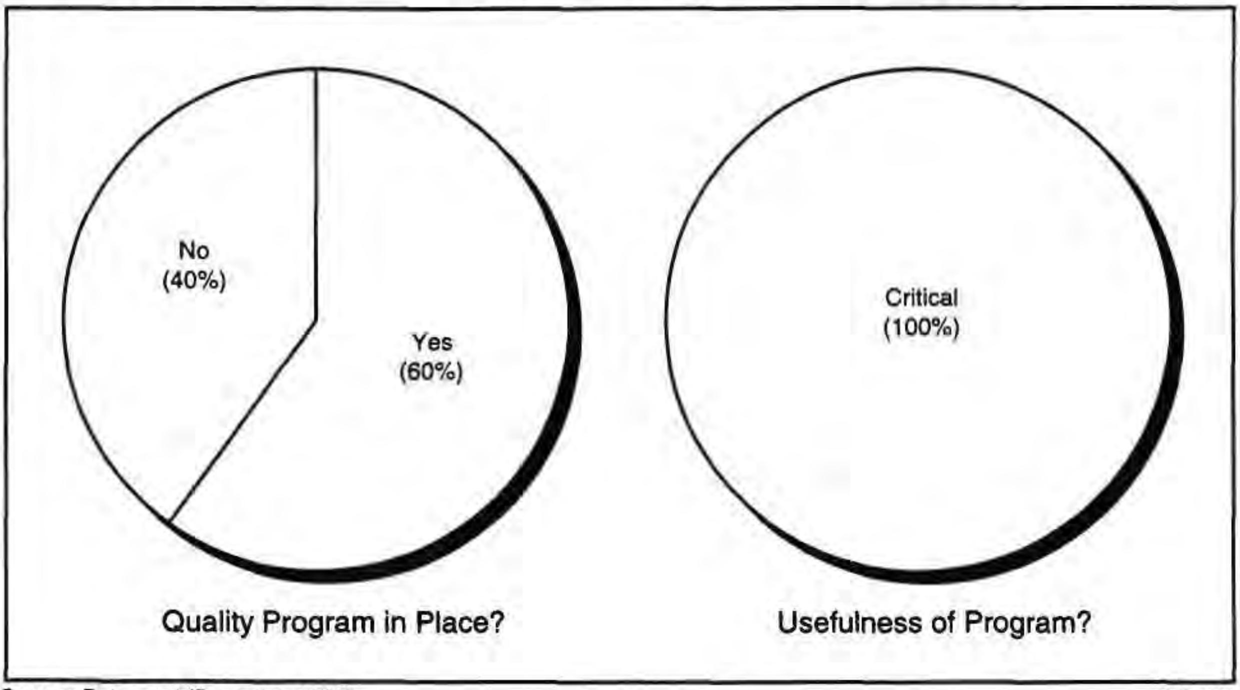
Figure 4-43
Premise Communications Industry Contract Manufacturer Use



Source: Dataquest (December 1992)
G2001347

Contract manufacturers are used by 60 percent of this sample, with the length of time a contractor was used averaging more than 10 years.

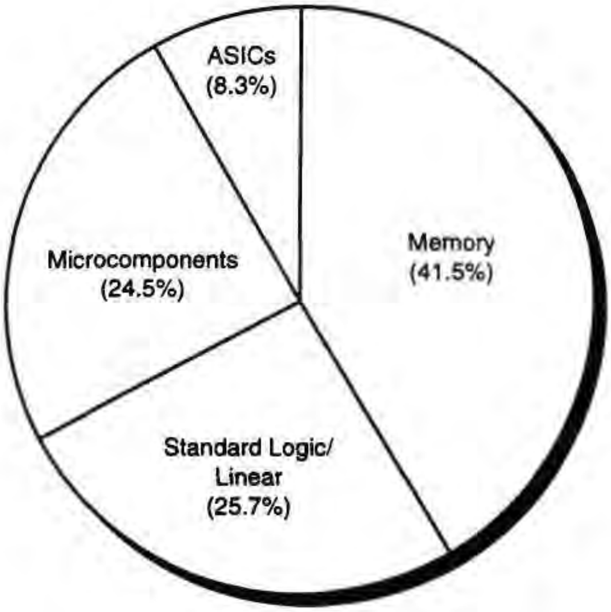
Figure 4-44
Premise Communications Industry Quality Improvement Program Status



Source: Dataquest (December 1992) G2001348

The 60 percent of the respondents with a formal quality program in place all find the exercise critical for doing business.

Figure 4-45
Other Communications Industry Survey IC Purchases

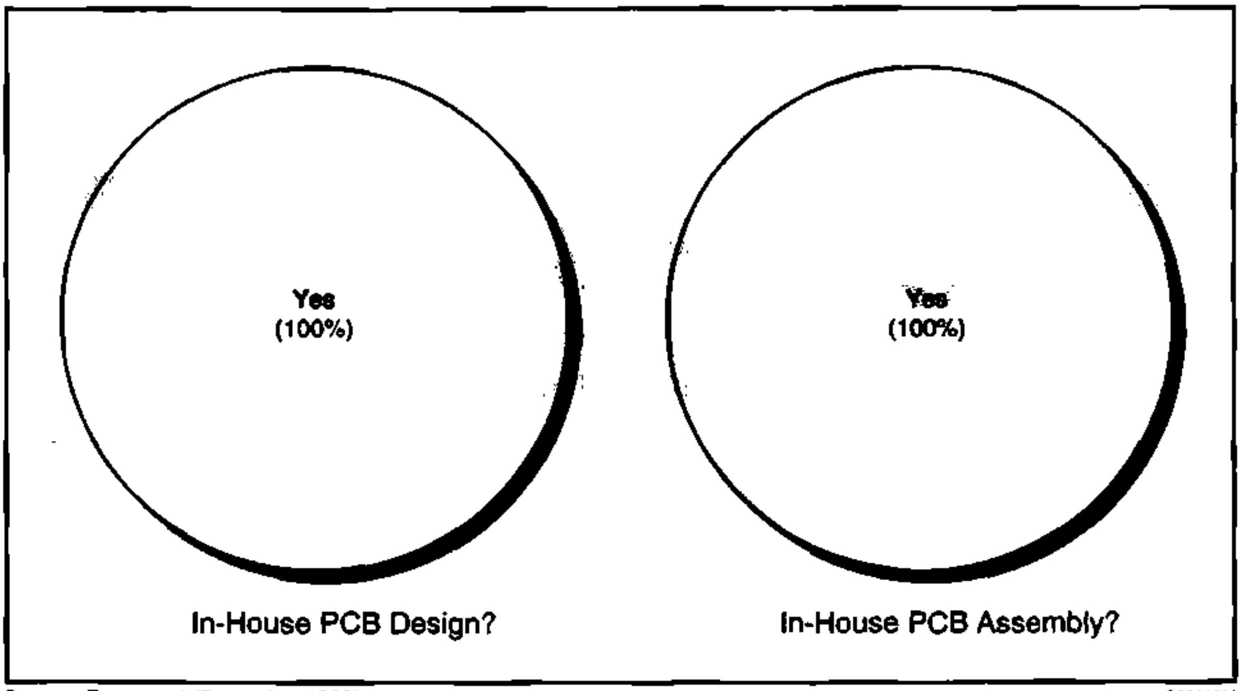


Source: Dataquest (December 1992)

G2001349

- *Sixty-six percent of the semiconductor purchase of this market segment goes to memory and microcomponent products.*
- *ASIC devices are expected to erode the usage of standard logic for this market because of space and voltage requirements.*

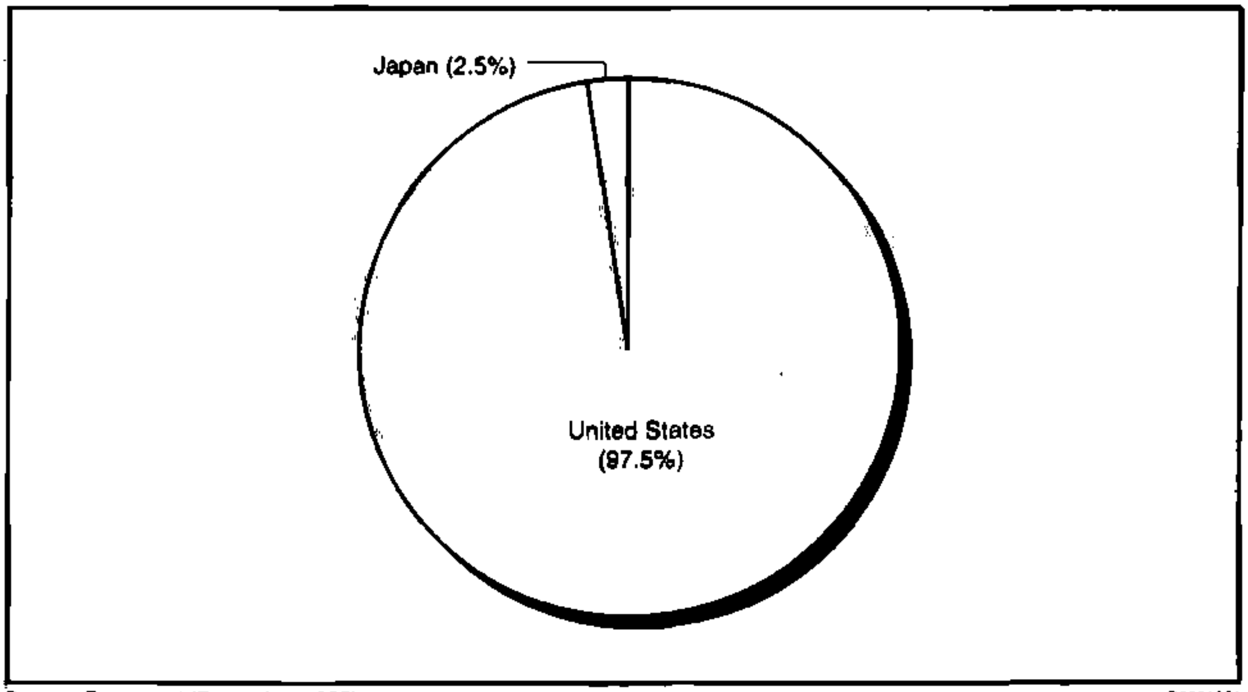
Figure 4-46
Other Communications Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992) G2001360

Because of the emerging/proprietary nature of this market, all circuit design and assembly is done in-house.

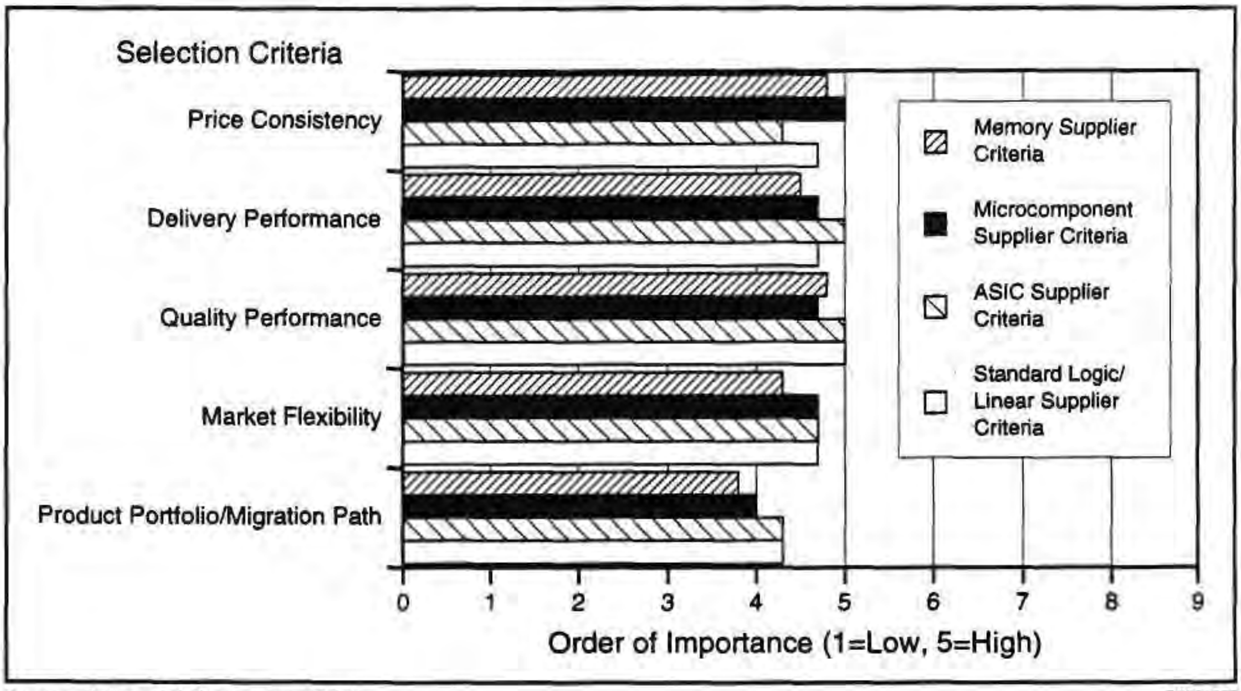
Figure 4-47
Other Communications Industry Physical Circuit Board Assembly Region



Source: Dataquest (December 1992)
G2001351

The vast majority (97.5 percent) of all assembly for this sample is done in the United States because of supply logistics and the current size of the market.

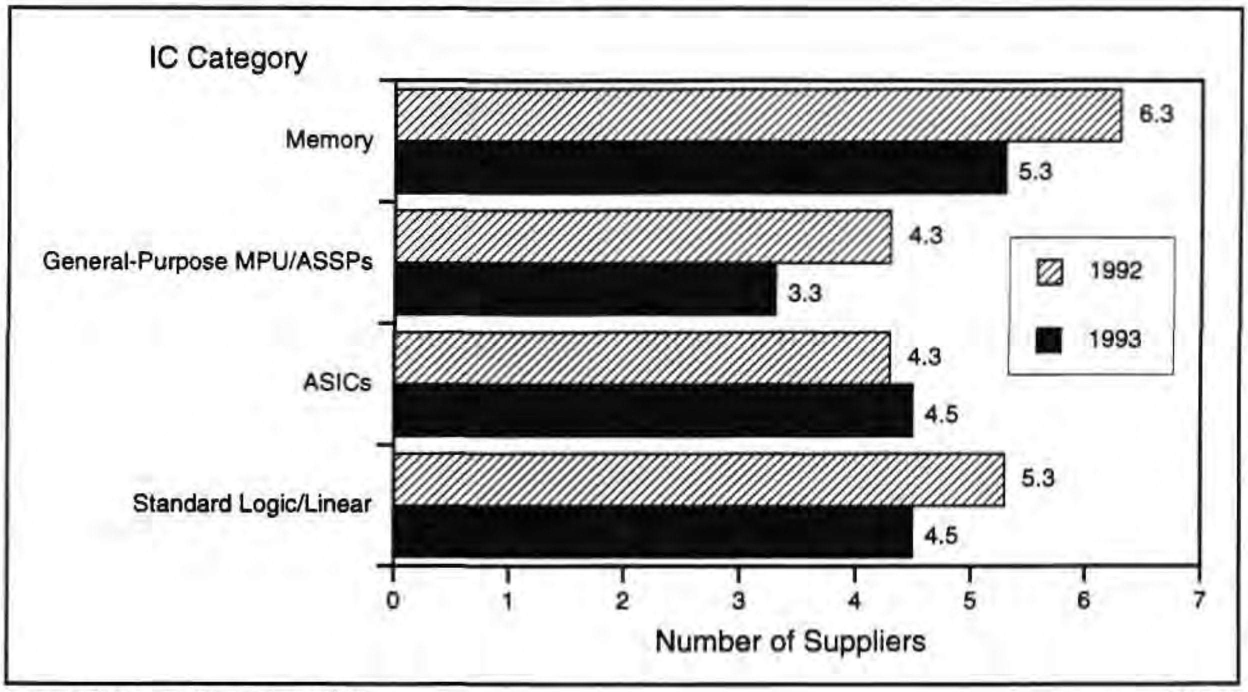
Figure 4-48
Other Communications Industry Semiconductor Supplier Selection Criteria



Source: Dataquest (December 1992)
G2001352

Although microcomponent suppliers are selected primarily on price consistency, ASIC suppliers are primarily judged on adherence to delivery schedules and quality specifications for this segment.

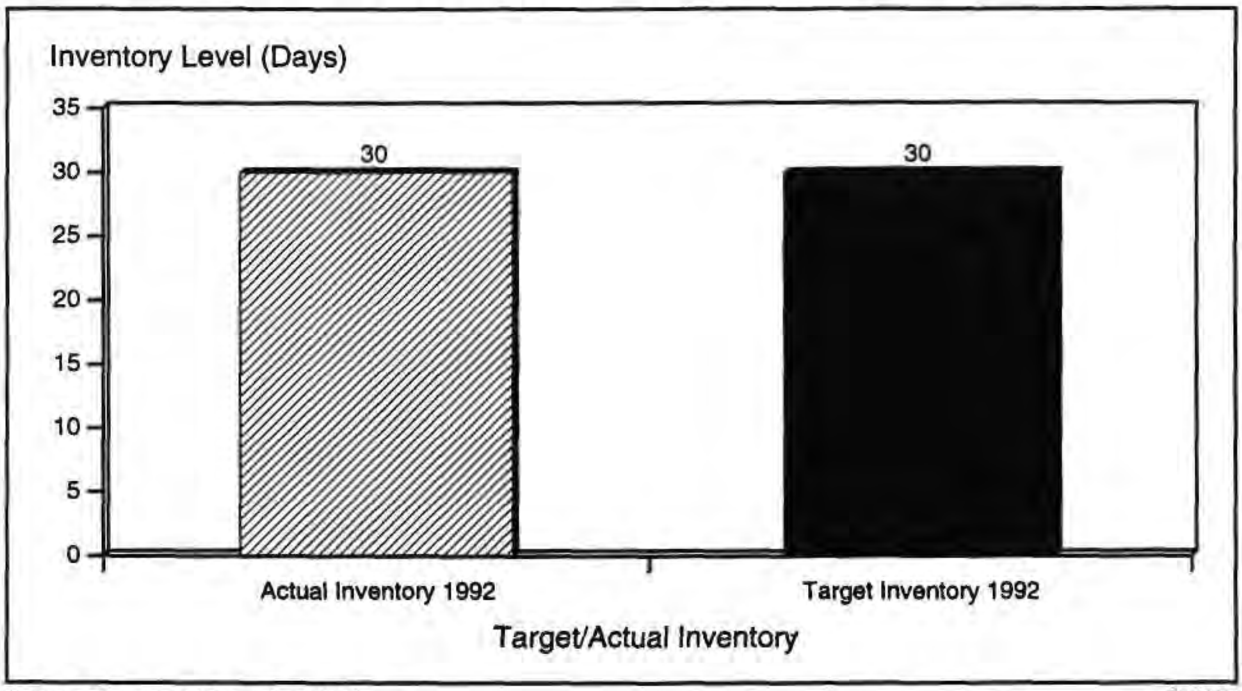
Figure 4-49
Other Communications Industry Supply Base Trend



Source: Dataquest (December 1992)
G2001353

Aside from a small increment in the ASIC supply base, all other supplier levels are expected to decline next year.

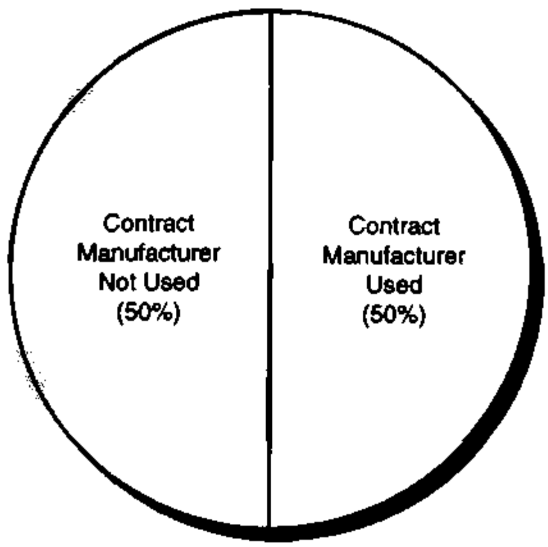
Figure 4-50
Other Communications Industry Semiconductor Inventory Status



Source: Dataquest (December 1992) G2001354

This segment of the industry is at its target semiconductor inventory level of 30 days. With the industry average at 20 days, this may be a challenge for these companies.

Figure 4-51
Other Communications Industry Contract Manufacturer Use

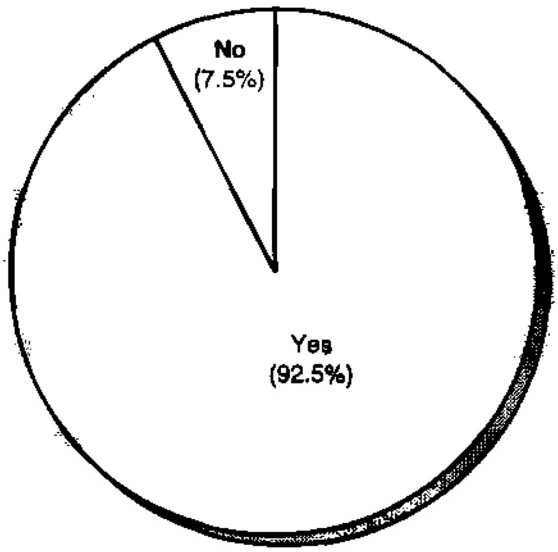


Source: Dataquest (December 1992)

G2001395

- *Although half of the respondents use contract manufacturing, the average period is only three years.*
- *As this market grows and becomes more commoditized, the level of contract manufacture is expected to grow.*

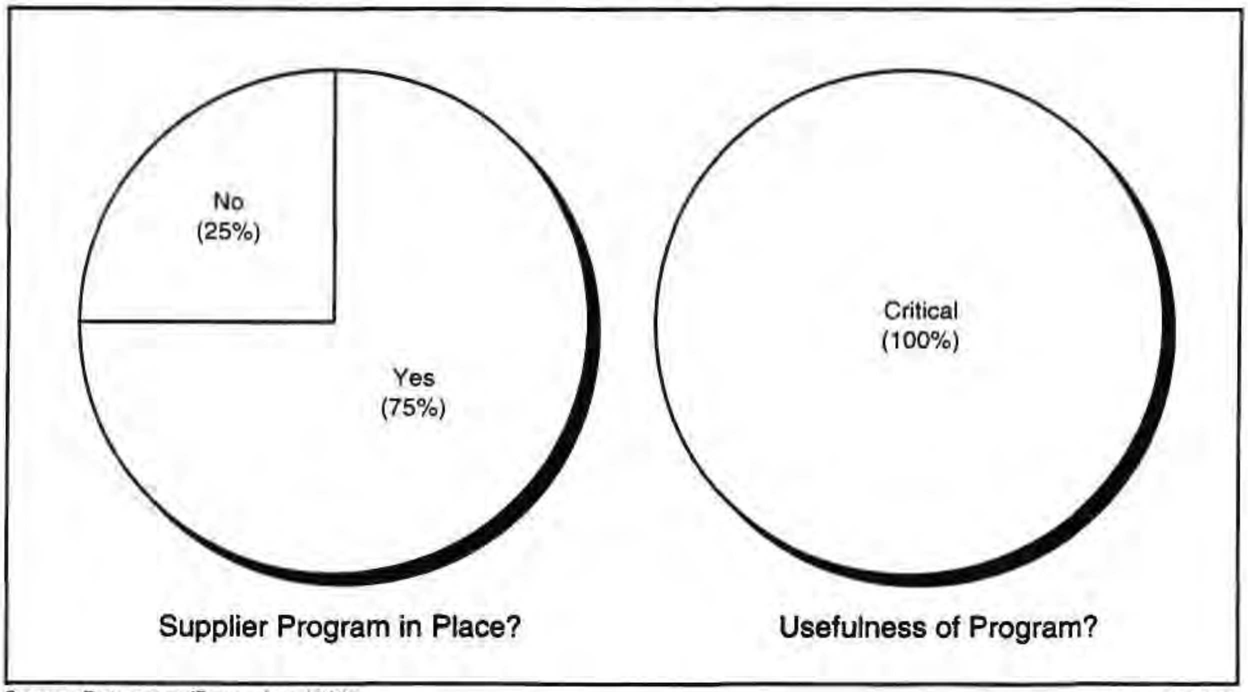
Figure 4-52
Other Communications Industry Semiconductor Distributor Use



Source: Dataquest (December 1992) G2001356

Because of the relative low volume of semiconductors in this segment's purchases, distribution plays a large role in supplying the service and devices this segment now needs.

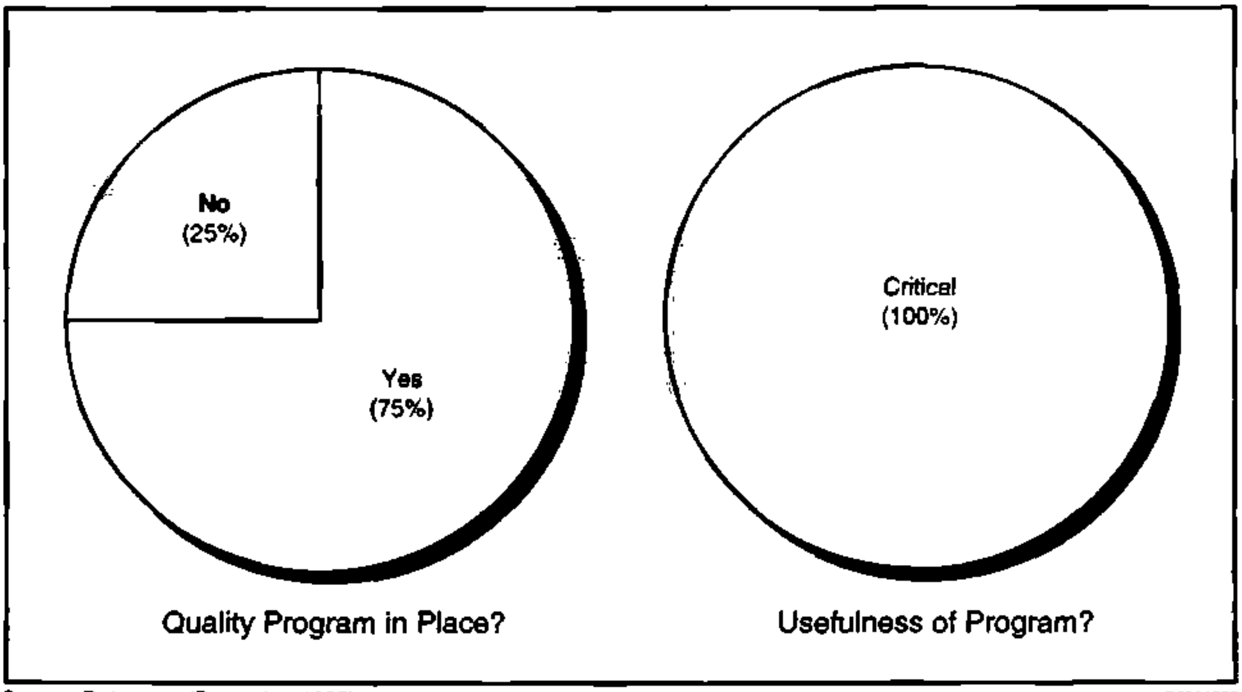
Figure 4-53
Other Communications Industry Strategic Supplier Status



Source: Dataquest (December 1992) G2001357

- *Despite their small size, many companies in this industry have strategic supplier programs in place.*
- *For those that do have them, all see the relationships as critical to business success.*

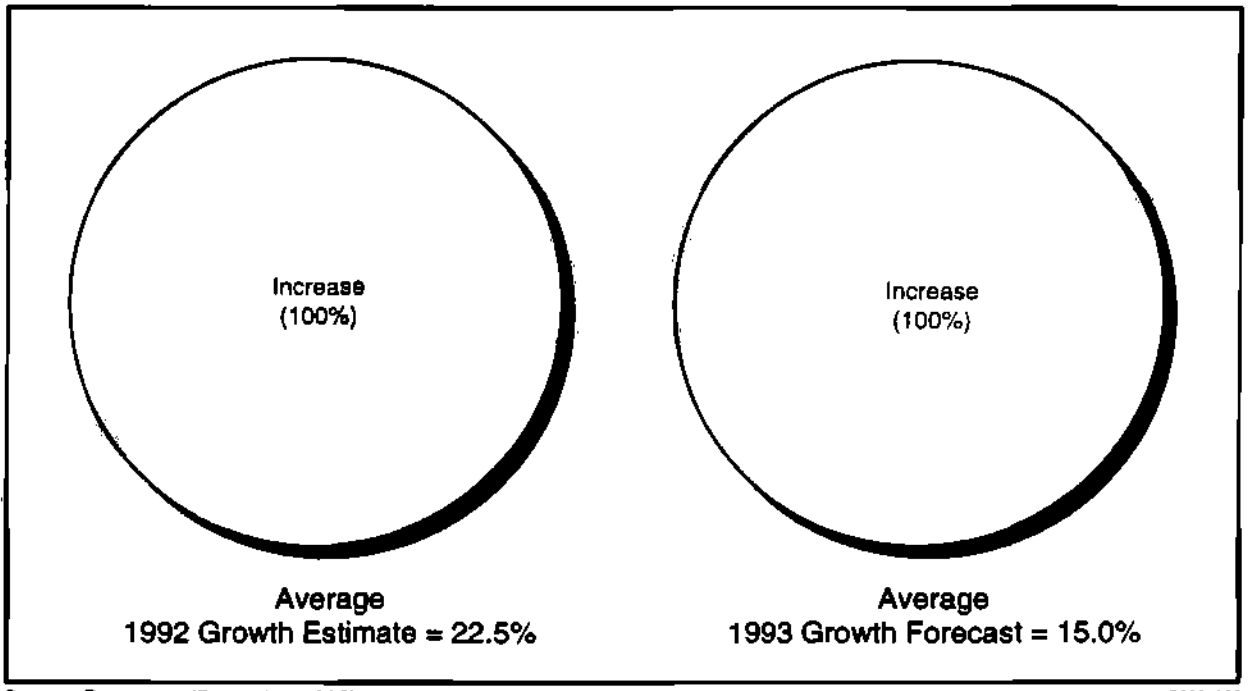
Figure 4-54
Other Communications Industry Quality Improvement Program Status



Source: Dataquest (December 1992) G2001358

- *Although three-fourths of the sample did not have a strategic supplier program, a like 75 percent have a formal quality improvement program running.*
- *Of those in quality improvement programs, all deemed them critical.*

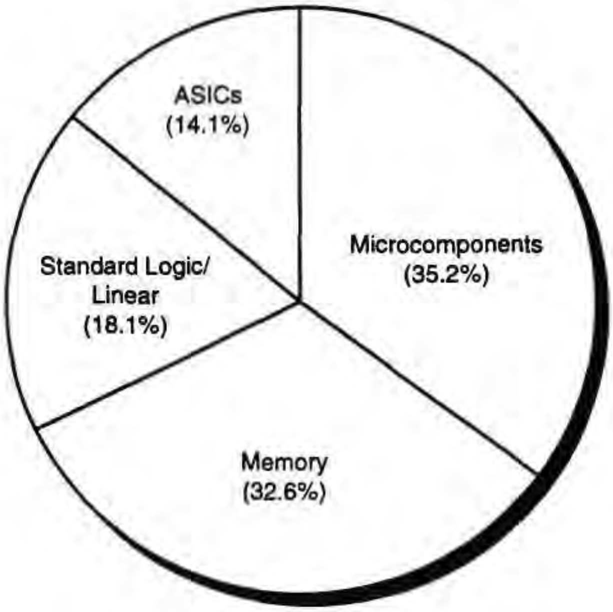
Figure 4-55
Other Communications Industry Surveyed Growth Outlook



Source: Dataquest (December 1992)
G2001359

For both years 1992 and 1993, it was unanimous that the industry would grow: an aggressive 22.5 percent in 1992 and an optimistic 15.0 percent in 1993.

Figure 4-56
Instrumentation Industry Survey IC Purchases

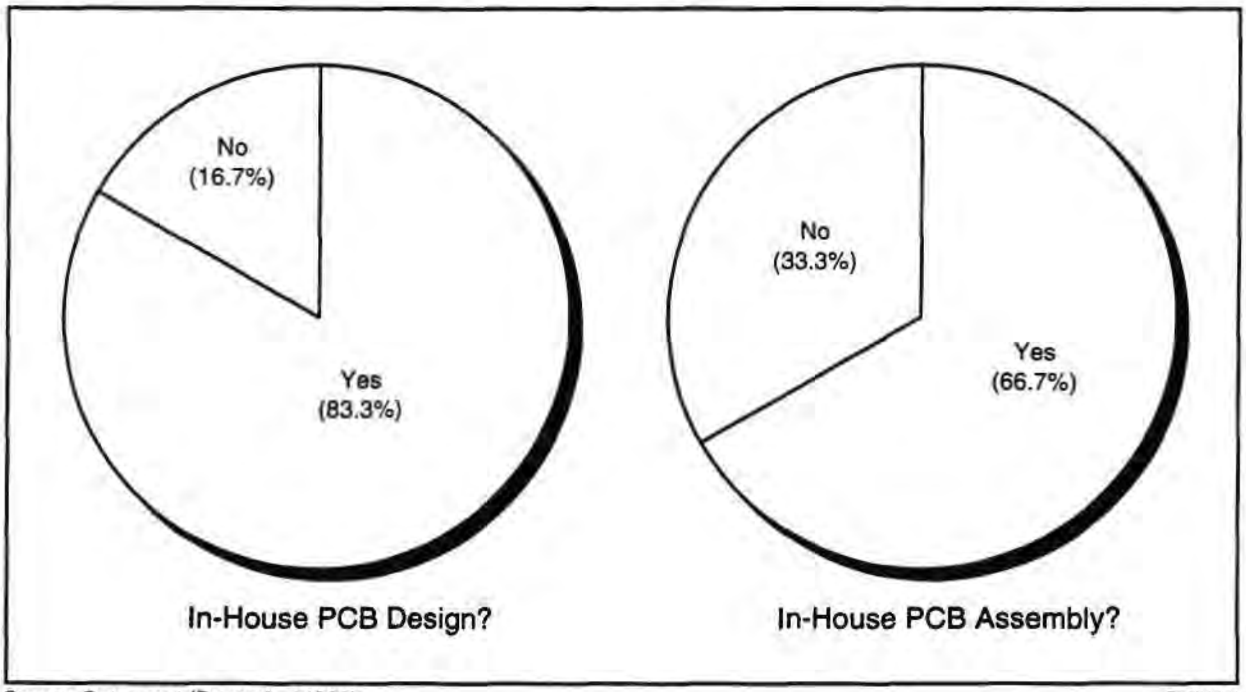


Source: Dataquest (December 1992)

G2001360

- *More than two-thirds of the semiconductor buy goes to memory and microcomponents, with an emphasis on embedded control ASSPs.*
- *Standard logic and linear still outweigh the ASIC solution because space is often not a critical issue with instruments.*

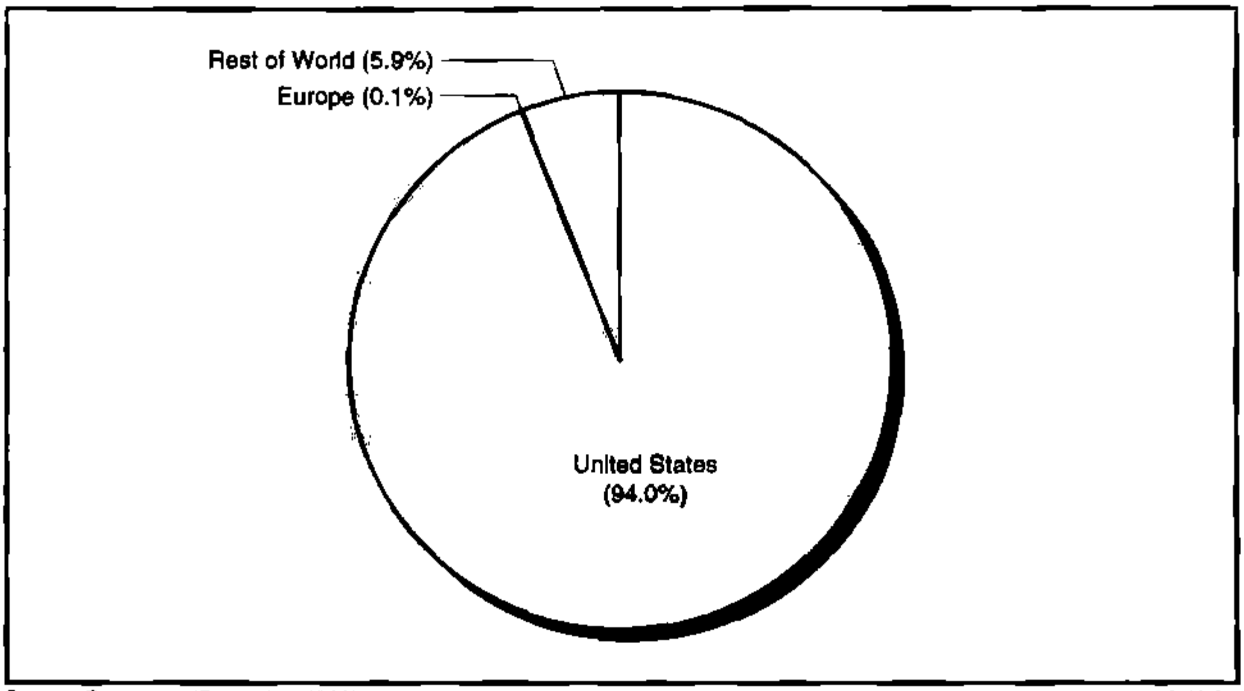
Figure 4-57
Instrumentation Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992) G2001361

A strong 83.3 percent of circuit boards are designed by the respondents, and a third are assembled by contract manufacturers.

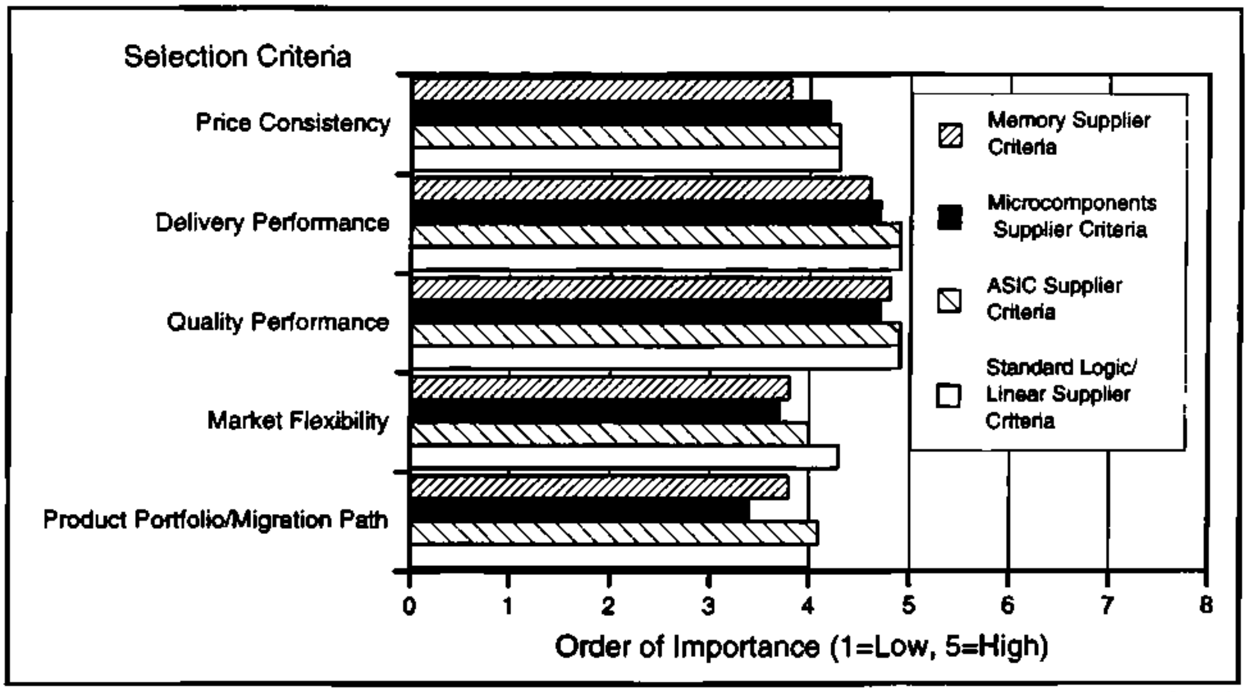
Figure 4-58
Instrumentation Industry Physical Circuit Board Assembly Region



Source: Dataquest (December 1992)
G2001362

The United States remains the region where most of this segment's physical assembly is performed, followed distantly by the Asia assembly base.

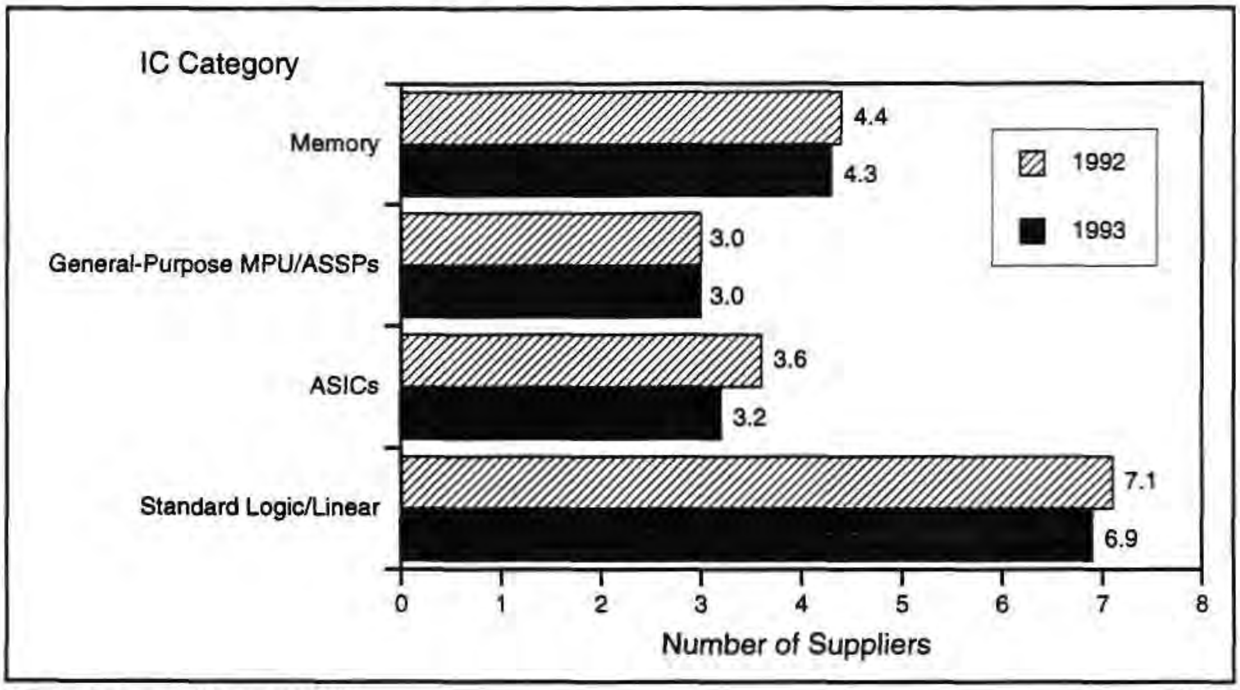
Figure 4-59
Instrumentation Industry Semiconductor Supplier Selection Criteria



Source: Dataquest (December 1992) G2001363

Quality and delivery performance are the key criteria that the instrumentation sample uses in selecting its semiconductor suppliers.

Figure 4-60
Instrumentation Industry Supply Base Trend

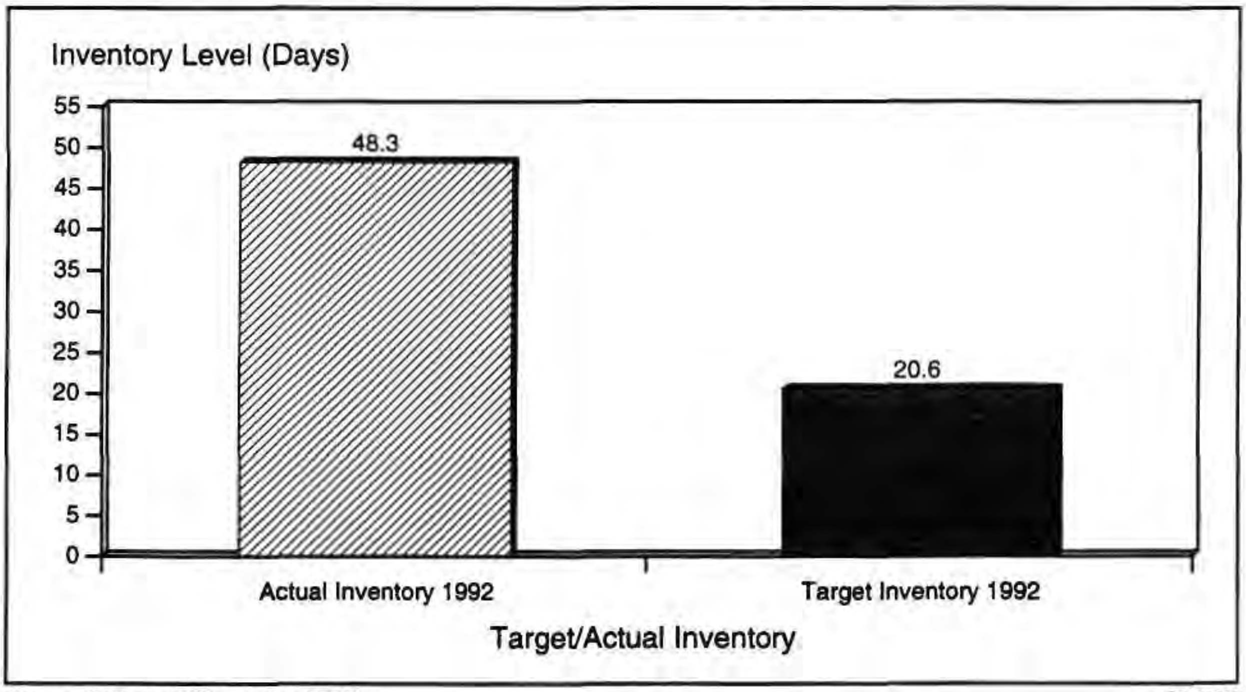


Source: Dataquest (December 1992)

G2001364

For the most part, the supply base for this segment is static, with a few minor changes expected to be made as users balance their new requirements with their existing suppliers.

Figure 4-61
Instrumentation Industry Semiconductor Inventory Status

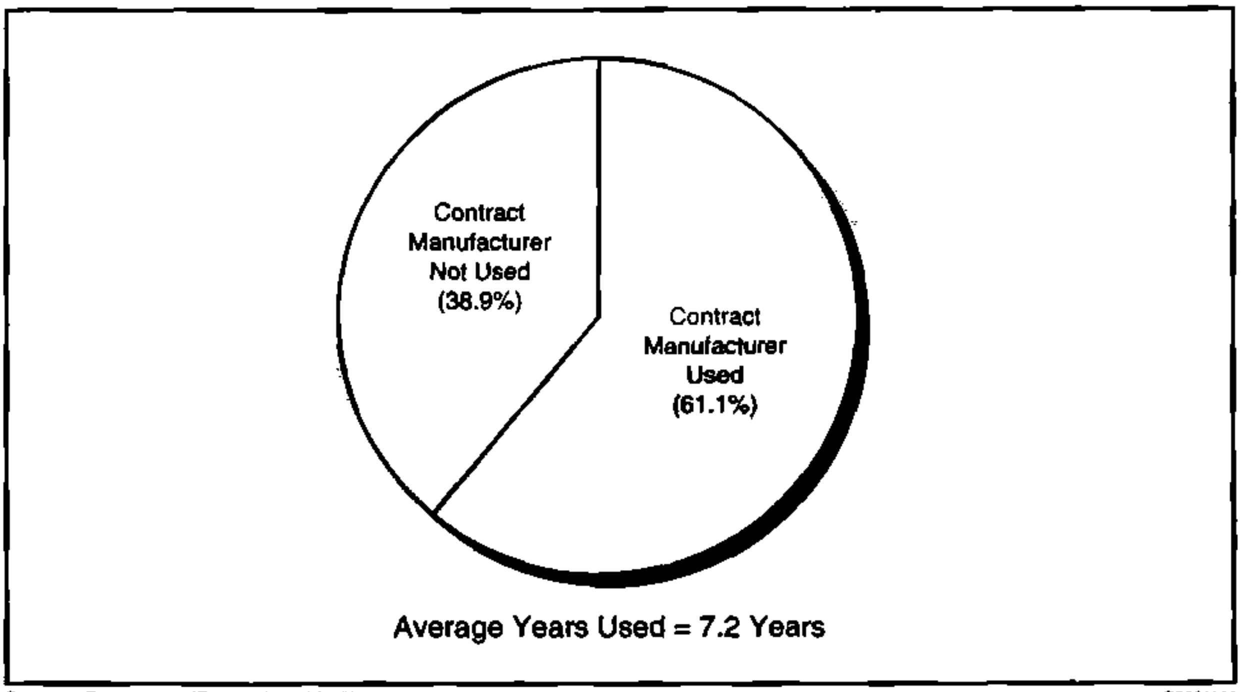


Source: Dataquest (December 1992)

G2001365

The respondents in this segment have an excess semiconductor inventory situation that needs addressing. There is opportunity for suppliers to work more closely with this market segment in order to lower the user costs and increase business levels.

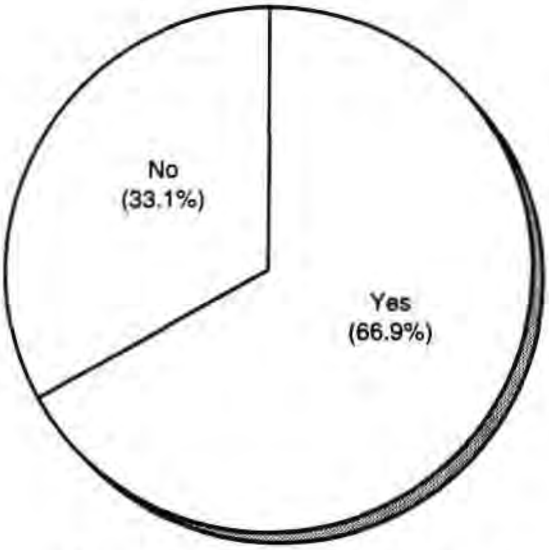
Figure 4-62
Instrumentation Industry Contract Manufacturer Use



Source: Dataquest (December 1992) G2001366

Contract manufacturing is being used by more than 60 percent of the sample and for an average of 7.2 years.

Figure 4-63
Instrumentation Industry Semiconductor Distributor Use

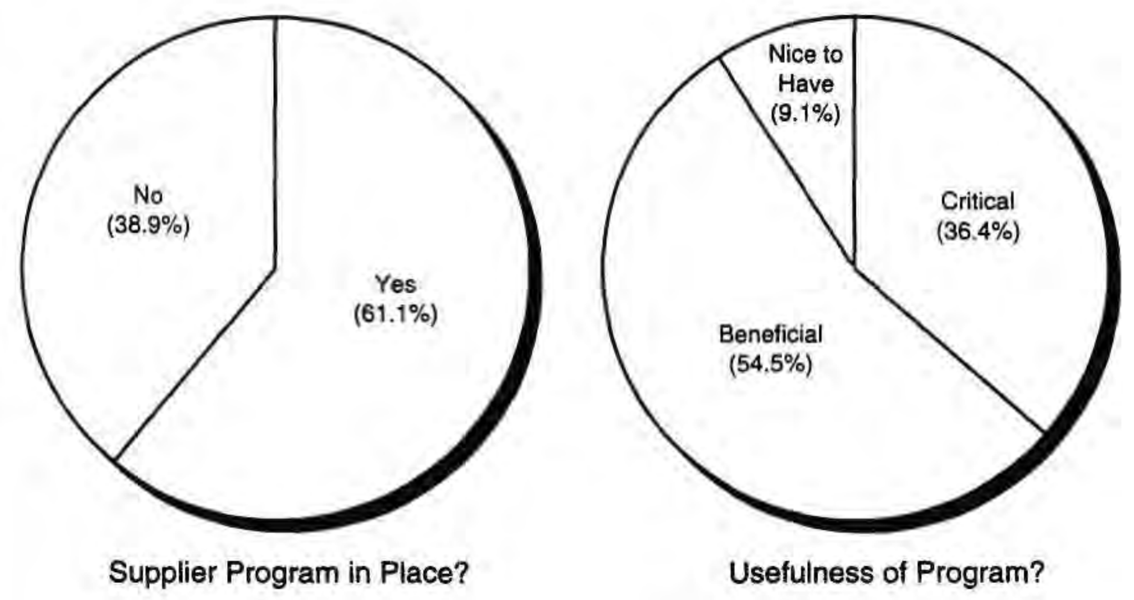


Source: Dataquest (December 1992)

G2001367

Two-thirds of the respondents use distribution because of the relative low volumes and specific needs of this market.

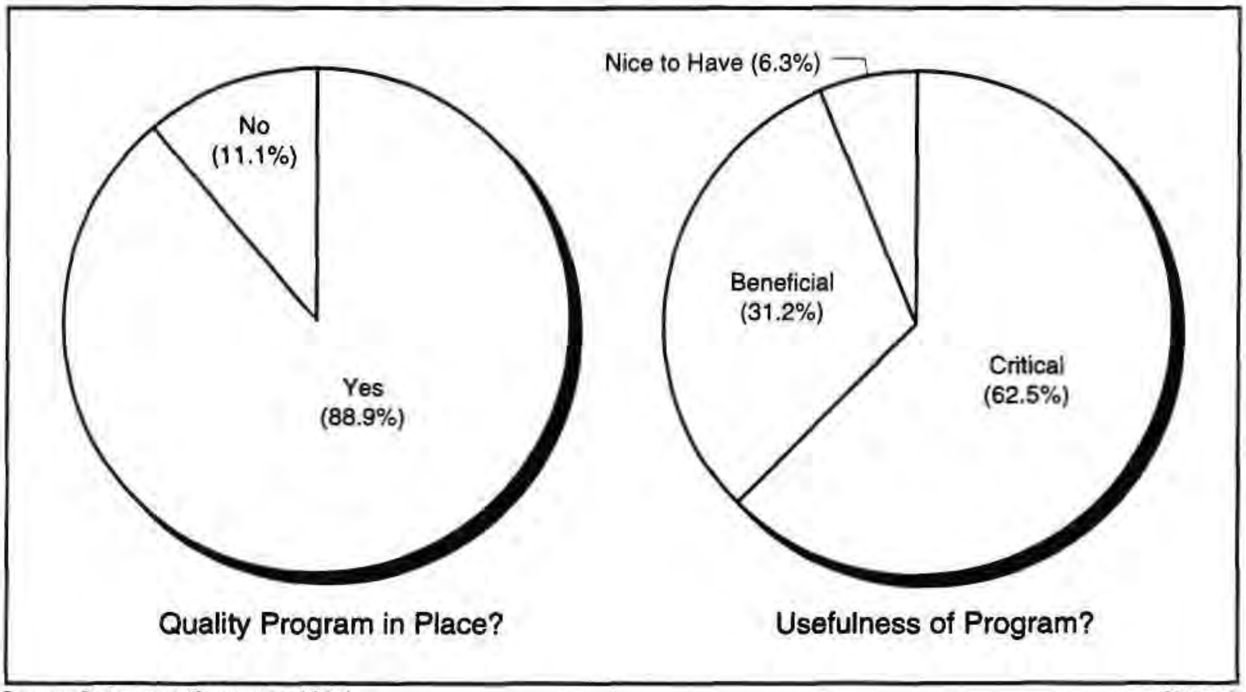
Figure 4-64
Instrumentation Industry Strategic Supplier Status



Source: Dataquest (December 1992)
G2001368

Although 61.1 percent of the respondents have a strategic supplier program in place, more than 90 percent of those in the program find it beneficial or critical to business operation.

Figure 4-65
Instrumentation Industry Quality Improvement Program Status

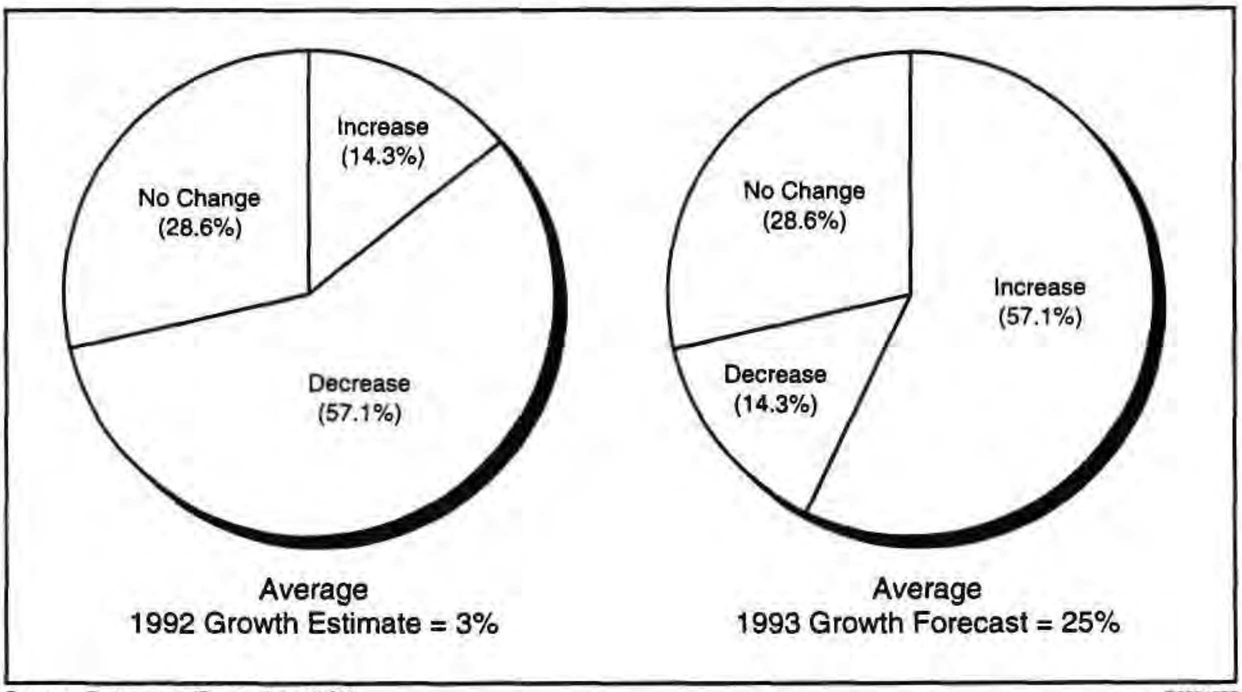


Source: Dataquest (December 1992)

G2001369

A strong 89 percent of the sample uses a quality improvement program and more than 62 percent find the program critical to operation.

Figure 4-66
Instrumentation Industry Surveyed Growth Outlook

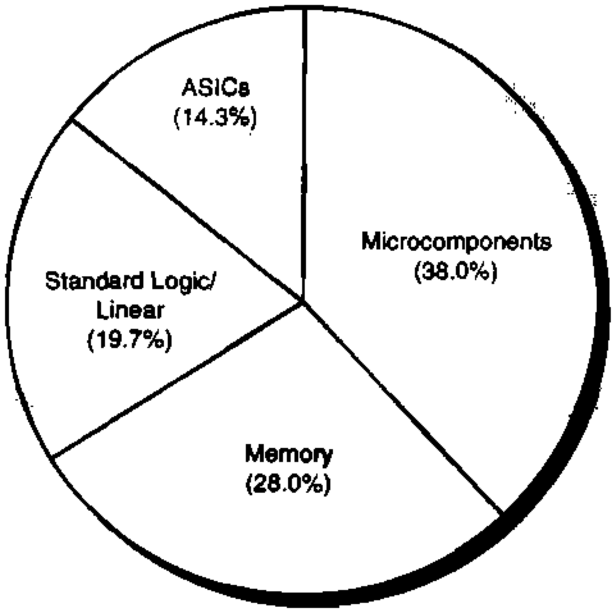


Source: Dataquest (December 1992)

G2001370

Although a majority see this segment declining in growth in 1992, a like 57.1 percent see the market turning around in 1993 at an average 25 percent growth.

Figure 4-67
Other Industrial Survey IC Purchases

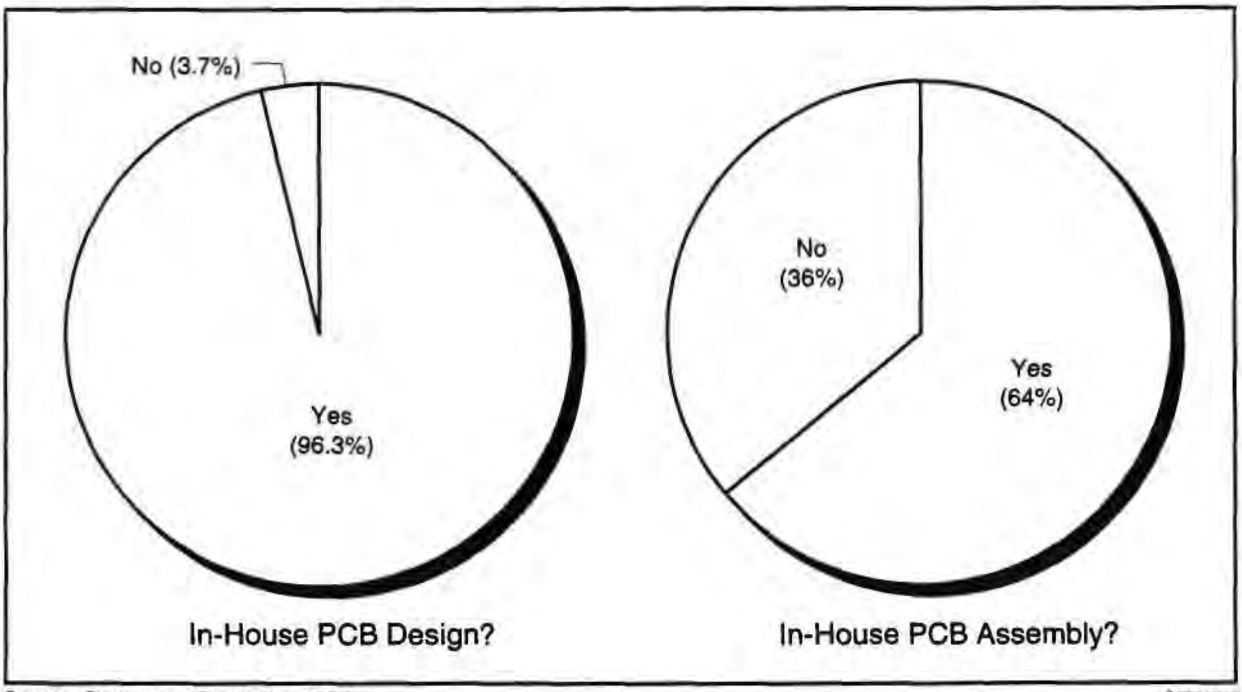


Source: Dataquest (December 1992)

G2001371

- *Two-thirds of the semiconductor purchase again goes to memory and microcomponent services.*
- *Much of the 38 percent of microcomponent usage goes to embedded control microcontrollers and ASSP devices.*

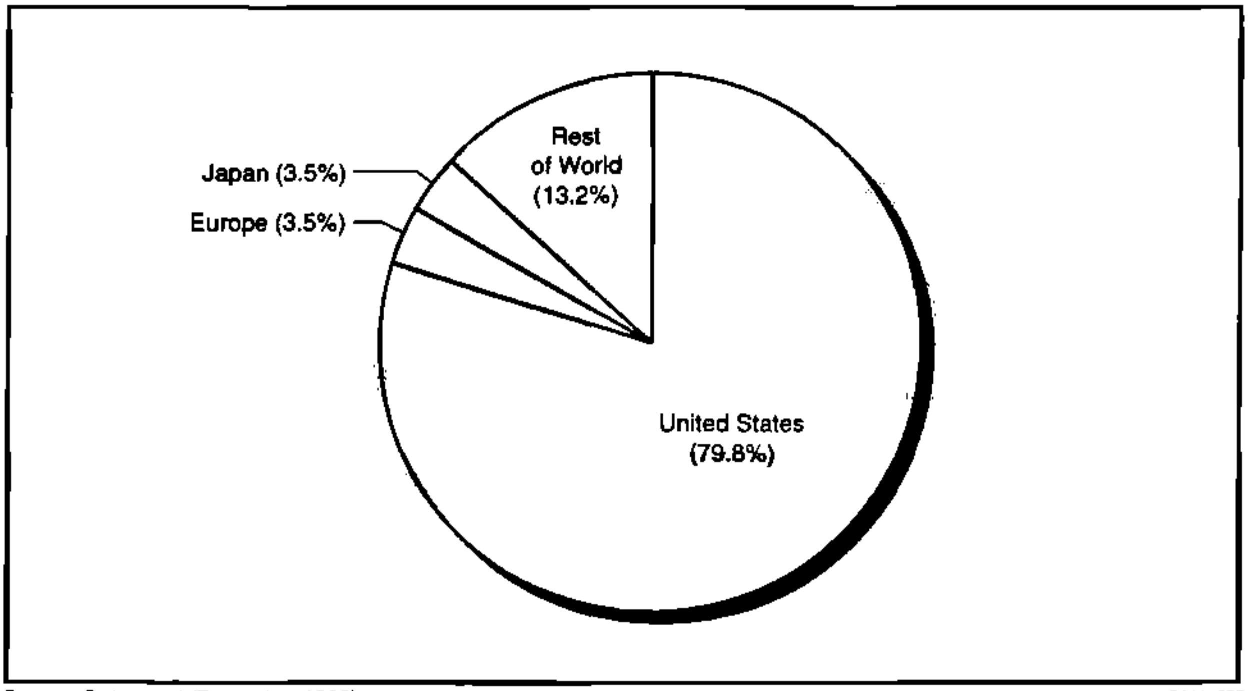
Figure 4-68
Other Industrial Circuit Board Design and Assembly



Source: Dataquest (December 1992) G2001372

A large majority (96.3 percent) of respondents design their own circuit boards, while 36 percent utilize contract manufacturers to assemble them.

Figure 4-69
Other Industrial Physical Circuit Board Assembly Region

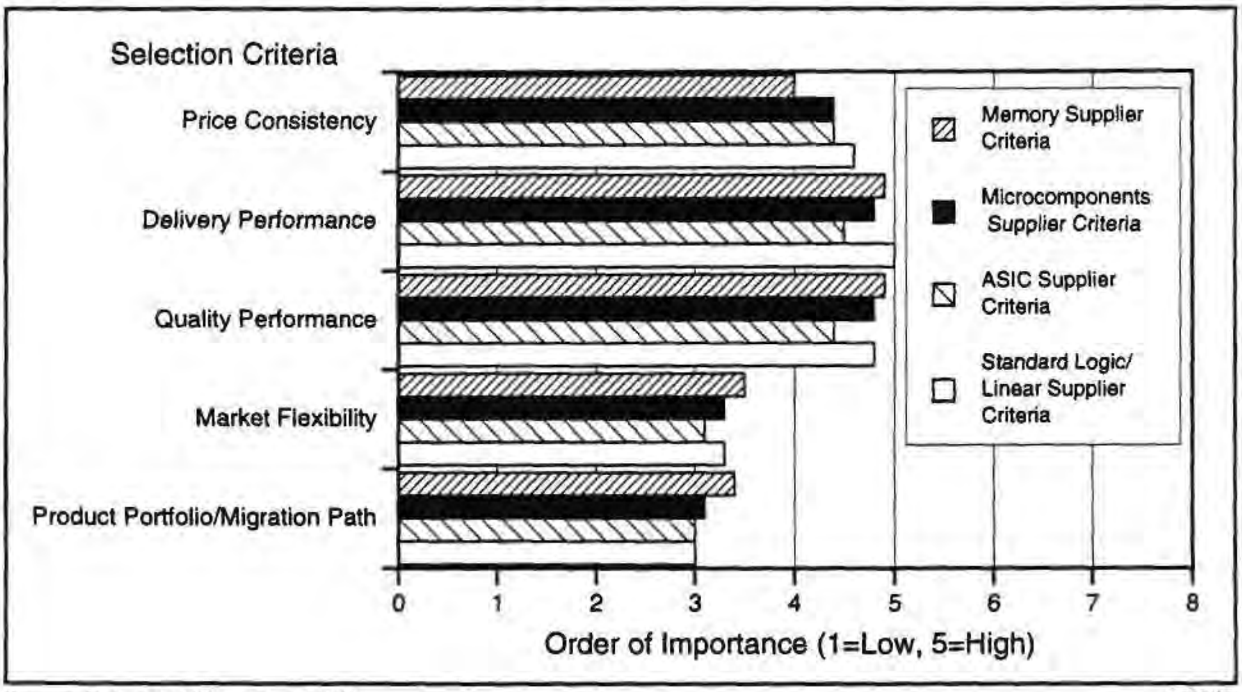


Source: Dataquest (December 1992)

G2001373

Although nearly 80 percent of this segment's circuit boards are assembled in the United States, 13.2 percent are assembled in Asia outside of Japan.

Figure 4-70
Other Industrial Semiconductor Supplier Selection Criteria

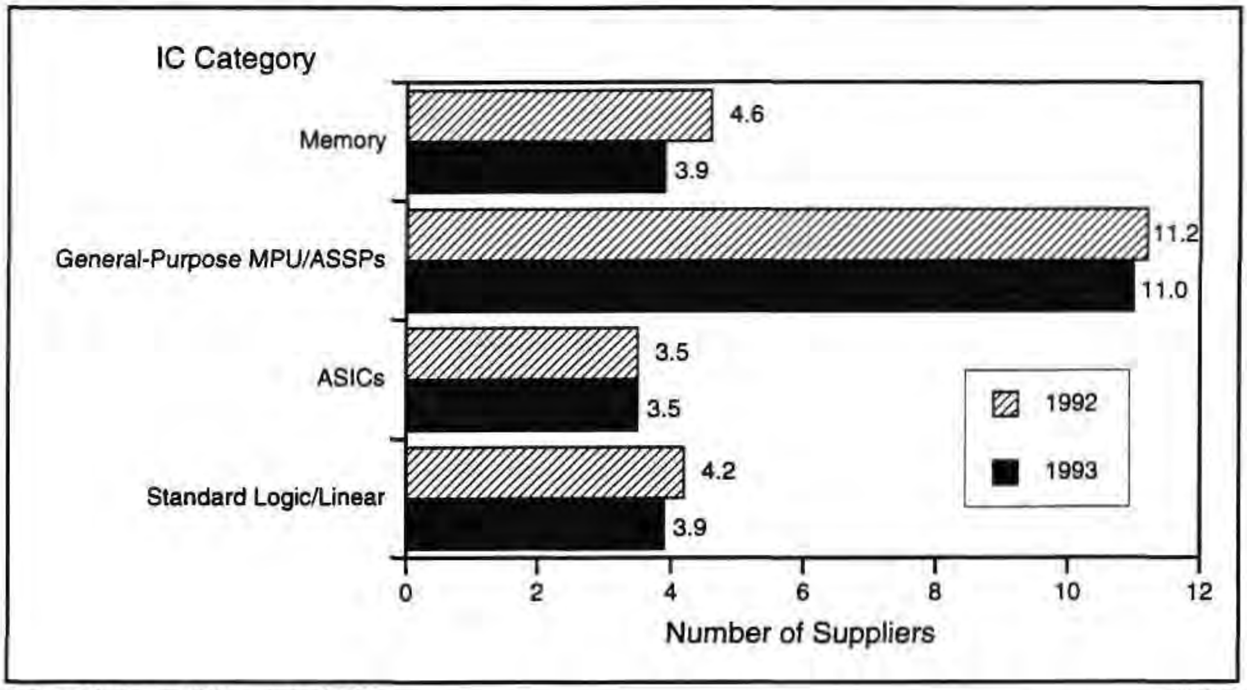


Source: Dataquest (December 1992)

G2001374

Because of the relatively higher usage of memory and microcomponents, these two supplier groupings have generally higher selection criteria than the rest of the industry.

Figure 4-71
Other Industrial Supply Base Trend

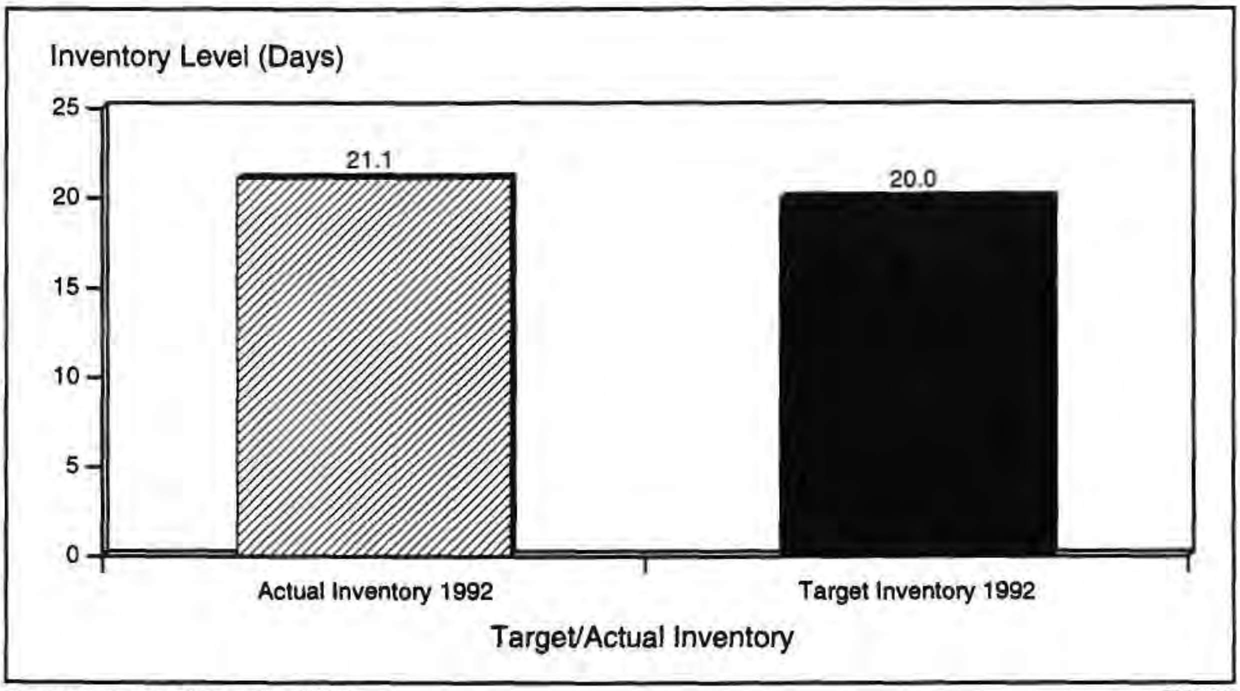


Source: Dataquest (December 1992)

G2001375

For the most part, the supply base for this segment is slowly declining, yet the high level of MPU/ASSP suppliers may have room for further reduction.

Figure 4-72
Other Industrial Semiconductor Inventory Status

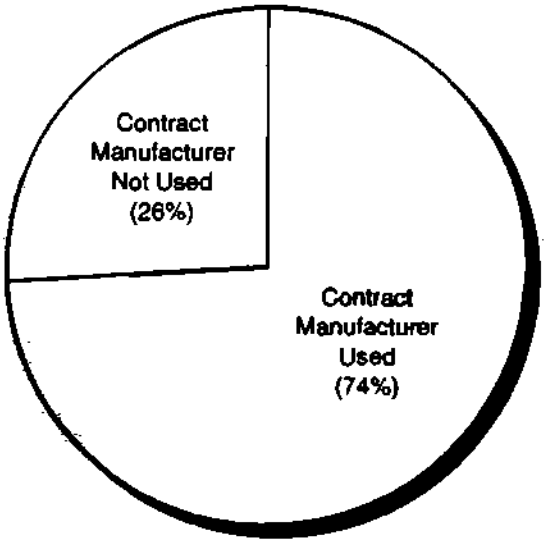


Source: Dataquest (December 1992)

G2001376

The target/actual inventory levels for this grouping are very much under control, reflecting good use of contract manufacturing.

Figure 4-73
Other Industrial Average Contract Manufacturer Usage

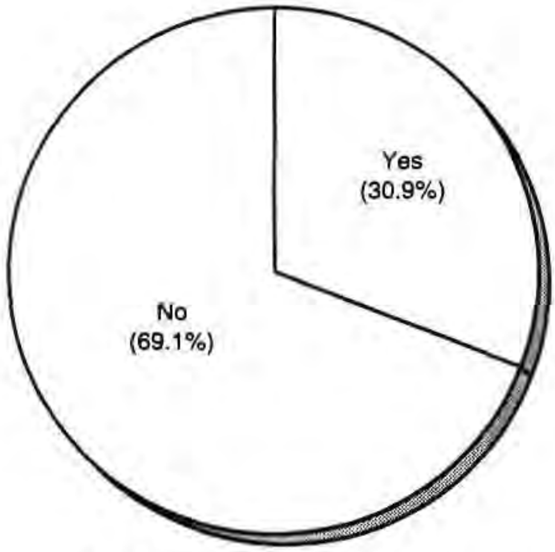


Source: Dataquest (December 1992)

G2001377

This segment of our survey was the largest user of contract manufacturing and on average has used this option for nearly 10 years.

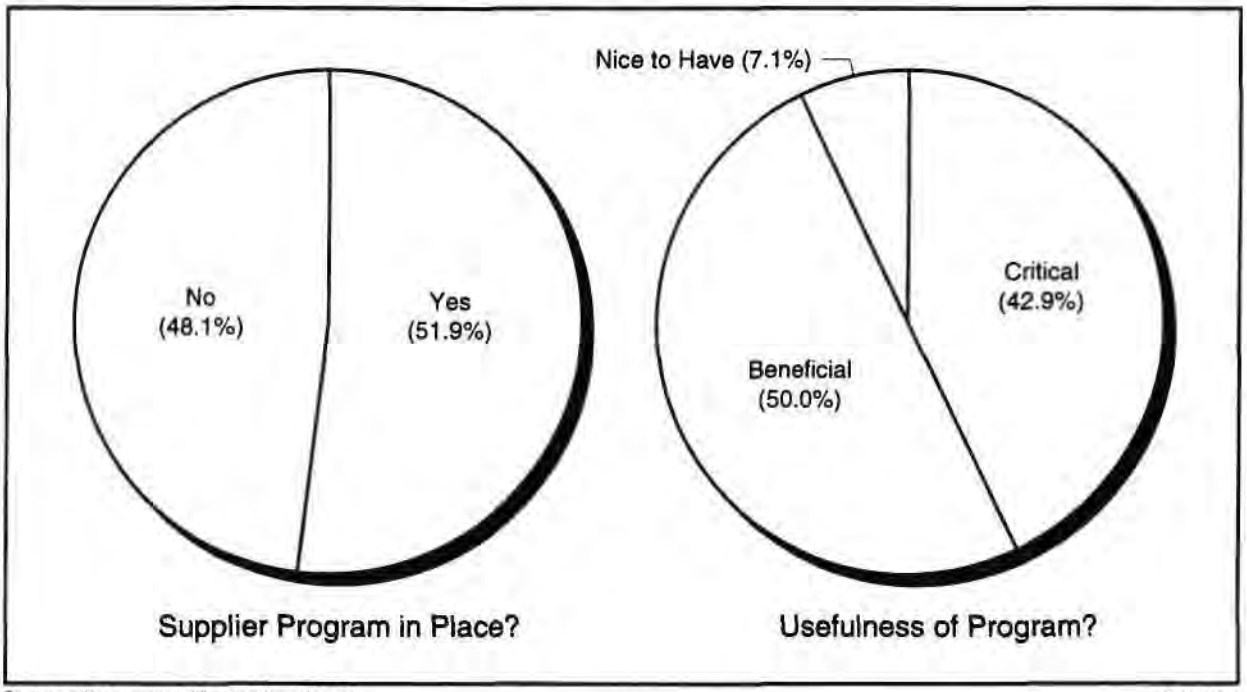
Figure 4-74
Other Industrial Semiconductor Distributor Use



Source: Dataquest (December 1992) G2001378

Although this sample is a large user of contract manufacturing, only 31 percent claim to use distribution. It is possible that much of the contract manufacturing is turnkey business.

Figure 4-75
Other Industrial Strategic Supplier Status

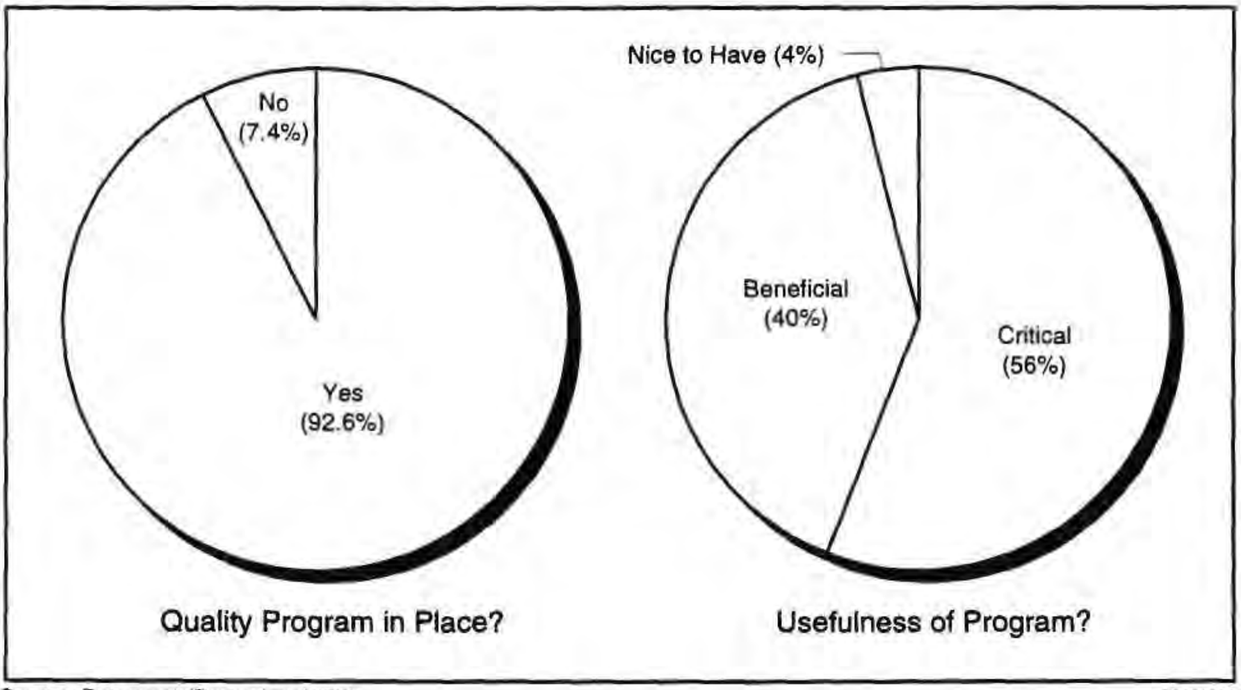


Source: Dataquest (December 1992)

G2001379

- *A bare majority (51.9 percent) of this sample utilize a strategic supplier program.*
- *For those with plans in place, 93 percent find the exercise either beneficial or critical to operations.*

Figure 4-76
Other Industrial Quality Improvement Program Status

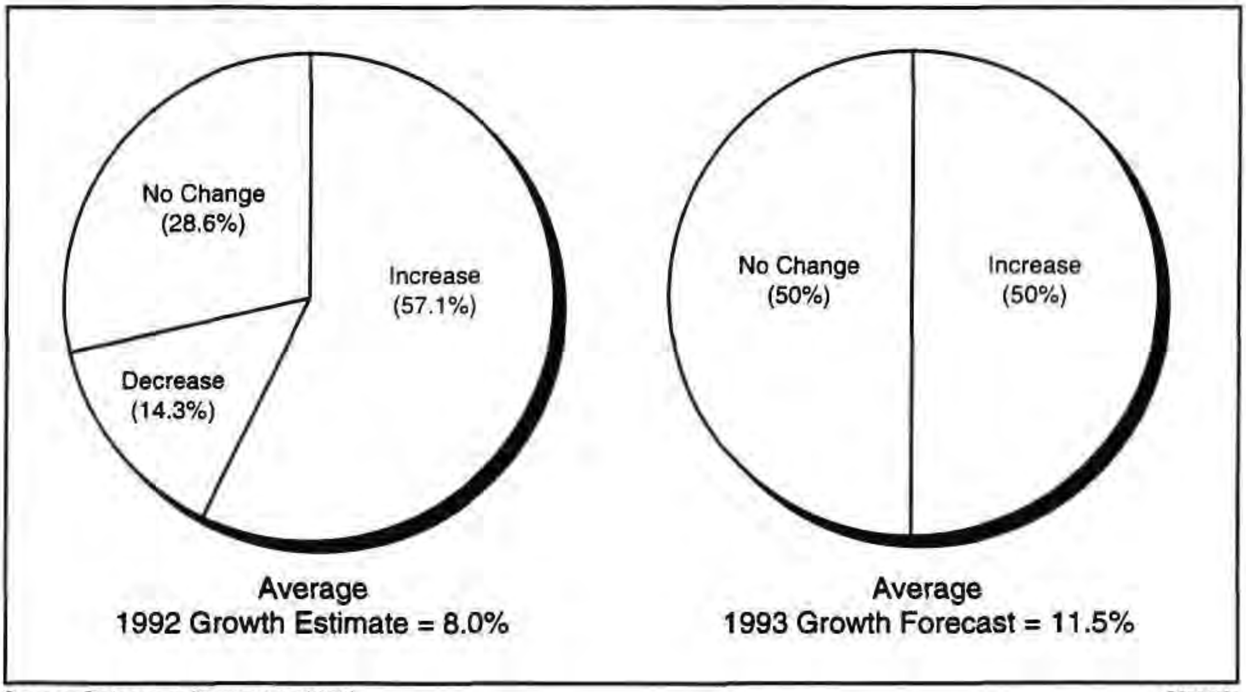


Source: Dataquest (December 1992)

G2001380

- *Another strong 93 percent of the respondents have a formal quality program in place.*
- *Fifty-six percent of the quality program participants found the exercise critical for business success.*

Figure 4-77
Other Industrial Surveyed Growth Outlook

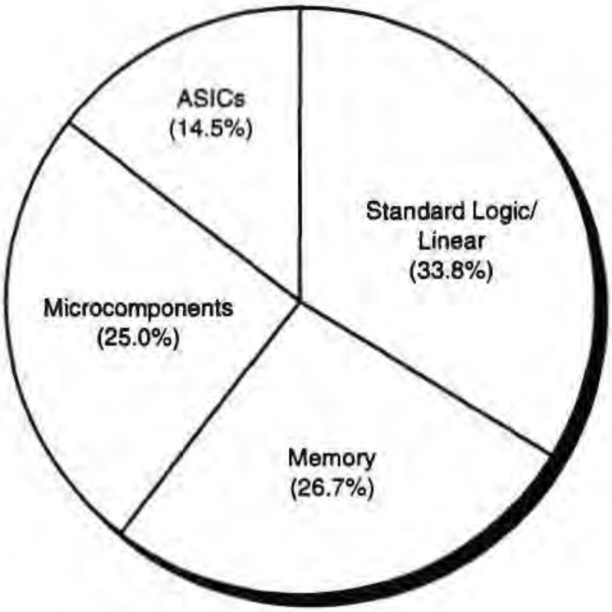


Source: Dataquest (December 1992)

G2001381

- *Although nearly 60 percent of the sample expects 1992 business to grow an average 8.0 percent, 14.3 percent believe that business will decline.*
- *The group expecting declines in 1992 either has raised its outlook for 1993 to no change or to an average business improvement of 11.5 percent.*

Figure 4-78
Consumer/Automotive Industry Survey IC Purchases

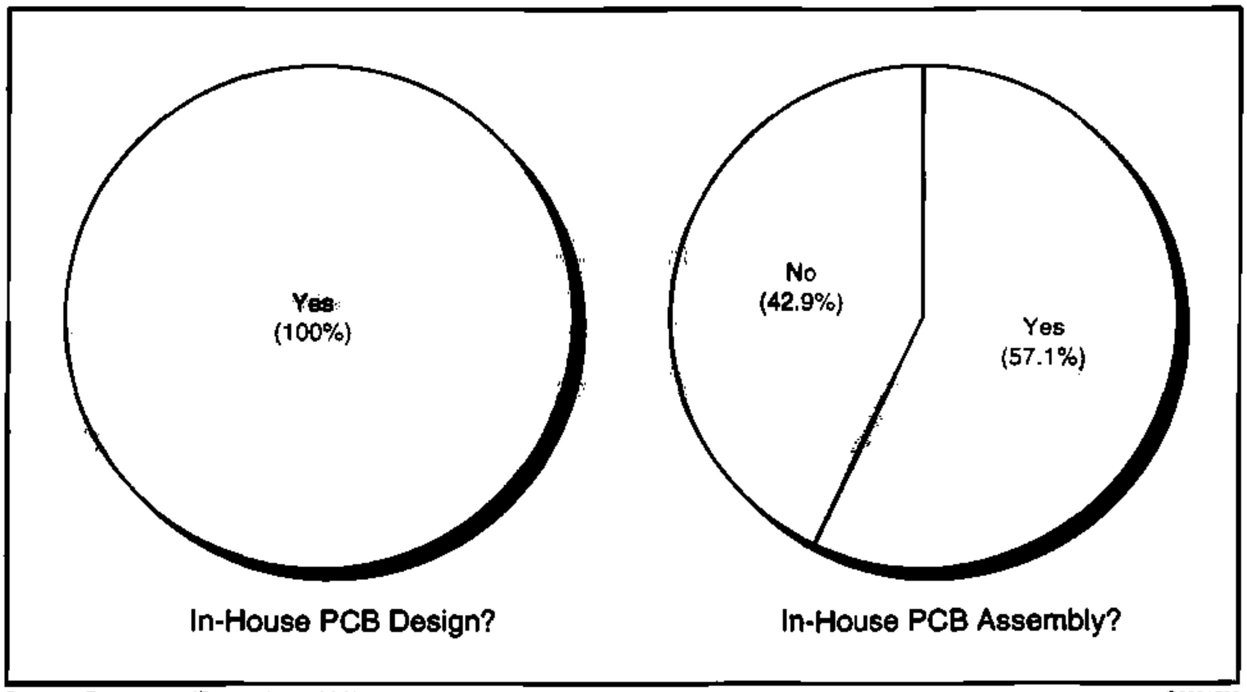


Source: Dataquest (December 1992)

G2001382

More than one-third (33.8 percent) of this segment's respondents' semiconductor procurement dollar goes to standard logic/linear services because of the high level of linear/analog devices used in both these industries.

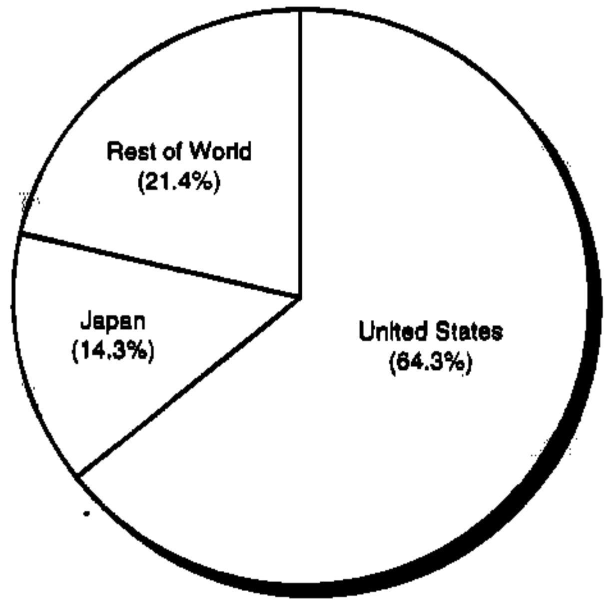
Figure 4-79
Consumer/Automotive Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992) G2001383

Although all respondents in the sample design their own circuit boards, 43 percent utilize outsourced assembly, most likely in the consumer market.

Figure 4-80
Consumer/Automotive Industry Physical Circuit Board Assembly Region

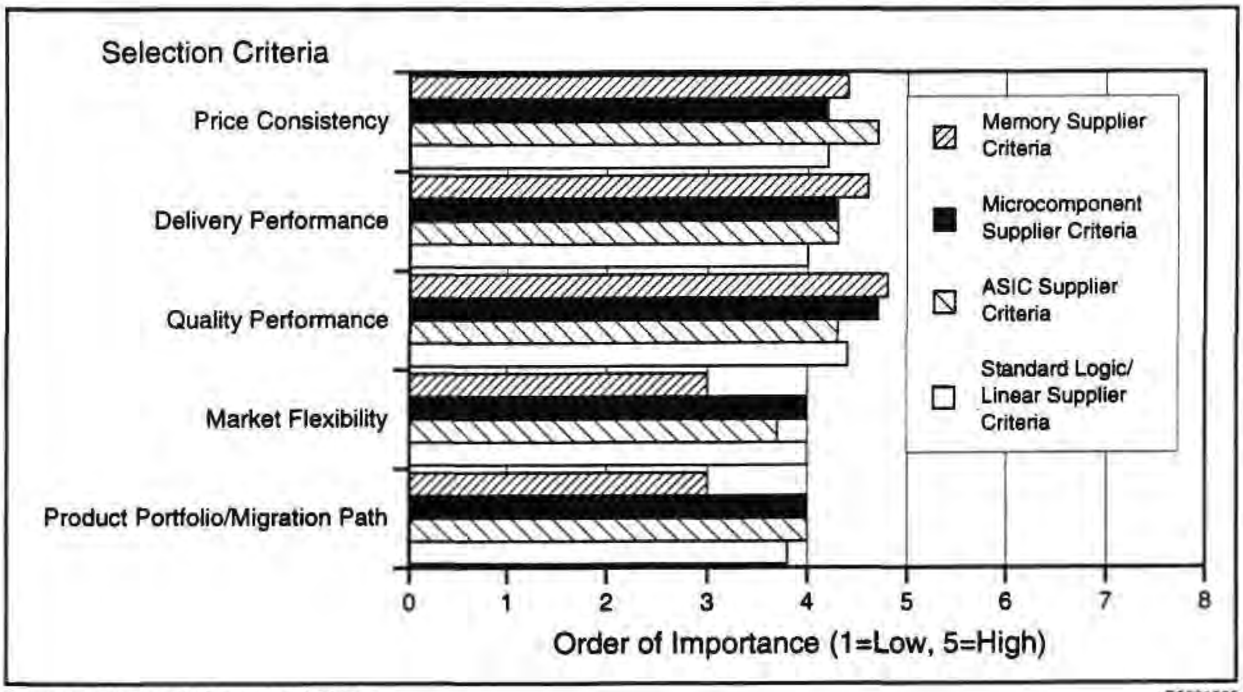


Source: Dataquest (December 1992)

G2001384

Nearly two-thirds (64.3 percent) of this segment assembles its circuit boards in the United States, followed by the Rest of World region with 21.4 percent.

Figure 4-81
Consumer/Automotive Industry Semiconductor Supplier Selection Criteria

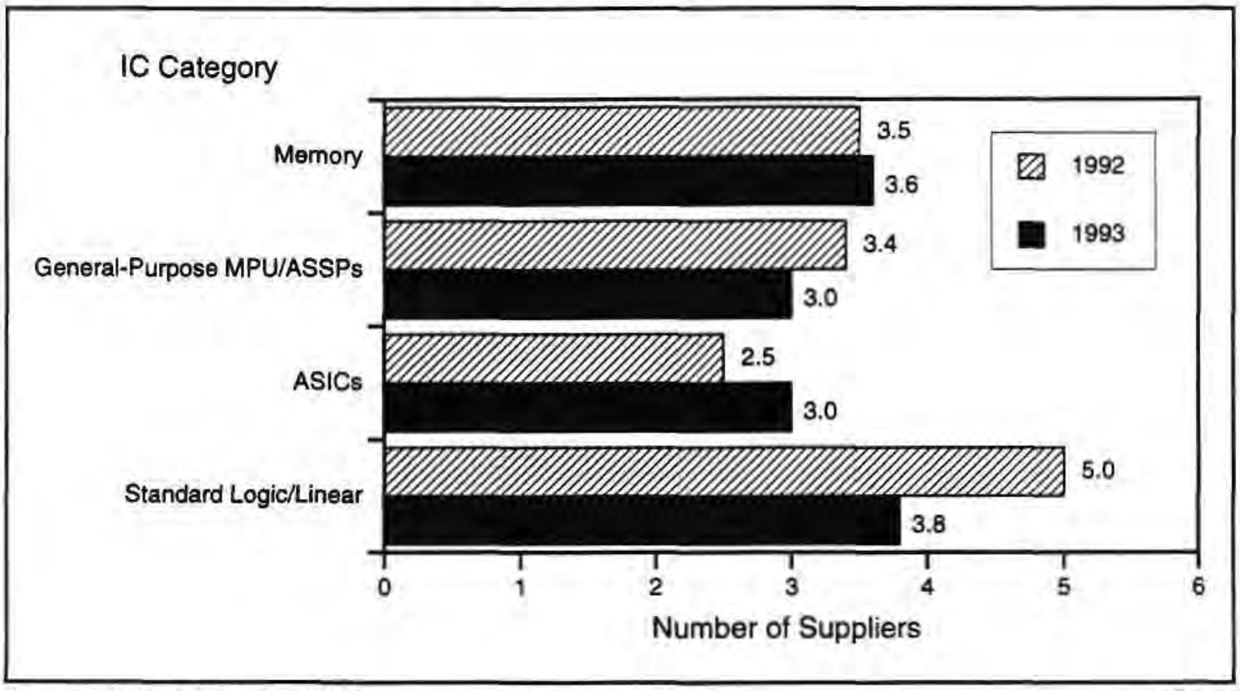


Source: Dataquest (December 1992)

G2001385

Memory and microcomponents are mainly selected based on quality and delivery, while ASIC suppliers are gauged first on price for this consumer/ automotive sample.

Figure 4-82
Consumer/Automotive Industry Supply Base Trend

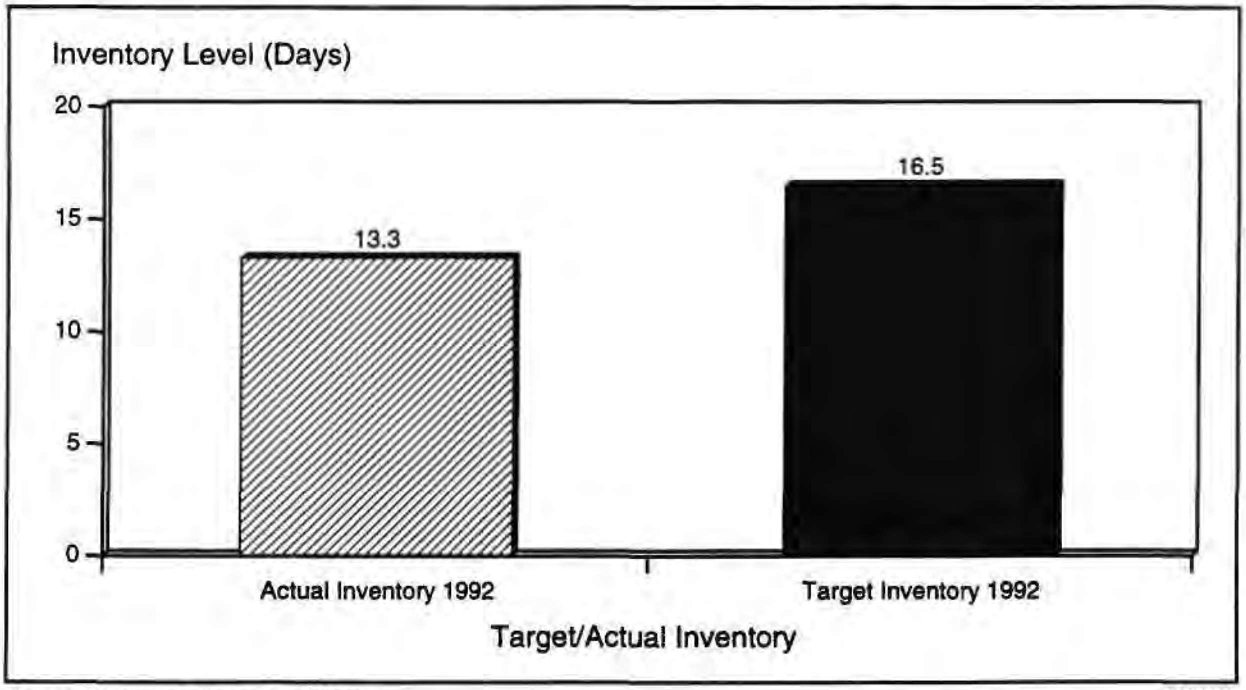


Source: Dataquest (December 1992)

G2001386

- *The supply base of this segment is churning, with planned reduction in supplies of microcomponents and standard/linear, while there are expected increases in the memory and ASIC supply base.*
- *An average supplier level of three apparently is the goal for this segment.*

Figure 4-83
Consumer/Automotive Industry Semiconductor Inventory Status

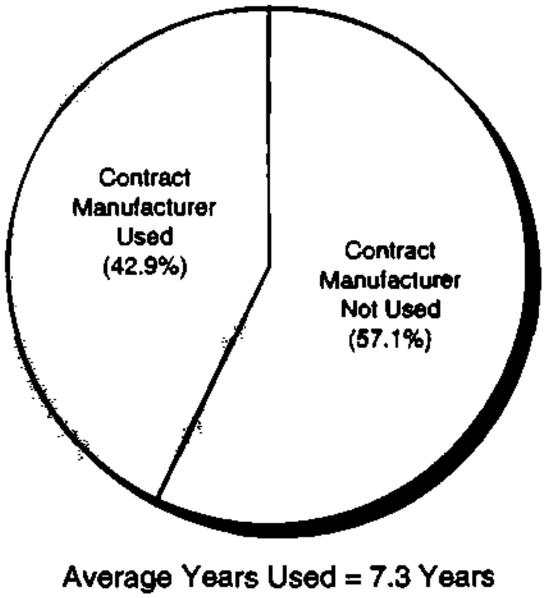


Source: Dataquest (December 1992)

G2001387

- *This is one segment that has actual semiconductor levels below target.*
- *Well under industry averages, this level of inventory control highlights how rapidly changing markets can benefit from good inventory management.*

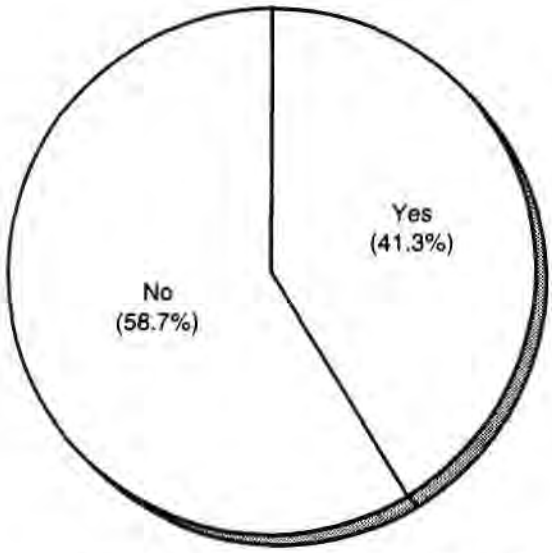
Figure 4-84
Consumer/Automotive Industry Contract Manufacturer Use



Source: Dataquest (December 1992) G2001388

- *This is the only segment that had more than half (57.1 percent) of the sample not using contract manufacturing.*
- *For the balance that did use contractors, the average length of time is 7.3 years.*

Figure 4-85
Consumer/Automotive Industry Semiconductor Distributor Use

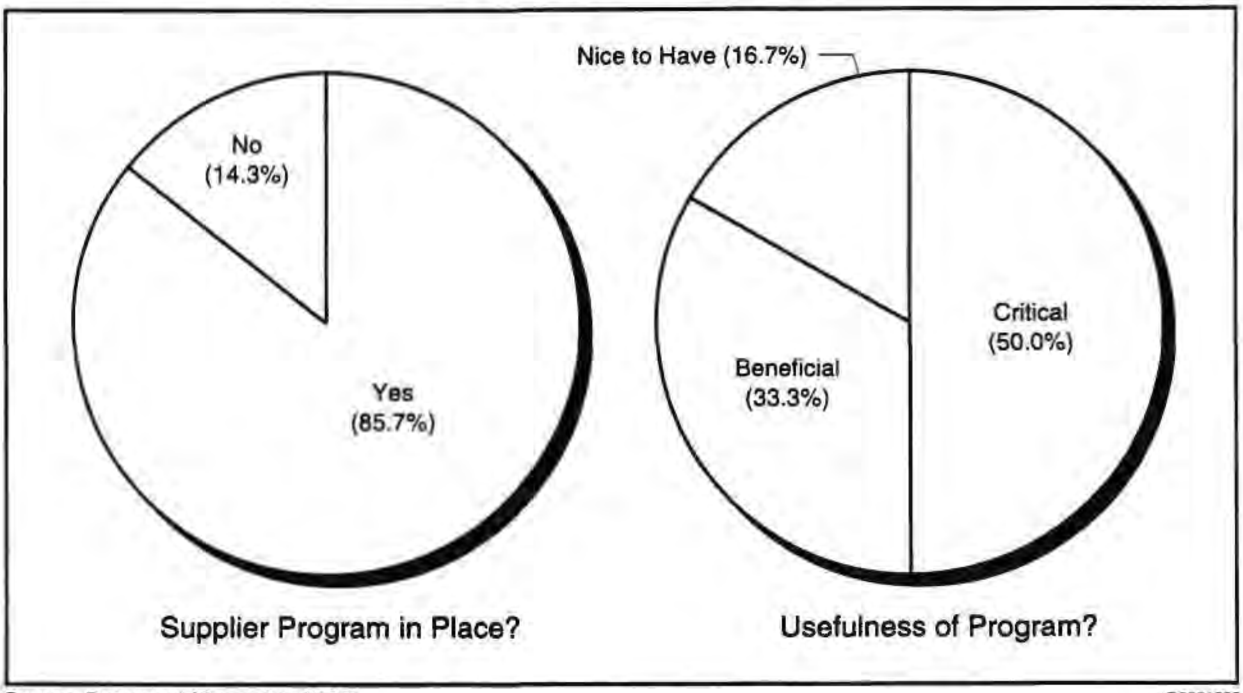


Source: Dataquest (December 1992)

G2001389

A comparable percentage (41.3 percent) of this sample reported using semiconductor distribution.

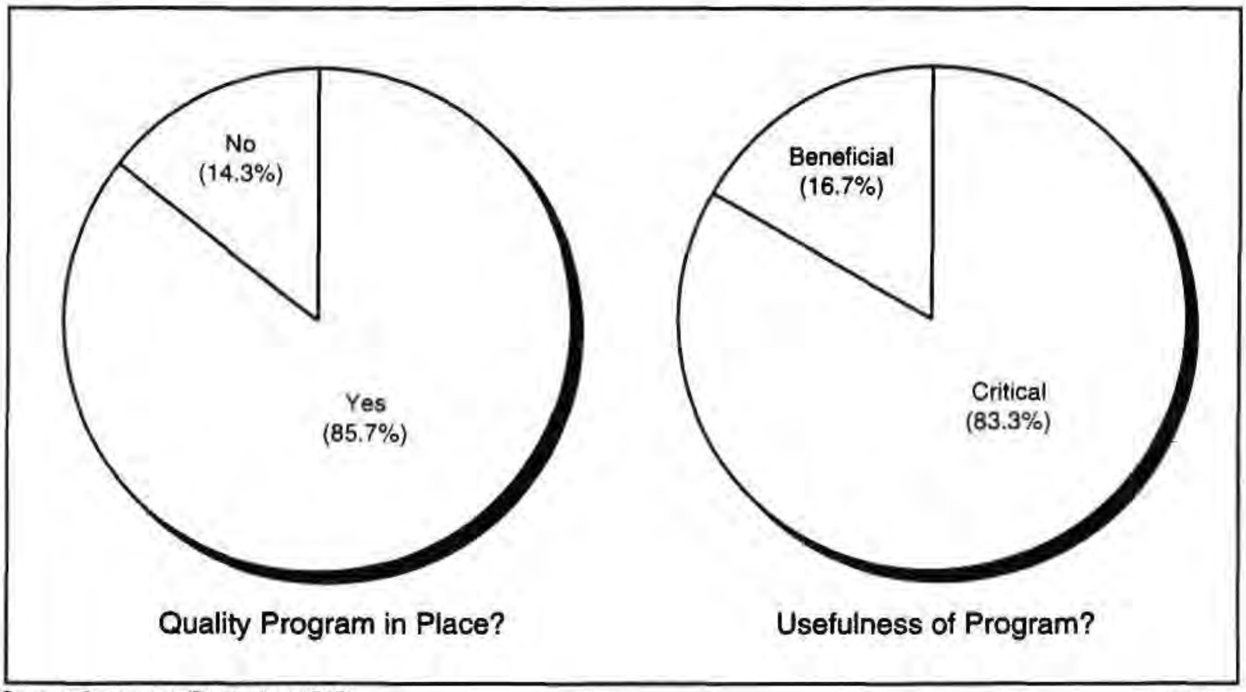
Figure 4-86
Consumer/Automotive Industry Strategic Supplier Status



Source: Dataquest (December 1992) G2001390

A strong 86 percent of the respondents have strategic supplier programs in place and half of those using plans note that they are critical to ongoing operation.

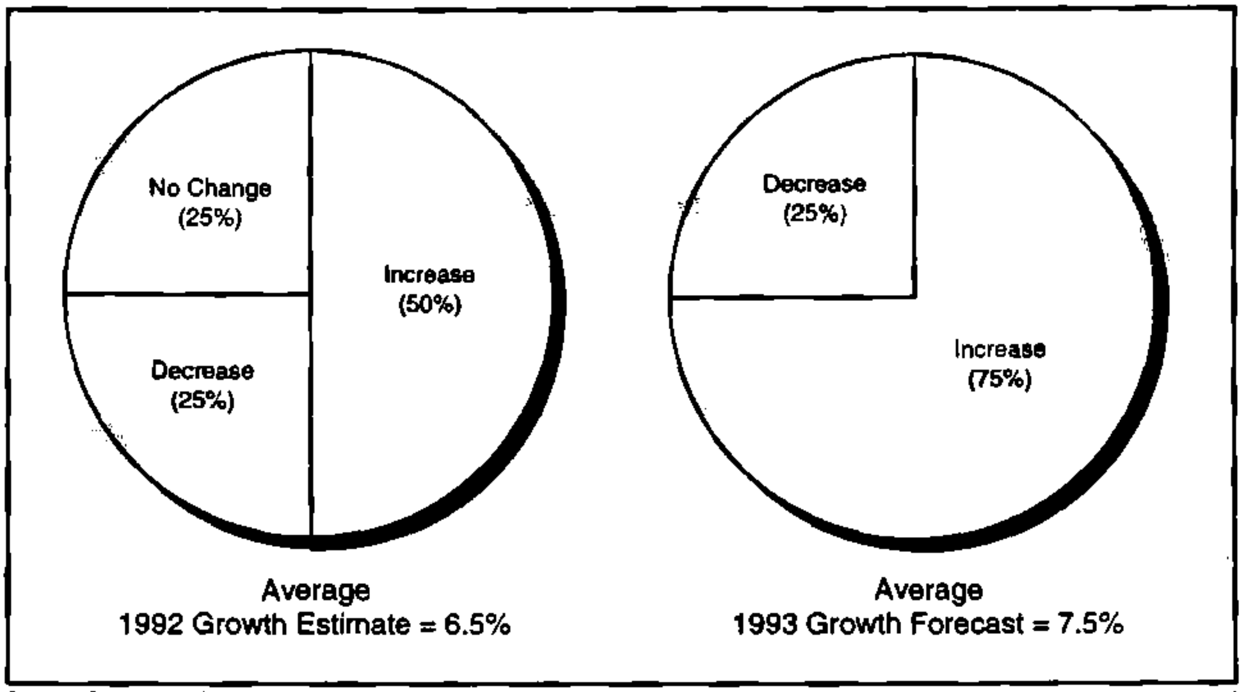
Figure 4-87
Consumer/Automotive Industry Quality Improvement Program Status



Source: Dataquest (December 1992) G2001391

A like 85.7 percent of this segment's respondents have in place formal quality improvement programs, which are critical to the business of 83.3 percent of the participants.

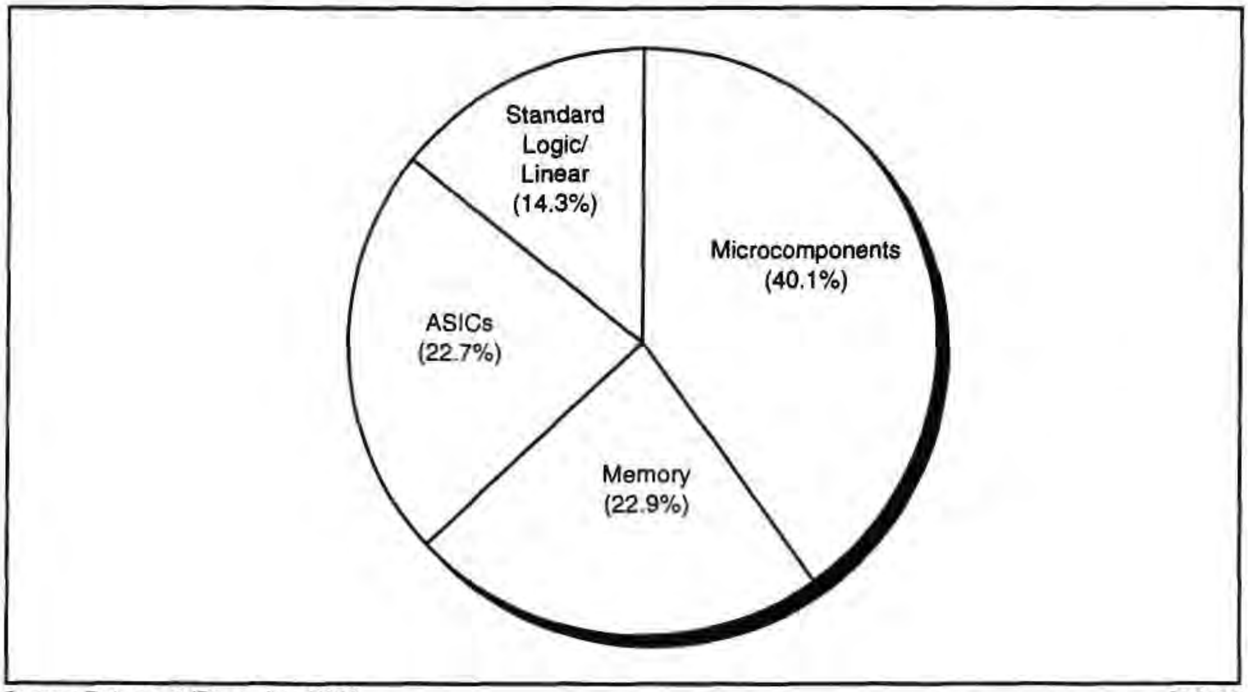
Figure 4-88
Consumer/Automotive Industry Surveyed Growth Outlook



Source: Dataquest (December 1992) G2001392

- *Because of economic uncertainty, 25 percent of the respondents expect business to decline in 1992, while half expect to see a modest uptick of 6.5 percent.*
- *Three-fourths of the respondents expect business to improve an average 7.5 percent in 1993.*

Figure 4-89
Military/Aerospace Industry Survey IC Purchases

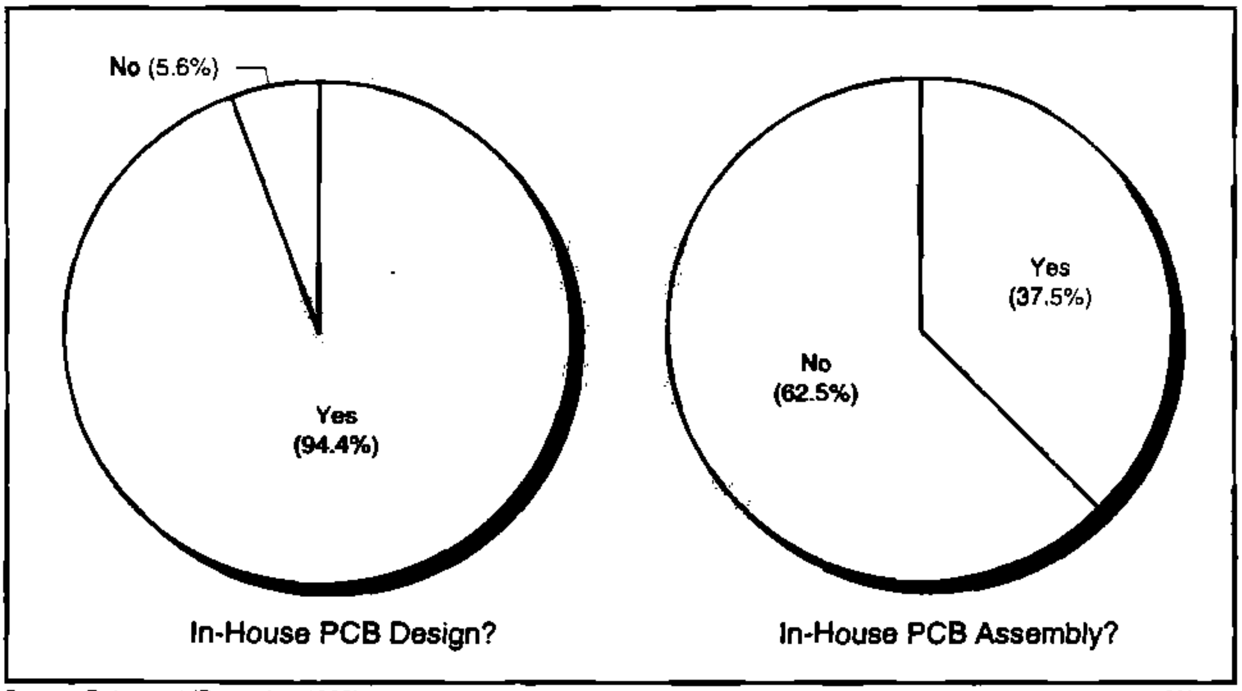


Source: Dataquest (December 1992)

G2001393

The largest portion of this segment's semiconductor buy goes to the microcomponent segment, with more than 40 percent being spent there.

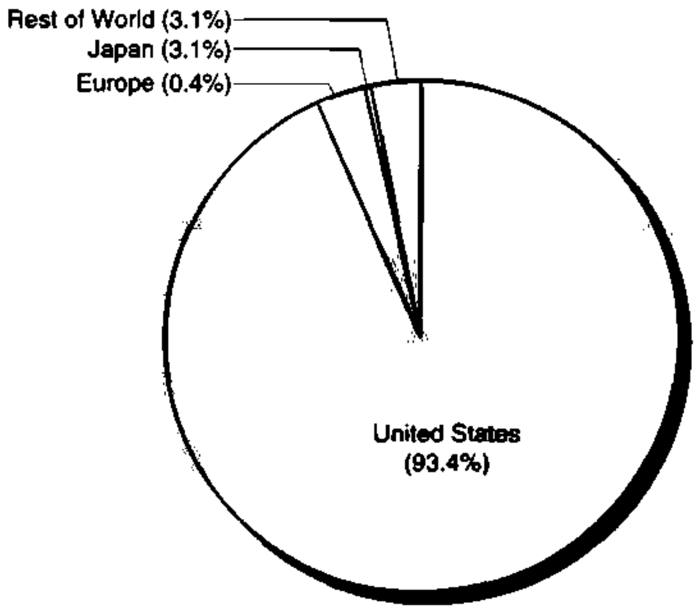
Figure 4-90
Military/Aerospace Industry Circuit Board Design and Assembly



Source: Dataquest (December 1992)
G2001394

Nearly 95 percent of the respondents design their own circuit boards, yet nearly two-thirds subcontract out their assembly because of the high overhead and low volume associated with this market.

Figure 4-91
Military/Aerospace Industry Physical Circuit Board Assembly Region

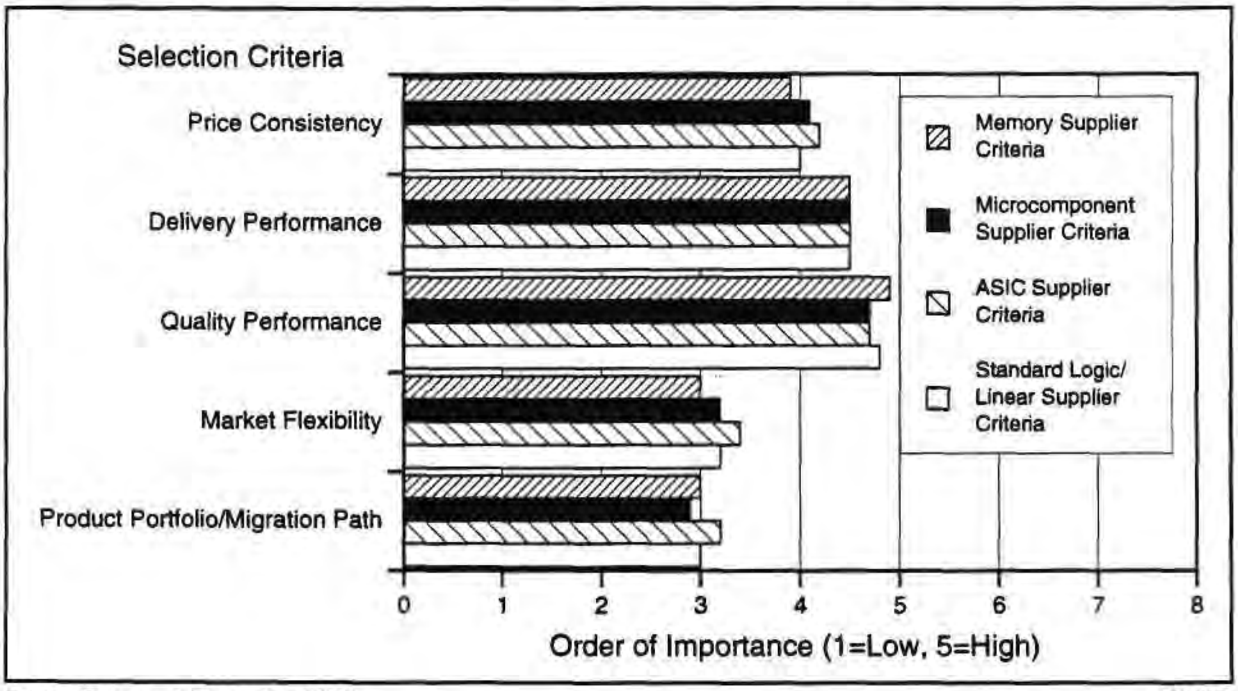


Source: Dataquest (December 1992)

G2001385

The lion's share (93.4 percent) of physical assembly is done in the United States, yet a small portion is being done in Japan and Asia.

Figure 4-92
Military/Aerospace Industry Semiconductor Supplier Selection Criteria

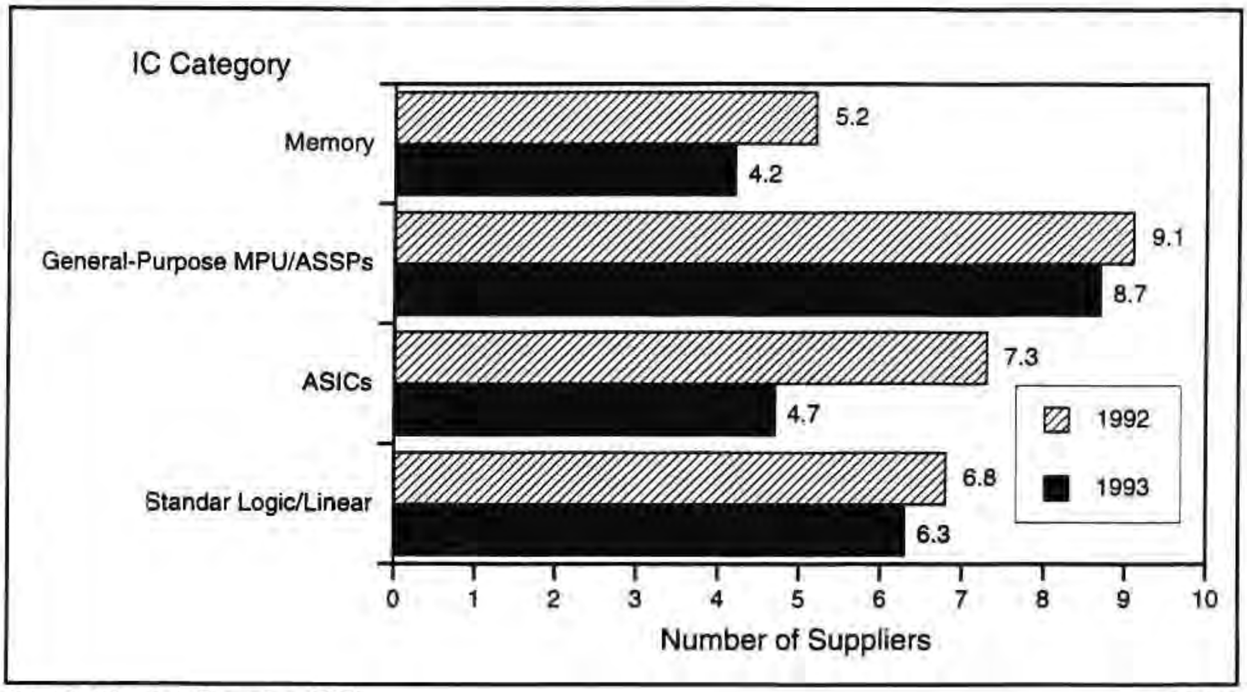


Source: Dataquest (December 1992)

G2001396

Very much like the overall industry, this segment of the market keys on quality and then delivery when selecting a semiconductor supplier, be it an OEM, distributor, or contract manufacturer.

Figure 4-93
Military/Aerospace Industry Supply Base Trend

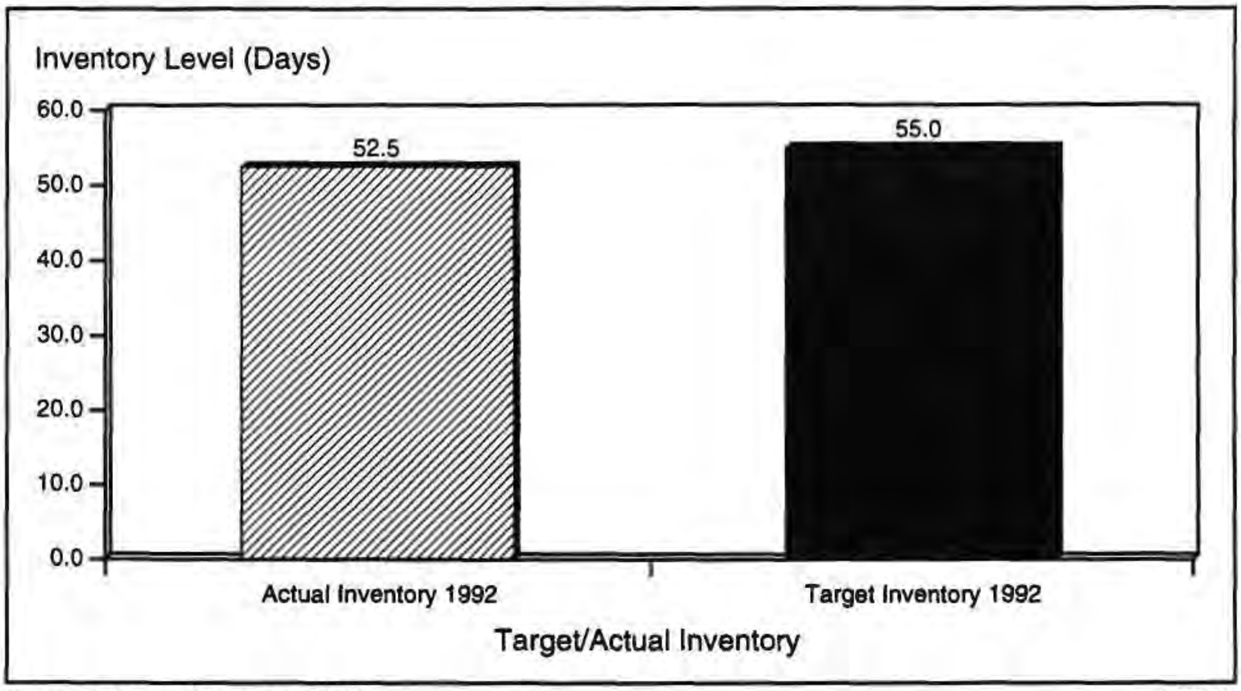


Source: Dataquest (December 1992)

G2001397

Aside from incremental reduction in the memory and standard logic/linear supplier levels, the microcomponent and ASIC supply base is expected to be reduced for this segment next year.

Figure 4-94
Military/Aerospace Industry Semiconductor Inventory Status

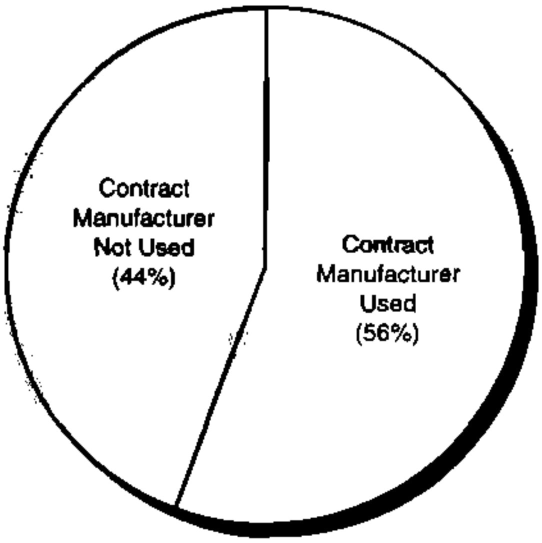


Source: Dataquest (December 1992)

G2001398

- *Although relatively high, compared with commercial industry standards, the target to actual inventory levels for this subset are well under control.*
- *Government contracts often require 60 days or more of inventory to always be on hand.*

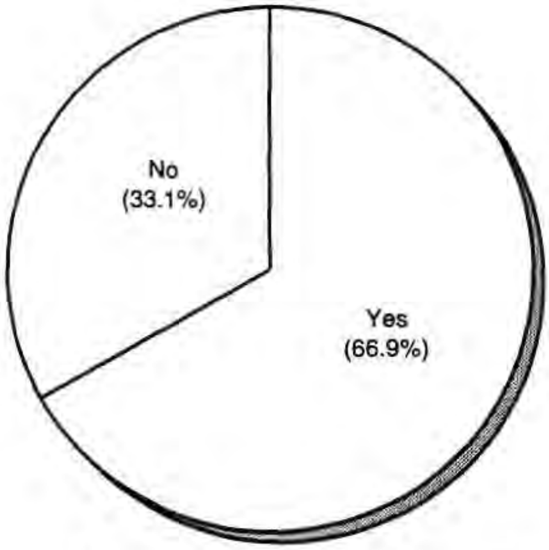
Figure 4-95
Military/Aerospace Industry Contract Manufacturer Use



Source: Dataquest (December 1992) G2001399

- *Although the average percentage of contract manufacturing use is within the overall industry average, the average length of time subcontractors have been used is 16 years.*
- *Because of the nature of this industry, much work is completed by subcontracting out assembly and manufacturing.*

Figure 4-96
Military/Aerospace Industry Semiconductor Distributor Use

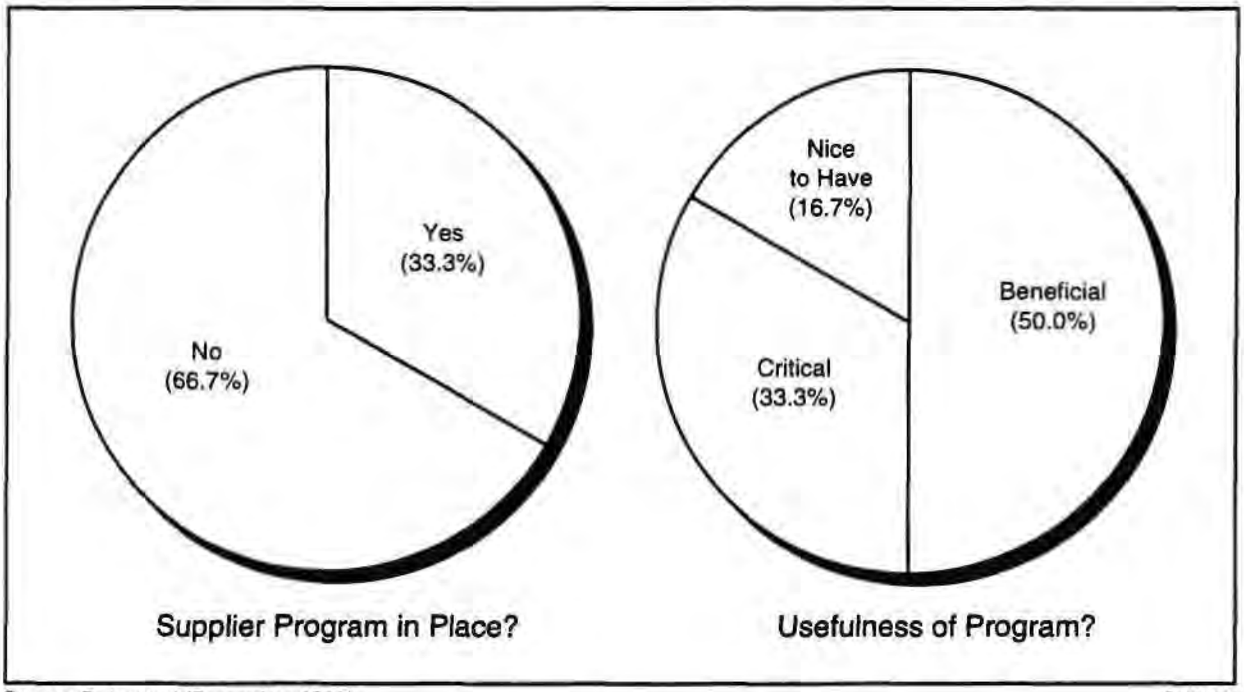


Source: Dataquest (December 1992)

G2001400

More than two-thirds (66.9 percent) of this market segment uses semiconductor distribution because of the relatively low volume and special needs of this industry.

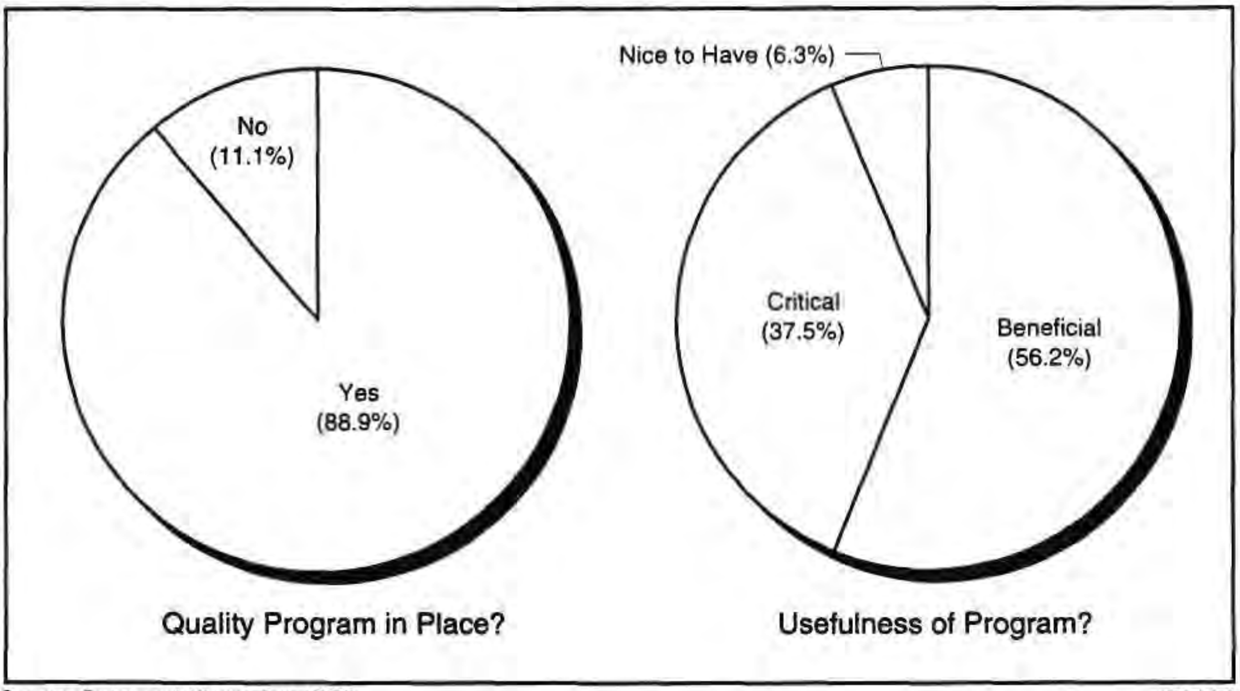
Figure 4-97
Military/Aerospace Industry Strategic Supplier Status



Source: Dataquest (December 1992) G2001401

- *Because of the low unit volumes involved, it is not surprising to see a low level of strategic supplier programs in place.*
- *Compared with distribution usage, a strong correlation exists where distribution customers do not need strategic supplier programs—their distributor provides the services of such a program.*

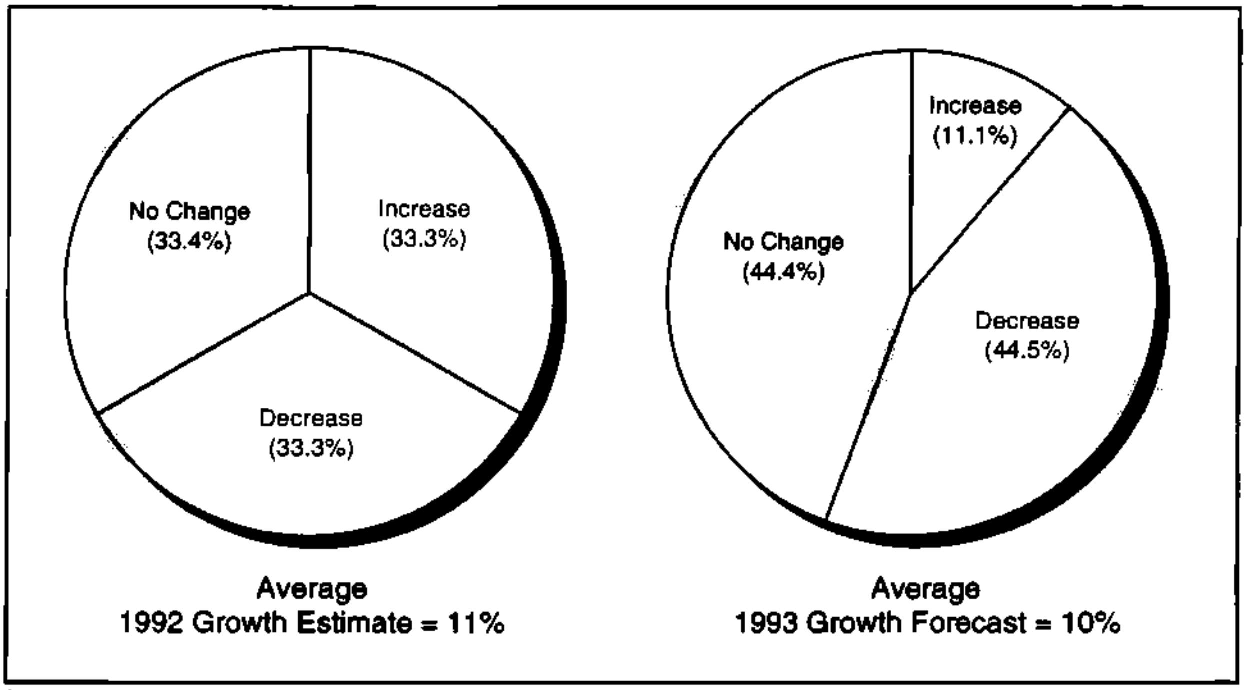
Figure 4-98
Military/Aerospace Industry Quality Improvement Program Status



Source: Dataquest (December 1992)
G2001402

Because of the nature of military contracts, it is surprising to see that more than 11 percent of the respondents do not have a quality program in place.

Figure 4-99
Military/Aerospace Industry Surveyed Growth Outlook



Source: Dataquest (December 1992) G2001403

- *The responses were equally split regarding the economic outlook for 1992, with those that expect growth seeing an increase of 11 percent.*
- *Because of the smaller response to the 1993 outlook, a more bleak forecast appears. Yet for those expecting business to improve, the average increase is expected to be 10 percent.*

Chapter 5
Semiconductor User Needs, by Product Category

This chapter focuses on purchasing information as seen from an IC category perspective. The information and analysis should be useful for those individuals interested in product granularity. We chose the following four areas to detail:

- Memory ICs
- Microcomponent ICs
- ASIC
- Standard logic and analog

These categories were chosen to keep the survey manageable and to cluster products that exhibit similar buying behavior.

This chapter is organized into the four product categories mentioned. We will examine, from the OEM's perspective, semiconductor supplier selection criteria, quality definitions, and the number of qualified semiconductor suppliers within each product category. Regarding supplier selection criteria, we asked purchasers to note the importance of the following five factors:

- Pricing consistency—Maintaining predictable (plannable) pricing practices, regardless of fluctuating market conditions.
- Delivery performance—The ability to deliver the correct product order when specified.
- Quality performance—The ability to deliver product that meets or exceeds required incoming quality levels.
- Market flexibility—A supplier's ability to be flexible with delivery schedules and quantities to match fluctuating OEM demand.
- Product portfolio and migration path—The breadth, depth, and plans for products needed by the customer.

On the quality question, we asked OEMs to define minimum acceptable incoming quality on a defective ppm basis. We also asked OEMs to identify the number of qualified suppliers in each product area for 1992 and the planned number for 1993.

Memory ICs

Figures 5-1 through 5-8 detail the survey results from buyers of memory ICs on supplier selection criteria, quality definitions, and number of suppliers. Memory ICs include such products as DRAMs, SRAMs, VRAMs, ROM, EPROM, EEPROM, flash, and various combinations and specialty products such as dual ports.

Microcomponent ICs

Figures 5-9 through 5-16 detail the survey results from buyers of microcomponent ICs on supplier selection criteria, quality definitions, and number of suppliers. Microcomponents include such products as microprocessors, microcontrollers, coprocessors, DSP microprocessors, processor support functions (DMA controllers, among others), dedicated controllers (networking, graphics, and storage), and various functional chip sets.

ASICs

Figures 5-17 through 5-24 detail the survey results from buyers of ASICs on supplier selection criteria, quality definitions, and number of suppliers. ASICs include such products as PLDs, FPGAs, gate arrays, cell-based ICs, custom ICs, and variations combining these.

Standard Logic and Analog ICs

Figures 5-25 through 5-32 detail the survey results from buyers of standard logic and analog ICs on supplier selection criteria, quality definitions, and number of suppliers. Included in this category are family and interface logic products as well as standard analog functions such as amplifiers, regulators and references, data conversion, and consumer circuits.

Summary

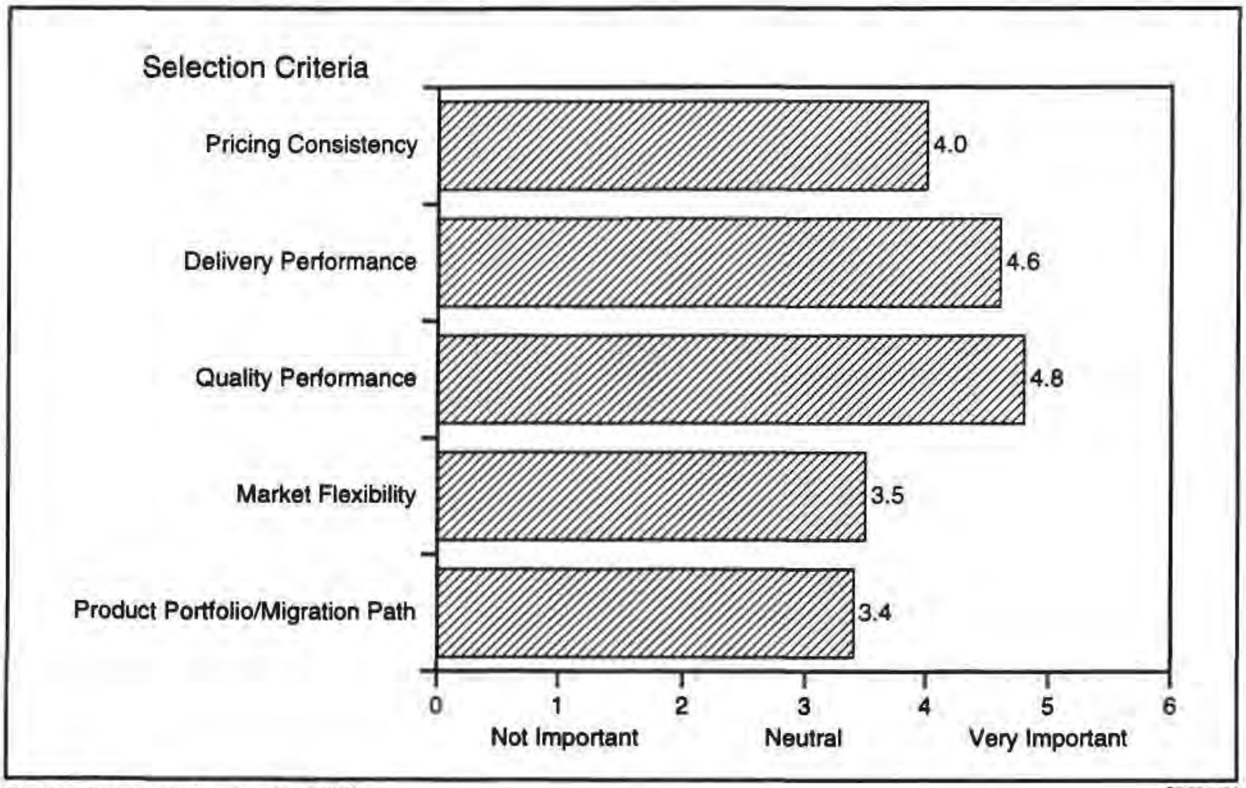
On average, quality and delivery performance remain the most stringently employed supplier selection criteria. Microcomponents (MPUs, among others) was the only category of product where pricing was a serious contender as a selection criteria. This perception is probably because of the relative higher prices of these parts and the limiting sourcing options in some cases.

Quality performance across the board was clearly a prerequisite to doing business. All four surveyed product areas had average minimum acceptable quality levels of about 60 ppm. The higher volume businesses such as PCs required even more restrictive quality performance.

The high ranking of delivery performance, especially in ASICs, seemed to underscore the importance of timing in today's global market. With product life cycles running under two years in many some volume segments, even a week slippage can hurt an OEM's market positioning.

Approved supplier lists are slated to shrink next year for almost all industries, for all semiconductor products. OEMs on average maintained eight microcomponent, six standard logic and analog suppliers, five ASIC, and five memory suppliers during 1992. High-volume users tended to keep the number smaller, whereas military/aerospace users had nearly double the amount in some cases.

Figure 5-1
Memory IC Supplier Selection Criteria: Overall

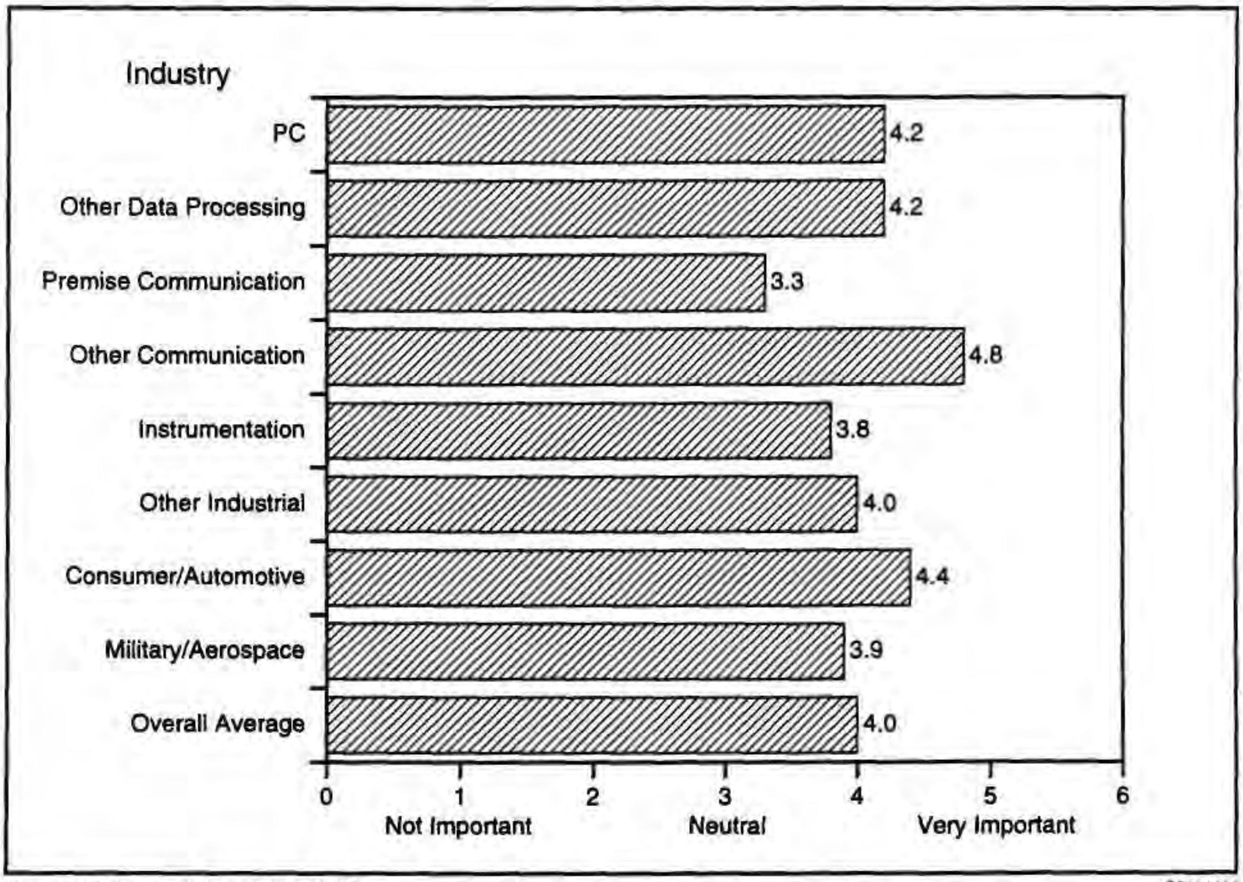


Source: Dataquest (December 1992)

G2001404

- *Quality and delivery performance are the top criteria when it comes to selecting a memory supplier. This is a surprising result given the extreme cost sensitivity of areas such as PCs and consumer electronics during their recent profitability slump.*
- *Quality and pricing are most likely prerequisite factors, whereas delivery has become more of a defining issue.*

Figure 5-2
Memory IC Supplier Selection Criteria: Pricing Consistency

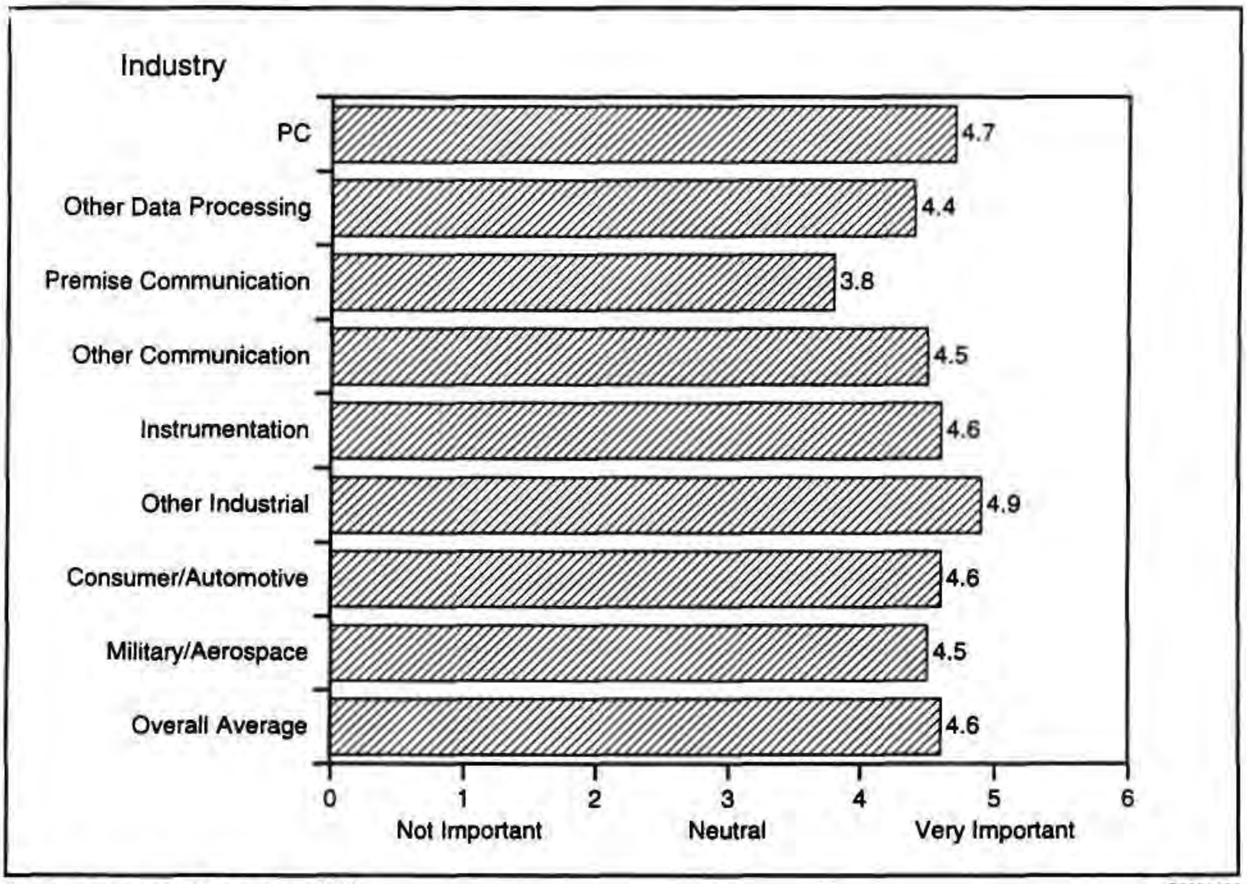


Source: Dataquest (December 1992)

G2001405

With the exception of the communication categories, pricing consistency is fairly level in relative importance across industries.

Figure 5-3
Memory IC Supplier Selection Criteria: Delivery Performance

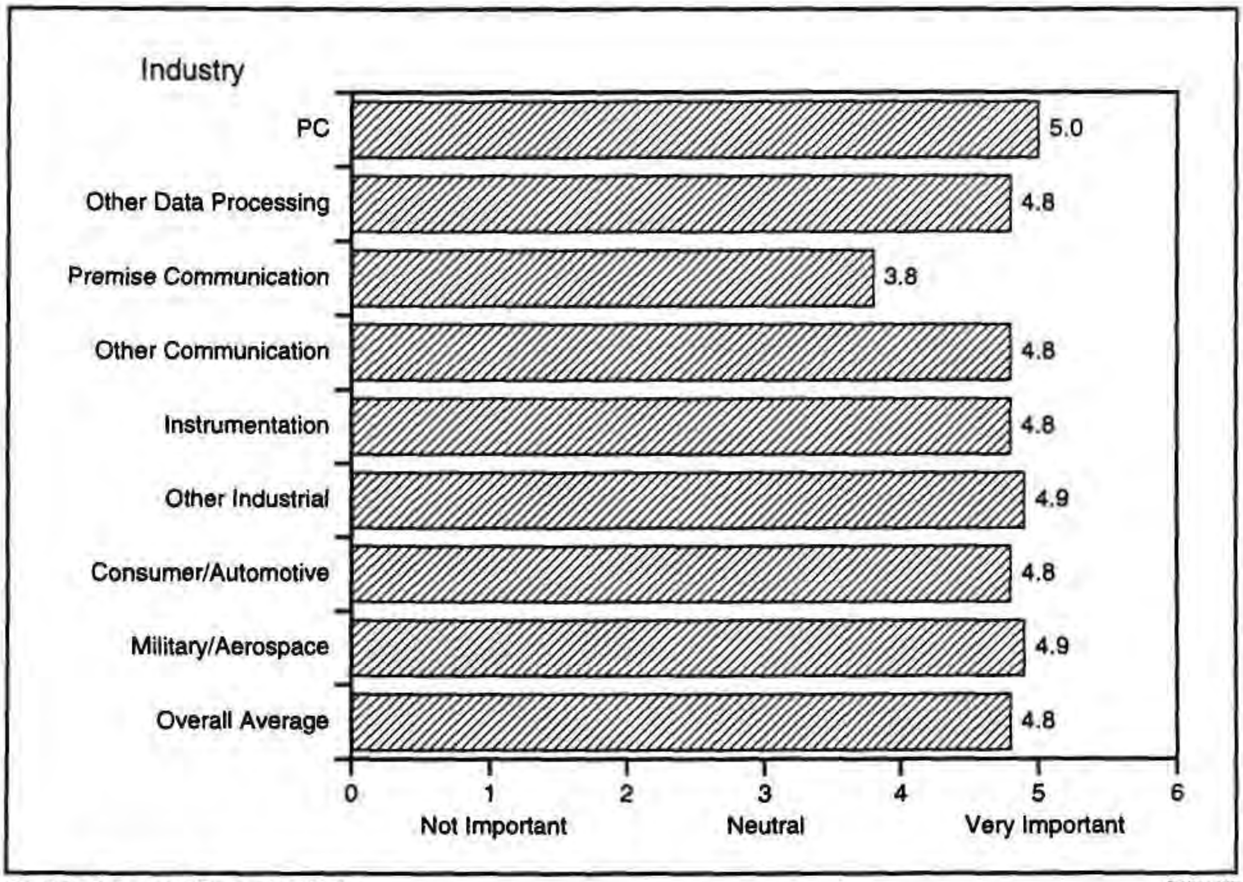


Source: Dataquest (December 1992)

G2001406

Just-in-time delivery has become a true competitive weapon as OEMs depend on it for not only cost management but to ensure quick time to market for their products.

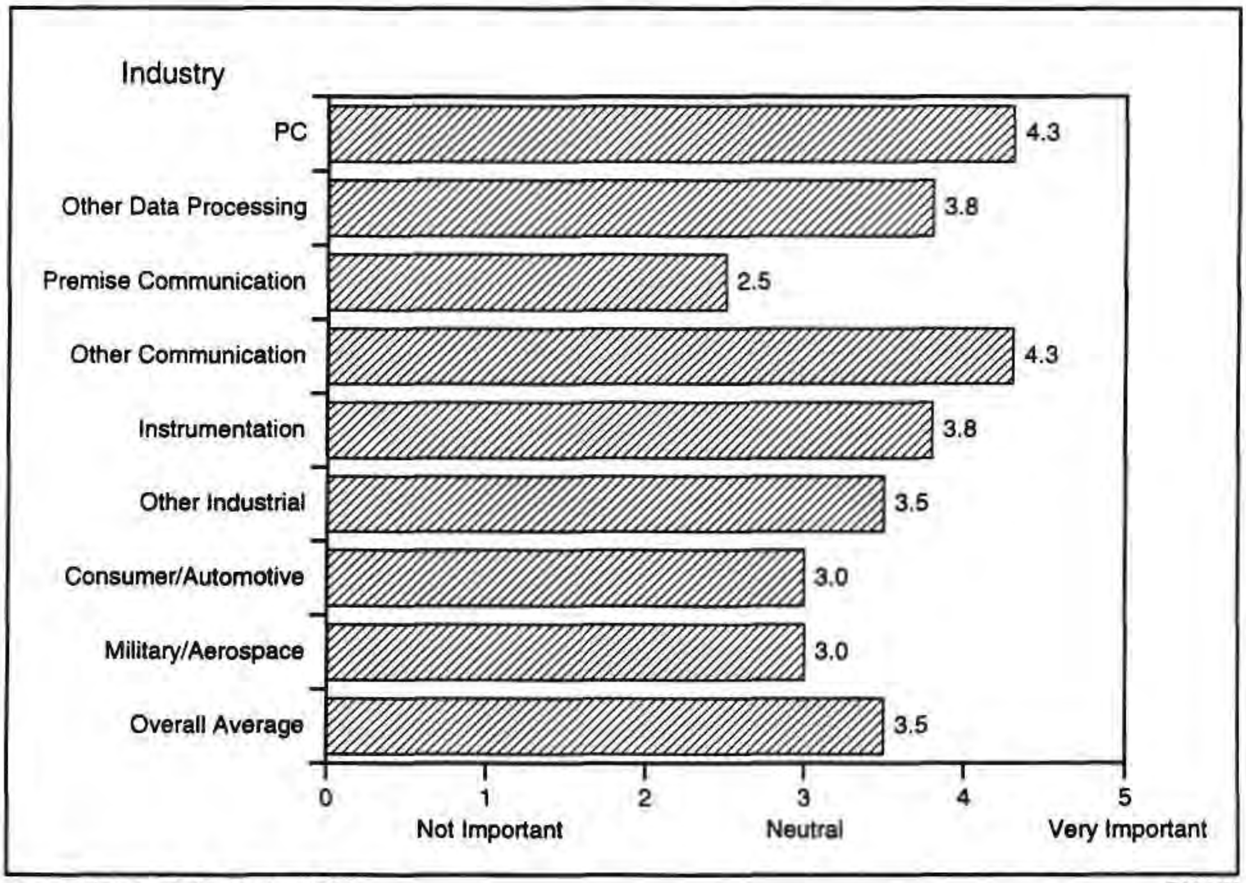
Figure 5-4
Memory IC Supplier Selection Criteria: Quality Performance



Source: Dataquest (December 1992) G2001407

Superior quality is clearly a prerequisite before any business can take place.

Figure 5-5
Memory IC Supplier Selection Criteria: Market Flexibility

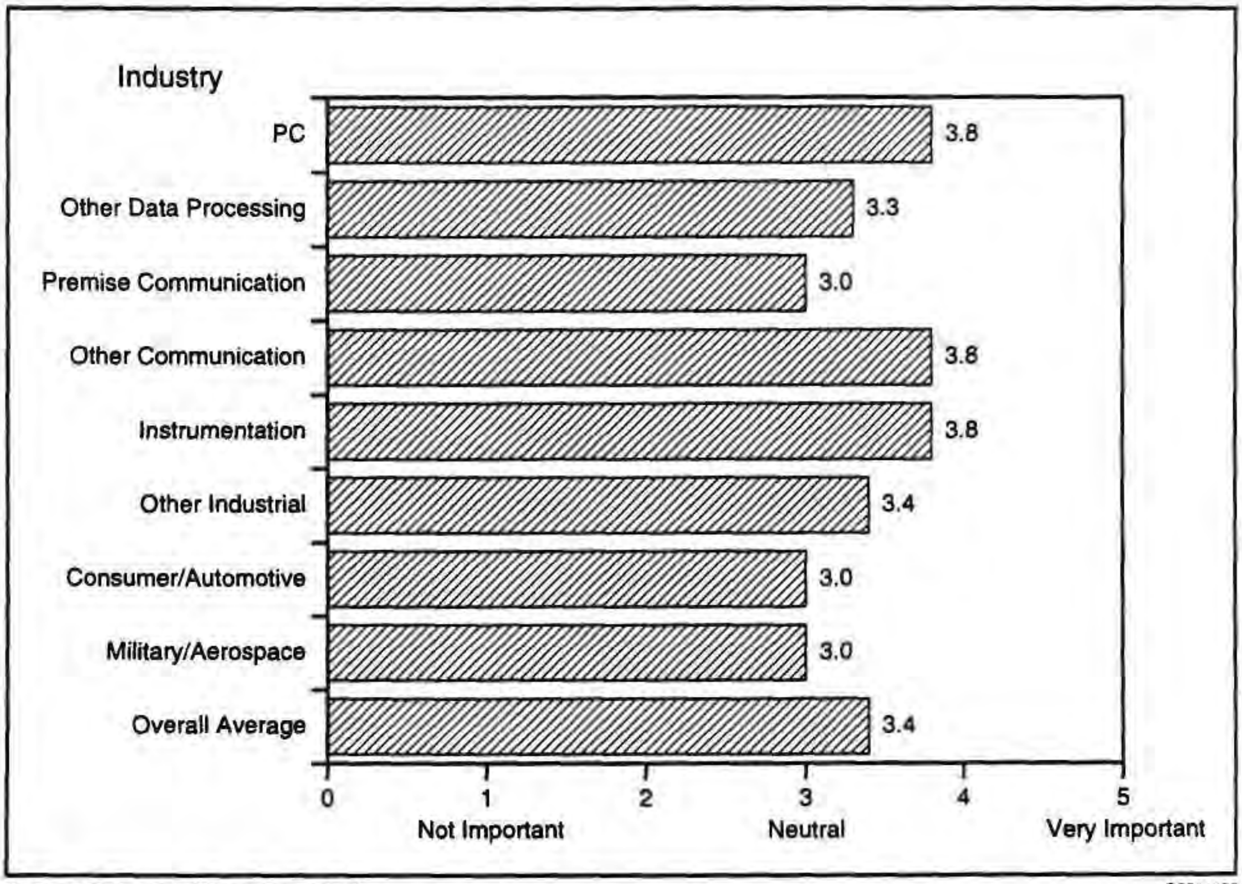


Source: Dataquest (December 1992)

G2001408

This is less of an issue because memory suppliers remain bountiful, and multiple suppliers can be substituted for most parts.

Figure 5-6
Memory IC Supplier Selection Criteria: Product Portfolio and Migration Path

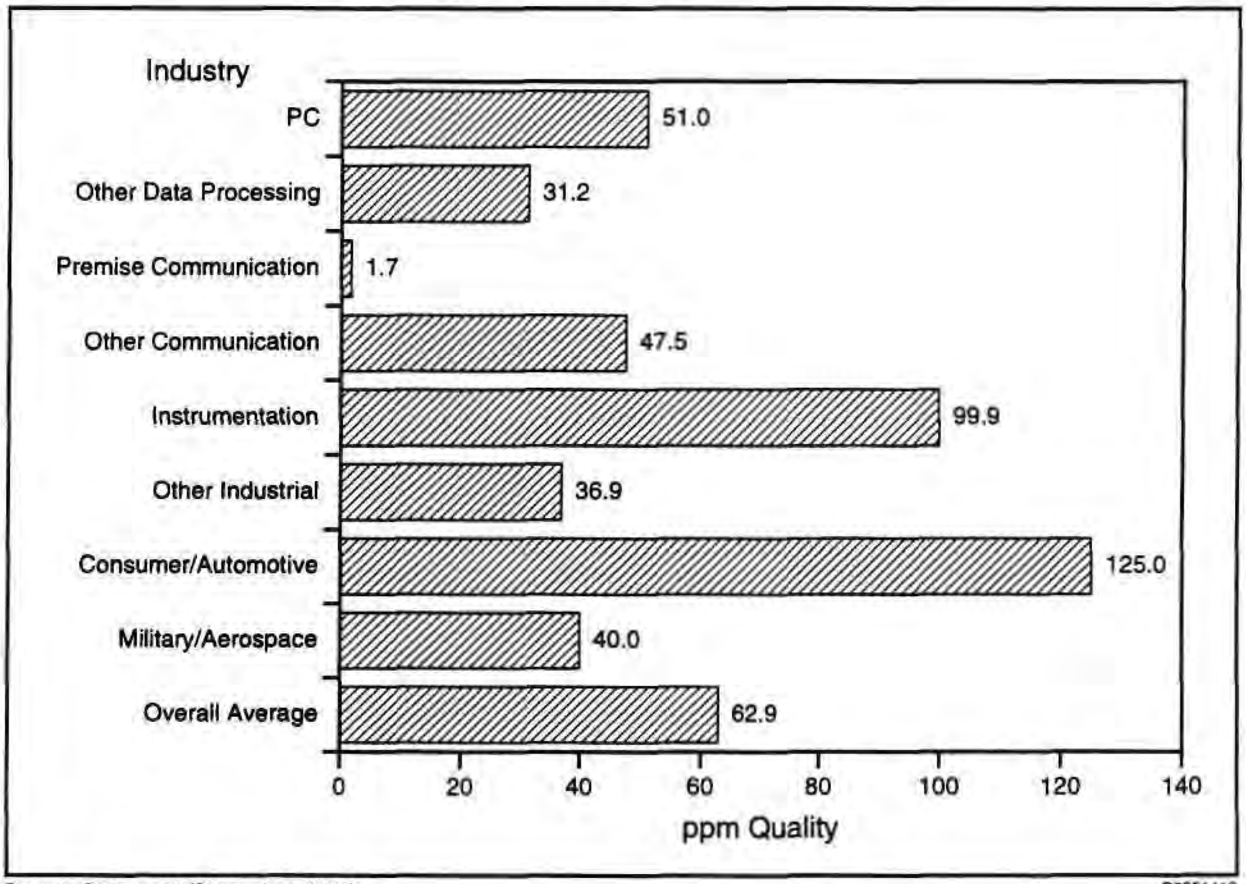


Source: Dataquest (December 1992)

G2001409

The somewhat predictable nature of memory product improvements (for example, denser and faster) make this less of an issue.

Figure 5-7
Minimum Necessary Quality for Memory ICs (ppm)

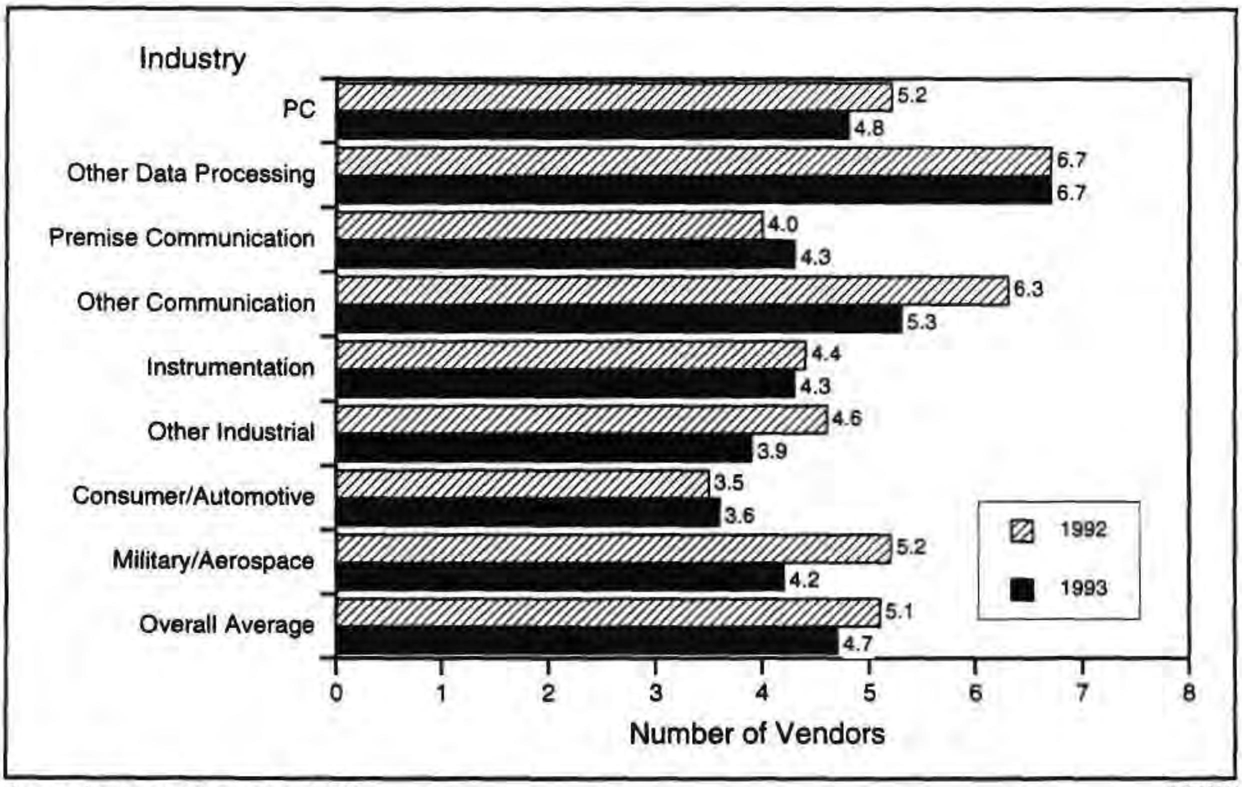


Source: Dataquest (December 1992)

G2001410

Buyers for memory-intensive products such as computers and laser printers appear to desire stricter quality standards than the average.

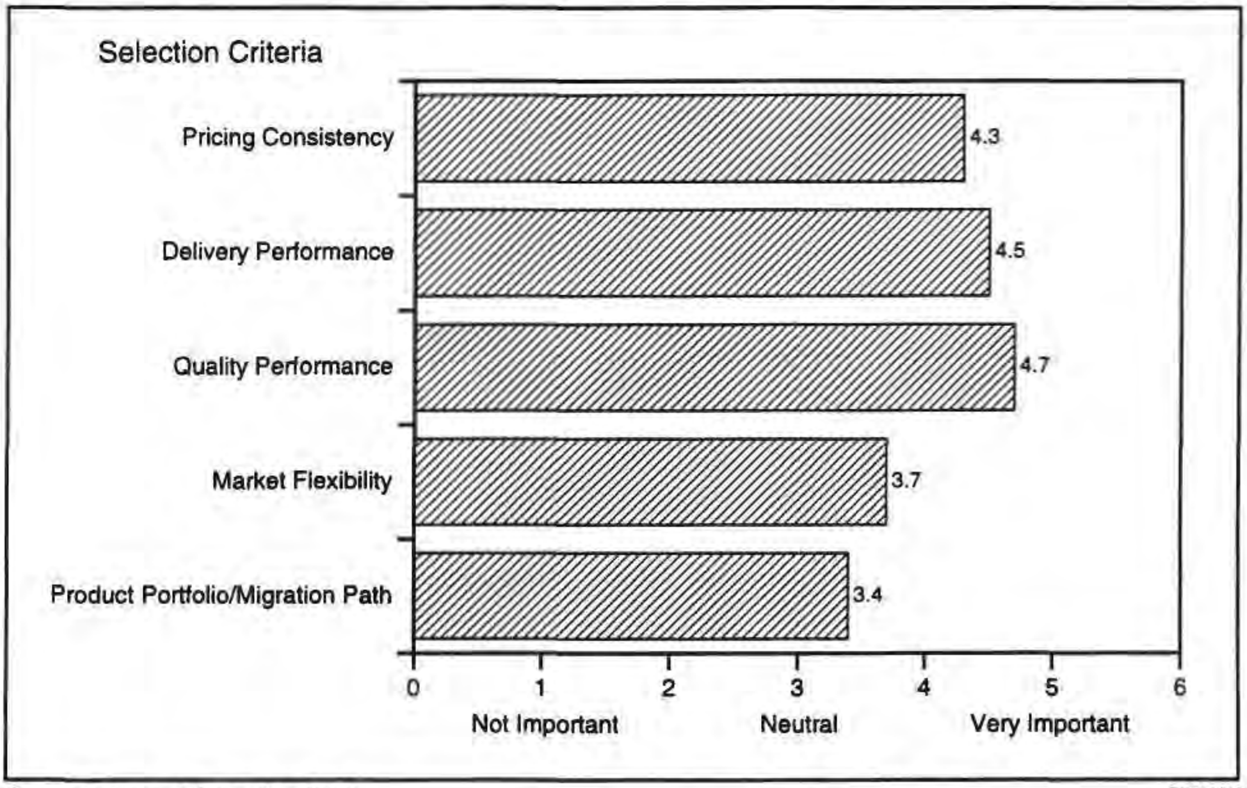
Figure 5-8
Number of Memory IC Suppliers



Source: Dataquest (December 1992) G2001411

On average memory buyers maintained about five separate memory suppliers in 1992, with plans to reduce that number in 1993.

Figure 5-9
Microcomponent IC Supplier Selection Criteria: Overall

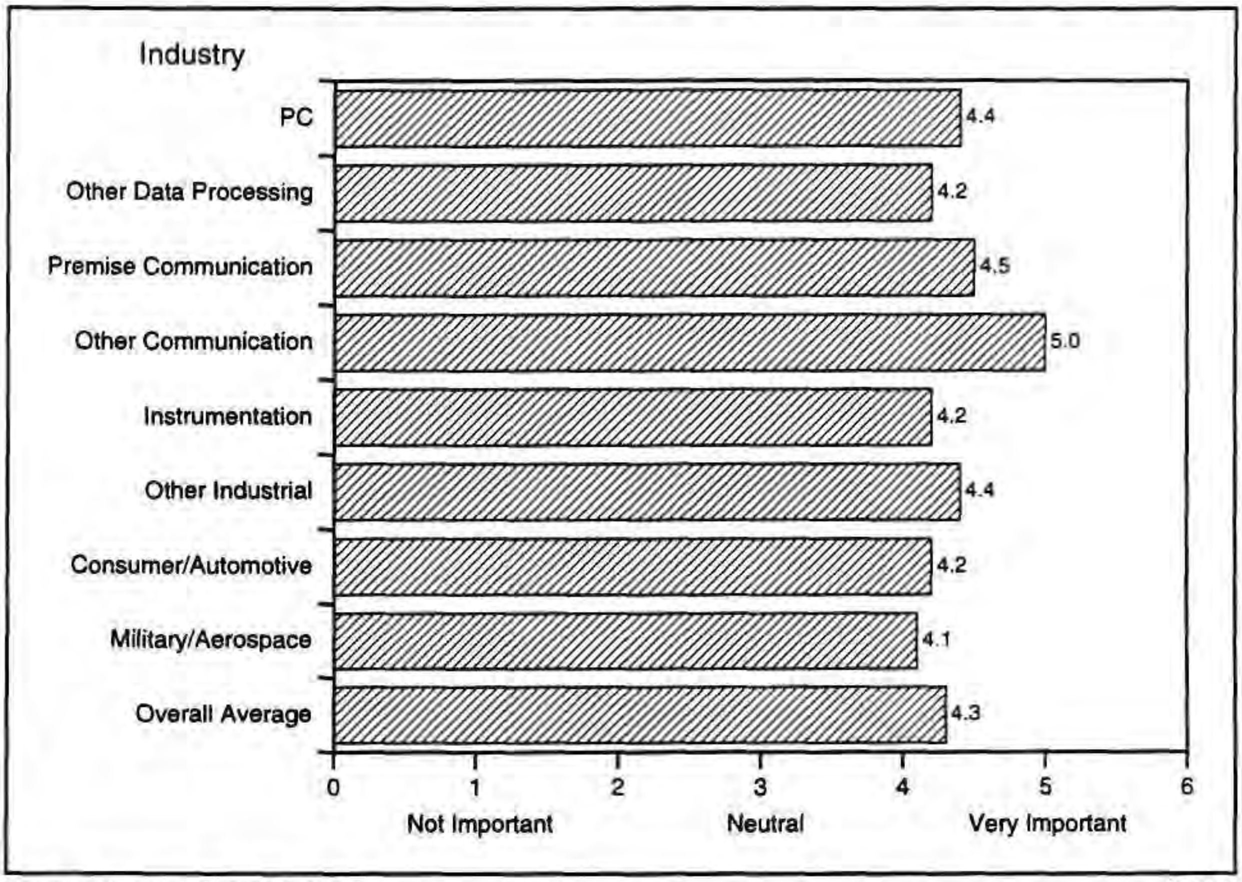


Source: Dataquest (December 1992)

G2001412

Quality and delivery performance are also the top criteria, with pricing, however, being more of a consideration than in other product areas.

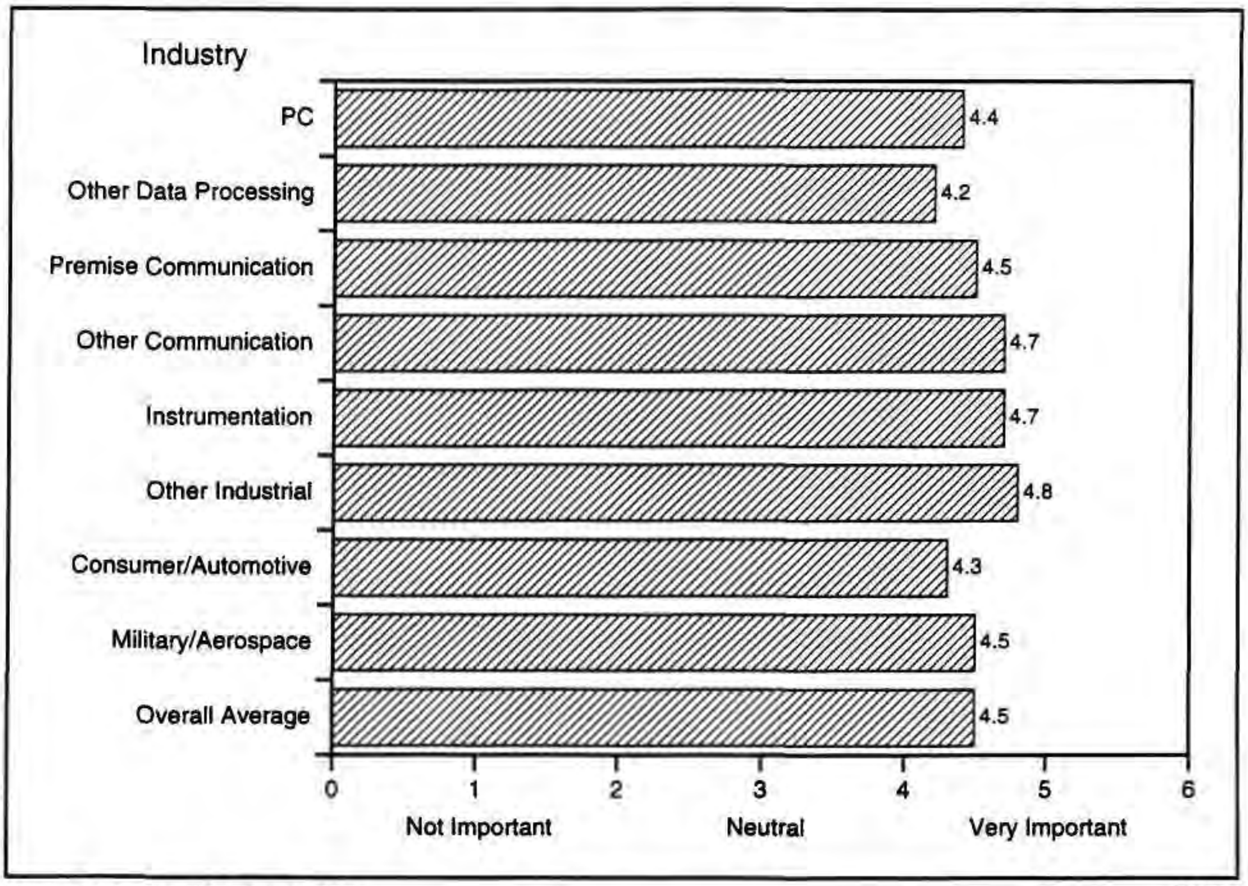
Figure 5-10
Microcomponent IC Supplier Selection Criteria: Pricing Consistency



Source: Dataquest (December 1992)
G2001413

With the exception of the communication categories, pricing consistency is fairly level in relative importance across industries.

Figure 5-11
Microcomponent IC Supplier Selection Criteria: Delivery Performance

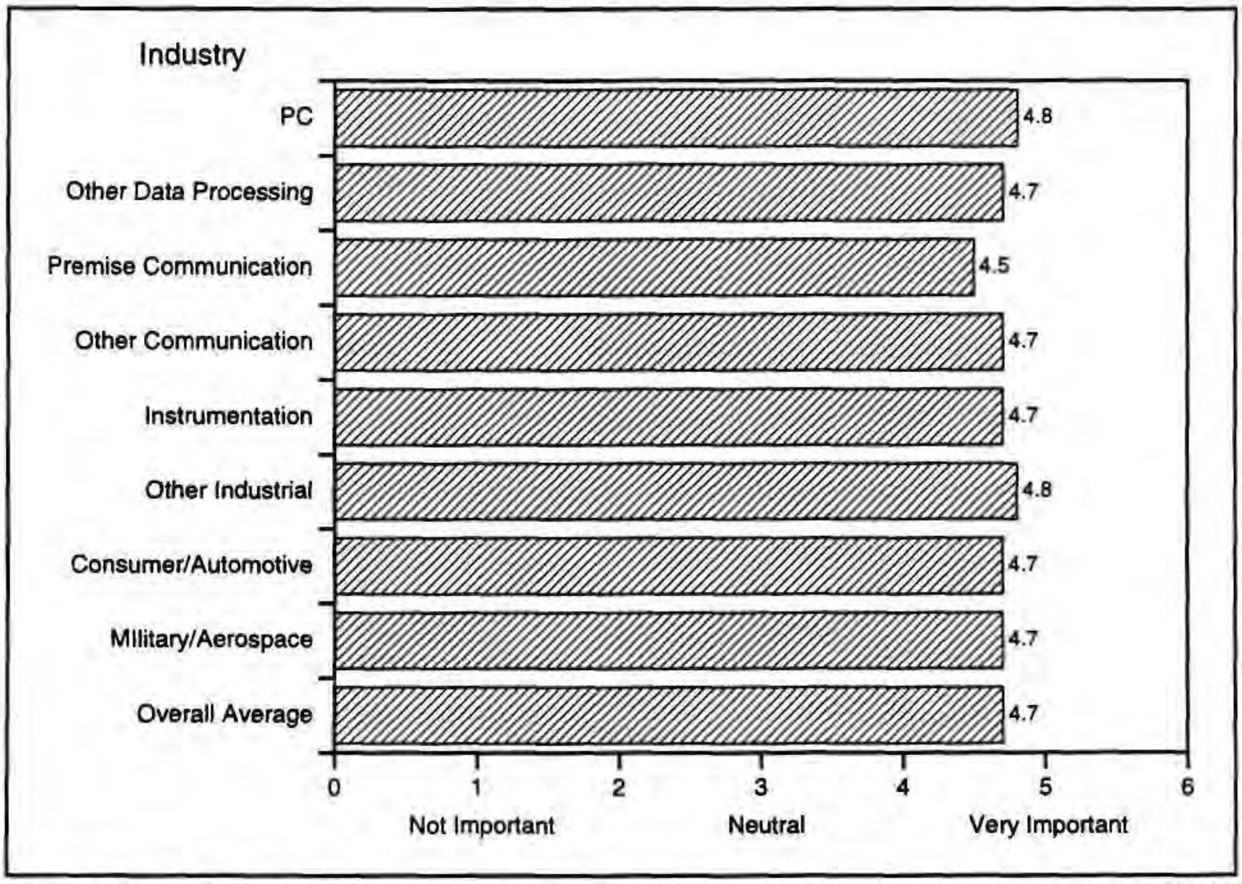


Source: Dataquest (December 1992)

G2001414

Apparently delivery is an important issue for the more fragmented industrial/ instrumentation industries.

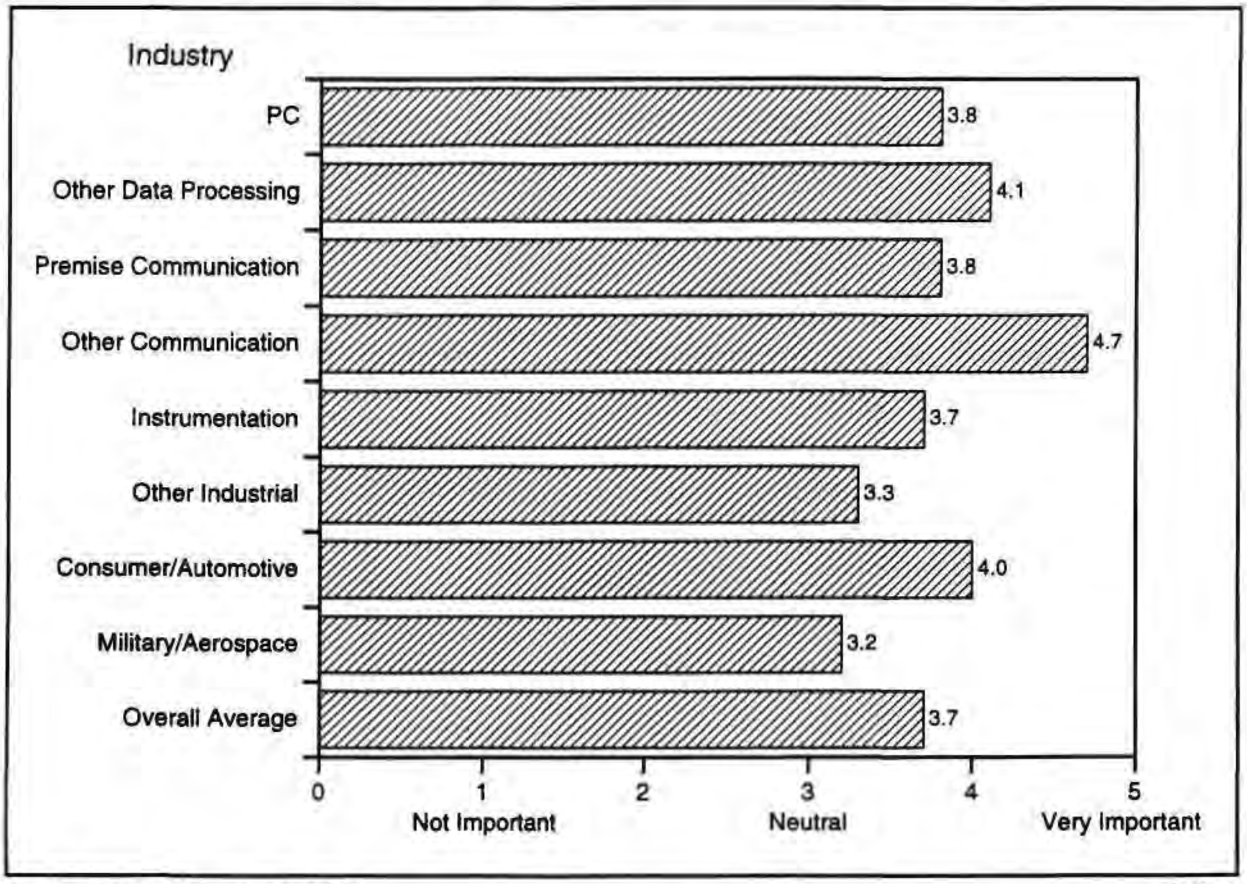
Figure 5-12
Microcomponent IC Supplier Selection Criteria: Quality Performance



Source: Dataquest (December 1992)
G2001415

Superior quality is clearly a prerequisite before any business can take place.

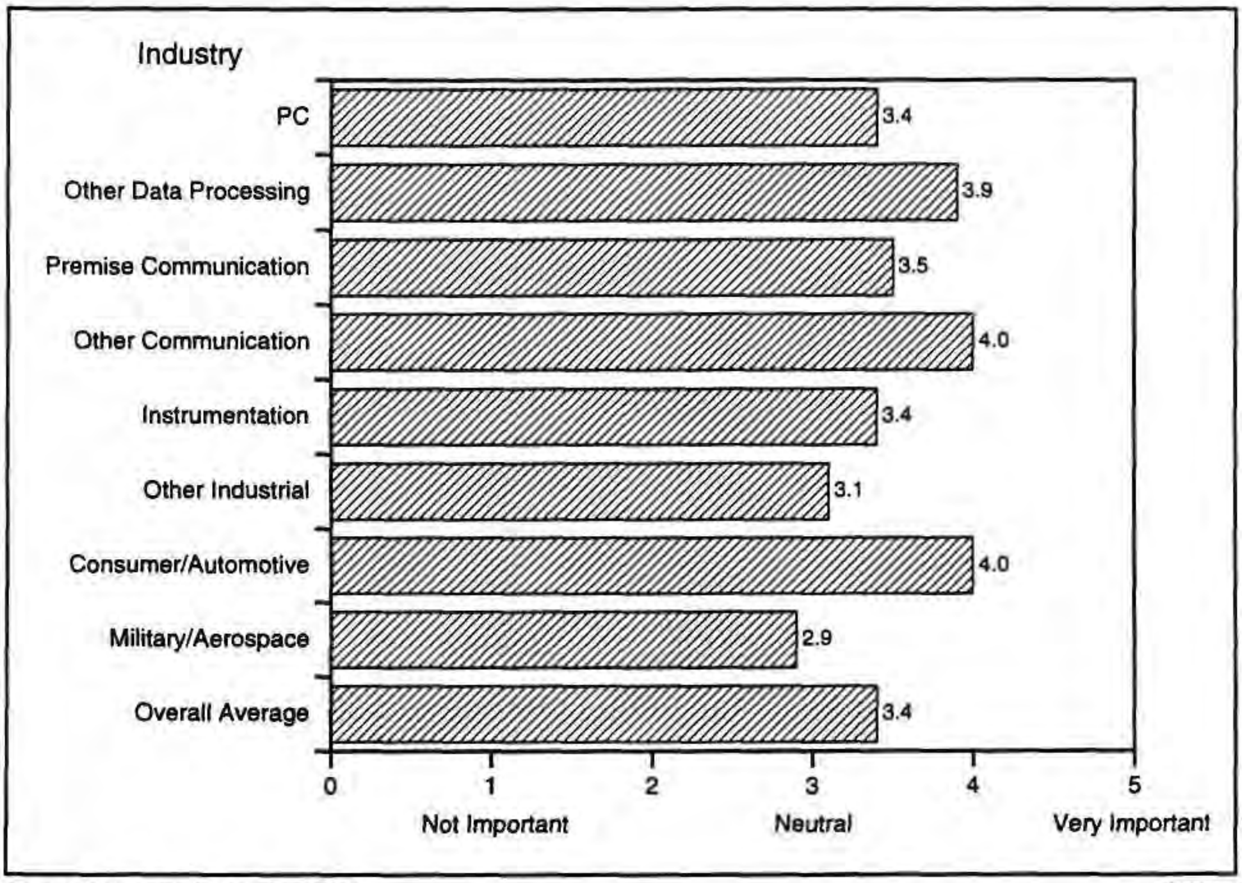
Figure 5-13
Microcomponent IC Supplier Selection Criteria: Market Flexibility



Source: Dataquest (December 1992) G2001416

Data processing, communication, and consumer/automotive desire the most flexibility because their markets remain subject to substantial fluctuations.

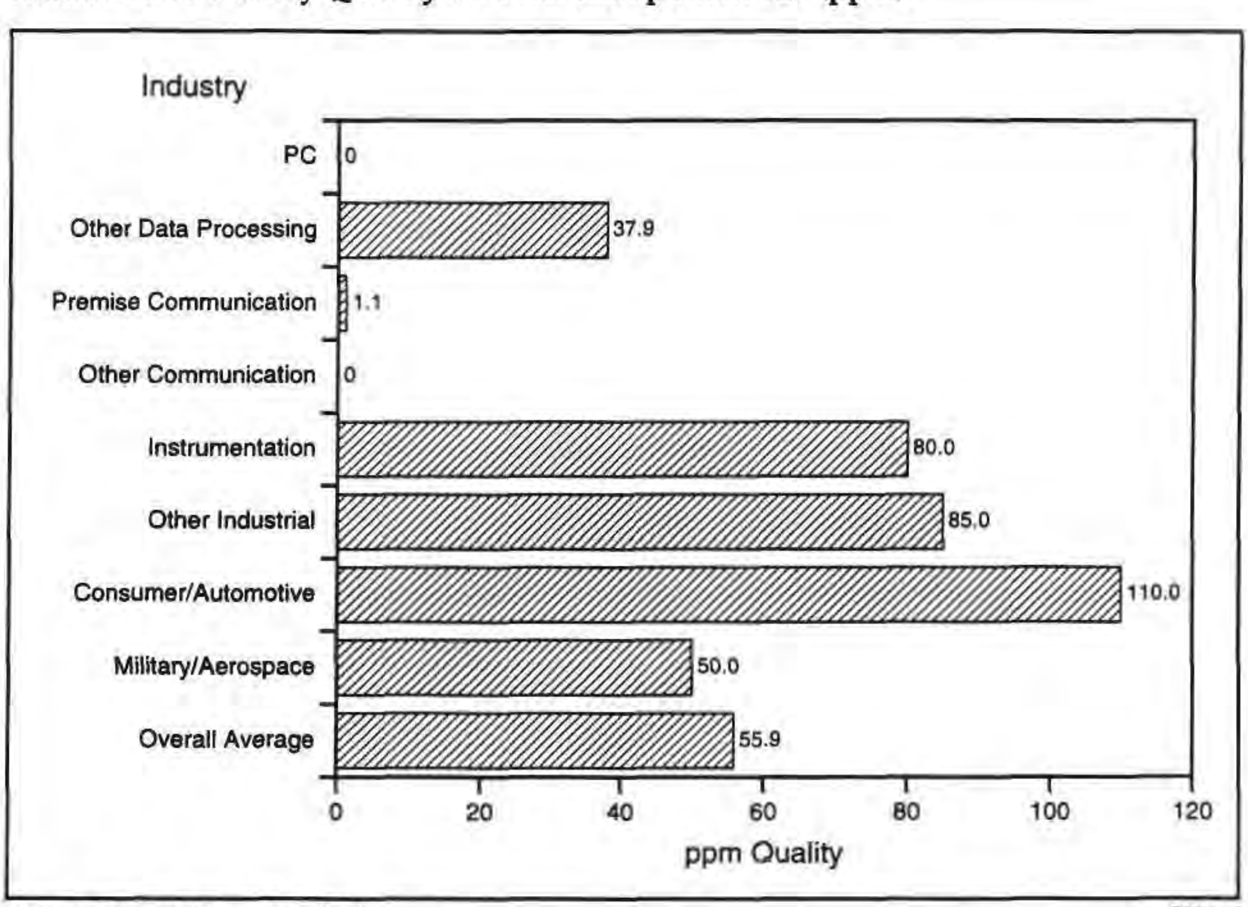
Figure 5-14
Microcomponent IC Supplier Selection Criteria: Product Portfolio and Migration Path



Source: Dataquest (December 1992) G2001417

This criterion is not much of a concern, except with performance-sensitive computer and communications OEMs.

Figure 5-15
Minimum Necessary Quality for Microcomponent ICs (ppm)

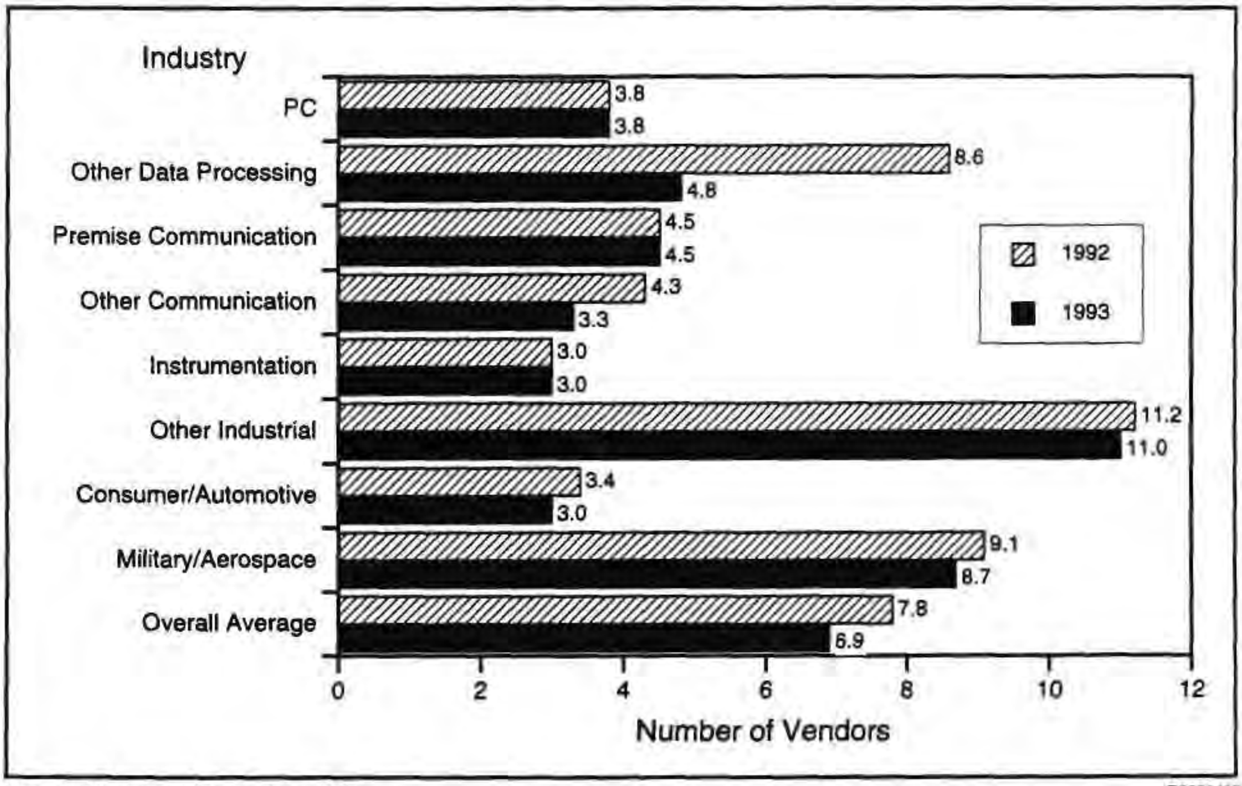


Source: Dataquest (December 1992)

G2001418

Probably because of ship-to-stock setups to reduce costs and improve time-to-market, the PC industry requires near perfect quality.

Figure 5-16
Number of Microcomponent IC Suppliers

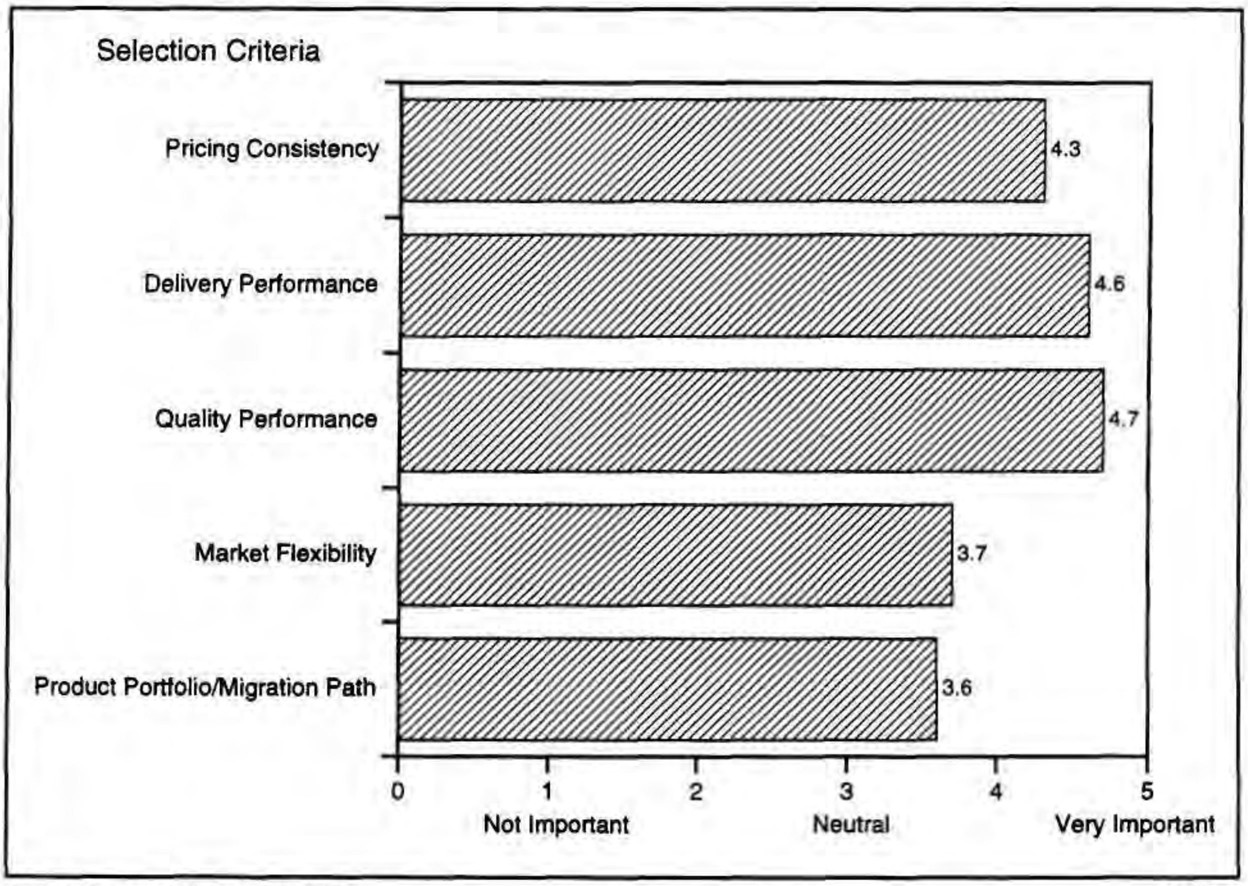


Source: Dataquest (December 1992)

G2001419

On average, microcomponent buyers maintained about eight separate suppliers in 1992, with plans to reduce that number in 1993 to seven.

Figure 5-17
ASIC IC Supplier Selection Criteria: Overall

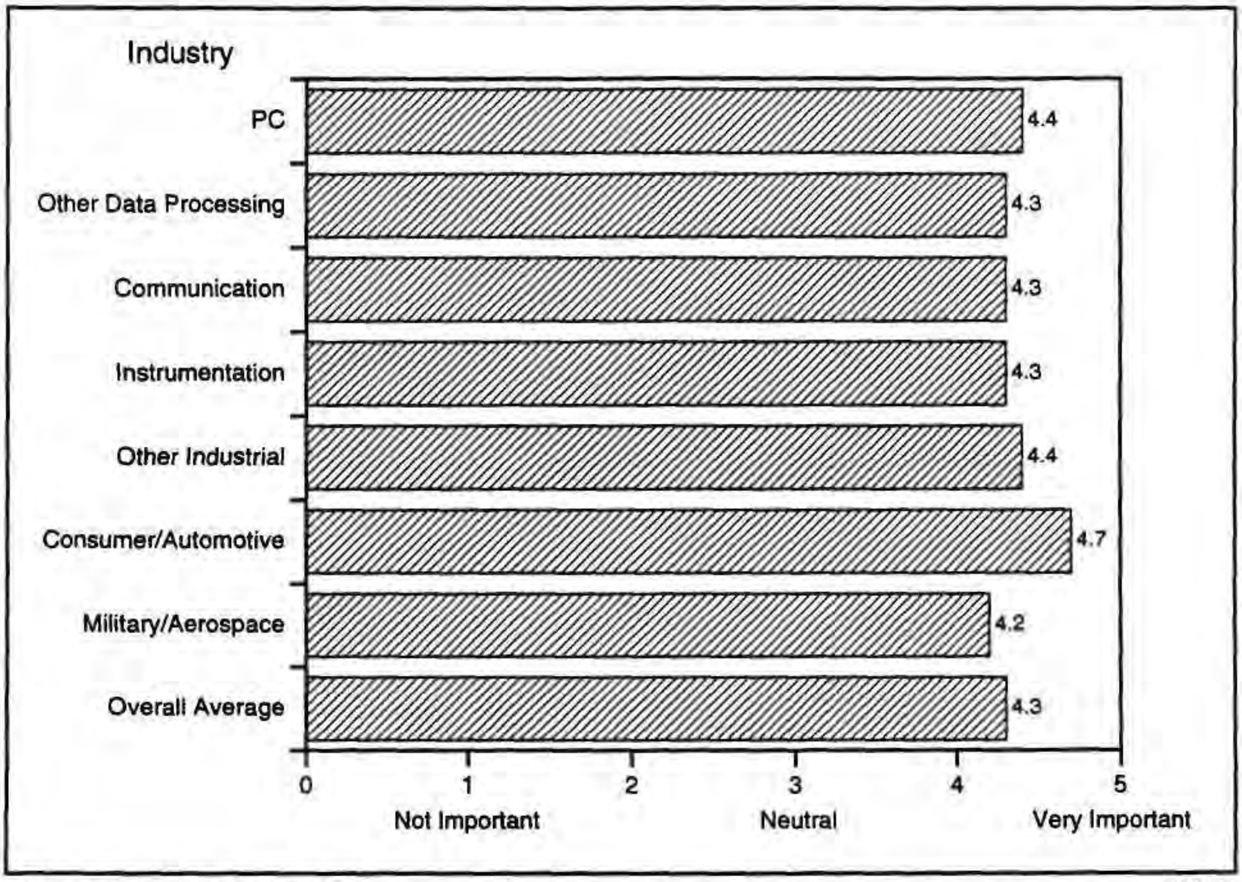


Source: Dataquest (December 1992)

G2001420

Delivery performance has risen in importance because ASICs and their prototypes remain a technology that OEMs need for getting to market quickly.

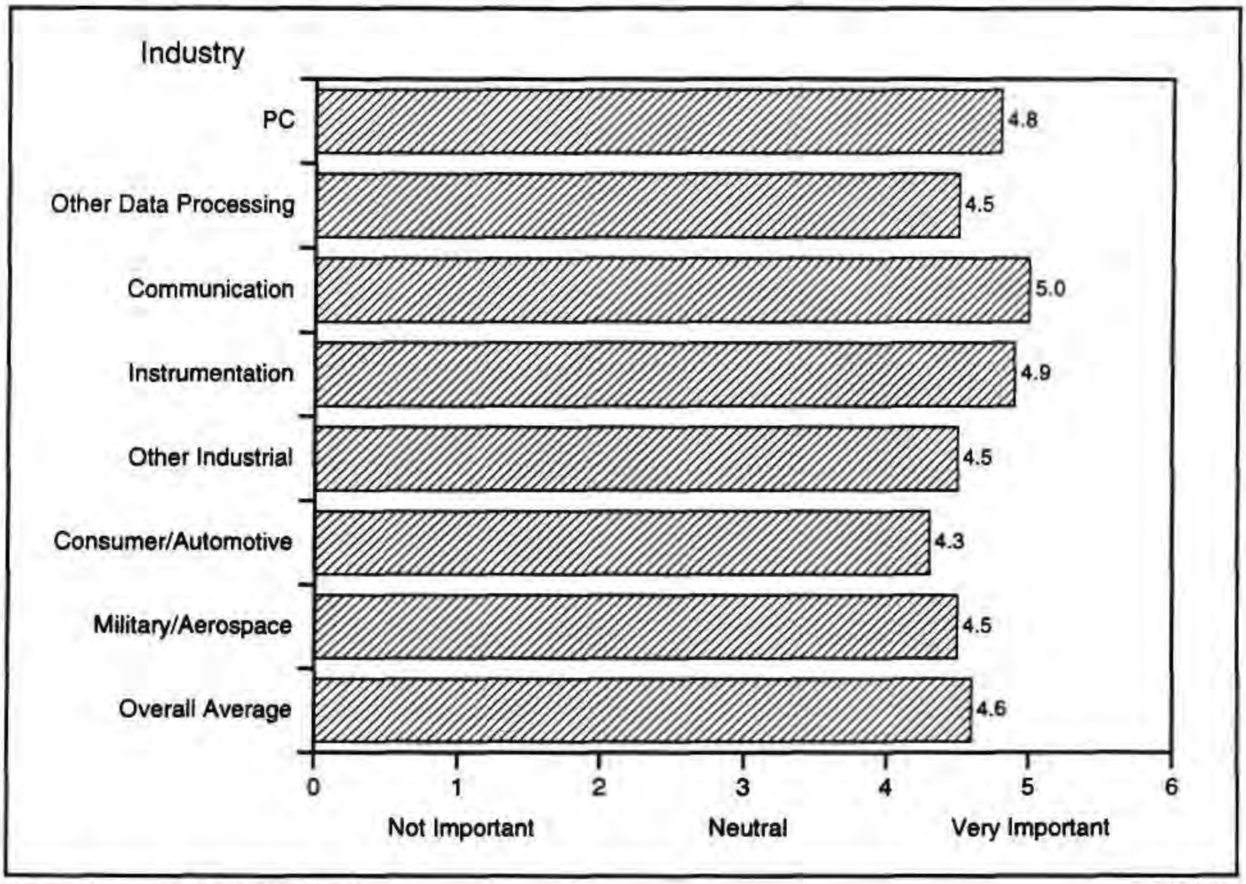
Figure 5-18
ASIC IC Supplier Selection Criteria: Pricing Consistency



Source: Dataquest (December 1992) G2001421

With the exception of the cost-sensitive consumer/automotive areas, pricing consistency is fairly level in relative importance across industries.

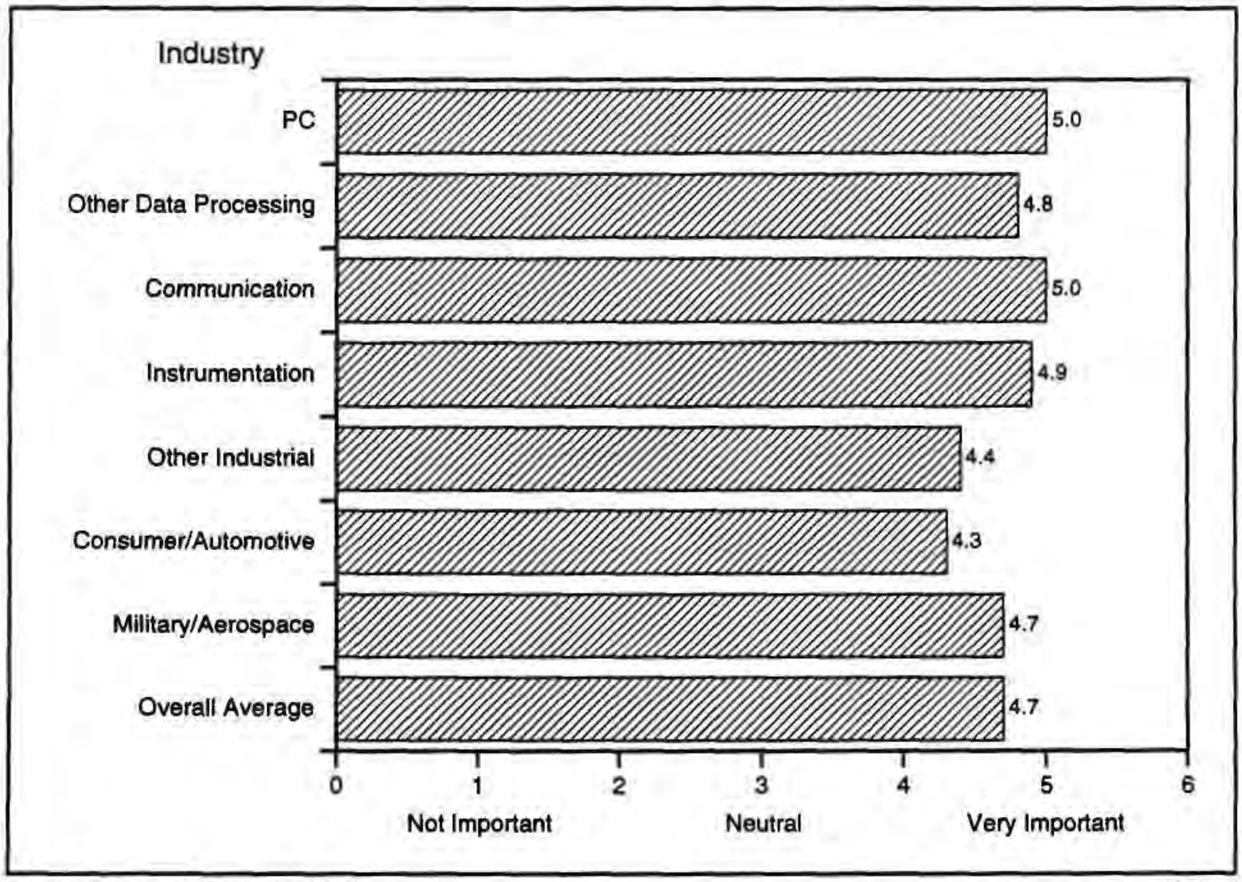
Figure 5-19
ASIC IC Supplier Selection Criteria: Delivery Performance



Source: Dataquest (December 1992) G2001422

Although important to almost all industries, delivery performance is crucial to the communications industry, which is heavily dependent on customization and differentiation by using ASICs.

Figure 5-20
ASIC IC Supplier Selection Criteria: Quality Performance

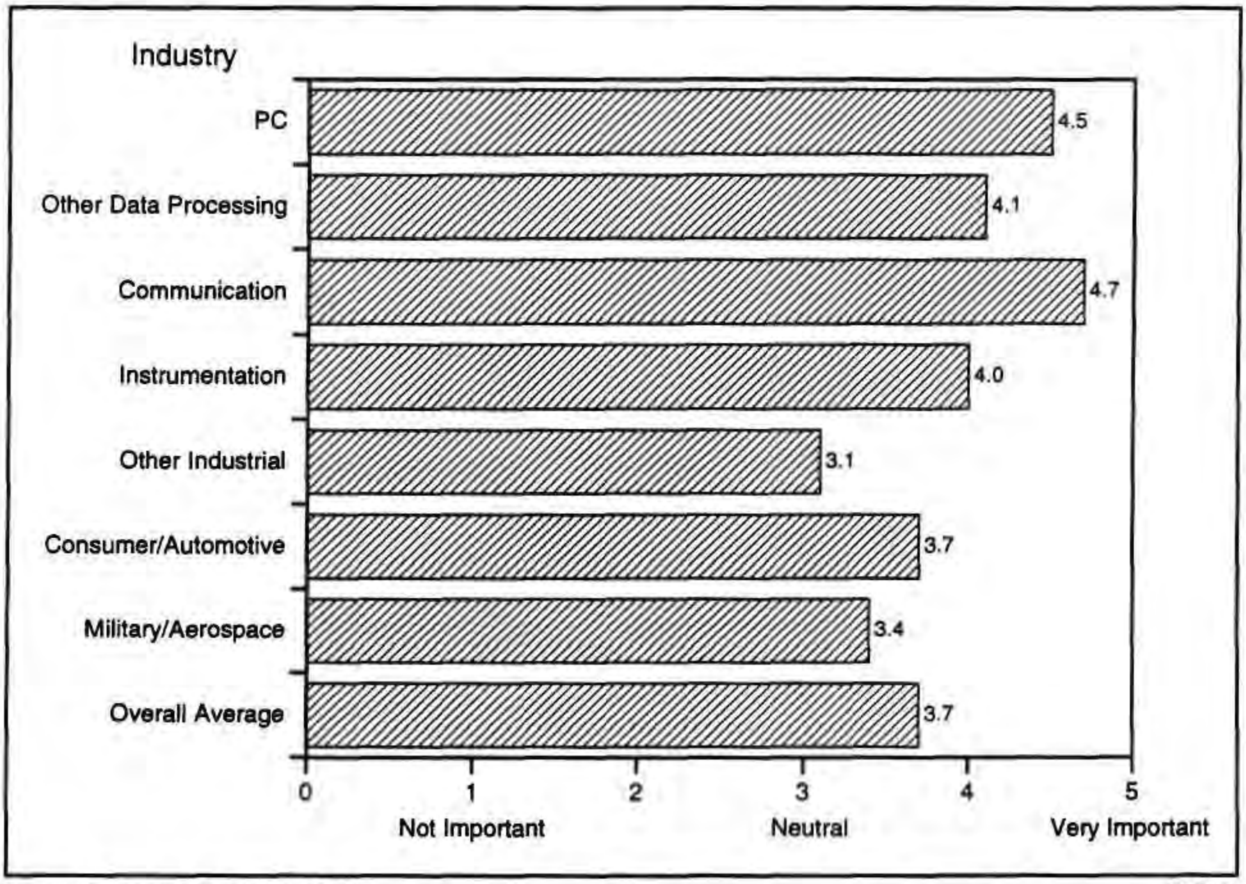


Source: Dataquest (December 1992)

G2001423

The semicustom and design-crucial nature of ASICs seems to shape expectations about quality and design fidelity.

Figure 5-21
ASIC IC Supplier Selection Criteria: Market Flexibility

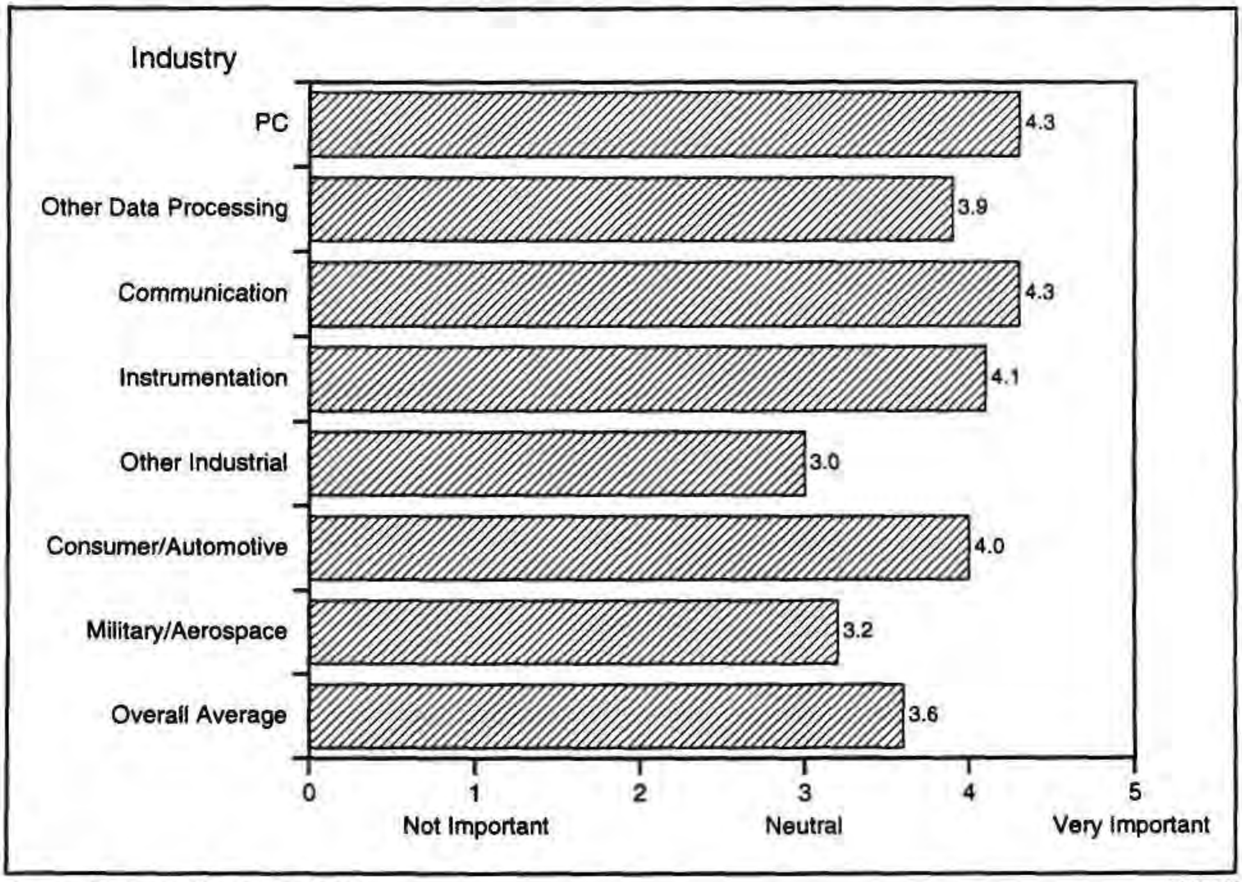


Source: Dataquest (December 1992)

G2001424

Communications and PC OEMs desire the most flexibility.

Figure 5-22
ASIC IC Supplier Selection Criteria: Product Portfolio and Migration Path

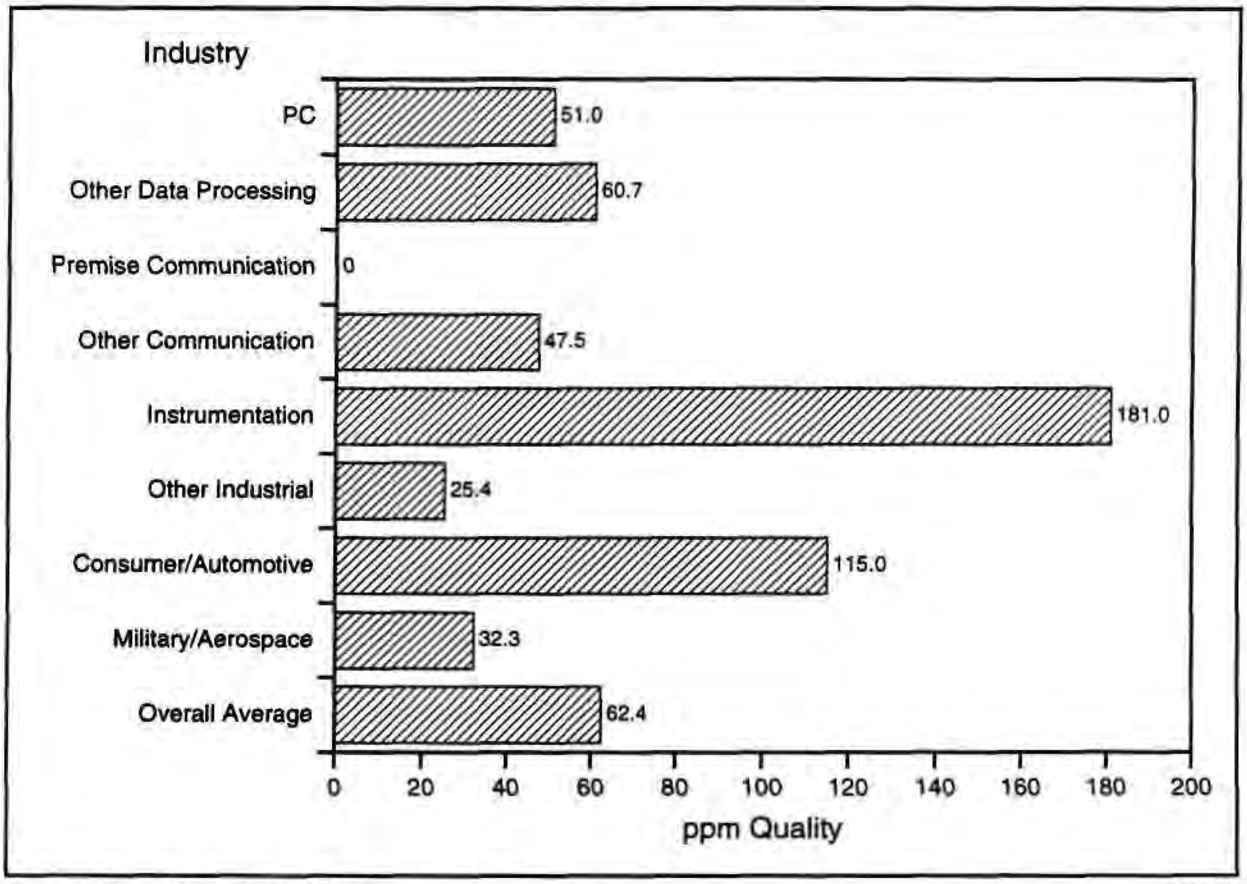


Source: Dataquest (December 1992)

G2001425

OEMs with performance-sensitive applications in computing and communication are concerned about supplier plans to update their ASIC process and design technologies.

Figure 5-23
Minimum Necessary Quality for ASICs (ppm)

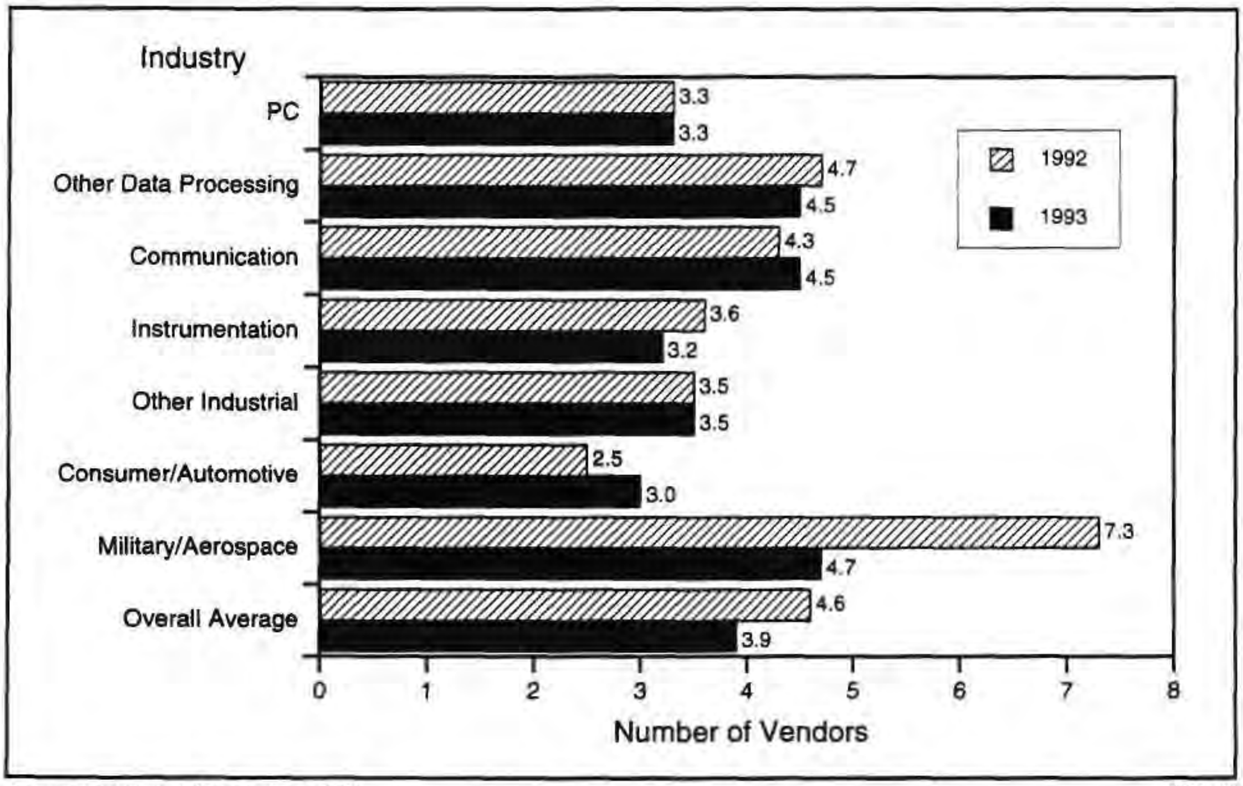


Source: Dataquest (December 1992)

G2001426

Higher-volume ASICs users such as computing and communications OEMs are requiring commensurate higher-quality levels.

Figure 5-24
Number of ASIC Suppliers

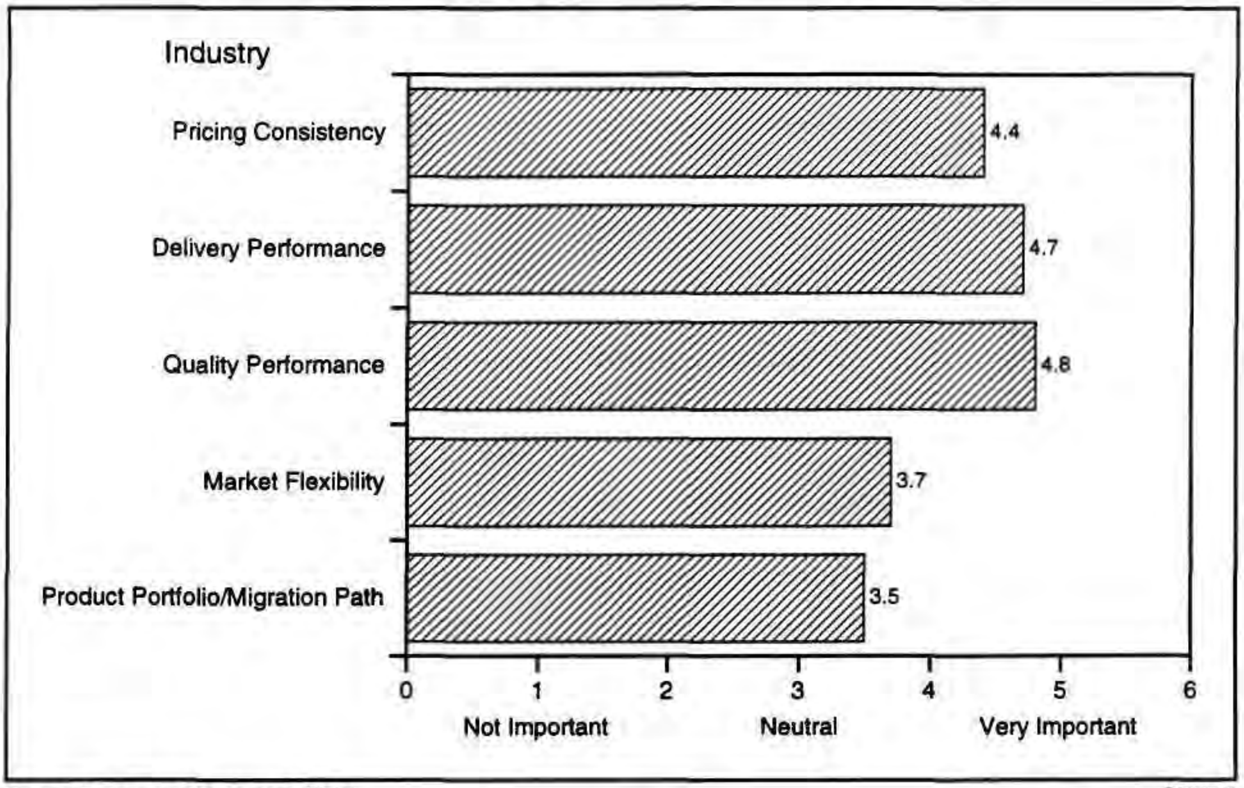


Source: Dataquest (December 1992)

G2001427

On average, ASIC buyers maintained about five separate suppliers in 1992, with plans to reduce that number in 1993 to four.

Figure 5-25
Standard Logic and Analog IC Supplier Selection Criteria: Overall

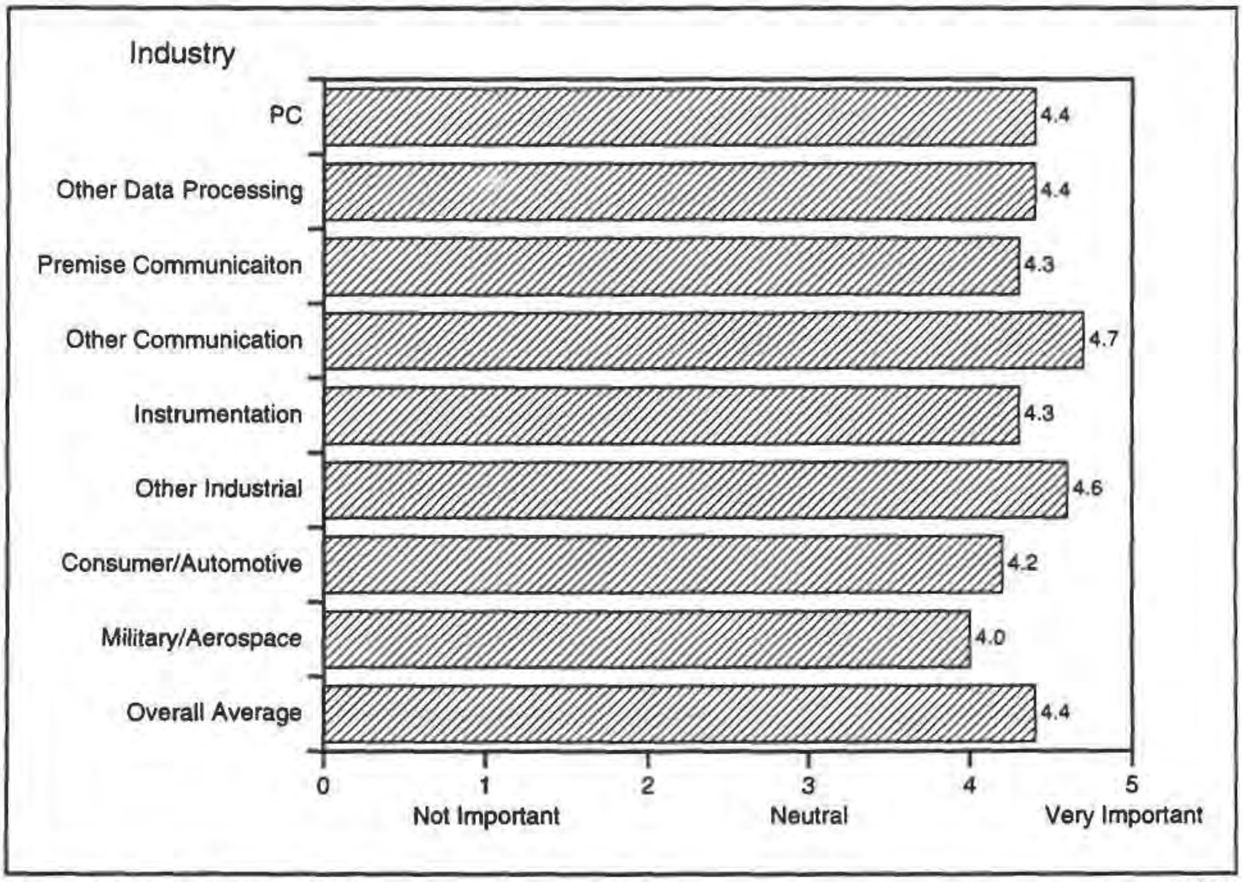


Source: Dataquest (December 1992)

G2001428

Delivery and quality performance share the spotlight in importance.

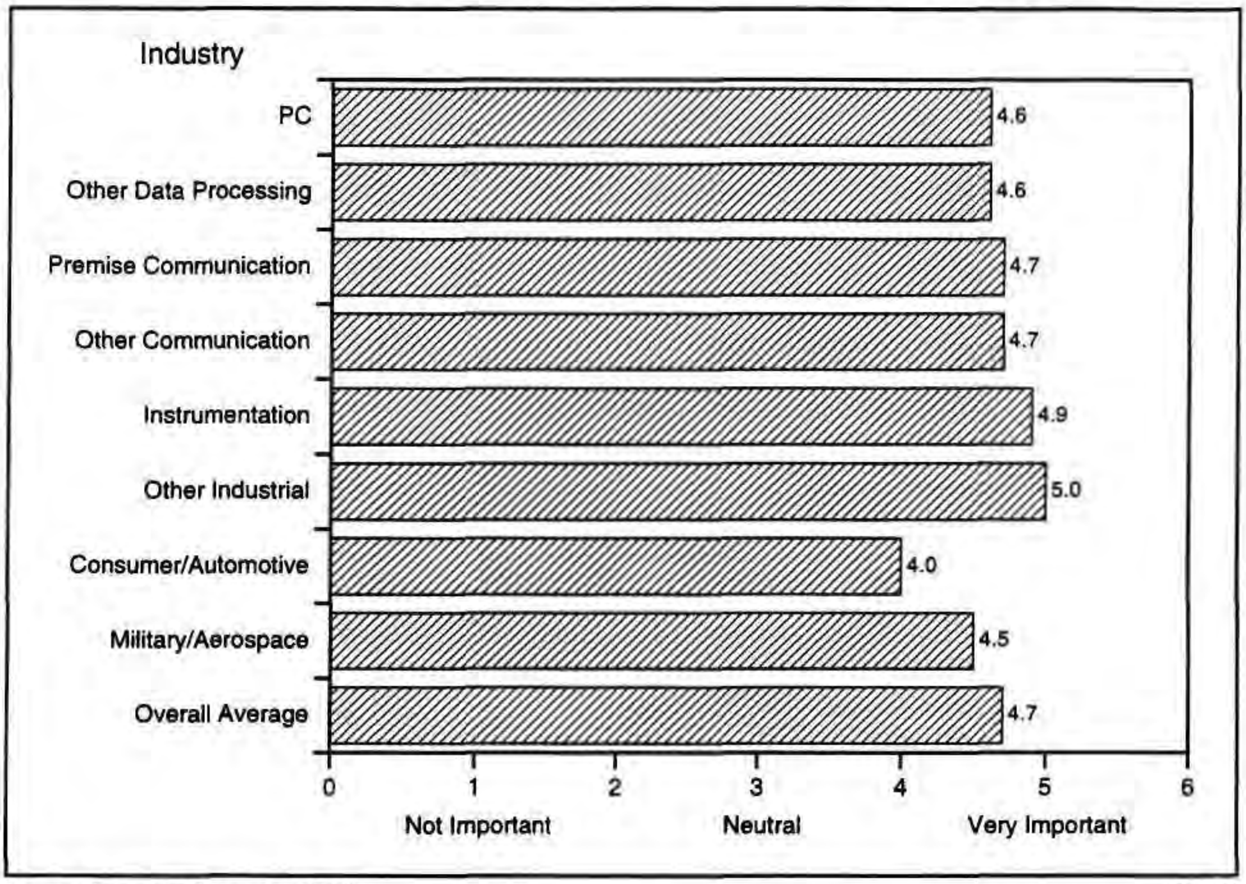
Figure 5-26
Standard Logic and Analog IC Supplier Selection Criteria: Pricing Consistency



Source: Dataquest (December 1992) G2001429

Analog-intensive categories such as communication and industrial are more sensitive to pricing issues.

Figure 5-27
Standard Logic and Analog IC Supplier Selection Criteria: Delivery Performance

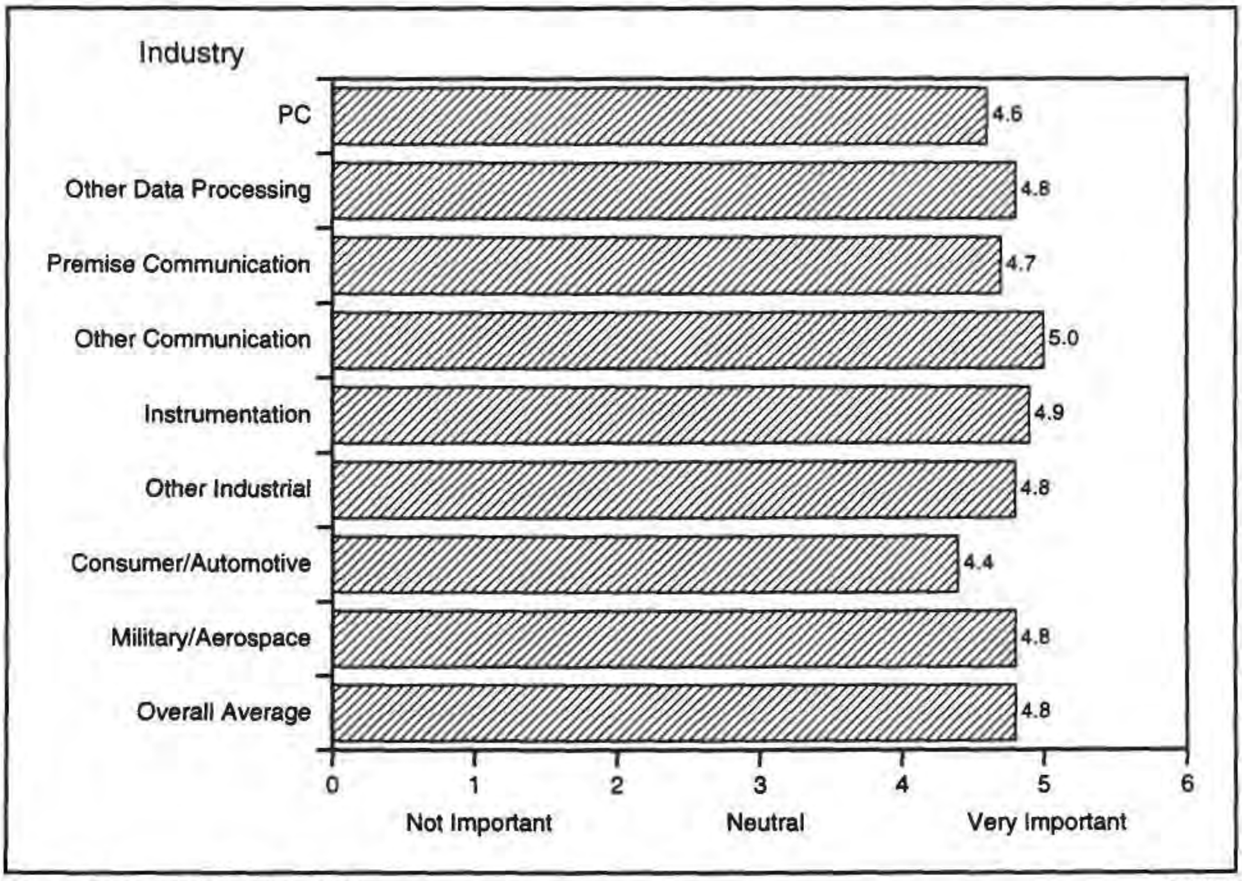


Source: Dataquest (December 1992)

G2001430

As with pricing, analog-intensive applications such as communication and industrial are more sensitive to delivery issues.

Figure 5-28
Standard Logic and Analog IC Supplier Selection Criteria: Quality Performance

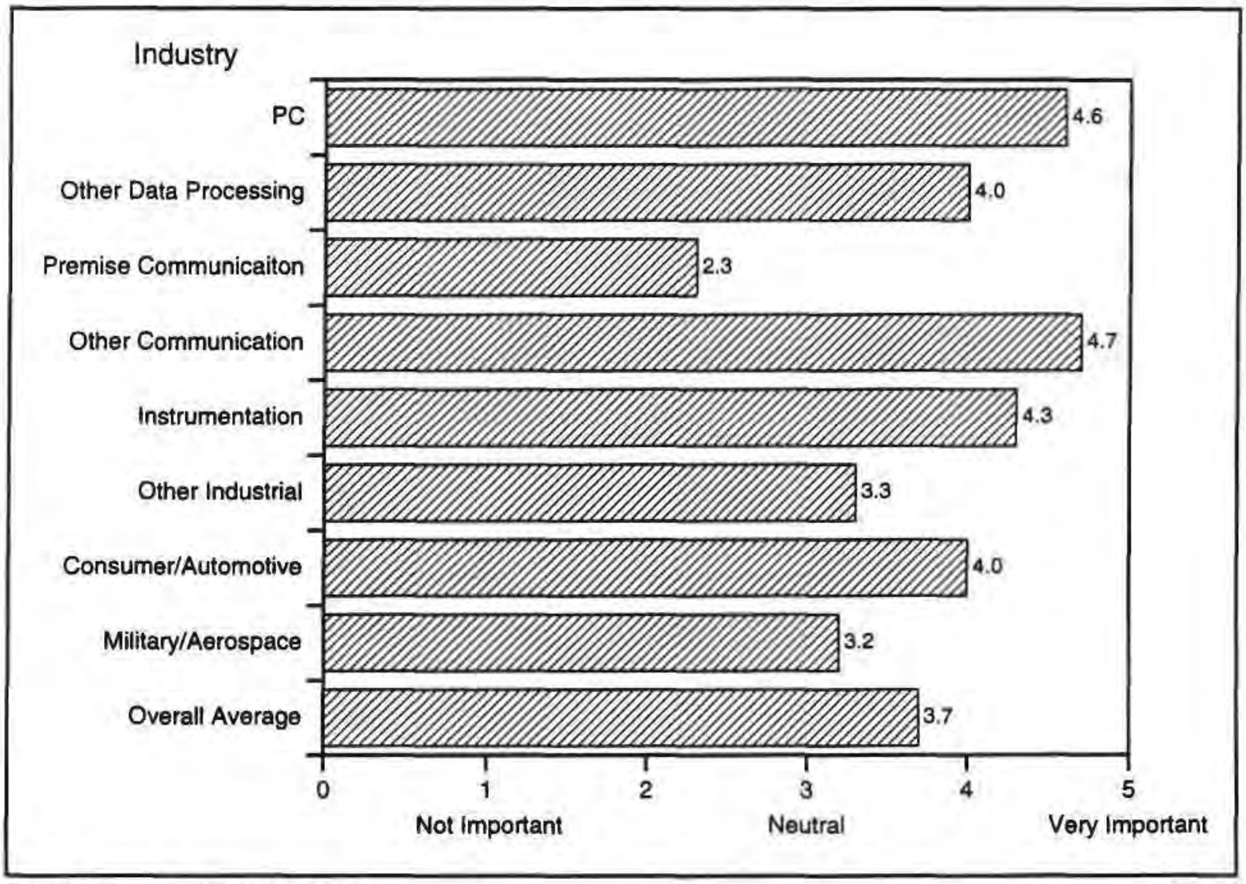


Source: Dataquest (December 1992)

G2001431

This criterion clearly is a prerequisite for doing business.

Figure 5-29
Standard Logic and Analog IC Supplier Selection Criteria: Market Flexibility

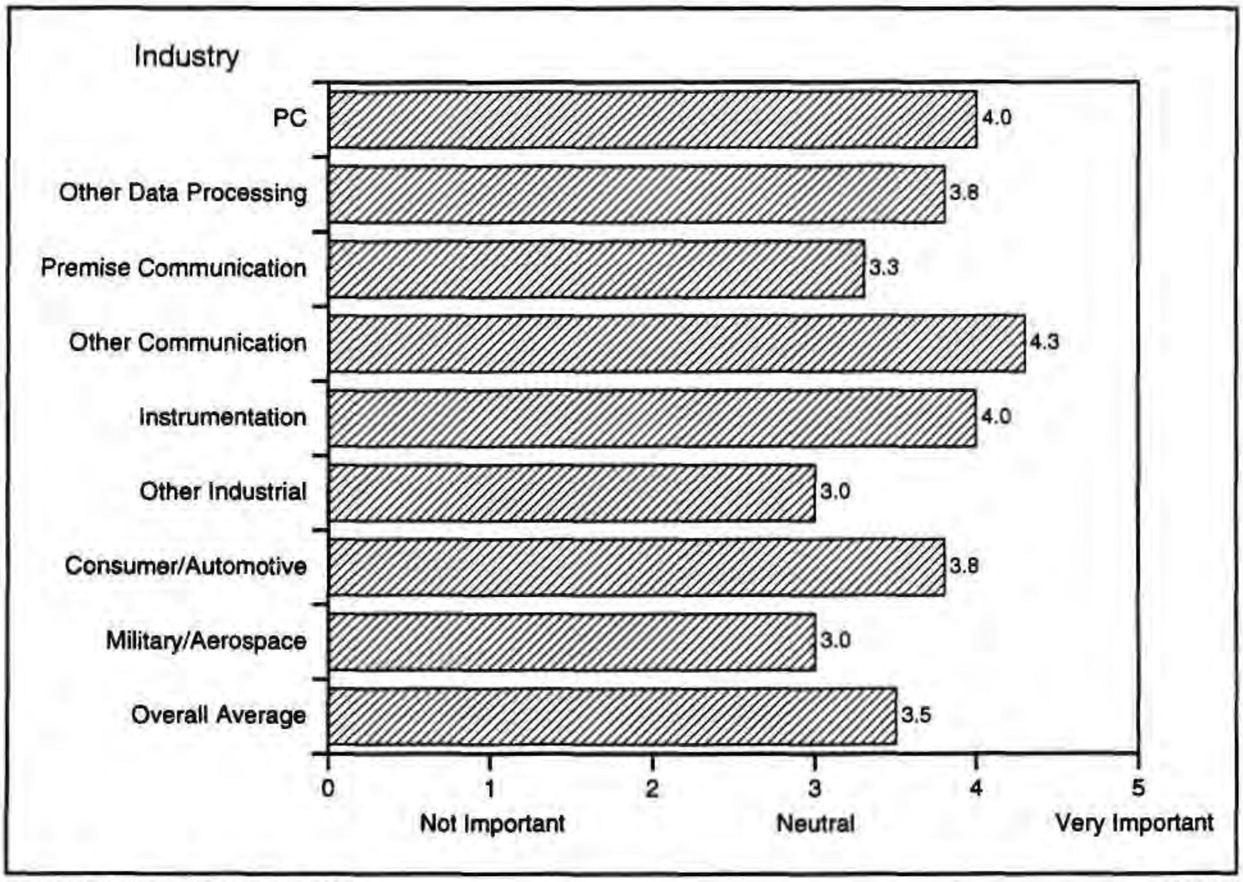


Source: Dataquest (December 1992)

G2001432

Communications and PC OEMs desire the most flexibility.

Figure 5-30
Standard Logic and Analog IC Supplier Selection Criteria: Product Portfolio and Migration Path

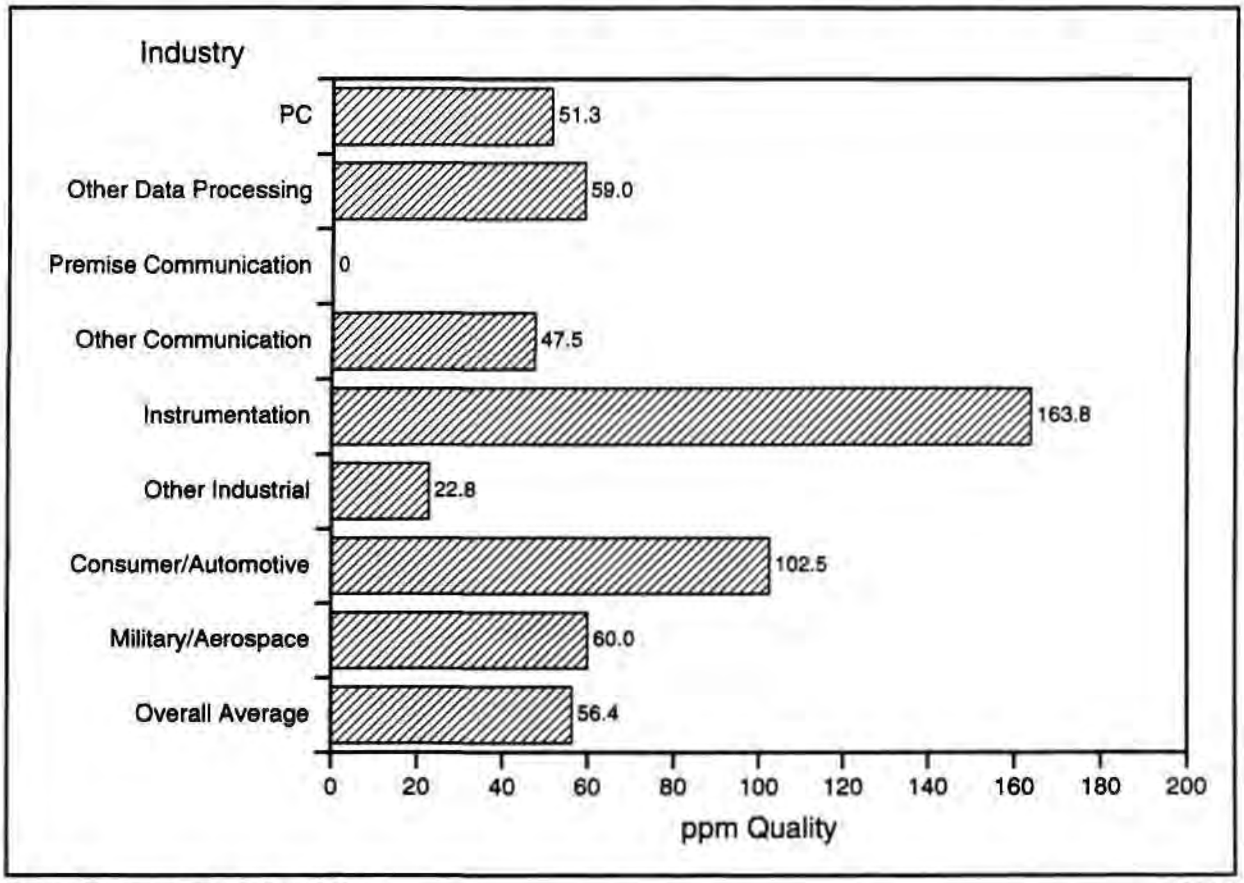


Source: Dataquest (December 1992)

G2001433

Product plans appear to be more crucial to performance-sensitive OEMs in computing and communication.

Figure 5-31
Minimum Necessary Quality for Standard Logic and Analog ICs (ppm)

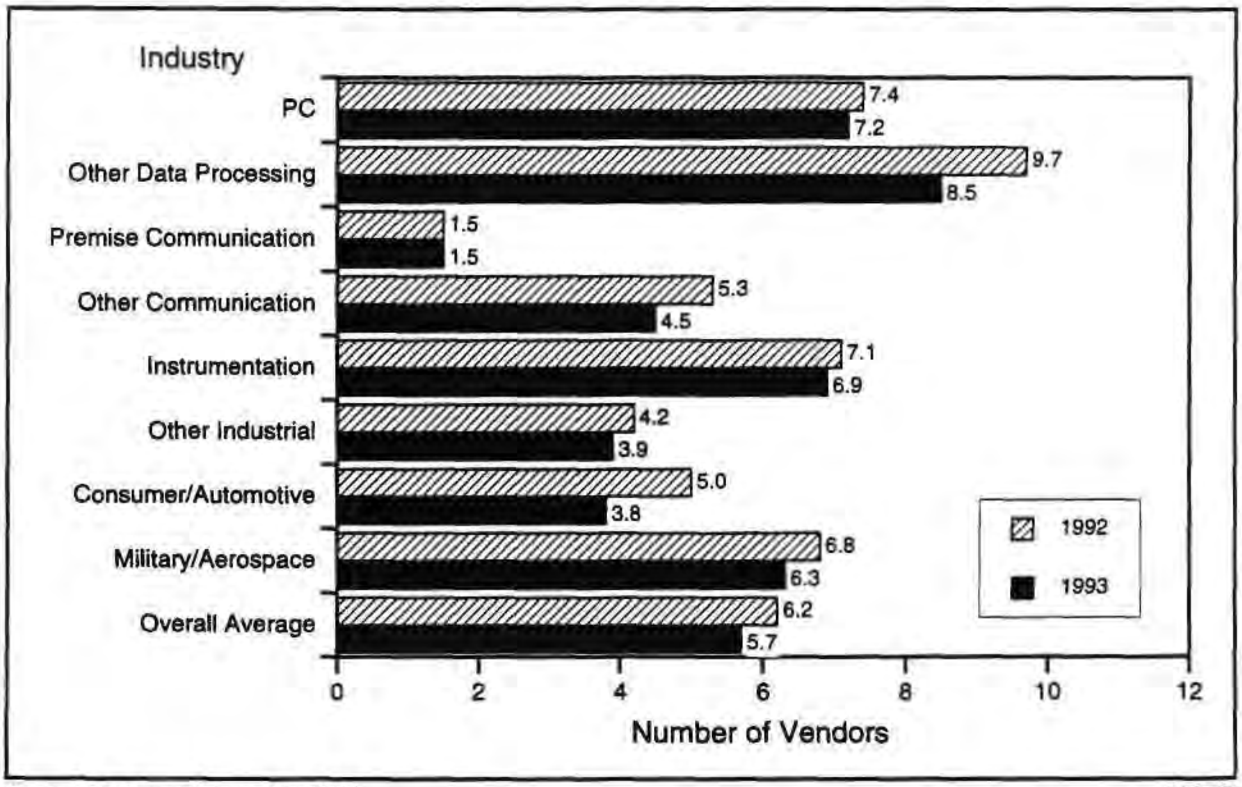


Source: Dataquest (December 1992)

G2001434

Higher-volume users such as computing and communications OEMs are requiring commensurate higher-quality levels.

Figure 5-32
Number of Standard Logic and Analog IC Suppliers



Source: Dataquest (December 1992) G2001435

On average, standard logic and analog buyers maintained about six separate suppliers in 1992, with plans to reduce that number in 1993.

Chapter 6
Recommendations

Semiconductor Marketers

The primary picture that emerges from this report is that chip companies should be aware that relationships are not sacrosanct and eventually are subject to objective tests. OEMs are putting a substantial amount of rigor into managing their costs and hitting aggressive product development schedules, and suppliers that do not provide adequate service are left out. They want fewer, committed suppliers that will help share in the upside and downside phases of the business cycle.

Clearly quality is a go or no-go issue. Either a supplier has world-class, consistently delivered quality better than 60 ppm on average, or it is put on probation or disqualified as a supplier. Delivery performance, on the other hand, seems to separate the weak from the strong suppliers. Shipping to the customer the right product (no mis-shipments) within an acceptable JIT window (+5,-0 days, for example) is the goal to maintain. If anything is important today for OEMs, it is the vitality and speed of product development, and a consistent on-time supplier delivery track record will win a bigger share of annual requirements.

As a final recommendation, those that want to play in the big leagues had better be professional. The data from this survey indicate that high-volume markets such as PCs, peripherals, customer premise communications equipment, and consumer and automotive products demand a higher degree of commitment. In general, these markets require better quality, more exacting delivery, and rock-bottom pricing relative to other markets. In other words, a supplier that wants big volume had better be prepared with benchmarkable programs in process control and outgoing quality, minimal manufacturing cycles, inventory investment to buffer release fluctuations, and a general commitment among its personnel to get the job done.

Semiconductor Users

This study answers many questions regarding what is meant by high quality, on-time delivery, average use of a contract manufacturer, and the like, based on responses from some of the largest or most prominent electronics companies in the United States The process of benchmarking operations against regional competition involves the use of impartial parameters to gauge performance. Semiconductor users can make this information work for them by using it as a basis for comparing themselves against averages in the industry in which they compete, and in efforts to improve semiconductor supplier performance.

The major issues of semiconductor price, availability, and lead time continue to require excellent forecast communication between user and supplier. Both parties are reminded that these issues involve two-way sharing of information. The two main areas that require supplier maintenance (supplier discipline)—high quality and meeting delivery commitments—tacitly imply that semiconductor suppliers now are adequately meeting customer needs in these areas. Pressure should be kept on suppliers to keep quality and delivery commitments.

This report has presented many detailed parameters that should be coordinated and prioritized on an individual company basis in order to get the best use from them. If a little groundwork is done, this information will provide a solid foundation for growth in 1993 and beyond.

Chapter 7
Biographies

Gregory L. Sheppard
Director and Principal Analyst, Semiconductor Group

Role at Dataquest

Mr. Sheppard is responsible for coordinating worldwide semiconductor applications research for Dataquest. Besides his own areas of research, he oversees the research of the Semiconductor Application Markets Worldwide (SAM) service. In addition, he has participated in various custom research projects concerning semiconductor applications.

Program Responsibilities

Specific areas of expertise include:

- Workstation, midrange, high-performance applications
- Multimedia applications
- Communications applications
- Military/aerospace and automotive applications

Mr. Sheppard is a specialist on the end use or application of semiconductors. His scope of analysis includes both economic and technical trends regarding the semiconductor content of electronic equipment.

Professional Experience

Prior to Dataquest, Mr. Sheppard was Worldwide Business Analysis Manager at Fairchild Semiconductor Corporation. In that position he coordinated the worldwide product and market plan that drove investment decisions. He has also been a participant in the World Semiconductor Trade Statistics (WSTS) organization and the American Electronics Association. Previously, he worked in engineering management at GTE Corporation, specializing in communications systems design and decision aid systems.

Education

University of Colorado: B.S., Electrical Engineering/Computer Science, 1979

University of Southern California: M.S., System Management, 1982

Mark Giudici

Director/Principal Analyst, Semiconductor Procurement Service

Role at Dataquest

Mr. Giudici is responsible for tracking and analyzing emerging semiconductor procurement issues and trends. He also covers regional semiconductor prices and cost modeling issues. In addition, he has participated in various custom research projects involving procurement needs and regional price differentials.

Program Responsibilities

Specific areas of expertise include:

- ASIC product/trend analysis
- Worldwide regional price trends
- Cost modeling of semiconductors
- Strategic semiconductor procurement practices

Mr. Giudici is a specialist in the trend analysis and cost-based pricing of semiconductor procurement. His scope of analysis involves both macroeconomic and tactical trends that affect the availability and procurement of semiconductors.

Professional Experience

Prior to joining Dataquest, Mr. Giudici spent eight years in both the computer and semiconductor industries, where he held a variety of financial and marketing positions. Most recently, he was a Product Marketing Engineer with Gould-American Microsystems, where he was responsible for cost modeling and marketing semicustom and foundry-custom semiconductor components.

Education

California State University, Chico: B.S., Business Administration

University of Oregon: M.B.A., Business Management

Eric K. Shigemoto

Market Research Associate, Research Operations

Role at Dataquest

Mr. Shigemoto is a Market Research Associate in the Research Operations Group at Dataquest. Focusing on end-user research, he is responsible for designing and implementing primary research studies. His other responsibilities include questionnaire design, programming, and data analysis. The scope of projects Mr. Shigemoto manages includes Dataquest's User Wants and Needs surveys, custom consulting projects, and Dataquest's syndicated SCORE Customer Satisfaction product.

Program Responsibilities

The end-user research areas that Mr. Shigemoto is responsible for within the Research Operations Group include the following:

- User Wants and Needs—Examination of buying patterns and budgets, and future product and purchase plans
- Custom consulting studies—Custom end-user research, often involving conducting interviews worldwide
- SCORE Customer Satisfaction—A syndicated product analyzing customer satisfaction of desktop computers. Users of desktop computers are contacted on a quarterly basis.
- Surveys for *Dataquest Perspectives*—Event-driven analyses of various technology markets

Professional Experience

Prior to joining Dataquest, Mr. Shigemoto worked as a Market Research Analyst focusing on custom and syndicated research studies at OmniTrak Group Incorporated. His primary responsibilities at OmniTrak included questionnaire design, programming, data analysis, and report writing.

Education

San Jose State University: B.S., Marketing, Minor in Advertising

Mario Morales

Senior Interviewer, Field Interviewing, Research Operations Group

Role at Dataquest

Mr. Morales is the senior interviewer of Field Interviewing in the Research Operations group at Dataquest. With a staff of up to 39 interviewers, including 13 permanent interviewers and a flex staff of 25, Mr. Morales is responsible for assisting the supervisor with scheduling, coordination, and data collection of end-user surveys, vendor shipments, pricing, and market share statistics. The scope of these projects varies from small, specific studies targeting a population of 15 respondents to large quarterly studies with as many as 5,000 end-user interviews. Mr. Morales also acts as a project leader for international projects that require surveys conducted in Spanish, in which he is fluent. In addition, Mr. Morales has responsibility for monitoring and managing the networked computer-aided interviewing system.

Program Responsibilities

Mr. Morales assists with scheduling and training for the field interviewing area within Research Operations. His responsibilities include the following:

- Monitoring 39 telephone interviewing stations
- Twenty eight computer-aided telephone interviewing stations, with automated sample management, online monitoring, and quota updating
- Paper and pencil surveys checked for quality and accuracy to accommodate open-ended interviews
- Quarterly customer satisfaction surveys with end users
- High-level executive and technology-specific interviews
- Monthly and quarterly panels interviewed for semiconductor pricing surveys
- Focus group recruitment for our on-site focus group facility

Education

Mr. Morales attends Evergreen Valley College in San Jose, California, where he is completing an A.A. degree in Business Marketing. He will pursue a B.S. degree in Marketing and Economics at San Jose State University in spring 1993.

Appendix A
Survey Questionnaire

General Information

Hello, this is ______________________ from Dataquest Incorporated. We're conducting a study on semiconductor purchasing and your input would be most important to us.

Would you be the person who is in charge of purchasing semiconductors that have been selected to be used in the last two or three years at your location?

If not, is there someone else at your location I might speak to who would be knowledgeable in this area?

Do you have a few minutes to answer some questions? The results of this study will be used by leaders of the semiconductor industry as an industry benchmark series from which to improve upon. (If needed: *this is not a sales call and your answers will be kept completely confidential.)*

Q.1 Do you purchase semiconductors for the entire company, a single division, or just your department/work group? (ONE RESPONSE)

- Entire company ❑
- Single division ❑
- Department/Work group ❑
- Refusal ❑

Q.2 Dataquest segments electronic equipment into six categories. Which of the following describes your company's main lines of business? (READ LIST; ALLOW MULTIPLE RESPONSES)

- Data processing ❑
- Communications ❑
- Industrial/Manufacturing ❑
- Consumer ❑
- Military/Aerospace ❑
- Transportation ❑

Q.3 Please list the 3 main types of equipment in which your company uses the semiconductors that you buy. What is the first main type? (ONE RESPONSE)

- Data Processing—Computers ❑
- PCs ❑
- Workstations ❑
- Midrange ❑

Mainframe ❑
Super ❑
Other ______
Data Processing—Data Storage ❑
Disk ❑
Optical ❑
Tape ❑
Other ______
Data Processing—Input/Output ❑
Optical scan equipment ❑
Plotters ❑
Printers ❑
Terminals ❑
Other ______
Data Processing—Dedicated Systems ❑
Banking ❑
Office automation ❑
Point-of-sale terminals ❑
Smart cards ❑
Other ......
Data Processing—Graphic/Video Add-In Boards ❑
Data Processing—Other ______
Communications—Customer Premises Communications ❑
Business communications systems ❑
Data PBX ❑
Facsimile ❑
Local area networks ❑
Modems ❑
Single-line phones ❑
T-1 multiplexers ❑
Video teleconference ❑
Other ______
Communications—Public Telecommunications ❑
Switching equipment ❑
Transmission equipment ❑
Other ______
Communications—Radio ❑
Amateur ❑
Broadcast receive/transmit ❑
Cellular radio/telephone ❑
Mobile system ❑
Other ______

Communications—Studio ☐
Audio equipment ☐
Video equipment ☐
Other ____________
Industrial/Manufacturing—Security/Energy Management: Alarm Systems ☐
Other ____________
Industrial/Manufacturing—Manufacturing Systems ☐
Automated material handling ☐
Robot systems ☐
Semiconductor production ☐
Test equipment ☐
Other ____________
Industrial/Manufacturing—Instrumentation ☐
Analytical/scientific ☐
Geophysical ☐
Meteorological ☐
Other ____________
Industrial/Manufacturing—Medical Equipment ☐
All ☐
Industrial/Manufacturing—Miscellaneous Equipment ☐
Laser (not communications/medical) ☐
Power supplies ☐
Vending machines ☐
Other ____________
Consumer Products ☐
Appliance ☐
Audio equipment ☐
Garage door opener ☐
Color TVs ☐
Personal electronics ☐
VTRs (VCRs) ☐
Consumer products ☐
Other ____________
Military/Aerospace—Military Defense ☐
Avionics ☐
Communications ☐
Electronic warfare ☐
Missiles/weapons ☐
Shipboard ☐
Space ☐
Commercial aerospace ☐
Other ____________

Transportation—Auto/Light Truck ❑
Body controls ❑
Power train ❑
Auto/light truck ❑
Other__________
Don't know/refusal/no response ❑

(IF QUESTION 3 IS "Don't know/refusal/no response," THEN SKIP TO QUESTION 6)

Q.4 What is the second main type? (ONE RESPONSE)
Data Processing—Computers ❑
PCs ❑
Workstations ❑
Midrange ❑
Mainframe ❑
Super ❑
Other__________
Data Processing—Data Storage ❑
Disk ❑
Optical ❑
Tape ❑
Other__________
Data Processing—Input/Output ❑
Optical scan equipment ❑
Plotters ❑
Printers ❑
Terminals ❑
Other__________
Data Processing—Dedicated Systems ❑
Banking ❑
Office automation ❑
Point-of-sale terminals ❑
Smart cards ❑
Other__________
Data Processing—Graphic/Video Add-In Boards ❑
Data Processing—Other__________
Communications—Customer Premises Communications ❑
Business communications systems ❑
Data PBX ❑
Facsimile ❑
Local area networks ❑
Modems ❑

Single-line phones ☐
T-1 multiplexers ☐
Video teleconference ☐
Other ____________
Communications—Public Telecommunications ☐
Switching equipment ☐
Transmission equipment ☐
Other ____________
Communications—Radio ☐
Amateur ☐
Broadcast receive/transmit ☐
Cellular radio/telephone ☐
Mobile system ☐
Other ____________
Communications—Studio ☐
Audio equipment ☐
Video equipment ☐
Other ____________
Industrial/Manufacturing—Security/Energy Management: Alarm Systems ☐
Other ____________
Industrial/Manufacturing—Manufacturing Systems ☐
Automated material handling ☐
Robot systems ☐
Semiconductor production ☐
Test equipment ☐
Other ____________
Industrial/Manufacturing—Instrumentation ☐
Analytical/scientific ☐
Geophysical ☐
Meteorological ☐
Other ____________
Industrial/Manufacturing—Medical Equipment ☐
All ☐
Industrial/Manufacturing—Miscellaneous Equipment ☐
Laser (not communications/medical) ☐
Power supplies ☐
Vending machines ☐
Other ____________
Consumer Products ☐
Appliance ☐
Audio equipment ☐
Garage door opener ☐

Color TVs ☐
Personal electronics ☐
VTRs (VCRs) ☐
Consumer products ☐
Other____
Military/Aerospace—Military Defense ☐
Avionics ☐
Communications ☐
Electronic warfare ☐
Missiles/weapons ☐
Shipboard ☐
Space ☐
Commercial aerospace ☐
Other____
Transportation—Auto/Light Truck ☐
Body controls ☐
Power train ☐
Auto/light truck ☐
Other____
Don't know/refusal/no response ☐

(IF QUESTION 4 IS "Don't know/refusal/no response," THEN SKIP TO QUESTION 6)

Q.5 What is the third main type? (ONE RESPONSE)

Data Processing—Computers ☐
PCs ☐
Workstations ☐
Midrange ☐
Mainframe ☐
Super ☐
Other____
Data Processing—Data Storage ☐
Disk ☐
Optical ☐
Tape ☐
Other____
Data Processing—Input/Output ☐
Optical scan equipment ☐
Plotters ☐
Printers ☐
Terminals ☐
Other____

Data Processing—Dedicated Systems ☐
Banking ☐
Office automation ☐
Point-of-sale terminals ☐
Smart cards ☐
Other ______
Data Processing—Graphic/Video Add-In Boards ☐
Data Processing—Other ______
Communications—Customer Premises Communications ☐
Business communications systems ☐
Data PBX ☐
Facsimile ☐
Local area networks ☐
Modems ☐
Single-line phones ☐
T-1 multiplexers ☐
Video teleconference ☐
Other ______
Communications—Public Telecommunications ☐
Switching equipment ☐
Transmission equipment ☐
Other ______
Communications—Radio ☐
Amateur ☐
Broadcast receive/transmit ☐
Cellular radio/telephone ☐
Mobile system ☐
Other ______
Communications—Studio ☐
Audio equipment ☐
Video equipment ☐
Other ______
Industrial/Manufacturing—Security/Energy Management: Alarm Systems ☐
Other ______
Industrial/Manufacturing—Manufacturing Systems ☐
Automated material handling ☐
Robot systems ☐
Semiconductor production ☐
Test equipment ☐
Other ______
Industrial/Manufacturing—Instrumentation ☐
Analytical/scientific ☐

Geophysical ❑
Meteorological ❑
Other__________
Industrial/Manufacturing—Medical Equipment ❑
All ❑
Industrial/Manufacturing—Miscellaneous Equipment ❑
Laser (not communications/medical) ❑
Power supplies ❑
Vending machines ❑
Other__________
Consumer Products ❑
Appliance ❑
Audio equipment ❑
Garage door opener ❑
Color TVs ❑
Personal electronics ❑
VTRs (VCRs) ❑
Consumer products ❑
Other__________
Military/Aerospace—Military Defense ❑
Avionics ❑
Communications ❑
Electronic warfare ❑
Missiles/weapons ❑
Shipboard ❑
Space ❑
Commercial aerospace ❑
Other__________
Transportation—Auto/Light Truck ❑
Body controls ❑
Power train ❑
Auto/light truck ❑
Other__________
Don't know/refusal/no response ❑

Q.6 What is the average market life cycle of your principal product?

____

Q.7 In days, what is your definition of on-time delivery? (e.g., +2 -0, or ±2 days)

____

Q.8 Do you currently use a contract manufacturer?
- Yes ☐
- No ☐
- Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 8 IS "No," THEN SKIP TO QUESTION 10)

(IF THE ANSWER TO QUESTION 8 IS "Don't know/refusal," THEN SKIP TO QUESTION 11)

Q.9 How many years have you used one?

____

(PLEASE ANSWER QUESTION 10 IF ANSWER TO QUESTION 8 WAS "No")

Q.10 Do you plan on using a contract manufacturer in the next year?
- Yes ☐
- No ☐
- Don't know/refusal ☐

Q.11 Does your company design its own circuit boards?
- Yes ☐
- No ☐
- Don't know/refusal ☐

(IF THE ANWER TO QUESTION 11 WAS "No" OR "Don't know/refusal," PLEASE SKIP TO QUESTION 16)

Q.12 What percentage of the circuit boards were made in-house in 1992?

______________________________(percent)

Q.13 What percentage of the circuit boards will be made in-house in 1993?

______________________________(percent)

(IF THE ANSWER TO QUESTION 8 IS "No" or "Don't know/refusal," THEN SKIP TO QUESTION 16)

Q.14 Does your company purchase the semiconductors used by the outside contractors?
- Yes ☐
- No ☐
- Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 14 IS "No" or "Don't know/refusal," THEN SKIP TO QUESTION 16)

Q.15 Are terms decided by the contractor?

Yes ❑
No ❑
Don't know/refusal ❑

Q.16 Of all the purchasing issues you expect to face next year, what would be the major one? (ONE RESPONSE)

ASICs ❑
Availability ❑
Cost control ❑
Develop key supplier/user relationships ❑
Government regulations ❑
Just-in-time inventory control ❑
Memory products ❑
New products/obsolescence ❑
On-time delivery ❑
Packaging standards ❑
Pricing ❑
Quality/reliability ❑
Lead time ❑
Development schedules ❑
Allocation ❑
ASICs design tools ❑
Flexibility/service ❑
Other (specify) ________________
Don't know/refusal ❑

(IF THE ANSWER TO QUESTION 16 IS "Don't know/refusal," THEN SKIP TO QUESTION 22)

Q.17 What would be the second major purchasing issue you expect to face? (ONE RESPONSE)

ASICs ❑
Availability ❑
Cost control ❑
Develop key supplier/user relationships ❑
Government regulations ❑
Just-in-time inventory control ❑
Memory products ❑
New products/obsolescence ❑
On-time delivery ❑
Packaging standards ❑
Pricing ❑
Quality/reliability ❑
Lead time ❑

- Development schedules ☐
- Allocation ☐
- ASICs design tools ☐
- Flexibility/service ☐
- Other (specify)________
- Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 17 IS "Don't know/refusal," THEN SKIP TO QUESTION 19)

Q.18 What would be the third major purchasing issue you expect to face? (ONE RESPONSE)

- ASICs ☐
- Availability ☐
- Cost control ☐
- Develop key supplier/user relationships ☐
- Government regulations ☐
- Just-in-time inventory control ☐
- Memory products ☐
- New products/obsolescence ☐
- On-time delivery ☐
- Packaging standards ☐
- Pricing ☐
- Quality/reliability ☐
- Lead time ☐
- Development schedules ☐
- Allocation ☐
- ASICs design tools ☐
- Flexibility/service ☐
- Other (specify)________
- Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 18 IS "Don't know/refusal," THEN SKIP TO QUESTION 19)

Q.19 On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important is (response to Q.16) to you?

- Not at all important ☐
- Not very important ☐
- Neutral ☐
- Somewhat important ☐
- Very important ☐
- Don't know/refusal ☐

Q.20 On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important is (response to Q.17) to you?

Not at all important ☐
Not very important ☐
Neutral ☐
Somewhat important ☐
Very important ☐
Don't know/refusal ☐

Q.21 On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important is (response to Q.18) to you?

Not at all important ☐
Not very important ☐
Neutral ☐
Somewhat important ☐
Very important ☐
Don't know/refusal ☐

Q.22 Does your company have a regular, ongoing procedure of supplier evaluation?

Yes ☐
No ☐
Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 22 IS "No" OR "Don't know/refusal," THEN SKIP TO QUESTION 24)

Q.23 On what parameters does your company evaluate suppliers?

Quality ☐
Delivery ☐
Technical support ☐
Price ☐
Other (specify)________________
Don't know/refusal ☐

Q.24 What are one or two key factors ("cardinal sins") that can cause a current supplier to lose business from your company?

____

____

Q.25 Do you have a strategic partnering program in place?

Yes ☐
No ☐
Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 25 IS "No" OR "Don't know/refusal," THEN SKIP TO QUESTION 27)

Q.26 Would you consider the program critical, beneficial, or nice to have?
- Critical ☐
- Beneficial ☐
- Nice to have ☐
- Don't know/refusal ☐

Q.27 Do you have a quality improvement program in place?
- Yes ☐
- No ☐
- Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 27 IS "No" OR "Don't know/refusal," THEN SKIP TO QUESTION 30)

Q.28 Is it an internal or a supplier program?
- Internal ☐
- Supplier ☐
- Both ☐
- Don't know/refusal ☐

Q.29 Would you consider the program critical, beneficial, or nice to have?
- Critical ☐
- Beneficial ☐
- Nice to have ☐
- Don't know/refusal ☐

Q.30 Who are your three major suppliers of semiconductors?

____

____

____

Q.31 Which one of these suppliers do you prefer to do business with?

____

Q.32 What percent of your 1992 semiconductor purchases were used in _____
(FIRST MAIN TYPE IN QUESTION 3) (TOTAL OF ALL TYPES MUST = 100%)
(DK = Don't know; REF = Refusal)

(IF "No Second Type" IN QUESTION 4, THEN SKIP TO QUESTION 35)

Q.33 What percent of your 1992 semiconductor purchases were used in _____
(SECOND MAIN TYPE IN QUESTION 4) (TOTAL OF ALL TYPES MUST = 100%)
(DK = Don't know, REF = Refusal)

(IF "No Third Type" IN QUESTION 5, THEN SKIP TO QUESTION 35)

Q.34 What percent of your 1992 semiconductor purchases were used in ______ (THIRD MAIN TYPE IN QUESTION 5) (MUST = 100%) (DK = Don't know; REF = Refusal)

Q.35 What percent of your 1992 semiconductor purchases were used in "Other types of equipment" ________ (MUST = 100%) (DK = Don't know; REF= Refusal)

Q.36 What was your company's (entire company/division/work group) total dollar value of semiconductor purchases for 1992? (ENTER IN HUNDRED THOUSANDS, e.g., 1=100,000)

____

Don't know/refusal .... ❑

(IF THE ANSWER TO QUESTION 36 IS NOT "Don't know/refusal," THEN SKIP TO QUESTION 38)

Q.37 What would you estimate your company's total dollar value of semiconductor purchases was for 1992?

Less than $1M .... ❑
$1M - $9.9M .... ❑
$10M - $24.9M .... ❑
$25M - $49.9M .... ❑
$50M - $99.9M .... ❑
$100M - $249.9M .... ❑
$250M or more .... ❑
Don't know/refusal .... ❑

Q.38 Of your semiconductor purchases, what percent of your manufacturing needs will be physically assembled on to circuit boards in the following four regions: USA, Japan, Europe, and Other? (TOTAL MUST EQUAL 100%)

USA______________________________
Japan______________________________
Europe______________________________
Other______________________________

Q.39 What would you expect your company's (entire company/division/work group) total dollar value of semiconductor purchases to be for 1993 ? (ENTER IN HUNDRED THOUSANDS, e.g.,1=100,000)

____

Don't know/refusal .... ❑

(IF THE ANSWER TO QUESTION 39 IS NOT "Don't know/refusal," THEN SKIP TO QUESTION 41)

Q.40 What would you estimate your company's total dollar value of semiconductor purchases will be for 1993?

- Less than $1M ☐
- $1M - $9.9M ☐
- $10M - $24.9M ☐
- $25M - $49.9M ☐
- $50M - $99.9M ☐
- $100M - $249.9M ☐
- $250M or more ☐
- Don't know/refusal ☐

Q.41 On a dollar basis, what percent of your total 1992 semiconductor purchases were in each of the following three categories: Integrated Circuit, Discrete, Optoelectronics? (TOTAL MUST = 100%)

- Integrated Circuit ____
- Discrete ____
- Optoelectronics ____
- Don't know/refusal ☐

(IF ANSWER TO QUESTION 41 IS "Discrete + 1-100%" CONTINUE, OTHERWISE SKIP TO QUESTION 43)

Q.42 What percent of your discrete purchases were for power devices?

____

Q.43 On a dollar bases, what percent of your 1992 integrated circuit purchases were in the following four technologies?

- Memory ____
- General-purpose microcomponents/ASSPs ____
- ASICs ____
- Standard logic/linear/analog ____

(FOR THOSE WHO ANSWERED 1-100% FOR "Memory" IN QUESTION 43, ASK QUESTIONS 44 THROUGH 53, OTHERWISE SKIP TO QUESTION 54)

Q.44 What percent of MOS "memory" are the following four products? (MUST = 100%)

- DRAM ____
- VRAM ____
- SRAM ____
- Nonvolatile ____
- Don't know/refusal ☐

On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important are the following criteria when selecting a memory vendor.

Q.45 How important is pricing consistency?
Not at all important__________
Not very important__________
Neutral__________
Somewhat important__________
Very important__________
Don't know/refusal ☐

Q.46 How important is delivery performance?
Not at all important__________
Not very important__________
Neutral__________
Somewhat important__________
Very important__________
Don't know/refusal ☐

Q.47 How important is quality performance?
Not at all important__________
Not very important__________
Neutral__________
Somewhat important__________
Very important__________
Don't know/refusal ☐

Q.48 How important is market flexibility?
Not at all important__________
Not very important__________
Neutral__________
Somewhat important__________
Very important__________
Don't know/refusal ☐

Q.49 How important is product portfolio and migration path?
Not at all important__________
Not very important__________
Neutral__________
Somewhat important__________
Very important__________
Don't know/refusal ☐

Q.50 What is the minimum necessary level of quality for memories, in PPM or AQL?

___

Q.51 How many memory vendors did you have in 1992?

___

Q.52 How many memory vendors do you expect to have in 1993?

___

Q.53 What new memory IC product features do you need for your next-generation products?

___

(FOR THOSE WHO ANSWERED 1-100% FOR "General-Purpose Microcomponents/ASSPs" IN QUESTION 43, ASK QUESTIONS 54 THROUGH 64, OTHERWISE SKIP TO QUESTION 65)

Q.54 What percent of general-purpose "microcomponents" are the following four products? (TOTAL MUST = 100%)

Microprocessors (MPU)___
Microcontrollers (MCU)___
Microperipherals___
DSP MPUs___
Don't know/refusal .... ☐

Q.55 What percent of your ASSP purchases were in each of the following categories? (TOTAL MUST = 100%)

System logic chip sets___
Graphics/video___
Communication___
Storage___
Other___

On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important are the following criteria when selecting a general-purpose microcomponent/ ASSP vendor?

Q.56 How important is pricing consistency?

Not at all important___
Not very important___
Neutral___
Somewhat important___
Very important___
Don't know/refusal .... ☐

Q.57 How important is delivery perfomance?

Not at all important_____

Not very important_____

Neutral_____

Somewhat important_____

Very important_____

Don't know/refusal ..... ☐

Q.58 How important is quality performance?

Not at all important_____

Not very important_____

Neutral_____

Somewhat important_____

Very important_____

Don't know/refusal ..... ☐

Q.59 How important is market flexibility?

Not at all important_____

Not very important_____

Neutral_____

Somewhat important_____

Very important_____

Don't know/refusal ..... ☐

Q.60 How important is product portfolio and migration path?

Not at all important_____

Not very important_____

Neutral_____

Somewhat important_____

Very important_____

Don't know/refusal ..... ☐

Q.61 What is the minimum necessary level of quality for general-purpose microcomponents/ASSPs in PPM or AQL?

_____

Q.62 How many general-purpose microcomponent/ASSP vendors did you have in 1992?

_____

Q.63 How many general-purpose microcomponent/ASSP vendors do you expect to have in 1993?

____

Q.64 What new general-purpose microcomponent/ASSP product features do you need for your next-generation products?

____

(FOR THOSE WHO ANSWERED 1-100% FOR "ASICs" IN QUESTION 43, ASK QUESTIONS 65 THROUGH 74, OTHERWISE SKIP TO QUESTION 75)

Q.65 What percent of ASIC purchases were in each of the following categories? (TOTAL MUST = 100%)

Bipolar gate arrays, cells, etc.______

Bipolar PLDs______

MOS gate arrays______

Mixed analog and digital______

MOS cell-based/custom______

MOS PLD/FPGA______

On a scale of 1 to 5, with 1 being not at all important and 5 being very important, how important are the following criteria when selecting an ASIC vendor?

Q.66 How important is pricing consistency?

Not at all important______

Not very important______

Neutral______

Somewhat important______

Very important______

Don't know/refusal........☐

Q.67 How important is delivery perfomance?

Not at all important______

Not very important______

Neutral______

Somewhat important______

Very important______

Don't know/refusal........☐

Q.68 How important is quality performance?

Not at all important______

Not very important______

Neutral______

Somewhat important______

Very important______

Don't know/refusal........☐

Q.69 How important is market flexibility?

Not at all important____________________

Not very important____________________

Neutral____________________

Somewhat important____________________

Very important____________________

Don't know/refusal .... ☐

Q.70 How important is product portfolio and migration path?

Not at all important____________________

Not very important____________________

Neutral____________________

Somewhat important____________________

Very important____________________

Don't know/refusal .... ☐

Q.71 What is the minimum necessary level of quality for ASICs, in PPM or AQL?

____

Q.72 How many ASIC vendors did you have in 1992?

____

Q.73 How many ASIC vendors do you expect to have in 1993?

____

Q.74 What new ASIC product features do you need for your next-generation products?

____

(FOR THOSE WHO ANSWERED 1-100% FOR "Standard logic/linear/analog" IN QUESTION 43, ASK QUESTIONS 75 THROUGH 84, OTHERWISE SKIP TO QUESTION 85)

Q.75 What percent of standard logic/linear/analog purchases were in each of the following categories? (TOTAL MUST = 100%)

Standard logic____________________

Data conversion____________________

Amplifiers____________________

Regulators/reference____________________

Interface____________________

Other____________________

Q.76 How important is pricing consaistency?

Not at all important________________________________

Not very important________________________________

Neutral________________________________

Somewhat important________________________________

Very important________________________________

Don't know/refusal .... ☐

Q.77 How important is delivery perfomance?

Not at all important________________________________

Not very important________________________________

Neutral________________________________

Somewhat important________________________________

Very important________________________________

Don't know/refusal .... ☐

Q.78 How important is quality performance?

Not at all important________________________________

Not very important________________________________

Neutral________________________________

Somewhat important________________________________

Very important________________________________

Don't know/refusal .... ☐

Q.79 How important is market flexibility?

Not at all important________________________________

Not very important________________________________

Neutral________________________________

Somewhat important________________________________

Very important________________________________

Don't know/refusal .... ☐

Q.80 How important is product portfolio and migration path?

Not at all important________________________________

Not very important________________________________

Neutral________________________________

Somewhat important________________________________

Very important________________________________

Don't know/refusal .... ☐

Q.81 What is the minimum necessary level of quality for standard logic/linear/analog, in PPM or AQL?

____

Q.82 How many standard logic/linear/analog vendors did you have in 1992?

____

Q.83 How many standard logic/linear/analog vendors do you expect to have in 1993?

____

Q.84 What new standard logic/linear/analog product features do you need for your next-generation products?

____

Q.85 Would you be willing to respond to a few additional questions about semiconductors?
- Yes .... ☐
- No .... ☐

(IF THE ANSWER TO QUESTION 85 IS "No," THEN SKIP TO QUESTION 100)

Q.86 Does your company produce semiconductors for captive use?
- Yes .... ☐
- No .... ☐
- Don't know/refusal .... ☐

(IF THE ANSWER TO QUESTION 86 WAS NOT "Yes," THEN SKIP TO QUESTION 89)

Q.87 What was the total market value in 1992? (ENTER IN THOUSANDS, e.g., 1=1,000)

____

Q.88 What types of semiconductors are you producing captively? (READ LIST; MULTIPLE RESPONSE)
- ASICs .... ☐
- ASSPs .... ☐
- DRAMs .... ☐
- Discretes .... ☐
- Microprocessors .... ☐
- Optoelectronics .... ☐
- Other (specify)______________________________
- Don't know/refusal .... ☐

Q.89 At what sites are engineering decisions on semiconductor selections made for what types of equipment? (RECORD COMPANY NAME, CITY, STATE, AND WHETHER IT'S A CORPORATE OR MANUFACTURING SITE)

____

____

Q.90 What percent of your 1992 semiconductor procurement was from distributors?

____

Don't know/refusal ☐

Q.91 The next few questions concern your electronic equipment production. Did your 1992 equipment sales increase, decrease, or remain the same compared to 1991?

Increase ☐
Decrease ☐
Remain the same ☐
Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 91 WAS "Increase," PLEASE ANSWER QUESTION 92)

(IF THE ANSWER TO QUESTION 91 WAS "Decrease," PLEASE ANSWER QUESTION 93)

Q.92 What percent increase?

____

Don't know/refusal ☐

Q.93 What percent decrease?

____

Don't know/refusal ☐

Q.94 Do you expect equipment sales in 1993 to increase, decrease, or remain the same compared to 1992?

Increase ☐
Decrease ☐
Remain the same ☐
Don't know/refusal ☐

(IF THE ANSWER TO QUESTION 94 WAS "Increase," PLEASE ANSWER QUESTION 95)

(IF THE ANSWER TO QUESTION 94 WAS "Decrease," PLEASE ANSWER QUESTION 96)

Q.95 What percent increase?

____

Don't know/refusal ☐

Q.96 What percent decrease?

____

Don't know/refusal ☐

Q.97 Next, I would like to ask you a few questions about your semiconductor inventory levels. Currently, what is your actual inventory level (USAGE RATE) in days?

____

Don't know/refusal ☐

Q.98 In terms of number of days, what level of semiconductor inventory would you like to have (targeted)?

____

Don't know/refusal ☐

Q.99 Do you expect your target semiconductor inventory levels to increase, decrease, or remain the same over the next 12 months?

Increase ☐
Decrease ☐
Remain the same ☐
Don't know/refusal ☐

I just have a few demographic questions and we will be finished with the survey.

Q.100 What it your job title?

Administrative Support/Clerical ☐
Analyst ☐
Educator/Trainer ☐
Engineer ☐
Executive/Owner ☐
Laborer ☐
Manager/Supervisor ☐
Operator/Fabricator ☐
Production Worker (assembly and process) ☐
Professional (Lawyer, Doctor, Consultant, Broker) ☐
Programmer/Software Developer ☐
Sales/Marketing/Customer Representative ☐
Scientist ☐
Service Provider (Nurse, Social Worker) ☐
Technician and Technical Support ☐
Tradesperson (Craft, Repair) ☐
Senior Buyer ☐
Buyer ☐
Purchasing Manager ☐
Procurement Manager ☐
Component Engineer ☐
VP Operations ☐
Other (specify)____________________
Don't Know/Refusal ☐

Q.101 What is your organization's primary line of business?

- Agriculture/Forestry/Fishing ☐
- Mining/Construction ☐
- Manufacturing: Durable ☐
- Manufacturing: Nondurable ☐
- Communication ☐
- Transportation/Utilities ☐
- Wholesale Trade ☐
- Retail Trade ☐
- Finance/Insurance/Real Estate ☐
- Services: Business/Legal/Engineering ☐
- Services: Other ☐
- Health or Social Services ☐
- Education ☐
- Government ☐
- Other (specify) ______
- Don't Know/Refusal ☐

Q.102 How many employees are there in your company?

- 1 to 9 ☐
- 10 to 19 ☐
- 20 to 49 ☐
- 50 to 99 ☐
- 100 to 299 ☐
- 300 to 499 ☐
- 500 to 799 ☐
- 800 to 999 ☐
- 1,000 to 1,999 ☐
- Greater than 2,000 ☐
- Don't know/refusal ☐

Q.103 Approximately, what is your organization's annual sales revenue?

- Up to $99,999 ☐
- $100,000 to $499,999 ☐
- $500,000 to $999,999 ☐
- $1M to $4.9M ☐
- $5M to $9.9M ☐
- $10M to $49.9M ☐
- $50M to $99.9M ☐
- $100M to $499.9M ☐
- $500M or greater ☐
- Nonprofit (Banking/Government/Education) ☐
- Don't Know/Refusal ☐

THAT CONCLUDES THIS STUDY. THANK YOU VERY MUCH FOR YOUR COOPERATION. I WOULD JUST LIKE TO CONFIRM YOUR NAME AND ADDRESS SO THAT I MAY SEND YOU YOUR SUMMARY RESULTS OF THIS STUDY.

Enter your interviewer number: (2 DIGITS)____________________

Respondent's Name:____________________

Company:____________________

Address:____________________

City: State: Zip Code:____________________

Phone Number: (XXX-XXX-XXXX) (Date) Int. No.____________________

Date: (6 DIGITS—MMDDYY)____________________

Enter your interviewer number: (2 DIGITS)____________________

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Chapter 1
Executive Summary

The *DRAM Procurement Guide* has two purposes, as follows:

- To present a balanced and informed perspective on the current condition and future direction of the DRAM marketplace
- To provide DRAM users with a long-term strategy for choosing tactics on DRAM suppliers, product technology, and pricing

The past two years have been tough ones for makers of DRAMs, with slim profits and ever-declining prices. Users continue to experience volatile pricing, a shifting supplier base, and periodic spot shortages such as the recent 256Kx4 VRAM glitches. Prices per bit have declined more than 70 percent since the end of summer 1989, ending a two-year period of tight supplies and high profits for DRAM makers. Since that time, demand and production have been in near balance, virtually eliminating the possibility of any supplier making the kinds of profits needed to finance the process development and facilities expansion for the next generation of DRAM devices.

Market Uncertainty

Though demand outside of Japan has perked up markedly in 1992, most industry participants are still hesitant about calling the end of the lean years, or adding capacity, or for users, making long-term commitments beyond the summer months. Manufacturers are all making every effort to improve their cost structures to remain competitive. Absent a significant strengthening in the latter half of 1992, we are likely to see further damage to the DRAM supplier base, reflected in red ink or, in severe cases, outright withdrawal from the market.

Evolving DRAM Supplier Base

Though Samsung, GoldStar, and Hyundai now have more than 25 percent of the DRAM market, the Japanese still control more than 55 percent, down from nearly 80 percent as recently as 1988-1989. Texas Instruments and Micron Technology remain the only two integrated U.S. merchant suppliers, though Motorola does a good business reselling 4Mb devices made by joint venture (JV) partner Toshiba and making and selling the 1Mb design supplied in 1987 by Toshiba in exchange for Motorola's MPU technology. For its part, Samsung has performed magnificently, vaulting from a me-too 256K DRAM maker to being the volume leader at 1Mb, and now, arguably the technical and production leader at the 16Mb density. It was the third-ranked producer for 4Mb DRAMs in 1991, behind Hitachi and Toshiba. NEC remains the third Japanese major, followed closely by Mitsubishi and Fujitsu. Siemens—Europe's sole supplier—though having signed on to both 16Mb and 64Mb JVs with IBM, has already announced that it will de-emphasize DRAMs in favor of ASICs and logic. Siemens keeps shifting: one month, the investments were too great, the profit opportunities too meager, and the risks too large to go on full force beyond the present 16Mb development program. The next month it announced a 256Mb alliance with IBM-Toshiba. Other DRAM suppliers include Oki Semiconductor, Vitelic, Matsushita, Alliance Semiconductor, NMB, Sanyo, and Sharp, which collectively account for about 10 percent of the total market.

IBM's announcement of an entry into the merchant market will certainly turn some heads, as it is assumed that its point of entry will be its 16Mb DRAM technology. It is already shipping the 16Mb into its own systems division products, notably the AS/400 minicomputer. The next 12 to 18 months should tell much about IBM's merchant capabilities and its continuing relationship with Siemens.

Strong Demand Trend

Since early 1992, there has been a resurgence of demand for DRAMs coming from PCs, led by 386/486 business and Windows 3.1 software. Since the late 1980s, software is seen as an important "silent driver" for DRAMs, not subject to any capital equipment procurement cycle, but slowly and significantly affecting the amount of memories that small systems in use require. Today, fully 80 percent of DRAM demand comes from computers and office equipment such as laser printers and fax machines.

Competitive Pricing

Prices for 4Mb crossed over those of 1Mb in mid-1991 on a per-bit basis, but the market for 1Mb DRAMs persists and is healthy. A fit of low prices late in the first quarter of 1992 was pushed back, but the low-end North America price as of midyear 1992—$3.10—is still below what anyone thought possible during the 1988 period of shortages. The price of 4Mb DRAMs entered 1992 at under $14.00 and are now about $11.00, en route to an expected price of $9.50 to $10.50 by year-end. Prices for 16Mb DRAMs are still near $140 per unit, far too high for price-conscious small systems makers that would rather stick with the 4Mb devices.

New Product Trends

Perhaps the most interesting developments in DRAMs recently have been the increased interest in Rambus-DRAMs (RDRAMs), and synchronous DRAMs, which offer users very high data rates to relieve constraints on systems design and eliminate the need for use of high-speed cache memories. Mitsubishi also recently announced a cache DRAM, appropriate for similar applications. Of course, video rams (VRAMs), which have been around for the better part of a decade, made up about 8 percent of the market in 1991 and are now available in 2Mb densities, with 4Mbs coming from TI by year-end.

Wide memories—x8, x9, x16, and x18—are also available from a number of suppliers at each density. Though these will take an increasing fraction of the market as time passes, they are still less than about 10 percent of total units shipments. This fraction can be expected to grow to about 25 or 30 percent of total units by midlife of the 16Mb DRAM.

Another very interesting development is the coming of low-power and 3V or 3.3V DRAMs. Driven both by the limits of shrinking design rules and by the demand for low-power chips for hand-helds, notebooks, palmtops, and other battery-backed-up products, a tremendous effort is under way to reduce power consumption at the chip level, to manage power consumption at the system level, and to extend battery life. Though the next stop is 3.3V, to replace the 5V standard first established in the early 1980s, there is really no reason to stop there. We can expect to see products operating from 2V or lower power supplies as we move into the 16Mb generation. Further out, prototypes of 64Mb DRAMs have been announced by many suppliers, but are truly five to seven years away from any kind of high-volume production. Beyond that, who knows? There are formidable technical problems to development of the 256Mb DRAM, not to mention the far-in-advance development costs and the high facility costs once the production decision is made. DRAM makers and necessarily their users as well face a far different future than they were accustomed to in the 1980s.

Risky Investment Outlook

In 1992, fully eight years before first revenue is generated, the DRAM industry will invest about $1 billion in development of the 256Mb device and the 0.2-micron process on which it is to be run. Similar, substantial investments can be expected for the nest three to five years, leading to volume production. Then the $800 million production facility must be built, as well. For example, the IBM-Siemens-Toshiba alliance on 256Mb DRAM product/process development—*excluding* manufacturing—will entail an investment of $1 billion. As a result, many DRAM makers are becoming increasingly concerned as to whether they will be able to reap a return on the investment that appears to confer only a small competitive advantage in the marketplace, and thus a reasonable profit and return on their investment. Add to this the slowing of the semiconductor industry's growth and the departure from the 100 percent per year bit growth driving the learning curve, and makers are understandably concerned about their ability to recover their costs if they continue down this road. No one can clearly see the answers, and, especially for those for whom DRAMs are a significant part of their overall revenue, there are few alternatives to forging ahead with the next-generation product, as incredible as that may sound.

A Snapshot of This Guide

Highlights of this guide include the following:

- It lays out Dataquest's worldwide forecast of PC-based demand for DRAM—today and through 1996.

- It takes you into hand-held PCs—a critical emerging application for DRAM and memory cards—which is timely, because the just-announced Intel-VLSI Technology alliance on 386SL microprocessors/chip sets sets the stage for an explosion of growth in the hand-held market.
- It provides information on DRAM life cycle/supply base evaluation (in Chapter 5) that can enable system manufacturers to achieve annual DRAM cost savings in excess of $100,000—in some cases, far in excess of $100,000.
- It apprises users regarding trends in package technology, which may become a severe barrier to adequate DRAM supply.
- It evaluates the strategic significance and market impact of global alliances such as the following:
  - IBM-Siemens-Toshiba
  - Hitachi-Goldstar
  - TI-Hitachi
  - TI-Hewlett-Packard-Canon and Government of Singapore
- It provides DRAM price forecasts that can mean significant cost savings *this year*—and guides long-term DRAM cost budgeting.

Chapter 2
Introduction

The purpose of this Dataquest guide is to provide in one source the majority of DRAM information needed by semiconductor procurement personnel in formulating sourcing and pricing decisions on a regular basis. The information also provides strategic market insight for any person who tracks the worldwide DRAM marketplace. The guide is divided into chapters that deal with specific areas of concern and interest to purchasers, component engineers, and other users of DRAMs. The report concludes with Dataquest's perspective on the issues that DRAM users and market players should consider for managing this volatile product market.

Chapter 3 and Chapter 4 present a demand-side perspective on the issues that affect the DRAM market. These chapters look at a key system application for DRAM—personal computers—which account for more than 50 percent of DRAM consumption. Chapter 3 starts with Dataquest's view of the trend in PC-based demand for DRAM during the 1992-1996 period. The chapter follows with Dataquest's assessment of the current condition and long-term trends in the worldwide PC market, setting the stage for Chapter 4, which looks at the hand-held PC market, a critical emerging application for DRAM and memory cards today and in 1996.

Chapter 5 provides Dataquest's 1992 assessment of the DRAM supply/supplier base. This information enables system manufacturers to coordinate system life cycles with DRAM product-technology cycles. Dataquest clients report annual cost savings—of about $100,000 or more—through this coordination approach. In this chapter, DRAM product life cycle analysis serves as the starting point for assessing the strategic posture and direction of leading suppliers, including technology, alliances, and fab capability. The scope of coverage is 256K through 64Mb DRAMs through the year 2000.

As the Executive Summary observes, converging market forces likely will increase supplier's long-term risks in the volatile DRAM market. Chapter 6 looks at a major impact of this market reality—an evolving worldwide network of DRAM technology alliances—which is headed by none other than IBM, which Dataquest views as the long-term wild-card player in the DRAM marketplace.

Chapter 7 addresses trends in package technology. Users of DRAM should realize that package constraints represent a potential barrier to the smooth flow of DRAMs to the user community.

Chapter 8 lays out Dataquest's North American DRAM price forecast—quarterly for 1992 and 1993 and long range for 1992 through 1996. The forecast is based on Dataquest's quarterly survey of major users and suppliers of DRAMs, VRAMs, and SIMMs. Some Dataquest clients report annual savings in excess of $1 million through our pricing forecasts. The chapter also uses DRAM life cycle pricing history for projecting the range of 16Mb DRAM pricing in North America during 1993. This assessment taps in Dataquest DRAM pricing information that dates before 1980 in the case of 16K and 64K density devices.

In Chapter 9 Dataquest shares a crisp perspective—formulated over 20 years of semiconductor market coverage—of the ever-changing and growing DRAM market as described in this guide.

Appendix A provides the biographies of the contributors to this guide: Ronald Allen Bohn, Rebecca Burr, Janet Cole, Robert Charlton, Ken Dalle-Molle, Mark FitzGerald, Mark Giudici, Lane Mason, Mary A. Olsson, Ade Olorunsola, Nicolas Samaras, and Lisa Thorell.

Chapter 3
Personal Computers: A Key Application for DRAMs

Chapter 3—combined with Chapter 4—gives a demand-side perspective on the issues that affect the DRAM market. These chapters focus on PCs because this system application accounts today for more than 50 percent of DRAM consumption. For example, despite market saturation of the desktop PC marketplace, enhanced 32-bit PC operating systems and applications such as Windows software will require wide-word DRAMs and VRAMs, the latter device for buffer memory in multimedia applications. This chapter assesses the state of the worldwide PC industry, from the traditional desktop market to the emerging hand-held and pen-based PC markets.

Table 3-1 presents Dataquest's view of the trend in PC-based demand for DRAM during the 1992 through 1996 period. The table includes a forecast of PC demand based on microprocessor type and an estimate of the quantity of main memory and add-on memory (in megabytes) that these systems will demand—which will consist largely of DRAMs or memory cards.

Readers should keep the following main points in mind as they move through this report:

- A PC system's total main memory usage on average should more than triple from under 4MB for 1992 to 11MB for 1996—which means long-term challenges for users
- Overall PC industry shipment growth has slowed dramatically. However, the portable PC segment should expand robustly for the next five years.
- Driven by the demand for networked client/server architectures, workstations will emerge as a fierce PC desktop competitor, yet significant barriers to workstation entry into the PC desktop market remain.
- Worldwide shipments of PC desktops decreased 100,000 units to 19.6 million units. However, the PC deskside market grew 67 percent to 981,200 units in 1991.
- Following a sterling performance in 1989 and 1990, 1991 worldwide PC laptop unit sales rose a mere 2 percent to 2.89 million units.
- The PC notebook market exploded in 1991, growing 179 percent to 1.14 million units worldwide

Table 3-1
Estimated PC-Based DRAM Consumption by Microprocessor Type—Preliminary
(Worldwide, Combined Desktop/Portable)
(PCs: Thousands of Units; Memory: Megabytes)

PC Type	1992	1993	1994	1995	1996
8080/8086	1,033	1,307	1,357	1,299	805
Total Main Memory	1.0	1.0	1.0	1.0	1.0
Main Memory	1.0	1.0	1.0	1.0	1.0
Add-On Memory	0	0	0	0	0
80286	1,259	452	222	106	0
Total Main Memory	2.0	2.0	2.0	2.0	2.0
Main Memory	1.0	1.0	1.0	1.0	1.0
Add-On Memory	1.0	1.0	1.0	1.0	1.0
80386 SX/SL	8,894	7,519	8,208	8,204	8,155
Total Main Memory	4.0	4.5	5.0	6.0	6.0
Main Memory	2.0	2.5	3.0	3.0	3.0
Add-On Memory	2.0	2.0	2.0	3.0	3.0
80386 DX	5154	3,526	2,052	1,298	560
Total Main Memory	6.0	7.0	8.0	9.0	9.5
Main Memory	3.0	4.0	5.0	6.0	6.5
Add-On Memory	3.0	3.0	3.0	3.0	3.0
80486 SX/SL	2,917	8,665	12,237	16,213	21,065
Total Main Memory	5.0	7.0	9.0	11.0	13.0
Main Memory	2.0	3.0	4.0	5.0	6.0
Add-On Memory	3.0	4.0	5.0	6.0	7.0
80486 DX/DX2	2,700	3,125	3,629	4,524	5,184
Total Main Memory	9.0	10.0	11.0	12.0	13.0
Main Memory	4.0	5.0	5.0	6.0	6.0
Add-On Memory	5.0	5.0	6.0	6.0	7.0
586	5	350	1,001	1,995	2,001
Total Main Memory	11	12	13	14	15
Main Memory	8.0	8.0	9.0	10.0	10.0
Add-On Memory	3.0	4.0	4.0	4.0	5.0
68XXX	4,332	4,730	4,966	5,436	4,830
Total Main Memory	5.0	6.0	7.0	8.0	9.0
Main Memory	3.0	4.0	5.0	5.0	6.0
Add-On Memory	2.0	2.0	2.0	3.0	3.0
Other PCs	416	162	101	53	49
Total Main Memory	0.5	0.5	0.5	0.5	0.5
Main Memory	0.5	0.5	0.5	0.5	0.5
Add-On Memory	0	0	0	0	0
Average Memory per PC	4.9	6.2	7.6	9.4	11.0

Source: Dataquest (August 1992)

- As the newest technology segment within the PC market, the pen-based market grew a dramatic 301 percent to 40,500 units shipped.
- We expect worldwide unit shipments sales of portables, including low-cost hand-held units, to outpace those of the desktop, deskside, and workstation markets combined by 1995, with portables reaching 61 percent of 1996 unit shipments.

State of the PC Industry

The PC industry can no longer be described as a monolith. At the low end, rapid technological developments within the portables sector have created new competitors and products, some forerunners of a new generation of consumer electronics appliances. At the high end, rapid price/performance improvements within the RISC-based workstation industry and the related need of workstation suppliers to move to broader-volume distribution channels signal a down flow of high-performance hardware and software technologies into the traditional PC desktop market.

In this world of extremes, PC suppliers face essentially three alternatives. At the high end, suppliers can maintain position and compete with suppliers of the rising tide of RISC desktops. At the low end, PC suppliers can adapt to enter the new lightweight portables segments. These high-end and low-end segments are clearly territories to provide value-added hardware and software technologies, particularly in the area of client/server operating environments and, for portables, communications technology and ROM-based productivity applications. In the middle is the commodity PC clone vendor with little to no product differentiation. This vast middle ground has primarily capitalized on the business inefficiencies and aftermarket created by the first-tier technology leaders. Dataquest sees this middle ground, which is overpopulated and uses formulaic "follower" strategies, as an increasingly vulnerable position.

Industry Performance

Overall PC industry shipment growth has slowed dramatically since the 1980s. By 1990, the five-year growth rate plummeted to 16 percent, with a scant 4.4 percent growth in 1991. Coupled with 1991's negative 8.5 percent revenue growth, the market returned only modest or negative profit, despite the fact that the industry shipped a record number of units worldwide.

On the one hand, several forces are combining to make the outlook for revenue growth and profitability relatively poor. These include the continued price erosion on the PC desktop, the continued emergence of new companies that successfully take share from established competitors, and rapidly shortening product life cycles. Added to this is the restructuring of the distribution channels, with the major-brand-name suppliers continuing to lose sales to suppliers specializing in mail-order houses, mass merchandisers, and superstores.

On the other hand, there are reasons for optimism. As with most industries facing slower growth and lower profit, the PC industry has begun consolidation. Industry alliances, such as the Apple and IBM joint venture, promise a leveraging of resources, decreasing the overhead associated with new product development.

Coupled with increased cost controls and the streamlining of organizations—witness the massive restructuring by Apple, Compaq, and IBM—and the expansion of these players into more direct distribution channels, there is the promise of some further earnings growth as well as a better match of product features and manufacturing forecasts to meet customer needs. Finally, the astronomical growth of the new portables and pen-based PC segments portends expanded market opportunities, providing computing to people who have never used a computer before.

The PC industry shipped a staggering 24.9 million units worldwide in 1991. However, 1991 worldwide PC market revenue fell 8.5 percent to $44.4 billion.

A decrease in the demand for PCs has been apparent in the United States for some time: from the double-digit unit shipments growth of the early 1980s, U.S. PC demand averaged only 8 percent compounded annually from 1986 to 1991. In 1991, U.S. unit shipments demand increased only 4.8 percent.

The PC market has always been fragmented. While the top 10 suppliers controlled 49 percent of the unit shipments volume in 1991, about 275 other suppliers controlled fractional amounts of the remainder.

On the one hand, leadership position among the top-tier suppliers has remained fairly stable. As the top revenue market leaders in 1987, IBM, Apple, NEC, and Compaq still maintain the top positions. Olivetti and Tandy have all lost position, while Atari and Europe-based Amstrad fell out of the top 25.

The market share loss by the leading players has been the gain of new entrants that have focused on specific new products and transformed the industry. Some companies created positions with new product categories better suited for personal mobility, for example, Toshiba's emergence via laptops in the late 1980s and HP's recent hand-held market entry with the HP 95LX.

Market Forecasts and Assumptions

This section represents Dataquest's forecast through 1996 for the PC market segments. Included in this analysis are a description of Dataquest's forecast methodology and market scenarios for the five-year period.

Notes on Methodology

The PC forecast is based on the following three elements of data:

- Microprocessor shipment data
- Worldwide supplier/supply-side data
- PC user/demand-side data

Microprocessor shipment data are collected as part of Dataquest's annual Semiconductor Industry Service annual survey, which is conducted in conjunction with the Semiconductor Industry Association.

Worldwide vendor/supply-side data are collected as part of Dataquest's annual PC vendor survey. In 1991, Dataquest surveyed more than 200 PC suppliers regarding their worldwide unit shipments and revenue. Companies are surveyed on a world regional basis. In addition, Dataquest conducts an annual survey of PC CAD distributors.

PC user research stems from Dataquest's *Score Report* product, a PC customer satisfaction survey and vendor ranking conducted with 1,000 U.S. PC users every quarter. Although the main focus is PC customer satisfaction, users are also surveyed regarding such key topic areas as purchasing plans and product delivery.

Market Forecasts

Dataquest projects that total PC worldwide unit shipments will grow at a compound annual growth rate (CAGR) of 11.29 percent from 1992 through 1996, reaching 42.6 million units shipments. More detailed PC forecasts follow later in this chapter.

Desktops versus Portables

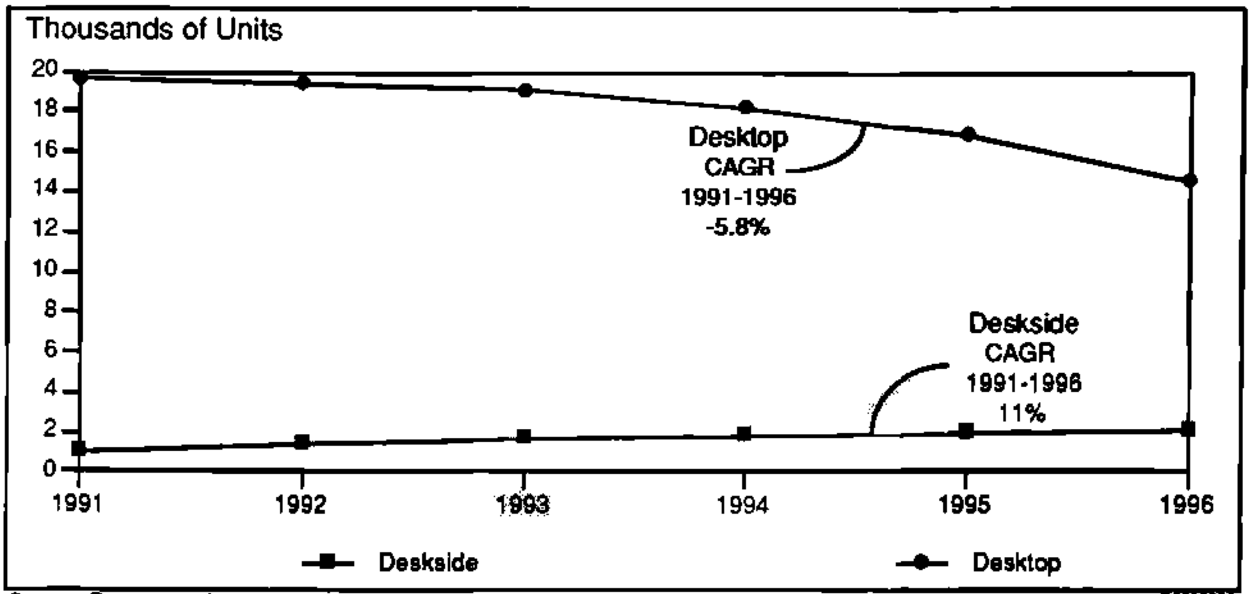
On the one hand, the traditional PC desktop market is vulnerable and mature, facing slow growth and increasing competition from performance-driven workstation suppliers with a better grip on user needs for networked, multitasking environments. Suppliers such as Hewlett-Packard, IBM, and Sun Microsystems are readying both their manufacturing production and distribution channels, as well as their RISC/OS licensing partners, to produce an onslaught of RISC clones to invade the PC replacement market.

On the other hand, the portables market, still in the early high-growth, low-penetration stage, is ripe for extravagant market expansion, with hand-held units promising entrance into the hypervolume sales of consumer electronics appliances.

Desktop and Deskside Markets

Figure 3-1 shows Dataquest's forecast for the worldwide PC desktop and deskside markets. Overall, we expect PC desktops to continue their decline in unit shipments, falling at a CAGR of 5.8 percent over the next five years.

Figure 3-1
Worldwide PC Desktop and Deskside Unit Shipments Forecast



Source: Dataquest (August 1992)

Key assumptions underlying our forecast for PC desktops include the following positive factors that would sustain demand:

- Radical price erosion
- The home market
- Multimedia capabilities

The sharp price erosion of 1991 intensified in the first half of 1992, suggesting that 1992's price declines will exceed those of 1991. Several of the first-tier and second-tier players—including Apple, AST Research, CompuAdd, Dell Computer, and Everex—announced substantial price reductions. Most significantly, in June 1992, Compaq shocked the industry with aggressive price points on its new ProLinea desktop line. Only a few days later, Dell counterattacked with still lower prices on equivalent models within its new Dimension series. Dataquest believes that the new 386 desktop pricing is lifting the demand torpor of 1991, spurring not only corporate purchases but a second wave of home PC purchases.

Dataquest sees a large upside opportunity in the home PC market. Only 1 out of every 14 PCs ships into the home market. However, with commercial spending plans down and end users more savvy about their computer needs, suppliers are shifting their low-end PC strategies to communicate directly with home PC users. Dataquest views national online information services such as Prodigy (now with 1.5 million subscribers) as key facilitators of home PC use.

Multimedia will also provide a reason for sustained PC desktop sales. IBM's promotion of its Ultimedia Center as well as its recent equity position in Red Shark, a developer of multimedia applications, indicates its seriousness in this direction. More importantly, the emergence of hardware-independent audiovisual description languages such as that from Fluent Machines will accelerate multimedia applications, reminiscent of the way that PostScript aided the desktop publishing market in the 1980s.

Key negative factors in our overall PC desktop forecast include the following:

- Market saturation (for example, desktop PC sales) are increasingly replacements for older, obsolete machines
- Market displacement by workstation desktops
- Market displacement by portables

Traditionally, new growth in the PC desktop market has been fueled by more powerful microprocessor technologies, specifically centered on the i86 and, to a lesser extent, the Motorola 68000 architectures. However, to the growing mass of PowerPC users, it has become increasingly evident that these CISC designs are not keeping pace with RISC processor performance. For example, the most powerful Intel CISC processor available, the 50-MHz 486 at 27 mips, is two to three times slower than the most powerful RISC desktop processors available. As much as a good share of this performance benefit is derived from floating-point optimization, PowerPC users in the technical and financial markets have some use for this compute power today. More importantly, desktop PC users of the mid-1990s, who are moving toward 32-bit multitasking operating systems and using distributed application software with graphical user interfaces, as well as multimedia and object-oriented environments, will have ample use of the compute power and the higher memory and storage capacities of workstations.

PC Deskstops and Workstations: A Blur

Simply put, by 1993 there will be little difference between a PC desktop and workstation desktop from either a technological or a marketing viewpoint. It is important to point out that we view this shift as a triumph of workstation technology over PC technology, not necessarily of the workstation suppliers or the PC suppliers. The challenge for traditional PC suppliers is learning to sell sophisticated boxes with multitasking operating systems and networking services. The challenge for workstation suppliers is in gaining manufacturing efficiencies, amassing indirect channels, and gaining significant PC ISV capture. Notably, neither side has moved significantly from its traditional position although workstation suppliers have made significant headway into the traditional PC VAR and distributor channels.

PC desksides will experience modest unit growth from 1991 through 1996—an 11 percent CAGR—but we do not expect this technology segment to sustain its position against the upcoming onslaught of higher-performance systems from both the workstation and midrange multiuser system computer segments.

Our PC deskside forecast is based on the following assumptions:

- On the positive side, the demand for desksides will be driven by the need for file and database servers among the growing networked PC population.
- However, desksides will come under increasing competition from both workstation desktop products and the relatively new breed of low-cost multiprocessor, midrange servers. Dataquest views 586-based multiprocessor systems as principally part of the workstation and midrange multiuser deskside market.

Portables Market

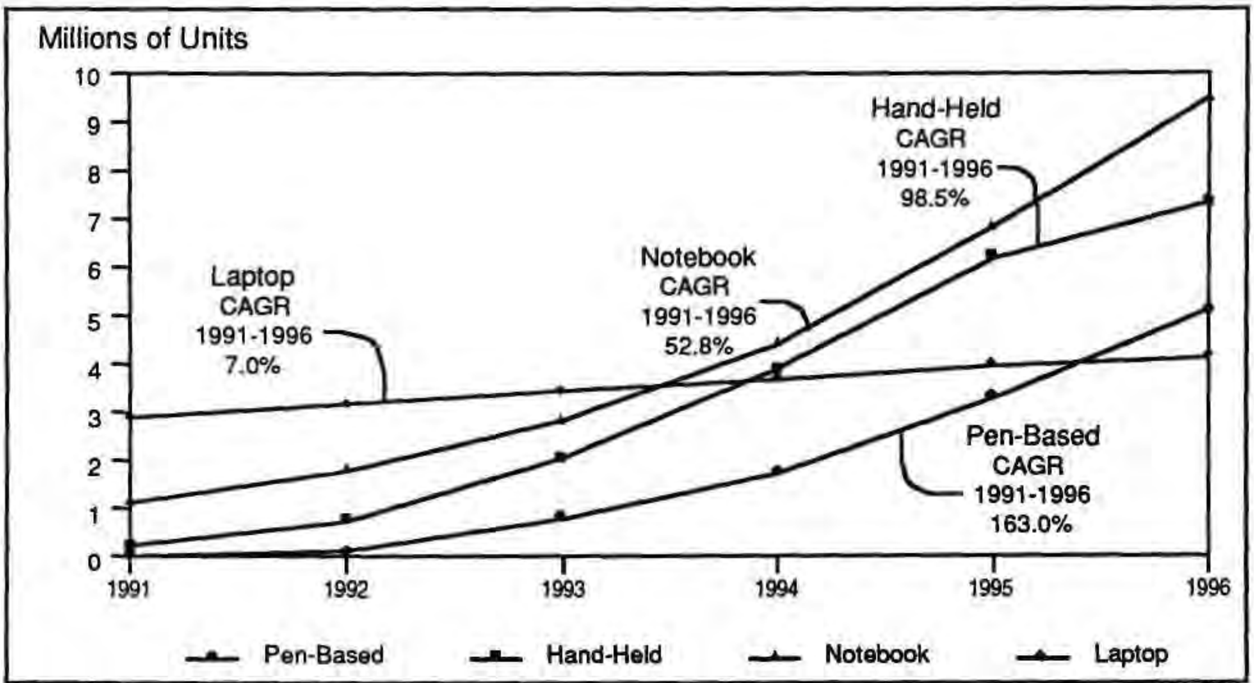
Overall, Dataquest foresees tremendous growth in the portables market. We anticipate that by 1995, worldwide unit sales of portables, including low-cost hand-held units with full or partial DOS compatibility, will outpace those of the desktop, deskside, and workstation markets combined, with portables reaching 61 percent of 1996 units shipments.

The spectacular growth opportunities lie with pen-based and hand-held PCs, which together will outnumber PC desktop shipments in 1996. The laptop segment exhibits a declining to negative growth pattern, primarily because of competition from the smaller, lightweight portables (see Figure 3-2).

Key factors influencing our forecast include the following:

- Overall, unit shipments growth opportunities will be related to miniaturized size and weight. Therefore, notebooks will outsell laptops by 1995 and hand-held PCs will outsell all other portable types.
- Portables, especially the hand-held and pen-based types, will expand the PC market by extending it to users who never used a computer before.
- An increasing number of users will use their portable as the first and only computer, enabling portables sales to displace desktop sales.
- For hand-held and pen-based PCs, early 1993 will mark the convergence of hardware, operating system, and applications availability, generating high-volume sales.
- With the development of applications specifically designed for pen input, there will be a ferocious demand for pen-based units.

Figure 3-2
Portable PC Worldwide Unit Shipments Forecast



Source: Dataquest (August 1992)

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Dataquest believes that its portable PC forecast is quite conservative, as several new specialized PC-type technology segments are not as yet included in the existing forecast. These segments include the following:

- Companion PCs, which fall into a subnotebook category and feature a ROM-based operating system and bundled application software
- Hand-held computing devices without DOS

Note as well that Dataquest's current hand-held PC forecast does not include the market for DOS-less electronic hand-held products such as the Sharp Wizard and the Casio BOSS.

An Ominous Sign?

Worldwide PC market revenue exhibited negative growth in 1991, the first revenue decline measured since Dataquest began tracking the industry. Key factors driving the restructuring of the PC industry include the following:

- Fragmentation of the singular desktop PC compute environment
- Networked, client/server architectures as the predominant compute environment of the 1990s
- The emergence of new product categories better suited for personal mobility

Fragmentation of the PC Desktop Industry

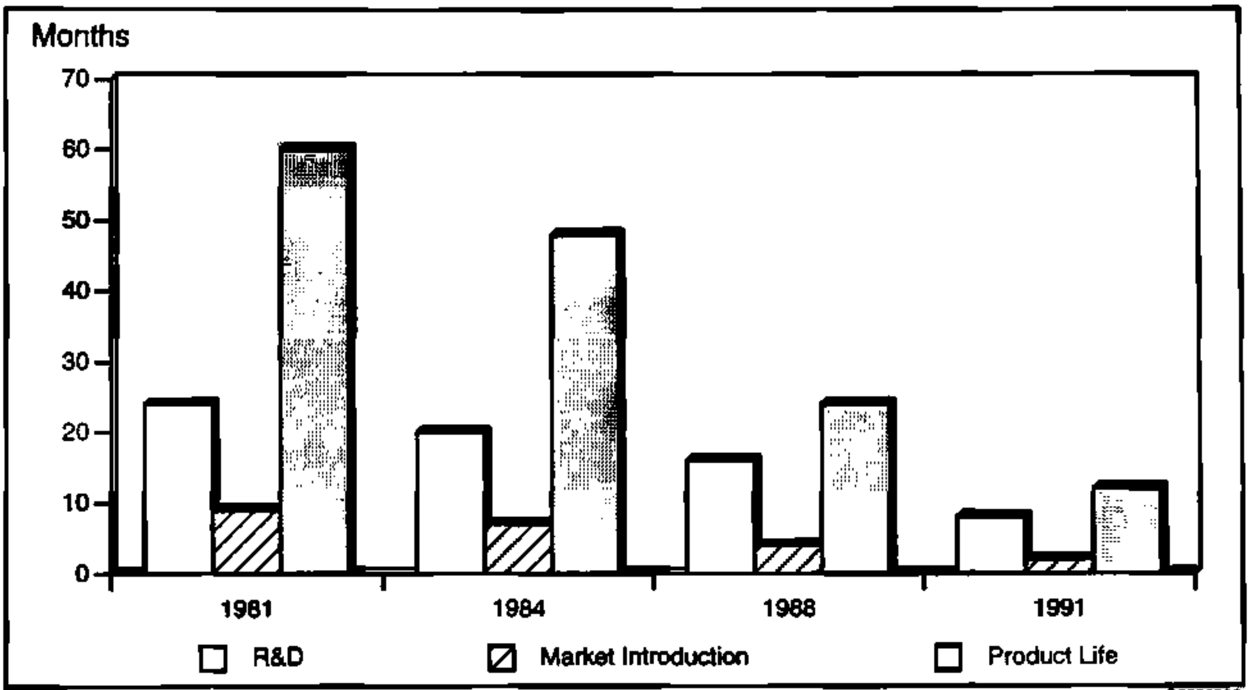
PC desktops still constitute the majority of revenue and unit shipments in this market. In 1991, PC desktops accounted for 79 percent of the worldwide shipments. As much as desktops are the mainstay of the PC industry, the dominance of PC desktops is the single-most determining factor in the characterization of the PC industry as one that is slowing in growth.

Why is this era ending? Is the decline the result of inherent purchasing, economic, or product life cycles? Or is it structural in nature? The answer is both.

Shrinking Product Life Cycles

The product life cycles of the PC industry have rapidly compressed (see Figure 3-3). The average product life of 60 months in 1981 has now diminished to a mere 12 months. The rapid advancement of microprocessor technology has driven R&D time and time-to-market introduction spans of a few months. In turn, the rapid obsolescence of products has driven slowing sales cycles—as customers delayed purchases waiting for the next processor generation. Product life cycle erosion is in a closed-loop degenerative state, with continuing price decline and new technology driving still shorter product life cycles.

Figure 3-3
U.S. PC Market Product Life Dynamics: 1981 through 1991



Source: Dataquest (August 1992)

G2000833

In response, suppliers have provided modular upgrade capability. Such upgrade capability is seen primarily as a means to ease end-user uncertainty about product obsolescence; it also forestalls switchovers to other suppliers' products that incorporate higher-speed processors.

Price Erosion

With a highly fragmented supplier market, price erosion has been a prevailing characteristic of the PC industry. In 1991, PC price erosion climbed to a 12-year high. Over a 12-month period, the average street price of 386SX/16 clones fell nearly 30 percent. In this same period, the average street price of 486/33 clones dropped nearly 20 percent.

This price erosion intensified in 1992 as Intel, the predominant PC microprocessor supplier, expanded its product line in the face of competitors such as AMD, Chips & Technologies, Cyrix, and TI. In order to differentiate its products, Intel launched an aggressive campaign to lure customers away from the competitor-laden 386 product and onto its 486, with a rigorous 50 percent drops in some X86 lines during the first half of 1992.

Workstations as Successful PC Replacement Products

Workstation suppliers have paraded the following key advantages of their products over traditional PC desktops:

- Built-in Ethernet networking and software networking services for file sharing and print serving
- The capability to connect to high-end UNIX servers already installed in the corporate environment
- More compute power, larger memory and storage capacity for meeting the needs of the emerging 32-bit operating systems, database management applications, multimedia applications, and object-oriented software environments
- Extensive experience and sophisticated in-house software engineering skills to provide support for multitasking operating system and networking services.
- For high-performance desktops, hardware integration that allows lower prices than those for equivalently configured PC systems
- One-stop shopping for sophisticated hardware, operating system, and networking services

There is growing evidence that workstation suppliers are making headway in invading the PC corporate upgrade environment. In a first-half 1992 Dataquest survey of 1,000 workstation users, Dataquest found that 30 percent of the workstation users were former PC users. Finally, within the $5,000 to $9,900 desktop price band, workstation vendor Sun ranked No. 4 in unit shipments share.

Barriers to Workstation Entry

As much as workstation suppliers offer a robust operating environment for PC users to connect to their legacy high-end UNIX systems, there are several barriers to their immediately displacing PCs desktop sales. Significant among these are applications availability and business model efficiencies.

Application Availability

The incontrovertible fact is that DOS today supports more than 20,000 applications. As much as workstation suppliers approach having 4,000 to 5,000 applications (including several significant mainstream PC software suppliers), there is the view that the availability of thousands of vertical niche applications—for example, legal services, dental/medical, and financial applications—and not the key applications has enabled the PC desktop as a volume platform. In addition, Dataquest's survey of PC ISVs finds that developers are still concerned that end-user demand for RISC-based platforms is still relatively low.

Business Model Efficiencies

It is not clear that workstation suppliers can compete with PC suppliers' cost structures. Workstation suppliers place a premium on R&D activities (to support their installed base of technical users), thus leaving considerably less to spend on sales and advertising expenses. In contrast, traditional PC suppliers place quite a premium on SG&A, as brand name recognition is a significant differentiation in this commodity market.

Another key point is that major PC suppliers ship about 500,000 systems per quarter, compared with major workstation suppliers' shipments of 20,000 to 50,000 systems per quarter.

The Emergence of Portables

PC product segment growth has shifted from traditional desktops to portables. Virtually all major PC suppliers now offer portable PC products. Low entry barriers, coupled with the upside opportunity represented in the sublaptop portables segments, have encouraged more new market entrants into an already fragmented industry. In turn, this has put the market share of established players under constant pressure.

Desktop Dependency

In 1991, the top 10 PC suppliers worldwide all experienced a decline in PC revenue, with the notable exceptions of Apple and Groupe Bull. This widespread decline occurred despite new product introductions in the high-growth portables sector by nearly all of these suppliers. The principal reason for this decline is the continued revenue dependence by all the top 10 suppliers—except Toshiba-on the declining desktop market.

Desktops

The market for PC desktops declined in 1991. Shipments fell from 1990's 19.7 million units to 19.6 million units. The persistent highly competitive conditions in the PC desktop clone market are apparent in the respective negative and flat growth results of IBM and Compaq, both of which are continuing to lose share to competitors such as Acer, Dell, and Everex that offer competitively priced clones. However, Apple and Commodore fared well with their price-point-conscious strategies and with Commodore's success in the European market.

PC Desksides

As a relatively new market, the PC deskside segment continued as one of the highest-growth PC markets. Capitalizing on the growing corporate trend toward networked client/server computing, the worldwide PC deskside market grew 67 percent to 981,200 units in 1991. PC deskside systems often support the leading-edge microprocessor technology and are often used as servers of multiuser systems. With a premium price for systems and a large installed PC client base in the corporate environment, IBM's brand name position has allowed it to sustain a majority market share, even while it dropped 13.5 market points.

This is relatively high-margin territory, and in 1991 it attracted new market entrants Arche Technologies, Digital Equipment Corporation, Hyundai, and TI. Apple entered this segment and rapidly captured third place in unit shipments' market share (3.8 percent) with the Quadra series, a product complementing Apple's large installed base of Macintosh client desktops.

However, players such as Dell and Mitac placed increasing price pressure on IBM, Victor, HP, and Advanced Logic Research, which collectively dived 28 market share points in 1991 as measured in unit shipments.

IBM to a great extent and HP to a certain extent were victims of their own mixed-platform strategies as their own sales forces pushed still-higher-margin RISC workstations into PC desktop accounts. Dataquest believes that this Trojan Horse strategy, with UNIX RISC-based servers supporting PC clients, indicates a product position shift of the broad-based platform suppliers. Dataquest believes that these players are preparing to woo their PC installed base onto the new PowerPC and PA-RISC systems of the mid-1990s.

Laptops

Because of ferocious price erosion, the 1991 laptop market was a brilliant case study of how rapidly maturation occurs in the PC technology segments. Following a sterling performance in 1989 and 1990, 1991 worldwide PC laptop sales rose a mere 2 percent to 2.9 million units shipped. To a great extent, PC laptop sales came under increasing pressure from sales of the smaller, more lightweight PC notebooks.

Toshiba, as one of the industry leaders in laptops, faced increasing competition. In the U.S. laptop market alone, Toshiba fell 45 percent in unit shipments, principally at the hands of major players Compaq, NEC, and IBM. Unfortunately, Toshiba did not enter the PC notebook market until late in 1991, a move that would have defended its PC market position overall. As much as Toshiba is under increasing pressure from both laptop and notebook suppliers, its 1991 entrance into the 486 Micro Channel Architecture (MCA) logic chip business—coupled with its DRAM, display, and CD-ROM technologies—promises to offer an advantage in future laptop and notebook designs—especially with IBM's renewed strength in this market.

Notebooks

The PC notebook market exploded in 1991, growing 179 percent to 1.14 million units shipped worldwide. This growth rate is all the more remarkable, given the shortage of hard drives and displays through a good part of 1991.

One primary reason that notebooks sold so well in 1991 was that end users were finally able to duplicate their desktop environments on a notebook, mainly because of more power microprocessors, the availability of monochrome VGA, and sufficient storage.

The fast pace and the pressures on this market were evident in its rapid fragmentation, taking a heavy toll on 1990 market leaders. Compaq, Sharp, and Epson together accounted for 70.6 percent of 1990 unit shipments. By year-end 1991, these suppliers accounted for only 14.7 percent of the worldwide notebook shipments.

Indeed, presence in the notebook market has proven to be more of a liability than an asset, with overproduction and inventory control put to the test. Suppliers with products scurry to off-load products with obsolete technology before new suppliers introduce new products. By the time the established suppliers reduce the prices on their older notebook product lines, new and advanced notebook products are available at competitive prices. Thus, market players such as Apple, AST, IBM, and Tandy, with zero to negligible notebook market share in 1990, together gained 27.6 percent of the market share of units shipped in a single year. Apple was particularly successful in gleaning about 10.5 percent of the worldwide notebook market with its PowerBook products, which appealed to its large, ready base of installed Mac users. This is an excellent example of how Apple's proprietary architecture has helped protect its market position. Similarly, Groupe Bull's gain shows how geographic focus shielded its opportunity for notebook volume growth.

With the proliferation of undifferentiated products from more than 65 suppliers, the notebook market suffered enormous price erosion. In the U.S. market, the notebook ASP dropped almost 20 percent in 1991. Despite this price erosion, notebook buyers in 1991 were still forced to pay a premium for portability, with a notebook costing up to twice as much as an equivalent desktop system.

Note that many Japanese laptop suppliers focused on Europe, Australia, and Southeast Asia in 1991 because of the prohibitive 100 percent U.S. tariffs. However, Dataquest expects many Japanese laptop suppliers to enter the U.S. marketplace in 1992 or 1993, fully rearmed with notebooks as a result of the U.S.-Japanese bilateral semiconductor accord in 1991, whereby these exorbitant tariffs were lifted.

Hand-Held PCs

Still in its embryonic stage of market maturation, the hand-held PC market grew a ferocious 121 percent in 1991 to $85.9 million, with unit shipments' growth of only 9 percent, or 237,599 worldwide shipments. The disparity in unit shipments and revenue growth in this market reflects the premium prices that buyers are willing to pay for these lightweight units.

The undisputed winner in DOS-based hand-held PCs was HP, which gained close to 46.3 percent market share based on unit shipments, shipping about 110,000 HP 95LX palmtops. The reason for the HP palmtop's great success was that it was first and foremost a business solution, with Lotus 1-2-3 in ROM, a full-function calculator, a personal information manager (PIM), and a LAN adapter option.

Dataquest notes that in a broader definition of the hand-held market, the HP 95LX clearly can be seen as a competitor of hand-held electronic appliances such as the Sharp Wizard and the Casio BOSS. From this viewpoint, HP's winnings were small, as Sharp and Casio together shipped more than 2 million of these products. The profound difference in shipment volume has everything to do with distribution channel: 22 percent of the 1991 U.S. hand-held products were shipped through consumer electronics outlets, whereas the majority of Sharp and Casio appliances went through these outlets.

Chapter 4, as noted, provides a closer look at hand-held PCs and their memory requirements, today and through 1996. Intel's recent alliance with VLSI Technology—which aims at 386SL chip sets—should set the stage for accelerate growth in the hand-held segment of the PC arena.

Pen-Based PCs

As the newest technology segment within the PC market, the pen-based market grew 301 percent to 40,500 units shipped. Continuing the theme of all new PC technology segments, the 1990 early market leader, GRiD Systems, lost some ground in 1991, as new players arrived on the scene.

As a technology poised for growth in the mass market of users unfamiliar with computer technology, pen-based computing in 1991 was limited by two chief market factors: late availability of pen-based operating systems and limited access of distribution. Note that, though pen-based technologies are ideally suited to the person who is not computer-literate, the primary sales channel in 1991 was that of the direct and VAR sales for computer companies, accounting for 77 percent of the pen-based units purchased.

Recommendations

Dataquest makes the following recommendations:

- System manufacturers should anticipate that the critical portable PC market will continue to fragment, as suppliers differentiate on technological features such as integrated cellular voice and fax capabilities—although ultimately there will emerge a "universal portable" and multiple-personality operating systems.
- Because of rapidly decreasing PC product life cycles, coupled with persistent price erosion, successful PC suppliers will need to support full portable product lines or desktop/deskside client/server offerings rather than point products. This approach, allowing economies of development costs and manufacturing, will be mandated in order to sustain reasonable margins within increasingly shortening product cycles.
- A related mandate is that users must coordinate PC system road maps with DRAM life cycle expectations toward a goal of competitive component pricing as outlined in Chapter 5.

Chapter 4
Hand-Held PCs: An Emerging Application for DRAM

As noted in Chapter 3, portable PCs (portables) represent a growth segment for PC manufacturers and prospective market entrants. Intel's recent alliance with VLSI Technology sets the stage for a new version of Intel's 80386SL device suitable for hand-held applications. In the portable PC market, hand-helds should be one of the most rapidly expanding segments over the next five years, with HP enjoying an early lead. A main point is that hand-held PCs should drive a key DRAM technology trend: the shift from embedded slow SRAM to embedded DRAM augmented by memory cards. This chapter takes a peek into hand-held PC systems today and gives a view of their expected evolution over the next half decade.

Portable PC terminology is confusing. Definitions change with time as technology races to fit a Cray supercomputer in a shirt pocket! In this section, Dataquest provides basic definitions and then discusses trends and semiconductor opportunities in the portable PC industry.

Definitions

A notebook PC is a desktop PC shrunk to the approximate size of 8.5 × 11 × 1.5 inches; it weighs 4 to 7 pounds.

A companion PC is basically a smaller notebook PC that typically measures 10 × 6 × 1 inches and weighs less than 3 pounds. It may use a floppy and a hard disk or silicon disk for mass storage.

A hand-held is a desktop PC shrunk to at least a size of 8.5 × 4 × 1 inches (more often 6 × 4 × 1 inches) and weighs less than 1.5 pounds. Because of size and power constraints, hand-held PCs do not use a hard disk for mass storage. Instead they rely on PCMCIA-type memory cards to fulfill this function. The memory card here performs dual functions: that of a removable mass storage device (hard disk) and of a floppy that allows for information exchange. The term palmtop is often used to indicate a similar class of machines. For our discussion we will focus on machines that support a standard operating system (OS) such as DOS.

A personal organizer is a small portable device (6 × 3 × 1 inches or smaller) typically running a proprietary OS and a small set of PIM utilities such as appointment calendars and phone books. Personal organizers do not run general-purpose software. They can, however, communicate with PCs for data transfers.

Why Do We Need Hand-Held PCs?

Even though portable PCs are getting smaller and lighter by the day, they are still cumbersome for many applications and users. It is true that notebook PCs have brought the computing power of the desktop to an 8 × 10 × 1-inch form factor weighing just under 5 pounds. But even though they fit in briefcases, they are still limited in a number of ways.

Portable PCs depend on expensive nonstandard rechargeable batteries that allow for just 2 to 4 hours of operation, which creates a problem: It is nice that such powerful full-fledged PCs can be taken on the road, but they tend to become temporarily useless once they run out of power. Of course they can be brought back to life when an AC outlet is found, but then, this is not much consolation inside an airplane! Another problem is the AC adaptor, which is not lightweight and takes up space. At 4 to 5 pounds (adaptor excluded), notebook PCs are still heavy for most users, who would prefer something much lighter if given a choice. More importantly these PCs are not socially accepted in meetings, while paper-based daytimers and organizers are. Portable PCs also are not very rugged, the weak points being the hard disk and to a lesser degree the LCD display. Finally, there is the cost issue: Notebook PCs still cost $1,500 to $4,000, excluding software.

Enter the hand-held PC, which is much smaller, much lighter, runs on off-the-shelf batteries (often standard AA) for up to 100 hours, fits in a shirt or vest pocket, costs a third the price of a notebook, runs most (if not all) PC application software, and easily connects with desktops.

Because the hand-held PCs run off-the-shelf software, they become almost as useful as the desktops. The key word here is almost. Some choices had to be made to downsize a desktop to a hand-held. There is no space or power to use a hard disk, which means that some alternate form of mass storage is needed. The only viable—and in the short-term, expensive—alternatives were solid-state disks and/or memory cards. The solid-state disk based on flash memory is the hard disk replacement; the memory card is the floppy.

Solid-state storage is a blessing in disguise. Because it is more expensive than the equivalent hard disk drive (HDD), it mandates that only the necessary software be built-in or carried along. This fact, limiting as it may at first glance seem, forces examination of the utility of the software carried along. Only absolutely necessary software is embedded in hand-held PCs because semiconductor mass storage is not cheap. On a per-megabyte basis a hard disk drive costs $3 to $4, whereas a flash memory disk/card may cost $50 to $75. By year's end it is expected that the cost disparity between hard disks and solid-state storage (flash) will be reduced to 5:1 as memory cards reach $25 per megabyte.

A point often missed in cost-per-megabyte discussions is that just 3MB of hard disk storage cannot be bought for $9! Even if the cost issue is ignored, hard disks cannot be used in hand-held PCs because they consume too much power and their size, even at the 1.8-inch form factor, is a problem. This may not hold true if and when low-power 1-inch HDDs become available. At that size most problems inhibiting their use in hand-helds should disappear. A 1-inch hard disk would be reasonably rugged and power nimble. For now, however, solid-state is the only alternative.

Hand-held PCs are not meant to replace the office PC; instead, they are expected to act as adjunct computers.

To the extent that hand-held PCs can effectively be used as take-along computers, their compatibility with the user's desktop PC is essential. However the ability to run all the software as the user's desktop is a questionable quality. The hand-held is more of an outgrowth from the organizer camp as opposed to the downsizing of the notebook PC. Attributes other than full compatibility are more important. For example, are the PIMs adequate and well designed? Is the hand-held small and easy to carry along and use? Is the keyboard useful for a reasonably small amount of typing? Are the batteries easy to find and do they last 50 to 100 hours? Is the display quality acceptable? How easy is it for the average user to connect the hand-held to a desktop and upload/download data? Is connectivity expensive? Successful hand-held implementations should have plenty of yes answers for this set of questions.

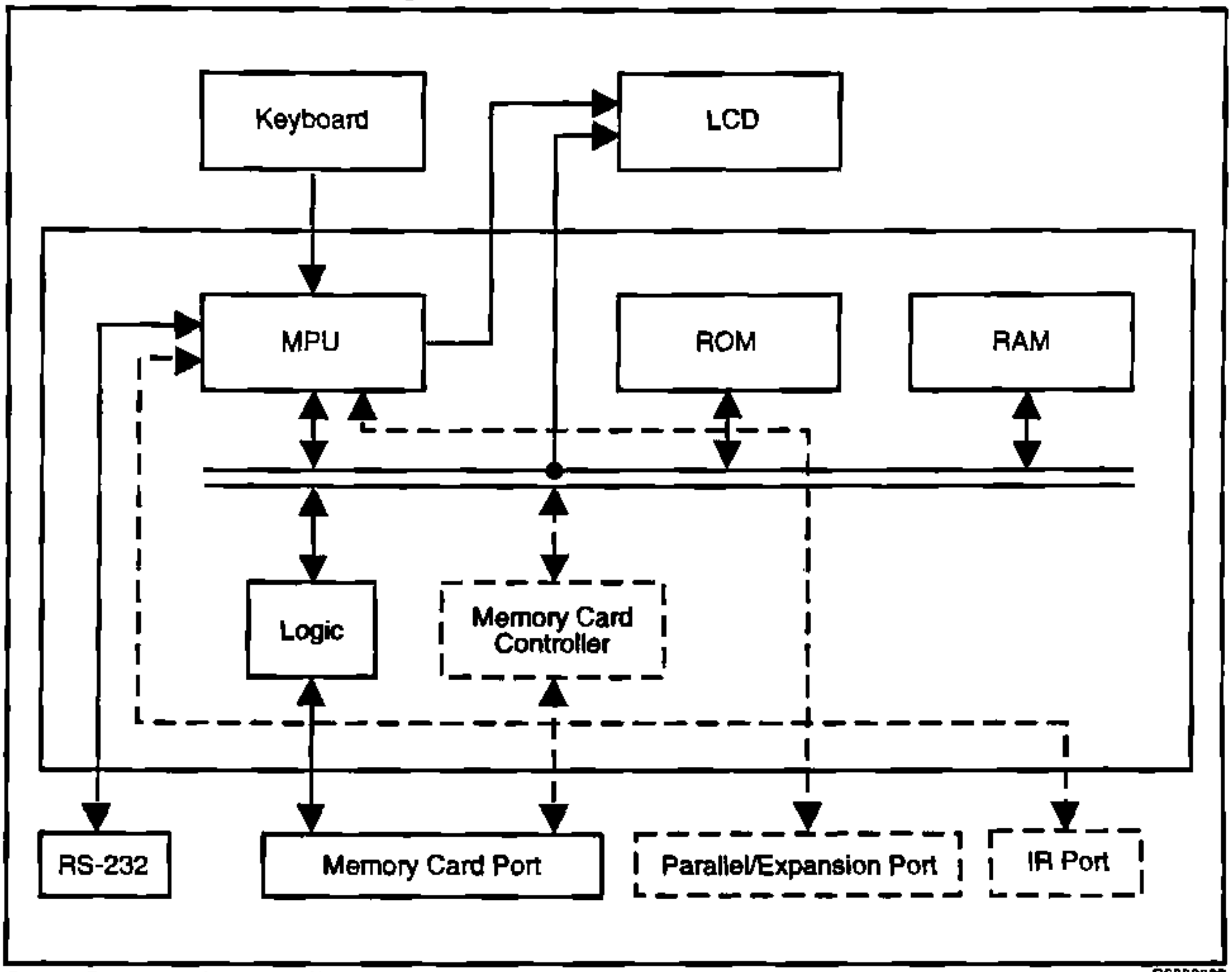
Who Uses Hand-Held PCs?

Beyond the on-the-go professional that needs something light for the road, a multitude of people use and will use these devices in a variety of environments. Weight, portability, and battery life are key features that make hand-held PCs attractive in industrial/commercial tasks on the factory floor to collect data, in shipping and receiving, for inventory and other tasks. Thus assuming that hand-helds deliver on the challenges at hand (ease of use, long battery life, and seamless connectivity), they stand to clearly dominate parts of mobile computing. Figure 4-1 shows a representative level of integration in today's hand-held PCs.

The trend in hand-helds is toward using a highly integrated MPU such as the NEC LH72001, the C&T F8680, the VADEM VG-230, or the Motorola LSC80018. The memory card port can be controlled in a number of ways. A memory card controller may be used if space and cost permit. Alternately, glue logic or even the MCU may be used for direct but less efficient control. This function will ultimately migrate to the MPU.

Table 4-1 shows hand-held unit projections based on Dataquest's Personal Computers group's forecast, which does not include personal organizers. Hand-held PC unit shipments are expected to grow at a CAGR of about 84 percent from 1992 to 1996. Both average selling

Figure 4-1
Hand-Held PC—Block Diagram



Source: Dataquest (August 1992)
G2000099

Table 4-1
Estimated Total Available Market, Worldwide Hand-Held PCs

	1992	1996	CAGR (%) 1992-1996
Units (K)	801	9,215	84.2
ASP ($)	330	280	-4.0
Semiconductor Content ($)	56	38	-9.2
Semiconductor TAM ($M)	44.8	350.2	67.2

Source: Dataquest (August 1992)

prices and hand-held semiconductor content are expected to come down following reasonably well-defined learning curves. The total available market for semiconductor vendors is projected to grow at a healthy rate of 67.2 percent over the same period. It should be noted that the semiconductor TAM figures do not include the substantial semiconductor memory (flash, ROM, and RAM) opportunities arising from memory card sales.

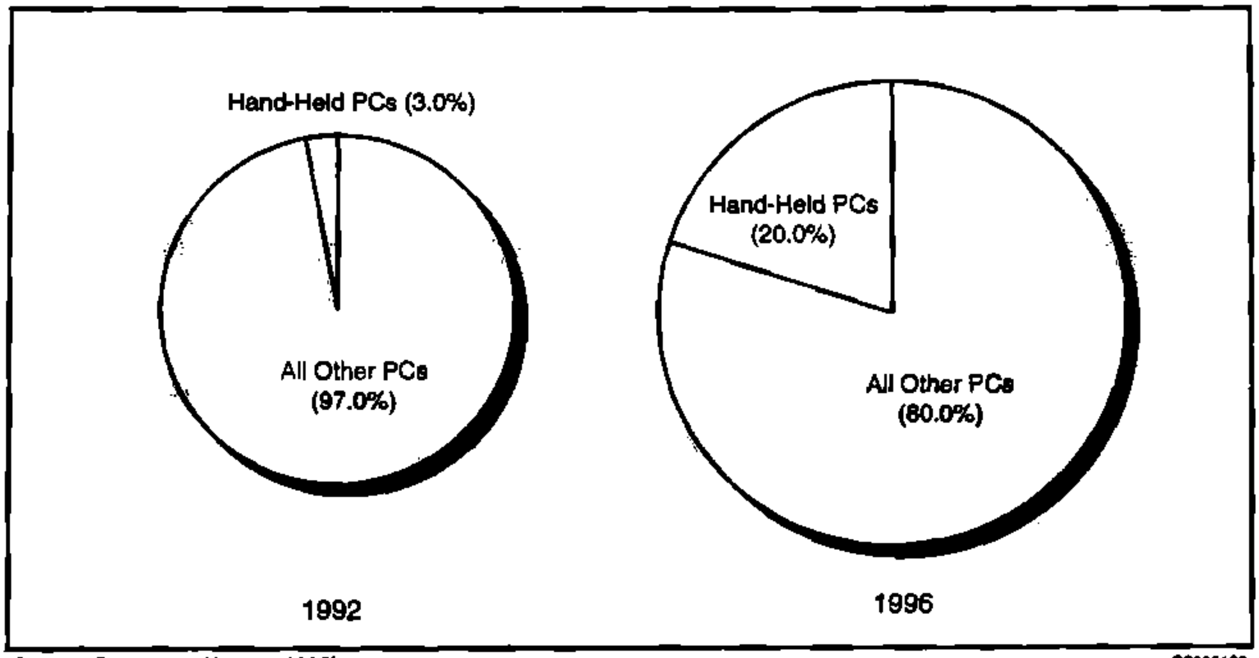
Figure 4-2 shows projected hand-held PC market share for 1992 and 1996.

Hand-Held PC Players

Players in the hand-held PC market, along with their status, are as follows:

- HP—In its second generation of product, HP 95LX 1MB.
- Poqet—In its second generation of product, Poqet PC.
- Sharp—About to enter the hand-held PC market with its PC-3000. Has participated in the organizer market with its Wizard product line.
- Casio—So far has offered a series of organizers (B.O.S.S. product line).

Figure 4-2
Worldwide Hand-Held PC Market Forecast



Source: Dataquest (August 1992)

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- Atari—Offers the Atari Portfolio. Sold close to 100,000 units in 1991.
- Sony—At present offers a line of hand-held PCs for the Japanese market that run a proprietary OS and accept pen input.
- PSION—Has offered a product that is similar to HP's 95LX but is based on a proprietary OS.

Semiconductor Opportunities and Trends

Opportunities and trends for semiconductors are described in the following paragraphs.

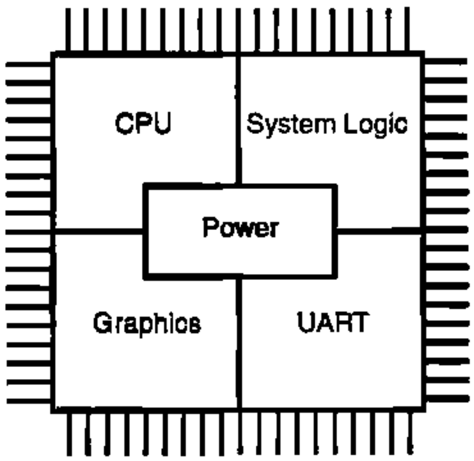
MPU

Because both space and power come at a premium, MPUs that integrate most if not all the functions needed to build a hand-held PC are now appearing to fill the gap. Figures 4-3, 4-4, and 4-5 are typical implementations. As high integration is achieved, board space and cost will be freed for other functions such as speech and handwriting recognition, and IR and RF communications capabilities. MPU speeds will increase, primarily driven by handwriting recognition, algorithmic demands, data compression speech processing, and communications needs.

Main Memory

Today 1MB of SRAM/PSRAM (pseudo RAM) is typically used. PSRAM is preferred for cost reasons. Two 4MB, 3/5V devices do the job. If the execute-in-place (XIP) function is successfully

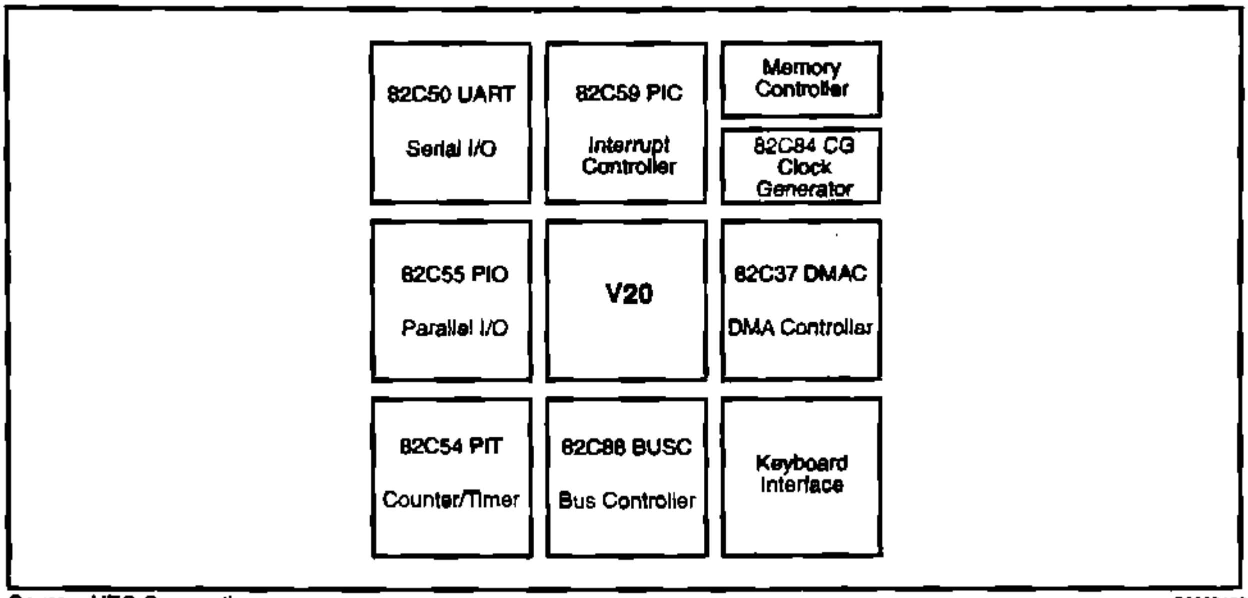
Figure 4-3
Block Diagram of the Chips and Technologies F8680 (PC/CHIP)



Source: Chips & Technologies Inc.

G2000101

Figure 4-4
Block Diagram of the NEC LH72001



Source: NEC Corporation G2000102

implemented, then main memory may increase marginally to 2MB. Flash will be used in the future because of nonvolatility and low power consumption; most likely it will replace at least a part or all SRAM/PSRAM.

ROM

The 1MB typically used today most likely will be replaced by flash in the near future. In this area hand-held PCs store their operating system (for example, DOS) and programs such as Lotus 1-2-3 and PIMs. The problem with ROM is that it cannot be changed and thus the hand-held PC may be rendered obsolete in a short period. Flash memory is far more appropriate for this function. The expected memory size is 2MB to 4MB in the near term, increasing to 10MB by the end of the decade.

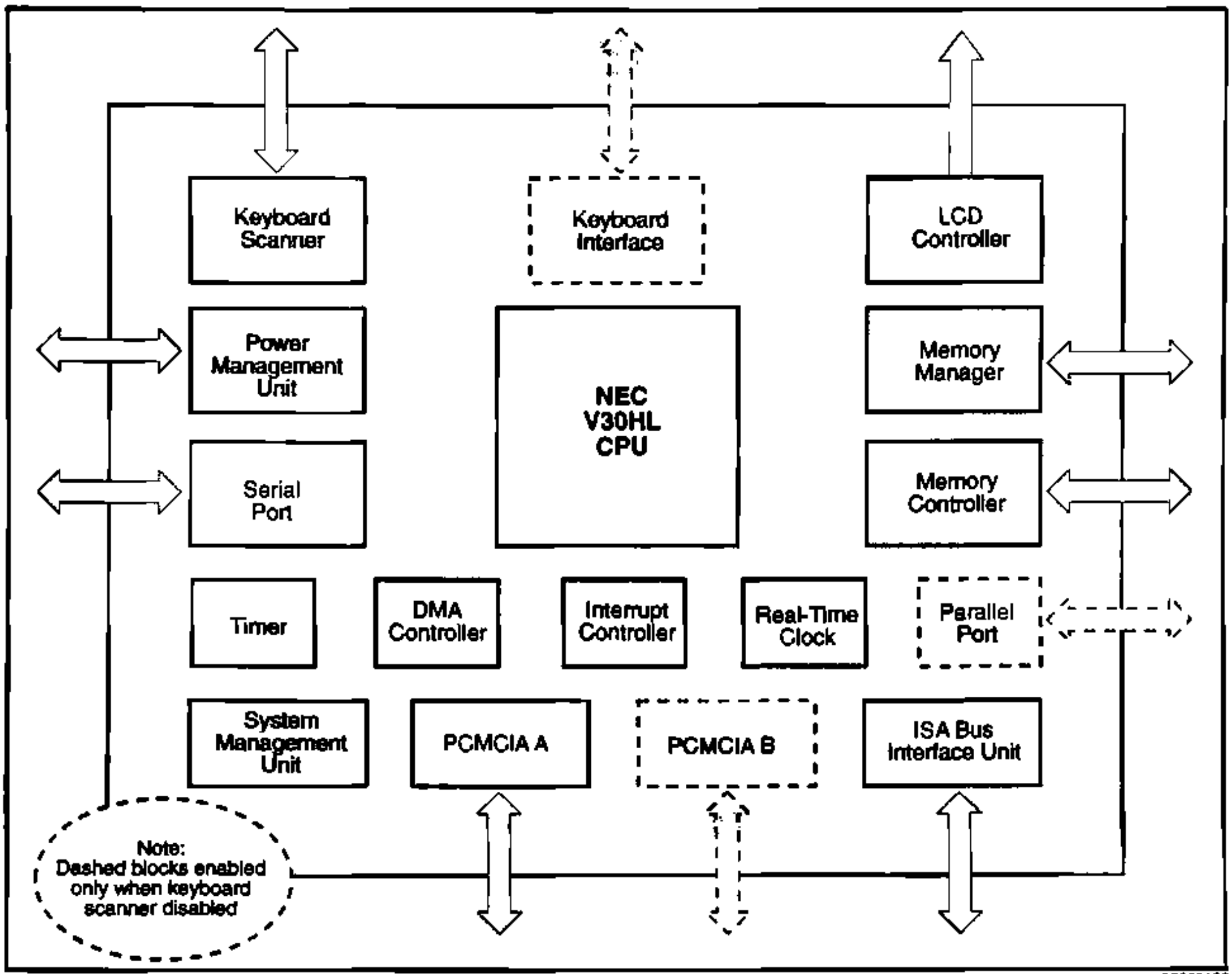
Mass Storage

Solid-state disks using flash memory with capacities on the order of 2MB to 5MB should be used in the near term; 10MB to 40MB should be used by 1995. Small densities should not be underestimated; by using software compression their size could be more than doubled, thus decreasing their apparent cost.

Data Compression

This function begs for eventual implementation in silicon, perhaps as part of a chip set at first, eventually to be integrated in the core MPU. Data compression is needed to offset the high cost of silicon-based memory used for mass storage.

Figure 4-5
Block Diagram of the VADEM VG-230



Source: VADEM

G2000109

Other Storage

Hand-held PCs will incorporate one or two PCMCIA-type ports supporting XIP. Flash and SRAM memory cards will be used as secondary storage devices. ROM memory cards will carry application software. Programming flash memory cards will become easy with the introduction of single-supply 5V devices now, and 3V in the future.

Connectivity

Connectivity is a key issue with devices such as hand-helds that tend to depend on the uploading and downloading of data to and from a desktop PC. Beyond the RS-232 type connections, infrared such as the one used by HP seems to be a very good alternative.

An infrared connection with the desktop may simplify the chore of transferring data and programs between a desktop and the hand-held. In the long run, with PCMCIA ports finding their way into desktops and notebooks, the memory card will be used to transfer data between hand-held and desktop PCs.

Communication

The HP 95LX hand-held can mate with the NewsStream receiver from Motorola. It allows the user to receive e-mail over national, regional, or local paging services. Most products offer built-in terminal emulation software that allows the hand-held to be tied up to a network such as CompuServe by using a modem. Modem and or wired/wireless fax capabilities may be integrated into hand-held PCs in the near future.

Who Makes Microprocessors for Hand-Held PCs?

The NEC V20 MPU is used by the HP95LX, the Poqet, and the Sharp Wizard series of products. It is by and large the microprocessor most commonly used in these IBM-compatible PCs.

A number of newcomer single-chip MPUs are poised to challenge this MPU. C&T introduced a single-chip highly integrated MPU, the F8680 (PC/CHIP), which also includes power management logic, a CGA-compatible LCD controller, a serial port, and IBM XT-compatible bus logic.

Newcomer VADEM will shortly introduce the VG-230, a device that incorporates the V30 MPU, a power management unit, serial port, timer, DMA and interrupt controllers, real-time clock, memory controller and manager, graphics LCD controller, and keyboard scanner.

Motorola is about to offer a highly integrated MCU, the LSC80018, to a small consortium of companies with the common goal of promoting a hand-held variant called PocSec for the Pocket Secretary. The LSC80018 features an 8-bit MCU that incorporates a graphics LCD controller, a real-time clock, an SPI, SCI, 3.5K of ROM, 448 bytes of RAM, and an 8MB MMU.

IC Peripherals for Hand-Held PCs

Table 4-2 lists memory card controller ICs, and Table 4-3 compares three hand-held computers. The Poqet has been around the longest. HP has been very well received, with sales on the order of 100,000 units for 1991. The Sharp PC-3000 is about to enter the market.

Dataquest Perspective

The need for portability must be balanced with the usefulness of a hand-held PC, which, depending on implementation, may be portable but not useful. A nagging problem in today's hand-held PCs is the human interface. A small hand-held with a tiny keyboard can fit in a pocket. Unfortunately, even the smallest amount of typing using such

Table 4-2
Memory Card Controller ICs

Intel	82365SL	Memory card controller	160-pin QFP
VLSI	VL82C107	Includes memory card Control function	128-pin QFP
Fujitsu	MB86301	Memory card controller	120-pin PQFP

Source: Dataquest (August 1992)

Table 4-3
Hand-Held PC Features

	HP95L × 1MB	Sharp PC-3000	Poqet
Size (Inches)	6.3 × 3.4 × 1.0	8.8 × 4.4 × 1.0	8.8 × 4.3 × 1.0
Weight	11 oz	1.23 lbs.	1.2 lbs
CPU/Speed	V20H at 5.37 MHz	80C88 at 10 MHz	80C88 at 7 MHz
System Memory	1MB SRAM	1MB SRAM	640KB SRAM
	1MB ROM	1MB ROM	768KB ROM
Keyboard	60 + 10 FN + 10 Apps	77 + 12 FN	77 + 10 FN
Display Column/ Emulation	40x16—MDA	80x25—CGA/ MDA	80x25—CGA/ MDA
Display Resolution	240 × 128	640 × 200	640 × 200
Batteries/Type	Two/AA	Three/AA	Two/AA
Memory Card Slot	1 PCMCIA-1.0	2 PCMCIA-1.0	2 PCMCIA-1.0
O/S	MS-DOS 3.22	MS-DOS 3.3	MS-DOS 3.3
Other Ports	3 wire RS-232	RS-232C	RS-232C
	Intra-Red	Parallel I/O	I/O bus (XT comp)
Opt. Peripherals	NewsStream Receiver	1.44MB 3.5" Floppy	1.44MB 3.5" Floppy
Built-In Software	Lotus 1-2-3 Ver 2.2	Lotus compatible	Scheduler
	Scheduler	Scheduler	Address/Phone Book
	Address/Phone Book	Address/Phone Book	Memo Editor
	Memo Editor	Memo Editor	Calculator
	HP Financial Calc	Calculator	File Manager
	DataComm	LapLink	Clock
	Filer	File Manager	ToDo list
	Clock/Stopwatch	Clock	
	ToDo list	ToDo list	

Source: Dataquest (August 1992)

a keyboard becomes a chore. That makes the hand-held effectively an organizer that can be connected to a desktop PC.

On the other hand, if the minimum useful size keyboard (such as the Poqet/Sharp PC-3000) is used, the hand-held cannot fit in a pocket and its usefulness is again reduced. The solution may be a hybrid product such as the HP 95LX where the keyboard keys are enlarged to a size closer to those in the Poqet/Sharp PC-3000 (QWERTY without separate numeric keypad) and where the pen input is allowed to supplement the keyboard. Both Sharp and Sony have demonstrated products that incorporate such a pen-based input device. Even though these are not hand-held PCs that run DOS, they are a step in the right direction. Making such devices PC-compatible is rather simple.

The key to success for hand-helds may be semiconductor devices that allow for a good machine-human interface, which may be handwriting on the LCD screen, voice recognition, or a combination of both, and provide seamless connectivity. If hand-helds succeed in being easy to use, then their unit volume potential will exceed our expectations.

Chapter 5
DRAM Product and Supplier Assessment

For many users, DRAMs rank as their most critical supply base concern. A key element to Dataquest's Semiconductor Procurement Service (SPS) strategy for DRAM demand management is for users to match system life cycles with DRAM life cycles. This evaluation enables systems manufacturers to compare their long-term system migration plans against DRAM life cycles for the purpose of managing DRAM costs and planning for DRAM product changes in those cases where system and DRAM life cycles do not match.

Based on Dataquest's 1991 DRAM market share ranking, this section evaluates the life cycle stage for DRAMs in 256K through 16Mb densities and assesses the evolving supply/supplier base for these critical products not only today but for the remainder of this decade. Modeled in the same fashion as previous Dataquest articles in our series of IC supply base reports, this chapter is organized in three main sections. The first section develops a guide to cost-effective procurement of DRAMs through the use of product life cycle analysis. The second section focuses on the top-ranked suppliers of DRAMs and looks at market positions, product strategies, technology strengths, strategic alliances, and the worldwide fab network of leading suppliers. The third section combines the analyses of DRAM life cycles and the supplier base. This section supports users of DRAMs in assessing which direction to take for DRAM products and suppliers over the long term.

DRAM Product Life Cycles

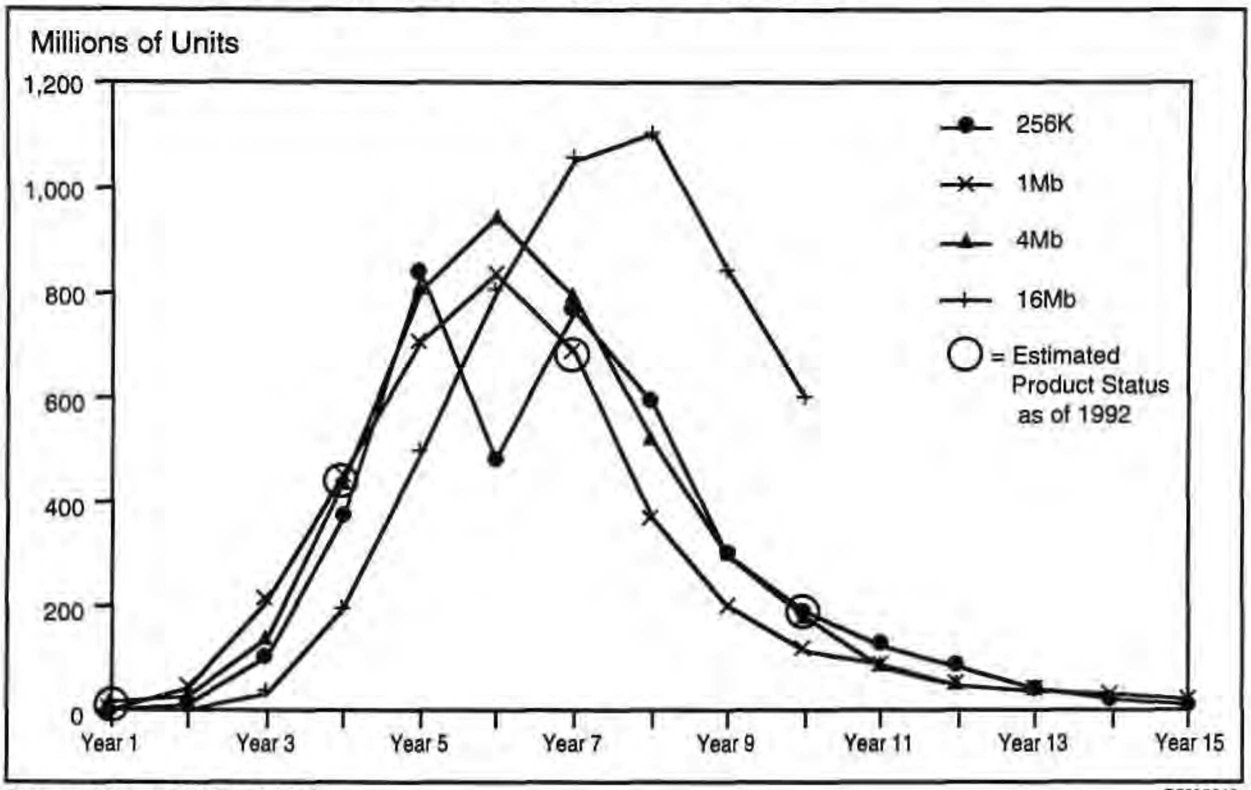
This section uses information on DRAM product life cycles as a guide to assist users in adjusting to forces affecting the marketplace over time. This section also lays the basis for other analysis based on DRAM life cycle curves.

DRAM Life Cycles by Product Density

Figure 5-1 shows a series of curves that map the product life cycle of DRAMs in densities of 256K to 16Mb. This figure is based on Dataquest's historical DRAM unit shipments and forecast information.

Figure 5-1 reveals that DRAMs experience a life cycle in the range of 15 years, excluding the R&D phase. The figure also illustrates

Figure 5-1
DRAM Product Life Cycles by Density as of August 1992



Source: Dataquest (August 1992)

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that DRAMs with densities of 4Mb and below typically reach the peak stage of the life cycle during the sixth year.

Historically a new density of DRAM has been introduced every three years—with a concomitant three-year interval for price-per-bit crossovers. The trend is toward longer DRAM life cycles as measured by the interval between price-per-bit crossovers.

Factors Affecting DRAM Life Cycle Behavior

Among the factors affecting DRAM life cycle behavior are system application trends, DRAM manufacturing trends, and the levels of R&D and capital spending. We believe that the huge R&D expense and fab costs associated with designing and manufacturing DRAMs with densities of 4Mb and greater account for the trend toward longer DRAM life cycles when compared to prior generations.

Key DRAM manufacturing trends include the move to ever smaller submicron processes, which will face ultimate laws of physics after the year 2000; the increased number of masks/processes; the rate of yield improvement; and the pace of the industry's shift to larger-size wafers (from 8-inch to 10- or 12-inch wafers).

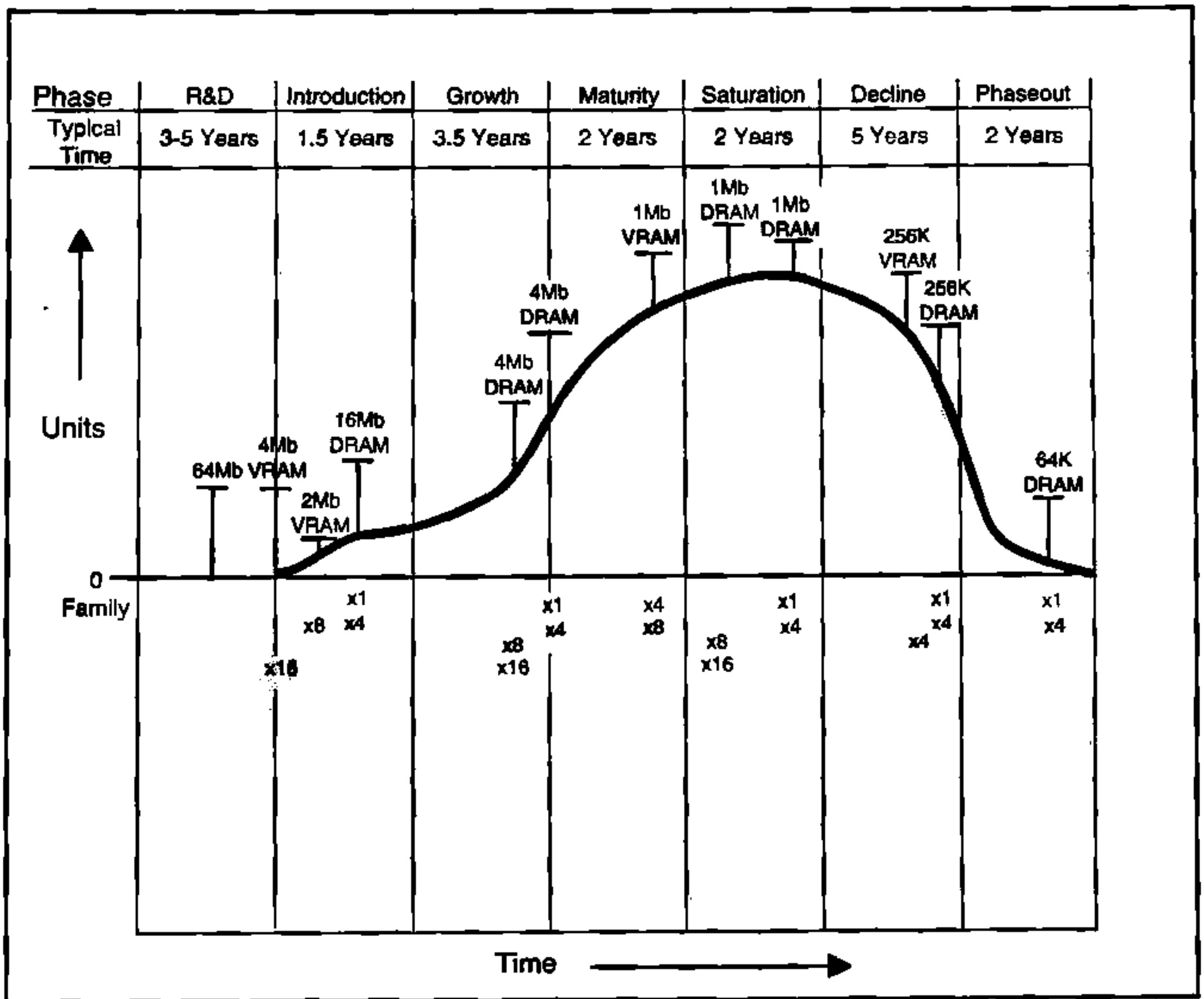
Significant application trends include the evolving relationship between system main-memory requirements and DRAM storage capacity. For example, growth in noncomputer DRAM demand (VCRs, telecom systems) means increased use of DRAMs with smaller storage capacity than that necessary for computer systems. Another application trend entails the growth in demand for low-voltage, low-power, high-speed systems—meaning increased consumption of wide DRAMs (x16).

A bottom-line financial factor that will affect megabit density DRAM life cycles is the industry's ability—or inability—to profitably sustain enormous levels of R&D and capital spending needed to produce ever denser and more complex DRAM devices on schedule (for example, 1Gb DRAM prototypes by the year 2000).

DRAM Life Cycles by Configuration

Figure 5-2 depicts the life cycles for DRAMs and VRAMs on the basis of organization. The figure breaks each stage into specific time intervals.

Figure 5-2
DRAM Product Life Cycles by Configuration as of August 1992



Source: Dataquest (August 1992)

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DRAM Life Cycle Stages

Figure 5-2 shows that the DRAM R&D stage occurs over a three- to five-year period. The DRAM introduction and growth stages extend for five years. The maturity and saturation stages—which total four years—represent the peak of the life cycle. The decline/phase out period typically persists for five to seven years. Figure 5-2 shows that the 1Mb DRAM life cycle—which peaked during 1991 in terms of unit shipments—should move through the decline phase starting in 1993. The 1Mb DRAM life cycle should extend well past 1995. Dataquest expects a long life for 4Mb DRAMs, with the life cycle peak not expected until the 1994 time frame. Figure 5-2 also shows that the 16Mb DRAM has entered the introductory stage of a cycle that should extend to the year 2000, and that 64Mb DRAMs are in the R&D phase. At the other end of the curve, the 256K DRAM continues to move through the decline stage.

DRAM Product Configurations

The x1 and x4 designs have been the mainstream DRAM organizations; however, the DRAM trend should be toward product proliferation in terms of wide-word configurations (x8; x16/x18), single in-line memory modules (SIMMs), the range of speeds, package choices (TSOP, ZIP), and specialty applications such as 2Mb VRAMs, synchronous DRAMs, and cache DRAMs. Figure 5-2 shows that the life cycle for the newer wide-word organizations lags behind that of the more familiar x1 and x4 configurations. SIMM life cycles are virtually the same as those of the underlying DRAM devices. VRAM life cycle lags the stage of the equivalent-density DRAM by about one year.

DRAM Suppliers

This section analyzes the product and market strategies of leading DRAM suppliers. The analysis covers each company's DRAM market ranking, product positioning, strategic alliances, and global fab network.

Users of megabit-density DRAMs should be aware that the introductory stage of the DRAM product life cycle can mean a competitive advantage for early entrants able to enjoy premium pricing through the introduction and growth phases of the product. Furthermore, the DRAM's extended maturity stage eventually tips the competitive balance to low-cost producers. Regarding the next-generation 16Mb DRAM, some 1992 reports to Dataquest indicate an aggressive pricing curve for the product during the forward stages of the life cycle; however, dumping allegations in North America against Korean suppliers have undercut that scenario.

Table 5-1 presents the 1991 worldwide ranking of DRAM suppliers by product. The table presents each company's ranking in terms of units for densities ranging from 256K through 4Mb.

Table 5-1
Top Worldwide DRAM Suppliers by Product

Supplier	1991 Revenue Ranking[1]	Unit Shipment Ranking by Product Density[2,3] 256K	1Mb	4Mb	16Mb
Toshiba	1	10	2	2	2
Samsung	2	1	1	3	
NEC	3	2	5	4	4
Hitachi	4	8	13	1	1
Texas Instruments	5	4	3	10	
Mitsubishi	6	6	9	6	7
Fujitsu	7	7	8	5	3
Micron	8	11	4	13	
Oki	9	5	11	7	6
Siemens	10	13	6	8	
Motorola	11	19	7	11	
Goldstar	12	9	12	12	
Hyundai	13	3	10	9	
Matsushita	14	12	15	14	5
Vitelic	15	16	16		
Total (Millions of Units)		299	835	138	0.1

Note: Total includes other suppliers not shown on table
[1]In terms of revenue
[2]Includes VRAMs
[3]In units
Source: Dataquest (August 1992)

Table 5-2 presents the estimated total worldwide fab capacity of leading DRAM suppliers, including percentage devoted to DRAMs.

Table 5-3 displays the worldwide network of DRAM technology alliances.

For a detailed analysis of DRAM technology alliances, see Chapter 6.

Tables 5-1, 5-2, and 5-3 are guides in the analysis of the 256K, 1Mb, 4Mb, and 16Mb DRAM supplier base.

Toshiba

Table 5-1 reveals that Toshiba holds a second-place ranking in both 1Mb DRAMs and 4Mb DRAMs as measured in unit shipments. Toshiba is waging a neck-and-neck battle with Samsung during 1992 for total DRAM market share leadership.

The vertically integrated Japan-based supplier positions itself as a leader in terms of DRAM manufacturing capability. Toshiba is well prepared to battle all suppliers for 4Mb and 16Mb DRAM market

Table 5-2
Estimated Number of Wafer Fabrication Production and Pilot Lines of Top-Ranked DRAM Suppliers

	North America	Japan	Europe	Asia/Pacific Row	Total No. of Lines	Total Theoretical Capacity[1]	Estimate of Percent Theoretical Capacity for 4Mb Drams
Toshiba[2]	0	29	0	0	29	158.6	17.0
Samsung	0	0	0	7	7	57.9	57.1
Hitachi	1	27	1	0	29	141.3	38.5
NEC	2	24	2	0	28	149.1	20.6
Texas Instruments[3]	10	5	4	1	20	92.2	35.9
Fujitsu	1	20	1	0	22	111.1	18.4
Mitsubishi	1	17	0	0	18	88.1	18.6
Micron	3	0	0	0	3	22.4	50.4
Oki	0	8	0	0	8	65.9	40.4
Siemens	1	0	7	0	8	35.4	34.2
Hyundai	0	0	0	5	5	26.3	50.0

[1] Theoretical capacity stated in millions of square inches of silicon per year
[2] Includes Tohoku Semiconductor (Japan)
[3] Includes TI/Acer
Source: Dataquest (August 1992)

Table 5-3
Estimated Worldwide DRAM Technology Alliances as of August 1992[1]

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances	
Supplier	Second-Source Agreements	Fab Agreements	Joint-Venture Agreements	Fab Agreements	Joint-Venture Agreements	Joint Development
Goldstar		Vitelic-MOSel				
Goldstar			Hitachi (FA)			
Hitachi	Goldstar					
Hitachi						TI (and 64Mb DRAM)
IBM						Siemens (and 64Mb DRAM)
IBM			Micron (LA)			
Intel	Goldstar (OEM)		Goldstar (OEM)			
Matsushita		Intel (also Sales Agency Agreement)				
Micron	NEC (Mutual OEM)		NEC (Mutual OEM)		NEC (Mutual (OEM)	
Micron	Sanyo (64Kx16 device)					
Motorola	Goldstar (OEM)		Goldstar (OEM)			
NMB			Hitachi (OEM arrangement based on Hitachi production technology)			
NMB			Ramtron International (JD)			
NMB					Ramtron	
Oki				Vitelic-MOSel	Vitelic-MOSel	
Sanyo			Mosaid			
TI			HP-Canon-Singapore		HP-Canon-Singapore	
TI			Acer			
TI	Mitsubishi					
Thorn-EMI	NMB (LA per Thorn's Inmos-based patent)					
Toshiba	Motorola		Motorola			
Toshiba	Siemens (LA)					

Definitions/Notes:
FA = Fab agreement: supplier offers fab capacity for partner's product technology. In most cases, the supplier provides fab capacity and produces the partner's DRAM design.
JD = Joint development: the companies jointly agree to develop new products, which may or may not be marketed separately.
JV = Joint venture: the companies form a new joint-venture company to develop, manufacture, and market new products.
LA = Licensing agreement: supplier receives or issues a license to partner for an up-front fee and/or royalties.
OEM = OEM arrangement: supplier sells product to alliance partner, which is sold under partner's name.
SA = Sales agency agreement: supplier sells its partner's products as either a sales representative or a value-added reseller.
SS = Second-source agreement: the companies agree to develop consistent specifications to ensure a second source.
[1]Excludes SIMMs (e.g., Wang's X9 SIMM) and other patent royalties.
Source: Dataquest (August 1992)

share. Even so, Toshiba has publicly expressed concern about the DRAM supply and demand outlook—not only for 1992 and 1993, but also the long term. A major concern for Toshiba is the accurate industry gauging of the DRAM fab capacity required to meet demand.

The industry giant should remain a leader in the DRAM market for the foreseeable future. During the short term, Toshiba will emphasize the 4Mb DRAM density. The information in Table 5-2 shows that Toshiba has started the shift to the 16Mb device that will become the mainstream product by the 1995/1996 time frame.

Toshiba's competitive product portfolio includes high-speed DRAMs, VRAMs, wide-word configurations, and SIMMs. Toshiba recently announced samples of synchronous DRAMs and RDRAM, the latter based on Rambus' high-throughput DRAM. Based on 1991 unit shipments, Toshiba is the leading supplier of 1Mb VRAMs. During 1992, Toshiba introduced a 2Mb VRAM. The supplier should be a major player in the 4Mb VRAM segment as the market emerges during 1993.

A key DRAM alliance for Toshiba is the well-publicized DRAM/MPU arrangement with Motorola. In this alliance, Toshiba provides the DRAM design and manufacturing technology. The alliance partners manufacture DRAMs in their joint Tohoku (Japan) fab, and Motorola resells them in world regions such as North America.

Users in Europe should monitor the evolution of the Toshiba-Motorola alliance as the rules on local diffusion become final. For example, Motorola has established five fabs in Europe. Toshiba has none outside Japan except for a small facility in North America (California); however, it has announced new fabs for Germany and North America (Oregon).

Toshiba also just announced an alliance with IBM and Siemens for 256Mb DRAM product/process development.

Samsung

Samsung of the Republic of Korea continues its impressive advance in the global DRAM marketplace, now aiming to move a notch higher into a first-place ranking. Samsung ranks first in the 256K and 1Mb segments, and third in the 4Mb arena. Samsung holds the No. 8 position in the 1Mb VRAM marketplace. A key factor is that the company has used a low-cost manufacturing strategy to gain share in world markets such as North America and Europe.

Dataquest advised last year that to protect its long-term position in the worldwide DRAM arena, Samsung must avoid trade friction—which would be challenging. A recent obstacle to Samsung's advance in North America is the dumping allegations by North America-based Micron Technology against Korea-based suppliers, allegations that have caused trade friction for Samsung. For example, during the first half of 1992, Samsung positioned itself for a forward-stage price strategy on the 16Mb device—similar to the 256K pricing scenario by Japan-based suppliers during the 1985-1986 period. Micron's allegations might throttle such aggressive pricing. Samsung also remains under trade scrutiny in Europe. Samsung's vulnerability to trade restraints is heightened by the lack of fabs outside Korea and the absence to date of any key DRAM alliances.

Regardless, Samsung now positions itself as a DRAM technology leader and aims for a global leadership role in the 16Mb marketplace. Users can expect a competitive product portfolio. As shown by its second-place ranking in the 4Mb segment and competitive position in the early stage of the 16Mb life cycle, Samsung ranks among the world leaders in the DRAM technology race.

NEC

NEC holds a second-place ranking in the 256K DRAM segment, the No. 5 ranking in the 1Mb arena, and fourth place in the 4Mb marketplace. NEC has somewhat of a reputation as a DRAM "follower of the leader." For example, NEC acts somewhat from a DRAM technology catch-up position—but the company does not trail the market leaders by far. The vertically integrated Japan-based company has successfully executed this strategy in past years by supporting superior manufacturing planning with deep-pockets financial strength.

NEC should remain a top worldwide DRAM supplier. Like other leading suppliers, NEC's long-term strategy focuses on DRAM densities of 4Mb and greater; however, the company is strong in some lower-density segments as well. For example, NEC is the leading supplier of 256K VRAMs and holds the No. 5 spot in the 1Mb VRAM arena. During the first half of 1992 it started volume production of 2Mb VRAMs. Users of 4Mb DRAMs can look to NEC for a competitive product portfolio including high-speed 4Mb DRAMs, wide-word configurations, SIMMs, and VRAMs.

NEC has positioned itself nicely to withstand potential trade friction in regions such as North America and Europe, having two fabs in each of those regions (see Table 5-2). The recently announced OEM arrangement with Micron (see Table 5-3) puts NEC onto the DRAM alliance map.

Hitachi

Hitachi, a Japan-based vertically integrated supplier, now battles Samsung and Toshiba, among others, to maintain its first-place ranking in the mainstream 4Mb segment, while migrating to the emerging 16Mb arena.

Hitachi's DRAM strategy continues to focus on the company's design expertise and manufacturing prowess, augmented by marketing skill. Users can expect a competitive product portfolio from Hitachi in terms of a full range of product speeds, configurations, and packaging options toward a goal of DRAM product differentiation. For example, Hitachi's 4Mb DRAM product line includes wide-word configurations, SIMMs, and high-speed DRAMs. Hitachi de-emphasizes 256K DRAMs and 1Mb DRAMs except for VRAM products. Hitachi ranks third in the 256K VRAM business (64Kx4) and sixth in the 1Mb segment (256Kx4; 128Kx8). The supplier will make an orderly move to 3V DRAM and 4Mb VRAM as those markets develop.

Hitachi's fab network includes one facility in both the European and North American markets—an important consideration in a period of rising trade tension. A sign of Hitachi's DRAM manufacturing prowess is that the fab network includes state-of-the-art 8-inch wafer capability.

Japan-based Hitachi has forged two key DRAM technology alliances—one with Korea-based Goldstar and the other with North America-based TI. The alliances are still evolving. For example, the alliance with TI on 16Mb DRAMs resulted in two different DRAM designs—but a common package. The 64Mb alliance aims at a second-source arrangement. Hitachi's 1Mb DRAM alliance with Goldstar is a second-source deal. In the 4Mb foundry arrangement, Goldstar makes the device using Hitachi's design, with the product sold by Hitachi.

Texas Instruments

TI trails the market leaders in the 4Mb DRAM business. The North America-based supplier ranks fourth in 256K density, third in the 1Mb arena, and is No. 10 in the mainstream 4Mb arena. In terms of global coverage, however, TI stands in good position to make a DRAM market advance over the next few years in each world region.

The industry giant offers a competitive 4Mb DRAM product portfolio that includes wide-word configurations and SIMMs. TI, which invented the VRAM in 1983, ranks second among suppliers of 1Mb VRAMs and fifth in the 256K VRAM marketplace. TI will bypass any 2Mb VRAM and concentrate on the 4Mb VRAM product, aiming for volume production during the fourth quarter of 1992.

TI centers one prong of its DRAM strategy on alliances that spread the risk and benefits of participation in the global DRAM business to a network of alliance partners that includes users, other suppliers, and governments. Table 5-3 presents information on a host of TI alliances. The joint venture agreement on 4Mb and 16Mb DRAMs among TI, Canon, HP, and the government of Singapore—along with the TI-Acer (Taiwan) alliance on 4Mb DRAMs—might serve over the long term as industry models of user-supplier alliances not only in DRAMs but also with other ICs. The TI-Hitachi alliance has been discussed. Another alliance not shown in Table 5-3 is a venture between TI and the Italian government to produce 4Mb DRAMs in Italy.

A second prong of TI's DRAM strategy calls for aggressive protection of its entire IC patent portfolio—whether through litigation or negotiation—toward the goal of collecting royalty payments. In fact, TI reports patent royalties and related payments as operating income on its balance sheet.

Users should expect continuing adherence by TI to this set of strategies.

Mitsubishi

Mitsubishi holds the No. 6 position among suppliers of 256K DRAMs and 4Mb DRAMs, and it is ninth in the 1Mb segment. The vertically integrated Japan-based company ranks second among suppliers of 256K VRAMs and fourth in the 1Mb VRAM segment. Mitsubishi sampled 2Mb VRAMs during the first half of 1992. Mitsubishi's 4Mb DRAM portfolio includes high-speed DRAM and wide-word configurations.

Mitsubishi remains a competitive world-class supplier. For example, Mitsubishi strives for process and packaging technology expertise, which might translate into a market advantage at the 16Mb and 64Mb densities. The zig-zag in-line package (ZIP) and the thin small-outline package (TSOP) were Mitsubishi innovations. Even so, if success in the 4Mb DRAM business serves as a key indicator of long-term success, the signals remain mixed regarding any ultimate leadership role for Mitsubishi.

Fujitsu

Fujitsu holds the No. 5 spot in the 4Mb DRAM market, but lower rankings in the 256K segment and the 1Mb market. For this vertically integrated Japan-based supplier, internal demand reduces the company's exposure to DRAM merchant market volatility.

Fujitsu's product portfolio will be competitive. Fujitsu has a market reputation for good DRAM technology (small die sizes). Users can look to Fujitsu for VRAMs. The company ranks third among suppliers of 1Mb VRAMs and fourth in the 256K VRAM marketplace, and will evolve with the market to higher-density VRAMs. Fujitsu has evolved its SIMM product portfolio in line with market demand trends (wide-word configurations). Fujitsu will place less emphasis on 256K and 1Mb DRAMs during 1992 and 1993.

Fujitsu has fab locations in Europe and North America in addition to Japan. To date, Fujitsu has not been a player in the world of DRAM technology alliances. Users can look to Fujitsu as a dependable and competitive long-term supplier of DRAMs.

Micron

Micron, a relatively small North American supplier surrounded by industry giants, ranks fourth in the 1Mb DRAM arena. Micron did not crack the top 10 in the 256K and 4Mb segments based upon 1991 unit shipments.

There are four prongs to Micron's competitive strategy. Unlike its vertically integrated competitors, Micron does not aim at leading-edge DRAM technology leadership. Instead, the first key prong of the company's strategy calls for leadership in low-cost DRAM manufacturing capability. For example, Micron is able to reduce its capital requirements—a critical concern for DRAM suppliers—through innovative mask-reduction techniques. Micron's product portfolio is weighted toward mature DRAM devices (1Mb DRAMs during 1992) because the market typically favors low-cost producers during this peak stage of the DRAM life cycle. A key to Micron's success is that the company gears its effort toward achieving die-shrinks for mature DRAMs, which means quality results in manufacturing and low market pricing.

Alliances, indicated by Micron's just-announced OEM arrangement with NEC, serve as another prong of the company's strategy. Another Micron alliance with IBM on DRAM manufacturing process technology has supported Micron to implement its low-cost manufacturing plan.

A third prong in Micron's competitive strategy is that the company utilizes the global legal system to protect its stake in the market. During the first half of 1992, Micron alleged that Korea-based suppliers dumped DRAMs into the North American market. The action could stifle the advance into North America and other world regions of suppliers such as Goldstar, Hyundai, and Samsung.

The fourth prong is that Micron aims to meet specialty memory needs. For example, users of 1Mb DRAMs can look to Micron for 64Kx16 DRAMs and 128Kx8 VRAMs. Another example is that Micron offers a triple-port DRAM. Micron ranks sixth among suppliers of 256K VRAMs and hopes to start volume production of 2Mb VRAMs during the third quarter of 1992.

Users can expect Micron to become an increasing force in the 4Mb DRAM segment as the product nears and then moves through the maturity stage of the life cycle during 1993 and 1994.

Oki

Oki ranks fifth in the 256K DRAM segment, No. 11 in 1Mb density, and seventh in the key 4Mb marketplace. The vertically integrated manufacturer has encountered somewhat uneven results in the brutally competitive DRAM business over the last several years.

Oki aims at leadership in the SIMM marketplace. As noted last year, users can expect Oki to be a leader in the move to 4Mb SIMMs and later to 16Mb modules. For example, Oki likely will ship the majority of its 4Mb DRAMs in the form of SIMMs.

Siemens

Siemens ranks sixth in the 1Mb DRAM market and eighth in the 4Mb segment.

The geographic focus for this vertically integrated Germany-based company has reverted to Europe, given the immense geopolitical changes in that region during the past several years and concomitant long-term opportunity. Users in Europe are likely to become more dependent on Siemens for DRAMs—certainly until other suppliers are producing there and especially if trade friction in that region increases. For example, the alliance between Siemens and IBM on 16Mb/64Mb DRAMs signals for users that Siemens's DRAM future aims more at serving European demand—including Eastern Europe—and less on North American or Asian demand.

There are other rationales for the alliance. For example, Siemens wants to reduce its risk exposure in the volatile DRAM marketplace. Significantly, Siemens ponders a shift in its strategic direction over the long term from the highly competitive memory business to other products such as ASICs—which makes unclear the company's ultimate goals regarding DRAMs of densities of 64Mb and greater—although the company just established the alliance with IBM-Toshiba on 256Mb DRAM development.

IBM

Another player has emerged on the scene, a player that could end up in Table 5-1 by next year. IBM, which at the time of this writing had just announced plans to enter the DRAM merchant market, should be a key wild card among DRAM suppliers—as shown by the alliance with Siemens and Toshiba on 256Mb DRAM.

Supply Base Analysis

This section uses information on DRAM product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for 256K through 4Mb DRAMs. This section blends the DRAM life cycle analysis and supplier evaluations to generate a summary assessment from a user's perspective on the anticipated DRAM supply and supplier base outlook.

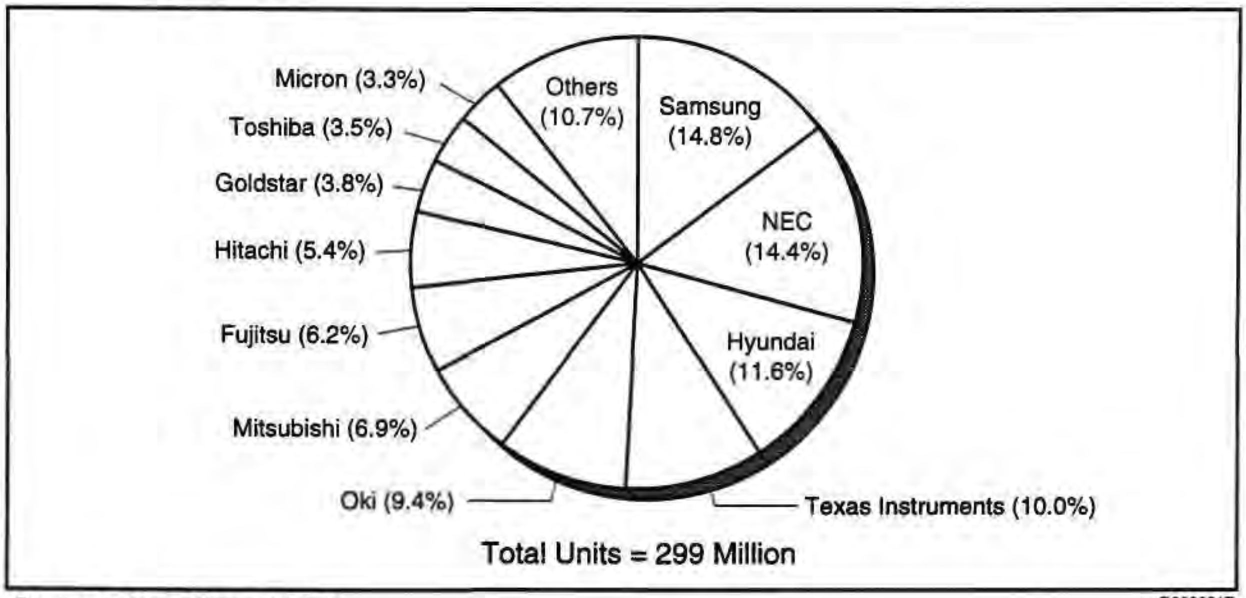
The goal of this section is not to present a detailed forecast on DRAM supply-demand trends, but rather to provide supply base managers with guidance as to whether users face a favorable or negative supply outlook for each density of DRAMs. Building upon the prior sections, factors affecting the supply base such as supplier strategies and strategic alliances are assessed here.

Figures 5-3, 5-4, and 5-5 guide the analysis in this section. Figure 5-3 shows the size of the 256K DRAM market in terms of units shipped during 1991 and a ranking of the suppliers of these devices including suppliers' shares. Figure 5-4 shows unit shipments and supplier ranking for 1Mb DRAMs. Figure 5-5 shows the same information for 4Mb DRAMs. Keep in mind that IBM's recent announcement does not specify its DRAM product strategy by density, although IBM's impact should be pronounced at densities of 16Mb and greater.

Supply Base for 256K DRAMs

Figure 5-3 shows the top-ranked 256K DRAM suppliers based on 1991 unit shipments. The figure reveals that leading suppliers, in descending order, are Samsung, NEC, Hyundai, TI, Oki, Mitsubishi, Fujitsu, Hitachi, Goldstar, and Toshiba. Table 5-1 shows the range of suppliers.

Figure 5-3
256K DRAM Supplier Base



Source: Dataquest (August 1992)

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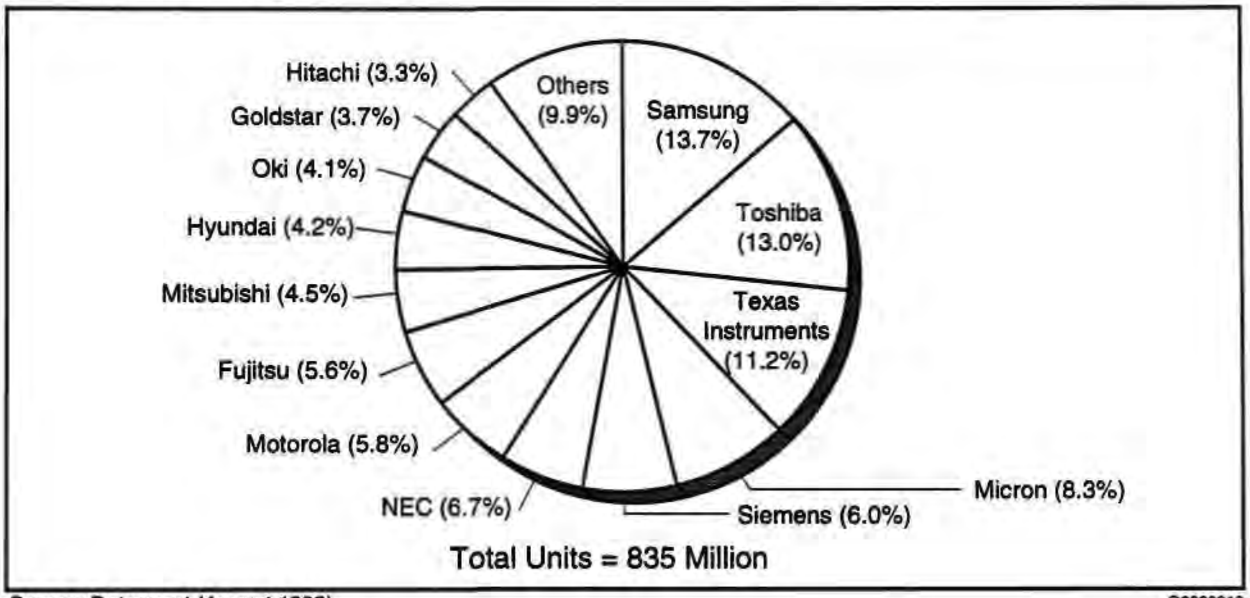
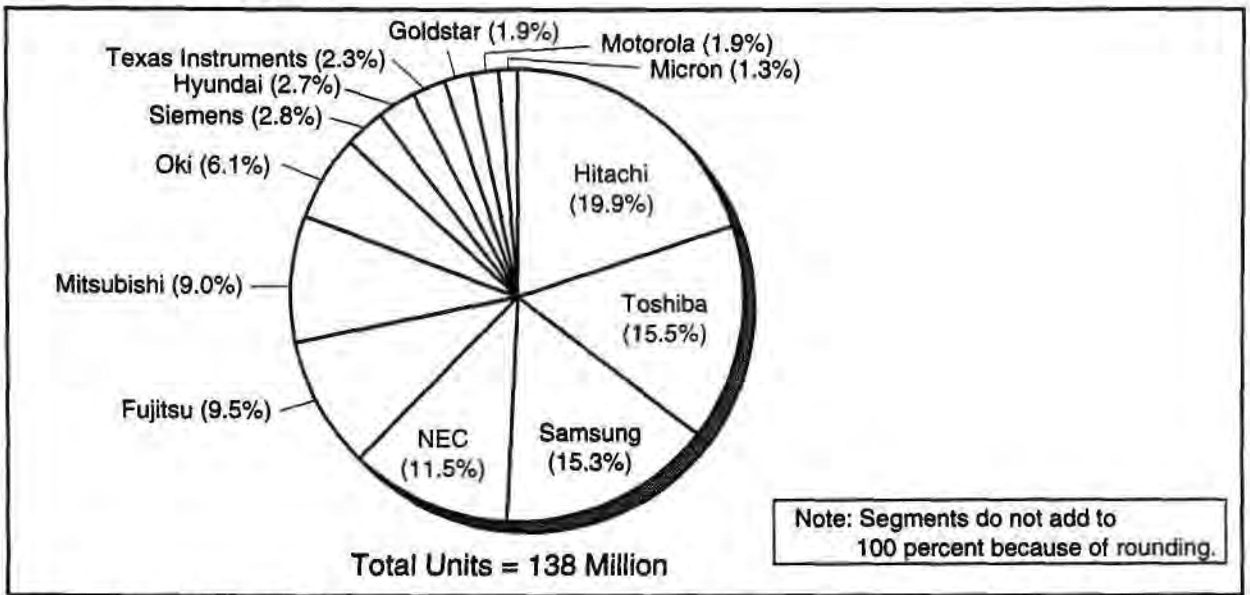
Figure 5-4
1Mb DRAM Supplier Base



Source: Dataquest (August 1992)

G2000818

Figure 5-5
4Mb DRAM Supplier Base



Source: Dataquest (August 1992)

G2000819

Figures 5-1 and 5-2 show that the 256K DRAM product is moving through the decline stage. Worldwide production of 256K DRAMs fell to 299 million units during 1991 versus a 1990 level of nearly 600 million units. The life cycle peaked during the 1988-1989 period.

Suppliers are migrating to higher-density devices that could cause short-term supply constraints for some users. In general, however, users face a favorable outlook in terms of supply because of decreasing market demand.

To minimize the likelihood of any supply line disruption, users should be prepared to forge long-term supply arrangements with current suppliers or else qualify new suppliers. For example, Korea-based suppliers likely will support users of 256K DRAMs in an effort to win qualification on other devices such as higher-density DRAMs. The life cycle for high-speed DRAMs lags behind that of general DRAM life cycles, so suppliers such as NMB should remain supportive to users of the higher-speed devices.

The 256K VRAM life cycle lags that of the garden-variety 256K DRAM by about a year, meaning somewhat longer support from suppliers on this device. NEC is the leading supplier, followed by Mitsubishi, Hitachi, Fujitsu, and TI. Users should target these companies for continuing support.

Supply Base for 1Mb DRAMs

Figure 5-4 presents the top-ranked 1Mb DRAM suppliers based on 1991 unit shipments. The figure shows that the top-ranked suppliers in descending order are Samsung, Toshiba, TI, Micron, NEC, Siemens, Motorola, Fujitsu, Mitsubishi, Hyundai, Oki, and Goldstar. Table 5-3 shows 1Mb DRAM alliances between these suppliers, including Goldstar/Hitachi, Motorola/Goldstar, Micron/NEC, and Toshiba/Motorola. Table 5-1 shows suppliers and their rankings.

The information in Figure 5-1 and Figure 5-4 reveals that worldwide production of 1Mb DRAMs totaled 835 million units in 1991, versus a 1990 level of just over 700 million units.

The 1Mb DRAM stands at the saturation point—or peak stage—of its life cycle. Supply will decrease as the device moves along the decline stage of the curve, but volume should still exceed 100 million units for 1995. Barring an unexpectedly severe cutback in capacity, users who plan carefully can expect an adequate supply of 1Mb products for the next several years.

Standard versus Specialized DRAM

Nevertheless, users must accurately forecast long-term 1Mb demand in terms of specifications such as speed, configuration, package, and application. Although the impact will be stronger at the 4Mb level, users of 1Mb DRAM will be affected by the market trend toward displacement in system applications of standard DRAMs by specialized DRAMs. Standard DRAMs refer to devices that are organized x1 or x4 and are contained in standard packages like SOJ, TSOP, or SIMM. Specialized DRAMs include VRAMs, wide-word configurations, cache DRAMs, and other DRAMs that offer special I/O, that serve graphics-based applications, or that will become part of a cell-based IC (CBIC) library.

The challenge for users of 1Mb DRAMs is to align themselves with an appropriate supplier or set of suppliers as the supplier base shifts during the 1992 to 1994 period. In order to target 1Mb DRAM suppliers for long-term support, users should look for suppliers that have recently increased or decreased market share. For example, the following suppliers increased market share by more than 1 percent in 1991: Goldstar, Hyundai, Micron, Siemens, and TI. North America-based suppliers such as Micron, Motorola, and TI likely will support demand from established customers, as will Europe-based Siemens. Korea-based suppliers such as Goldstar, Hyundai, and Samsung likely will support new users as well.

Japan-based suppliers will continue to de-emphasize 1Mb DRAM output. For example, the following suppliers lost more than 1 percent of market share during 1991: Fujitsu, Hitachi, Mitsubishi, NEC, Oki, and Toshiba. Their emphasis will be on higher-density 4Mb DRAM devices.

1Mb VRAMs

For users of 1Mb VRAMs, the supply base scenario is somewhat different. At the time of the writing of this report, some users had reported longer lead times during midyear 1992 for 1Mb VRAMs such as the 256Kx4 device. A possible cause is a supply and demand mismatch stemming from booming demand for Windows software—a graphics application that requires VRAM. If so, suppliers likely will adjust capacity accordingly during 1992 to meet demand.

The leading suppliers of 1Mb VRAMs, in descending order, are as follows: Toshiba, TI, Fujitsu, Mitsubishi, and NEC. Users should target these companies for longer-term support.

Supply Base for 4Mb DRAMs

Figure 5-5 presents the top-ranked 4Mb DRAM suppliers in terms of 1991 unit share. In descending order, the leading suppliers of 4Mb DRAMs are Hitachi, Toshiba, Samsung, NEC, Fujitsu, Mitsubishi, Oki, Siemens, Hyundai, TI, Motorola, Goldstar, and Micron. Goldstar/Hitachi, IBM/Micron, Micron/NEC, Motorola/Goldstar, and Toshiba/Motorola were among the major 4Mb DRAM alliances.

Global 4Mb DRAM production totaled 138 million units in 1991. The life cycle curves in Figures 5-1 and 5-2 show that the 4Mb DRAM device is now moving through the growth stage of the life cycle. The peak maturity stage should be reached during the 1994 to 1995 time frame, when annual output should exceed 800 million units. The 4Mb DRAM life cycle should extend toward the end of this decade.

Although the long-term supply base appears favorable for users of 4Mb DRAMs, there are some concerns. For example, the trend toward specialized DRAMs should mean continuing management challenges for users. The trend has picked up the pace in the 4Mb density marketplace—meaning periodic supply and demand mismatches as occurred during 1992 for some users of 1Mb VRAMs and/or ZIP devices. A more ominous example is public pondering by suppliers such as Toshiba regarding slower rates of DRAM capacity expansion compared to plans of two or three years ago—let alone outright capacity cutbacks.

4Mb DRAM Capacity: Differing Market Perspectives

At Dataquest's SEMICON/West Seminar, Dataquest's Mark FitzGerald, Senior Industry Analyst in the Semiconductor Equipment, Manufacturing, and Materials Service (SEMMS), provided a midyear 1992 update regarding the adequacy of 4Mb DRAM capacity for 1992 to 1993.

Tables 5-4 and 5-5—which were presented at the seminar—demonstrate why there are two differing market perspectives regarding the 4Mb DRAM capacity outlook for the second half of 1992 and 1993.

Readers should note at the outset of this analysis—as will be shown—that Dataquest has not changed its stated assumption that North American users can expect adequate 4Mb DRAM capacity for the next several years. Even so, Dataquest analysts continue to examine the worldwide supply-demand equation to determine whether there

Table 5-4
Capacity Utilization, Distribution of 1992 Slices (≤0.5 and <0.8 Micron) into 4Mb DRAM Die*

1.	Forecast 4Mb DRAM, Million Units per Month 1992	34.3	34.3	34.3	34.3	34.3	34.3
2.	Theoretical Die Capacity Million Units per Month in 1992	113	113	113	113	113	113
3.	Assumption of Percent Theoretical Die Capacity in 4Mb Production	50	60	70	80	90	100
4.	Adjusted Theoretical Die Capacity Assuming 70% Yield	39.6	47.5	55.4	63.3	71.2	79.1
5.	Capacity Utilization (%)	86.8	72.3	62.0	54.3	48.2	43.4

*77mm^2 die size/170 die per wafer
Source: Dataquest (August 1992)

Table 5-5
Delayed 200mm Fab Plans in Japan

	Products	Type of Fab
Fujitsu	16Mb DRAM	Production
Hitachi	4Mb/16Mb DRAM	Production
KTI	ASIC	Production
Matsushita	16Mb DRAM	R&D
Matsushita	16Mb/64Mb DRAM	Production
NEC	16Mb, MPU	Production
NEC	4Mb/16Mb DRAM, EPROM	Production
NKK	4Mb SRAM, ASIC, MPU	Pilot
Oki	16Mb DRAM	Production
Sanyo	16Mb DRAM	Production
Sharp	4Mb DRAM, ROM	Production
Toshiba	16Mb DRAM	Pilot
Toshiba	4Mb/16Mb DRAM	Production
Toshiba	4Mb/16Mb DRAM	Production
Toshiba	16Mb DRAM	Production

Source: Dataquest (August 1992)

should be any change to the assumption of adequate 4Mb DRAM capacity.

The Message of Tables 5-4 and 5-5

Table 5-4 provides an estimate for June 1992 of worldwide 4Mb DRAM capacity utilization. As shown in the footnote to Table 5-4, this capacity analysis assumes the availability of 170 4Mb DRAM die from each 0.5- through 0.8-micron wafer slice. The 4Mb DRAM capacity analysis in Table 5-4 flows on the basis of the following assumptions and estimates:

- Line 1. Dataquest estimates worldwide 4Mb DRAM at 34.3 million units per month during 1992.
- Line 2. Dataquest estimates theoretical die capacity from 0.5- through 0.8-micron fabs at 113 million units per month in 1992, as stated in Table 5-4.
- Line 3. Dataquest assumes the percentage theoretical die capacity in 4Mb DRAM production in a range from 50 percent to 100 percent.
- Line 4. Dataquest assumes a 70 percent yield rate for 4Mb DRAM manufacturers and then adjusts the information in Lines 2 and 3 into an estimate of 4Mb DRAM theoretical die capacity as measured in millions of units.

  Formula: Line 4 = Line 2 × Line 3 × 0.70.
- Line 5. Shows an estimate of 4Mb DRAM capacity utilization based on the estimate in Line 1 and the estimates/assumptions in Lines 2, 3, and 4.

  Formula: Line 5 = Line 1 / Line 4.

Table 5-5 shows 200mm fab plans that have been delayed in Japan by suppliers of 4Mb and 16Mb DRAMs.

Adequate 4Mb DRAM Capacity: Dataquest's Midyear 1992 Perspective

In his presentation at the Dataquest's SEMICON/West Seminar, Mr. FitzGerald noted that the conclusion he makes can be viewed as conservative. He assumed that just 70 percent of the 0.5-/-0.8-micron capacity is being used for 4Mb DRAMs during 1992—when in fact market reality would allow Dataquest to assume a higher percentage.

The salient point from Table 5-4 and the SEMICON/West Seminar is that Dataquest estimates current 4Mb DRAM capacity utilization at a 62 percent rate, which should mean adequate worldwide supply for users barring a major market change. Dataquest also believes that additional capacity will be available in the Republic of Korea over the next 12 to 18 months. Mr. FitzGerald's conclusion is that adequate 4Mb DRAM capacity exists as of midyear 1992.

A 4Mb DRAM Shortage?

A DRAM shortage should never be discounted. For example, what about the latest unverified reports (aka rumors) of a 1992 or 1993 DRAM shortage?

Table 5-5 shows that the worldwide network of 4Mb DRAM users must continue to monitor DRAM capacity trends. The main point from this table is that, in response to harsh DRAM market realities, Japan-based suppliers such as Fujitsu, Hitachi, NEC, and Toshiba have chosen to delay the opening of some 4Mb/16Mb DRAM fabs that otherwise would be open by now or else be opened during the period from mid-1992 through 1993. The table does not speak of cancellations nor close-downs of operating fabs, but rather of delays in schedule openings. Nevertheless, Dataquest expects that some of the delays will become permanent scuttles, which could over time change the long-term DRAM supply-demand scenario.

To answer the question posed earlier regarding a near-term shortage, the information in Table 5-4 indicates that any shortage during the second half of 1992 or the first half of 1993—should one occur—likely would be a short-term spot shortage. The impact would be much less than the massive DRAM supply base disruption that occurred during the 1987 to 1988 shortage.

What Will the Impact Be?

The upshot for DRAM supply base managers is that some long-established user/supplier relationships will likely be strained by increased emphasis on low-cost pricing by buyers. Suppliers in turn already search for more profitable product lines. To some extent, TI-type user/supplier alliances might become the best long-term protection for assured supply of 4Mb DRAMs. Nevertheless, under the current supply and demand scenario, users of 4Mb DRAMs still face a favorable supply base outlook through 1994.

Supply Base for 16Mb DRAMs

The 16Mb DRAM product is now moving through the introductory stage of its cycle. Table 5-1 shows which suppliers shipped 16Mb DRAMs during 1991. A host of other suppliers have entered or will soon enter this market.

The product life cycle of this part should extend beyond the year 2000. Early leadership for the next-generation product often signals future DRAM market leadership. For users looking ahead, Dataquest expects the 1994-1995 total ranking to be strongly influenced by 16Mb DRAMs. The battle during 1992 and 1993 in the 16Mb market between suppliers such as Hitachi, Samsung, TI, and Toshiba should set the stage for DRAM market leadership during the second half of this decade.

Long-Term Supply Base Concerns

Users should be forewarned that the trend toward DRAM product proliferation should intensify at densities of 16Mb and above, meaning tremendous long-term supply base stress. For example, at ISSCC 1992, representatives from DRAM manufacturers such as Hitachi, IBM, Mitsubishi, Etron (Taiwan), Toshiba, and TI expressed some pessimism regarding suppliers' ability to profitably overcome the technical barriers associated with long-term DRAM development. Why? Suppliers in the future must make numerous cost trade-offs, perhaps leading to some wrong choices, to accommodate the market trend toward DRAM product proliferation in regard to voltage levels, power, access time, refresh schemes, configuration, and chip/die size.

A long-term scenario shows standard DRAMs accounting for less than 50 percent of DRAM shipments. Dataquest believes that, at the 16Mb and 64Mb densities, DRAMs contained in SOJ and TSOP packages will hit a plateau in terms of their share of total DRAM shipments—with the curve for specialty DRAMs pointing upward.

What are the industry implications? For suppliers, the DRAM's role as a process and technology driver should become accentuated as the market moves beyond the 16Mb density—not only regarding other memory ICs but also other products including CBICs and digital signal processors. A result under such a scenario is that standard DRAMs would eventually become fab-fillers akin to the role today played by slow SRAMs. A related scenario, according to one ISSCC panel member, is that flash technology will eclipse DRAM technology by the end of this decade. Suppliers of flash memory, such as Intel, claim this will happen even sooner.

Adequate Long-Term Supply?

Users and suppliers are already debating whether there will be adequate long-term supply of 16Mb DRAMs to meet demand. The pro argument by users and suppliers is made by pointing to history. The con side says that huge costs in a time of changing financial and economic markets will translate into inadequate long-term supplies. This early debate should intensify during the second half of 1992.

Chapter 6
DRAM Technology Alliances

In 1986, Dataquest predicted that strategic alliances would be an electronics industry megatrend for the rest of this century. The strategic alliance megatrend will affect all users of DRAM for the rest of this decade. This chapter presents the evolving worldwide network of DRAM alliances and assesses the impact and strategic competitive significance of the top arrangements.

Table 6-1 shows the worldwide network of more than 20 DRAM technology alliances by product density as of August 1991. The footnotes to Table 6-1 provide the definitions for each type of alliance and highlight special arrangements. Alliances other than those listed at the top of Table 6-1 are noted in parentheses and defined in the table. This information includes internal and external consumption.

Dataquest conducted an informal poll of DRAM analysts in Tokyo, London, Seoul, Taipei, and San Jose, California, regarding the critical significance of each alliance in terms of strategic competitiveness and actual or prospective market impact. Table 6-2 shows Dataquest's perspective on the most significant worldwide DRAM alliances.

Tables 6-1 and 6-2 build on a mass of information and insight. Using that informational mass, this chapter analyzes the top six worldwide DRAM pacts regarding what each alliance partner gives and receives from the alliance—or does not give nor receive—with a focus on the long-term market implications for both DRAM users and IC suppliers.

Table 6-1
Top Worldwide DRAM Alliances

Top Worldwide DRAM Alliance	Market Impact (Current/Potential)
1,2. IBM/Siemens; Texas Instruments/Hewlett-Packard/Canon/Government of Singapore	1. IBM/Siemens
	2. Texas Instruments/Hewlett-Packard/Canon/Government of Singapore
3. Toshiba/Motorola	3. Hitachi/Goldstar
4. Hitachi/Goldstar	IBM/Micron
Hitachi/Texas Instruments	Texas Instruments/Acer
Texas Instruments/Acer	Toshiba/Motorola

Source: Dataquest (August 1992)

Table 6-2
Estimated Worldwide DRAM Technology Alliances as of August 1992[1]

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances	
Supplier	Second-Source Agreements	Fab Agreements	Joint-Venture Agreements	Fab Agreements	Joint-Venture Agreements	Joint Development
Goldstar		Vitelic-MOSel				
Goldstar			Hitachi (FA)			
Hitachi	Goldstar					
Hitachi						TI (and 64Mb DRAM)
IBM						Siemens (and 64Mb DRAM)
IBM			Micron (LA)			
Intel	Goldstar (OEM)		Goldstar (OEM)			
Matsushita		Intel (also Sales Agency Agreement)				
Micron	NEC (Mutual OEM)		NEC (Mutual OEM)		NEC (Mutual (OEM)	
Micron	Sanyo (64Kx16 device)					
Motorola	Goldstar (OEM)		Goldstar (OEM)			
NMB			Hitachi (OEM arrangement based on Hitachi production technology)			
NMB			Ramtron International (JD)			
NMB					Ramtron	
Oki				Vitelic-MOSel	Vitelic-MOSel	
Sanyo			Mosaid			
TI			HP-Canon-Singapore		HP-Canon-Singapore	
TI			Acer			
TI	Mitsubishi					
Thorn-EMI	NMB (LA per Thorn's Inmos-based patent)					
Toshiba	Motorola		Motorola			
Toshiba	Siemens (LA)					

Definitions/Notes:
FA = Fab agreement: supplier offers fab capacity for partner's product technology. In most cases, the supplier provides fab capacity and produces the partner's DRAM design.
JD = Joint development: the companies jointly agree to develop new products, which may or may not be marketed separately.
JV = Joint venture: the companies form a new joint-venture company to develop, manufacture, and market new products.
LA = Licensing agreement: supplier receives or issues a license to partner for an up-front fee and/or royalties.
OEM = OEM arrangement: supplier sells product to alliance partner, which is sold under partner's name.
SA = Sales agency agreement: supplier sells its partner's products as either a sales representative or a value-added reseller.
SS = Second-source agreement: the companies agree to develop consistent specifications to ensure a second source.
[1]Excludes SIMMs (e.g., Wang's X9 SIMM) and other patent royalties.
Source: Dataquest (August 1992)

IBM/Siemens

In terms of both strategic competitiveness and potential market impact, Dataquest analysts view the IBM/Siemens joint-development alliance on 16Mb and 64Mb DRAMs as the most significant alliance. On July 4, 1991, these two global giants extended their prior 64Mb DRAM joint-development program to joint manufacturing of the 16Mb device.

During the second quarter of 1992 Siemens made the following series of moves:

- Elected to not build a joint 64Mb DRAM fab with IBM
- Elected to align with IBM-Toshiba on 256Mb DRAM product/process development

What the Partners Give and Get

This section examines the "gives and gets" of the IBM/Siemens alliance. Readers should note in general that the items exchanged in many of the DRAM alliances shown in Table 6-1 sound similar (for example, process technology and risk reduction). The common strategic threads will be noted in the alliance assessments; however, this chapter spotlights unique or special alliance factors whenever possible.

IBM: Reducing Technology Dependence

IBM Corporation provides three tangibles for the 16Mb DRAM alliance: the basic device design, the 0.5-micron process technology (which runs on 8-inch wafers), and the fab in France. Siemens AG's practical contributions include capital and engineering talent—the latter for translating IBM's proprietary design into a product suitable for European and worldwide merchant market consumption (for example, an eventual shrink version).

What does IBM receive? Some practical elements have been indicated: an estimated 50 percent contribution by Siemens on fab costs and risk-sharing by Siemens on merchant market technology development. IBM is likely to receive a supply of 16Mb devices starting for systems such as the PS/2 line.

IBM aims for key long-term strategic benefits. First and foremost is a counterbalance in Europe—and, perhaps, eventually North America—to Japan's worldwide strength in DRAMs. Second is an evolution by IBM, which is an internal DRAM supplier as well as user, toward a global shared fab strategy, perhaps allowing for entry into the merchant market.

Siemens: A Stake in the DRAM Merchant Market

What does Siemens get in exchange for its capital and clout in European and other merchant markets? Siemens' DRAM efforts have been lagging. Now, it should be able to make a timely ramp up during the second half of 1992 in the 16Mb DRAM arena. An unresolved issue is whether Siemens will become an independent DRAM supplier or a supplier of IBM DRAM products.

Eventually, Siemens might be permitted to use IBM's 0.5-micron process to expand its ASIC product offerings. Siemens to date has received no license, however, to the IBM process.

64Mb DRAM Joint Development

The 16Mb manufacturing alliance accentuates the significance of the partner's prior joint-development effort on 64Mb DRAMs. The 64Mb alliance presumably was proceeding favorably, however, capital risk considerations in part caused Siemens to cancel a joint 64Mb DRAM fab.

The exchange items are similar; Siemens can promise 64Mb DRAM product technology to merchant market customers later this decade. IBM will be assured of supply for internal demand while balancing the strength of Japan-based suppliers.

TI/HP/Canon/Government of Singapore

In terms of strategic competitiveness, Dataquest analysts view the 4Mb/16Mb DRAM joint venture between TI, HP, Canon, and the government of Singapore as equal in significance to the IBM/Siemens arrangement. Dataquest analysts consider this arrangement to be second-most significant in terms of current or potential market impact. We believe that this alliance is a unique and perhaps trendsetting global consortium of DRAM users with their supplier.

TI: The Give and Get

TI (no mystery) supplies the DRAM technology and runs the Singapore joint-venture fab. The technology for 4Mb DRAMs is a 0.6-micron process using 6-inch wafers; for 16Mb devices, a 0.5-micron process and 8-inch wafers are used. This alliance conforms with TI's long-term strategy for spreading the risk associated with the volatile international DRAM business. In exchange for DRAM technology and know-how, TI reduces the risk associated with opening its fifth submicron CMOS manufacturing plant in Asia—a costly $300 million-plus venture. TI has an option to become the majority partner.

Besides capital contributions by the partners, TI has some likely—although not assured—major customers for the fab's output.

The alliance also provides TI with an expanded presence for serving users in Asia, including migrating Japan-based customers.

HP: A Network of Strategic Alliances

In addition to customer-name credibility, HP's major contribution to date is advanced customer payments. For HP, the alliance provides a guaranteed supply of DRAMs in line with its partnership share (nearly 25 percent) if quality/price conditions are acceptable to HP.

For HP, the real benefit is linked to its worldwide network of strategic alliances. The alliance should strengthen its alliance partners over the long term. For example, TI is one of the leading suppliers of DRAMs to HP. In turn, HP supplies computer and other systems to TI. HP and Canon have an alliance in the printer business. The strategic upshot for HP is that the alliance enhances the global position of TI—a key North America-based DRAM supplier—vis a vis other world competitors.

Canon: The Other DRAM-User Partner

Like HP, Canon, the second DRAM-user alliance partner, provides advanced customer payments in exchange for a guaranteed supply of DRAMs, given acceptable quality/price terms. In addition to strengthening HP and TI, two long-term alliance partners, Canon's IC manufacturing equipment group is likely to win increased account penetration at TI (and perhaps, over time, HP).

Government of Singapore: A Host of Benefits

The government of Singapore's main contribution is financial and other support. For Singapore, the alliance ensures a share of the joint venture's output of DRAMs to Singapore-based computer companies—a critical need there during periods of spot shortage. The alliance also advances Singapore's CMOS processing technology base for production of memory and ASICs (for example, gate arrays). The alliance puts the tiny city-nation on the global DRAM map.

Toshiba/Motorola

In terms of both strategic competitiveness and current and potential market impact, Dataquest analysts rank the DRAM alliance between Toshiba and Motorola as the third-most-significant arrangement. The first version of the alliance was formed during 1986 and expanded toward the end of 1990. Uncertainty associated with an alliance element—Toshiba's rights to Motorola's 68030 microprocessor—has diminished the market impact somewhat. Nevertheless, this alliance of two giants of the IC business, one Japan-based and the other North America-based, has had a direct impact on both DRAM market trends and the global competitive balance.

Toshiba

In this alliance, Toshiba provides the DRAM design and process technology. Toshiba leads the DRAM development efforts, including development of the 16Mb DRAM. In exchange, Toshiba receives the right to sell Motorola's 68030 MPU in Japan. Toshiba never received the rights to sell the 68030 (or the 68040) in world regions other than Japan.

The alliance arrangement enables Toshiba to supply 1Mb DRAMs from Motorola's Scotland fab while avoiding import duty and European reference pricing constraints.

Motorola

In exchange for Toshiba's limited license on the 68030, Motorola has received 1Mb and 4Mb DRAMs from the Tohoku, Japan, joint-venture fab. Motorola resells the product in regions such as North America and Europe. Motorola can produce 1Mb DRAMs in its worldwide network of fabs. The 4Mb DRAM can only be produced in the Tohoku fab. In order to gain worldwide rights to 4Mb DRAMs, Motorola presumably must give Toshiba worldwide rights on the 68030 or 68040.

For Motorola, a key long-term strategic goal of the alliance is acquisition of DRAM technology (for example, 16Mb DRAMs) and manufacturing know-how. An unresolved issue is whether Motorola will develop 16Mb DRAM alone or with Toshiba. For example, during 1991 Motorola and Toshiba terminated plans for a Europe-based DRAM/memory fab on the basis of competitive cost analysis, although other factors such as the 68030 negotiations played a role in the final decision. Nevertheless, Dataquest believes that eventually the Tohoku fab will produce 16Mb DRAMs for Motorola.

Hitachi/Goldstar

Dataquest views the DRAM alliance between Hitachi and Goldstar Electronics Company Ltd., which comprises a series of licensing and fab agreements between a first-tier, Japan-based supplier of DRAMs and an emerging IC power from Korea, as the third-most-significant DRAM pact in terms of current and potential market impact. The arrangement ranks fourth regarding strategic competitive significance. This agreement represents one of the key alliances between Japan- and Korea-based IC suppliers.

In this alliance, Hitachi provides the DRAM technology, including product design. During 1989, Hitachi designated Goldstar as a second source for Hitachi's 1Mb part, meaning a market boost for Goldstar's advance in global IC markets. In addition to establishing an alternate source for 1Mb DRAMs, Hitachi also receives some supply for resale.

Recently, Hitachi extended Goldstar's alliance to the 4Mb device. The Hitachi/Goldstar alliance is still evolving. For example, the 4Mb arrangement currently carries some of the hallmarks of a fab agreement and of an OEM arrangement. Nevertheless, this alliance is advancing although no official extension to 16Mb DRAM technology has apparently yet been made.

IBM/Micron

Several alliances tied for third place in terms of current and potential market impact. Dataquest analysts rank the alliance on 4Mb DRAMs between IBM and Micron Technology, two North America-based companies, among those deemed third-most-significant regarding market impact.

IBM provides the DRAM process technology, which runs on 8-inch wafers. Micron uses its own 4Mb DRAM design, having elected not to develop IBM's proprietary design for merchant market consumption. (Note the challenge for Siemens in the 16Mb arena.) For IBM, the alliance provides another balance to Japan's worldwide DRAM strength: a stronger, competitive, low-cost, North America-based supplier of DRAMs.

For Micron, the alliance provides access to IBM's process technology. The alliance also provides the relatively small company, which competes against the global DRAM giants, with a key long-term strategic partner. The agreement is likely to extend to the 16Mb device.

TI/Acer

Dataquest analysts rank the joint venture in 4Mb DRAMs between TI and Acer (Taiwan) as one of the third-most-significant DRAM arrangements in terms of current and potential market impact. The agreement also is tied for fourth place regarding strategic competitive significance. This agreement exemplifies another key user/supplier alliance, here between a North America-based supplier of DRAMs and a Taiwan-based user.

TI's Role

The give and gets for TI through this alliance are consistent with those of TI's alliance with HP, Canon, and the government of Singapore. In exchange for its technology, TI reduces the risk associated with construction of this $250 million-plus investment. The technology for 4Mb DRAMs is 6-inch wafers based on an advanced CMOS trench-capacitor design. This alliance purposely bypassed the 1Mb part but is likely to be extended to the 16Mb density.

Acer's Role

Acer's contribution will be capital—about 75 percent of the quarter-billion-dollar-plus cost. The joint venture marks Acer's entry into vertically integrated DRAM production. The real key for Acer is a guaranteed supply (50 percent) of the total output of the joint-venture fab, which should meet a full third of the 4Mb DRAM requirements for this system manufacturer. Past DRAM shortages have played havoc with Acer's manufacturing plans.

Hitachi/TI

Dataquest analysts view the joint-development agreement for 16Mb DRAMs between Hitachi and TI among the fourth-most-significant DRAM alliances in terms of strategic competitive significance. When Dataquest analysts ranked the alliances, the recent dramatic extension of the alliance to 64Mb DRAM, a second-source pact had just been announced. The strategic significance of this alliance between two giants of the DRAM business—one Japan-based and the other North America-based—has presumably increased since the announcement of the 64Mb deal at the end of November 1991.

The exchange items and goals behind this alliance in general are similar to those noted in the other alliance discussions. The bottom line is that both companies want to reduce the capital risk associated with developing new generations of DRAM. TI also views DRAM process expertise as a key stepping-stone for technology migration to digital signal processors (DSPs) and other advanced devices. Even so, the current results and evolution of this alliance have in some instances been unique.

16Mb DRAM Joint Development

The Hitachi/TI joint-development effort on 16Mb DRAMs led to design of an innovative DRAM package known as the lead on chip with center bond package, which both suppliers will use. By contrast, the 16Mb joint-development agreements resulted in two different 16Mb designs: Hitachi's stacked-cell structure and TI's trench-based storage cell approach.

64Mb DRAM: A Second-Source Arrangement

The goal of the 64Mb DRAM joint-development effort will be a second-source arrangement. Hitachi and TI will develop a common 64Mb DRAM design. They will also use common design automation and the same 0.35-micron manufacturing processing technology. The suppliers will separately engage in mass production and marketing.

As noted, the alliance strategically aims to reduce each partner's financial exposure to the risk of ultimately low-priced DRAM parts that can be exorbitantly expensive to develop. The alliance should also lead the partners to other technology paths for ASICs and DSP chips.

The alliance could affect the course of Japan-United States trade. Significantly, Hitachi took a license on TI's Kilby patent as part of the agreement. For TI, the Hitachi license strengthens the Kilby patent in Japan in the face of Fujitsu's ongoing legal challenge.

Outlook on DRAM Alliances

Everyone affected by the DRAM market—users, suppliers, investors, and governments—must prepare for the impact of the strategic alliance megatrend during the rest of this decade. Table 6-1 shows a nearly exhaustive list of DRAM technology alliances between suppliers or suppliers and users, including governments. The alliance table grew during the course of this chapter's preparation as new alliances were announced, extended, or modified.

Dataquest realizes that some alliances will terminate with little impact. As shown in Table 6-2, however, Dataquest's DRAM analysts in Tokyo, London, Seoul, Taipei, and San Jose now see or foresee sharp market impact and strategic competitive significance from alliances such as the IBM/Siemens pact, the joint venture among TI/HP/Canon/Government of Singapore, the Toshiba/Motorola deal, and the Hitachi/TI joint effort.

The economic realities of the 1990s indicate some long-term consolidation of the DRAM supplier base. DRAM alliances are not a sign of weakness, but rather a necessary step for survival. From the supplier side, DRAM alliance participants such as Hitachi, Motorola, TI, and Toshiba are not the weaklings of the IC world. Although Dataquest at present anticipates no universal trend toward DRAM user/supplier alliances, TI's strategy for Asia—for example, the Acer venture and the Singapore arrangement—emerges as one model for suppliers during the 1990s. DRAM alliances can also be a technology path to other products such as ASICs or DSPs. Readers should note that some of the DRAM players notably absent from Table 6-1 include AT&T, Fujitsu, Mitsubishi, and Matsushita.

What is the wild card in this whole set of global DRAM alliances? IBM, which in 1992 will be changing and assessing or reassessing its many business options. The IBM/Micron deal shows a limit to the impact of IBM's proprietary DRAM technology on the market, but IBM's impact remains significant. Dataquest analysts already foresee significant market impact and strategic competitive effect from the IBM/Siemens alliance, especially in world regions such as Europe and North America. As IBM reshapes its business during 1992 and thereafter, the DRAM market might also be reshaped.

Chapter 7
Package Technology

Semiconductor package constraints—which include technology as well as supply—may be a long-term barrier to adequate DRAM supply. The following chapter, which is based on results from Dataquest's recent multiclient study of semiconductor package technology, highlights the critical trends and forecasts in this critical arena.

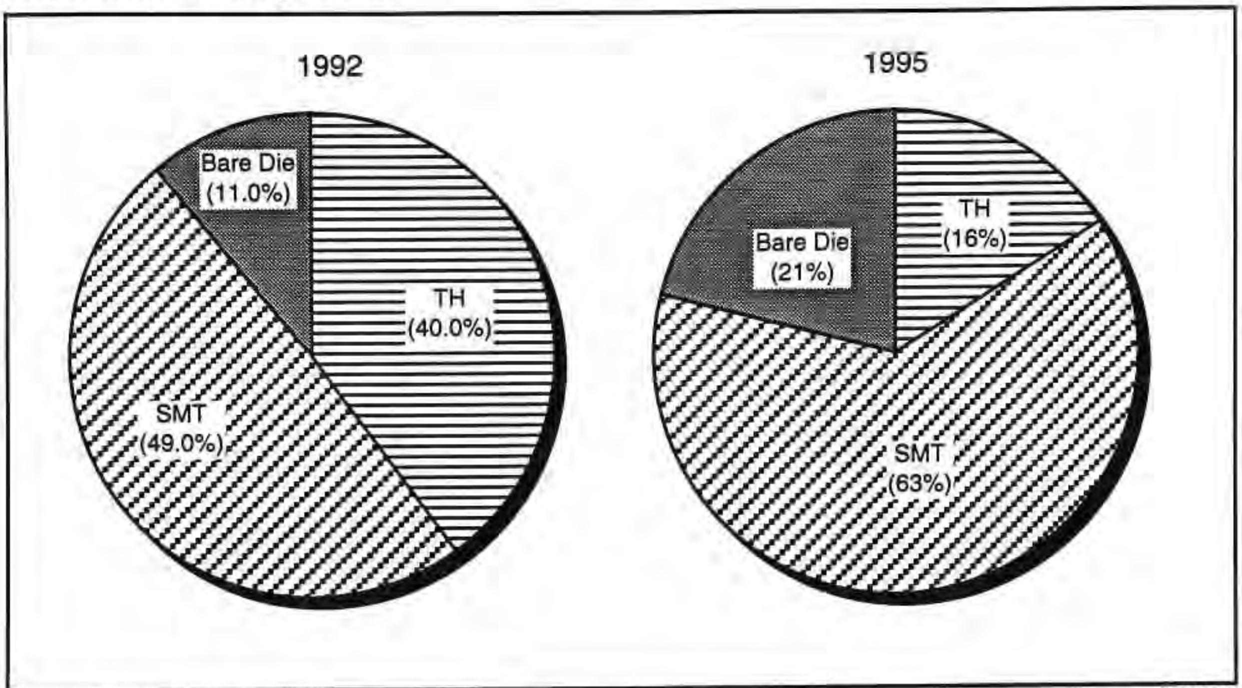
Semiconductor packaging, often referred to as the back end of semiconductor assembly, is in the forefront of activity and technical evolution. A review of 1991 package production worldwide shows that the through hole (TH) family of packages (DIPs, ZIPs, and PGAs), and specifically the DIP package, declined after a 28-year reign. With an eye toward the future, we expect surface mount (SM) packages to represent a 49 percent share of total packaged single chips, while bare die shipments are expected to represent an 11 percent share (see Figure 7-1). The majority of SM-packaged ICs are in the area of small outline (SO) and QUAD packages. Growth in the SO product area is driven by analog, logic, and memory devices. The QUAD configurations are used predominantly for high-density, high-pin-count ASICs.

ASIC devices, specifically gate arrays, continue to be the product area contributing to both package proliferation and high pin count. The data compiled in Figure 7-2 are a result of component suppliers and their estimates of lead count as a percentage of production over time. The lower-level 8- to 28-pin-count packages consumed more than 55 percent of the total share in 1991. This lower pin count level is expected to decline to less than 40 percent by 1994, as production shifts to the high-pin-count ASIC and microprocessor devices.

Table 7-1 shows the worldwide market for packaged ICs by package type. Growth in SO packages in 1991 was stimulated by the continuous shift of SRAMs and DRAMs from DIP/ZIP and larger SOIC packages to the thinner, finer-pitch SOJ/TSOP packages. Although most of the supply of DRAMs in TSOP packages is coming from Japan, the North American market continues to be the largest driver of custom DRAM modules. The breakout of DRAM SIMMs by organization for 1991 is in Figure 7-3.

A decline in MOS EPROM bookings and an increased demand for memory bare die used in COB applications caused a precipitous decline in the usage of CERDIP packages for 1991 and 1992. The largest consumers of nonvolatile devices in North America are designing in EEPROM, flash, and ROM devices in TSOP and COB

Figure 7-1
Worldwide Package Share



Source: Dataquest (August 1992)

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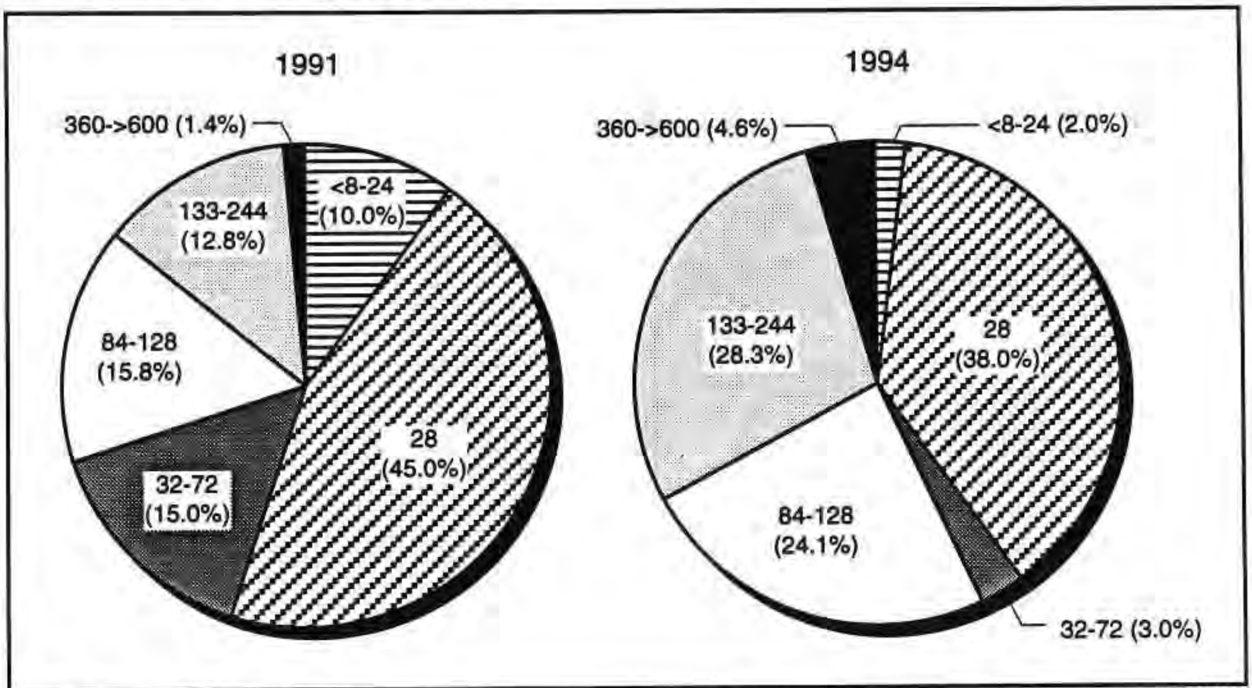
Figure 7-2
Worldwide IC Package by Pin Count



Source: Dataquest (August 1992)

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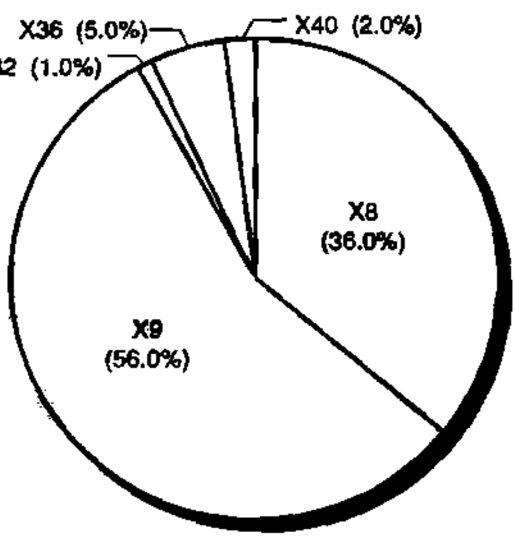
Table 7-1
Estimated Worldwide IC Package Production

	1990	1991	1992	1993	1994	1995	1996
Plastic DIP	20,575	17,549	14,264	11,056	8,120	5,818	4,350
Ceramic DIP	3,169	2,801	2,616	2,304	2,142	1,922	1,770
QUAD	4,068	5,169	7,024	10,140	14,399	16,781	18,550
Ceramic Chip Carrier	260	271	292	312	350	325	292
Plastic Chip Carrier	431	579	724	834	767	663	613
SO	10,602	12,053	13,576	14,809	16,860	19,058	20,811
Ceramic PGA	265	395	602	762	795	742	660
Plastic PGA	147	248	512	744	865	850	801
Bare Chip	2,878	4,153	4,905	6,604	9,409	12,011	16,053
Total	42,395	43,218	44,515	47,565	53,707	58,170	63,900

Source: Dataquest (August 1992)

Figure 7-3
Estimated MOS DRAM Module Organization



Source: Dataquest (August 1992) G2000697

configurations for use in 8-bit and 16-bit systems as well as memory cards. The "downsizing" drivers of electronics such as memory cards, laser printers and graphics, pocket calculators, video game systems, and laptop/palmtop segments are expected to be the largest drivers of higher-integration and smaller-size package growth.

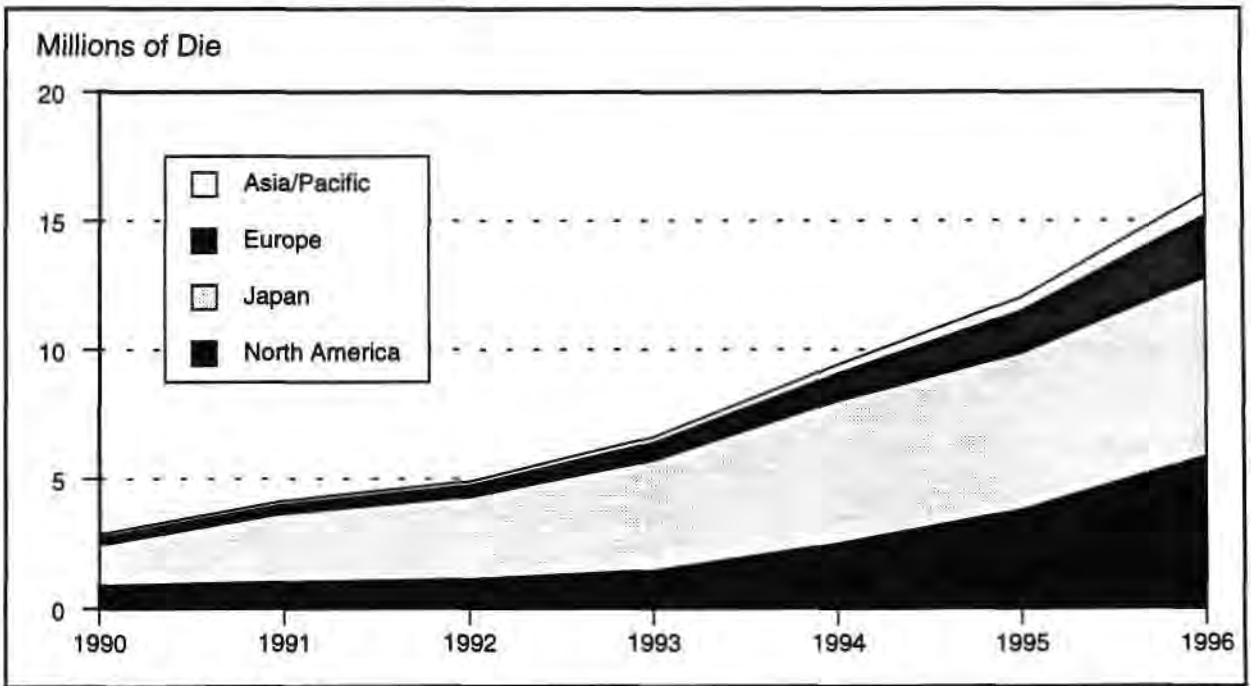
In the next five years, emerging package technologies will become an extension of the system designers' focus on the miniaturization of drive electronics. The challenge to the system designer is either to integrate more functions in a complex single chip or to integrate two or more chips into a cost-efficient module that would accomplish the same task. The forecast growth in the bare die market shown in Figure 7-4 assumes an initial growth in bare die usage in multichip module configurations.

Single Chip or Multichip: What Is the Best Solution?

Tasks that could be performed with many chips on the PCB must now be accomplished with fewer chips. The ultimate system goal is to have CMOS chips that consume less power, offer improved performance and increased reliability over previous generations, have a low profile, and, if possible, be cost-efficient. Will the ultimate goal be reached with a single chip capable of all these functions, or can this be attained with a multiple set of chips in a module configuration?

Dataquest defines a multichip module (MCM) as a set of multiple die attached through various means to a substrate. The IPC-defined categories for MCMs are MCM-L (L = laminated), MCM-C (C= ceramics), and MCM-D (D = deposited). The greatest demand for MCM technologies is expected to come from the data processing, consumer, and communications application markets. The consumer market is forecast

Figure 7-4
Worldwide Bare Die Consumption



Source: Dataquest (August 1992)

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to use most MCM-L configurations. The communications market will consume both MCM-L and MCM-C designs. However, the data processing MCM market will generate not only the largest amount of MCM revenue but also create the greatest amount of challenges to the MCM-D designer.

The benefits of MCM-D technology are that it provides the following:

- Monolithic performance (or better) at complexities not attainable by monolithic chips
- Lower-risk cost and schedule route to product development
- Economic advantages through faster ramping production cycles or lower-cost hardware
- Higher-complexity systems built without degrading performance
- 20 percent higher clock rates than single-chip solutions
- Mixed technology such as GaAs and silicon
- Use of optimized technology such as SRAMs and microprocessors
- Shorter design cycle times
- More available wafer vendors because acceptable yields can be achieved with wafers of lesser quality

The benefits of single-chip designs are as follows:

- It offers the least expensive alternative if the chip is not too complex.
- There is no need to deal with an MCM and chip supplier.

Table 7-2 is Dataquest's comparison of single-chip versus multichip costs. The table includes the cost of MCM assembly. The external package cost is assumed to be the same because both solutions have the same number of leads to the outside world. The substrate cost is typical for MCM-D. The assembly assumes wire bonding. The test and rework assumes the following:

- Rework cost is 10 times the assembly cost.
- One MCM has to be replaced.
- Chips have a 95 percent probability of being good.
- Module has $(0.95)^4$ = 81 percent probability of being good.
- Rework cost is spread over both good and bad modules.

Dataquest Perspective

Although packaging for high-pin-count ASICs and complex microprocessors is rapidly approaching technology limitations in terms of speed barriers and heat dissipation, the SMT available today will address the needs of both chip manufacturers and systems designers.

Table 7-2
Chip-Level Comparison of Single-Chip and Multichip Implementations of the Same System Function

	Multichip (Each Chip)	Single Chip
Relative complexity of Single Chip	-	4X
Edge Dimensions* (Mils)	380	730
Max. Peripheral I/O Pins**	152	292
Wafer Cost ($/sq. in.)	40	40
Gross Die Cost ($)	5.78	21.32
% Yield (Murphy Yield Stats.)	35.2	5.3
Yielded Die Cost ($)	16.43	398.56
Yielded Test Cost ($)	1.64	24.77
Net Die Cost ($)	18.07	423.33

*Assumes square chip. Allowance for bonding pads is a 15-mil border on all sides of the chip.
**Assumes one pin every 10 mils.
Source: C&H Associates, Dataquest (August 1992)

Financially, 1991 was not a good year for MCM start-up companies. Many closed their doors and others sought additional funding as orders were delayed by six months.

Ultimately, Dataquest believes that a complex single chip could displace an MCM-D design as single-chip cost efficiencies are achieved. More in-depth discussion on MCM technology is available in Dataquest's new multiclient study.

Chapter 8
DRAM Price Outlook

DRAMs represent the largest share of IC purchasing budgets for many electronic system manufacturers. First, a statement of Dataquest's IC pricing methodology. Next, Tables 8-1 and 8-2 present Dataquest's North American DRAM bookings quarterly forecast for 1992 to 1993 and our long-range forecast for the 1992 to 1996 period, respectively. We also include an assessment—which uses DRAM life cycle pricing information—to estimate the full-year 1993 range of prices for the 16Mb DRAM product.

Quarterly Price Survey Methodology

The Semiconductor Procurement Service (SPS) quarterly price survey provides information and forecasts for the North American bookings prices of more than 200 semiconductor devices. Dataquest collects North American bookings price information on a quarterly basis from North American suppliers and major buyers of these products. The methodology described 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 included are telecom and industrial houses. Regardless of country of origin, the suppliers that participate in the survey are located and book orders in North America.

Dataquest seeks the price of orders that were or will be booked in the current quarter. For example, during the February-March 1992 survey, Dataquest sought the North American bookings price for ICs booked during January-February 1992. In addition, we seek user-supplier forecasts of the bookings price for strategically important quarters (for example, the fourth quarter of 1992).

When all survey prices have been collected, SPS inputs the quarterly bookings prices into its database in several forms: total raw average and in some cases, 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 compare the current quarterly price forecast against the survey raw averages and the twice-monthly North American bookings

Table 8-1
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year
256Kx1 DRAM 80ns DIP	1.75	1.60	1.60	1.50	1.50	1.55	1.50	1.50	1.50	1.50	1.50
64Kx4 VRAM 120ns ZIP	3.20	2.95	2.70	2.70	2.70	2.76	2.65	2.65	2.65	2.65	2.65
1Mbx1 DRAM 80ns (DIP/SOJ)	4.35	3.80	3.50	3.45	3.40	3.54	3.40	3.40	3.40	3.40	3.40
64Kx16 DRAM 80ns SOJ	6.90	5.65	5.19	4.93	4.67	5.11	4.49	4.33	4.22	4.13	4.29
256Kx4 VRAM 100ns ZIP	9.31	7.75	7.30	6.85	6.56	7.12	6.18	5.95	5.55	5.25	5.73
128Kx8 VRAM 100ns SOJ	10.01	8.05	7.65	7.25	6.91	7.47	6.58	6.30	5.90	5.60	6.10
4Mbx1 DRAM 80ns SOJ	16.96	13.13	12.05	11.05	10.15	11.60	9.50	8.90	8.40	7.90	8.68
1Mbx4 DRAM 60ns SOJ	NA	14.45	13.25	11.96	10.91	12.64	10.17	9.35	8.78	8.18	9.12
512Kx8 DRAM 70ns	NA	NA	15.08	13.78	12.36	NA	11.23	10.56	9.89	9.27	10.24
256Kx16 DRAM 70ns SOJ	NA	16.00	15.50	13.99	12.79	14.57	11.75	11.00	10.30	9.75	10.70
256Kx18 DRAM 80ns SOJ	NA	17.07	16.75	15.55	14.70	16.02	13.75	13.00	12.40	12.00	12.79
1Mbx8 SIMM 100ns (2 pc)	NA	30.00	27.00	24.98	24.00	26.49	22.00	20.90	20.18	19.25	20.58
1Mbx9 SIMM 80ns (3 pc)	NA	33.27	30.45	28.79	27.72	30.06	25.00	23.77	22.00	20.75	22.88

(Continued)

Table 8-1 (Continued)
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; Dollars)[1]

Product	1991 Year	1992 Q1	1992 Q2	1992 Q3	1992 Q4	1992 Year	1993 Q1	1993 Q2	1993 Q3	1993 Q4	1993 Year
256Kx9 SIMM 100ns	13.85	12.70	12.53	12.65	12.50	12.59	12.50	12.50	12.50	12.50	12.50
256Kx36 SIMM 80ns[2]	49.86	47.00	44.40	42.20	40.00	43.40	37.17	35.50	34.30	33.81	35.19
512Kx36 SIMM 80ns (24 pc)	NA	82.00	80.40	77.75	75.39	78.88	73.00	71.00	69.00	68.00	70.25
4Mbx9 SIMM 80ns (9pc)	NA	130.2	116.8	112.5	107.4	116.7	96.35	88.00	82.00	77.50	85.96
1Mbx36 SIMM 80ns (9pc)	NA	131.0	122.0	107.0	100.0	115.0	97.00	87.00	80.00	76.00	85.00
4Mbx4 DRAM 70ns SOJ 400 mil	NA	180.0	149.0	119.6	95.0	135.9	83.25	74.18	66.09	57.25	70.19

NA = Not available

[1]Contract volume = at least 100,000 per order except VRAMs.

[2]Two-piece solution for 1993.

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.

Source: Dataquest (August 1992)

Table 8-2
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; Dollars)[1]

Product	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
256Kx1 DRAM 80ns DIP	1.55	1.50	1.65	1.85	2.00
64Kx4 VRAM 120ns ZIP	2.76	2.65	2.40	2.40	2.40
1Mbx1 DRAM 80ns (DIP/SOJ)	3.54	3.40	3.55	3.55	3.70
64Kx16 DRAM 80ns SOJ	5.11	4.29	4.12	4.12	4.15
256Kx4 VRAM 100ns ZIP	7.12	5.73	5.00	4.95	4.95
128Kx8 VRAM 100ns SOJ	7.47	6.10	5.25	5.15	5.15
4Mbx1 DRAM 80ns SOJ	11.60	8.68	6.06	5.50	5.50
1Mbx4 DRAM 60ns SOJ	12.64	9.12	6.15	5.56	5.55
512Kx8 DRAM 70ns	NA	10.24	6.21	5.69	5.60
256Kx16 DRAM 70ns SOJ	14.57	10.70	6.36	5.72	5.72
256Kx18 DRAM 80ns SOJ	16.02	12.79	6.54	5.91	5.90
1Mbx8 SIMM 100ns (2 pc)	26.49	20.58	15.44	15.00	14.00
1Mbx9 SIMM 80ns (3 pc)	30.06	22.88	16.44	16.00	15.00
256Kx9 SIMM 100ns	12.59	12.50	12.00	NA	NA
256Kx36 SIMM 80ns[2]	43.40	35.19	27.28	23.07	20.91
512Kx36 SIMM 80ns (24 pc)	78.88	70.25	56.20	45.54	45.00
4Mbx9 SIMM 80ns (9pc)	116.71	85.96	60.17	56.35	56.00
1Mbx36 SIMM 80ns (9pc)	115.0	85.00	59.50	57.75	56.10
4Mbx4 DRAM 70ns SOJ 400 mil	135.9	70.19	30.00	18.50	14.00

NA = Not available
[1]Contract volume = at least 100,000 per order except VRAMs.
[2]Two-piece solution for 1993-1996.
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (August 1992)

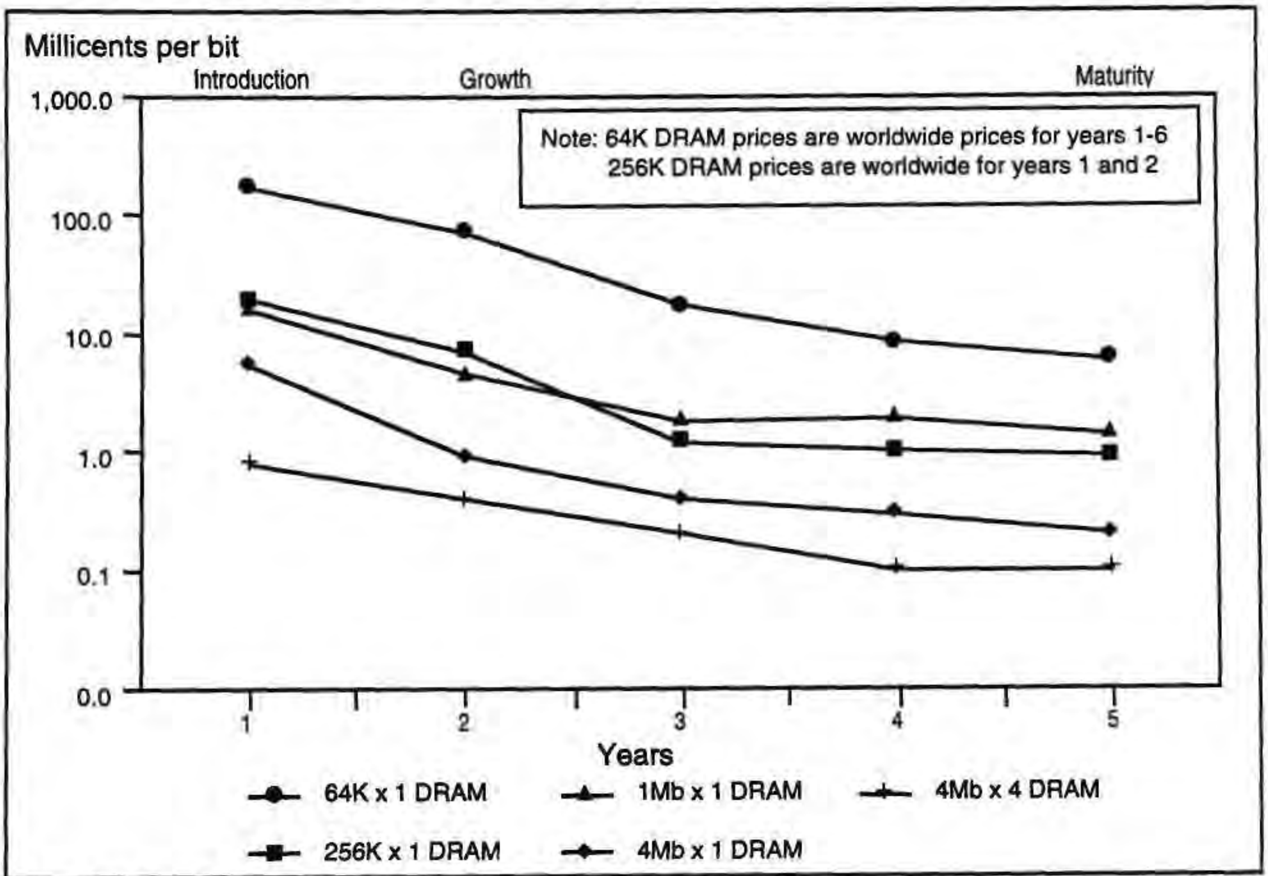
prices as published in the Online DQ Monday report. SPS analysts also establish assumptions regarding market supply-demand trends, supplier strategies, government action, and related factors. The preliminary SPS price forecast is formulated and then presented to Dataquest's semiconductor product analysts. 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.

DRAM Life Cycle Pricing

Because many DRAM users' eyes are on the next-generation 16Mb DRAM device, this section uses recent Dataquest research on DRAM life cycle pricing trends to assess the likely range of 16Mb DRAM pricing during 1993, the first full year of volume production of this device.

Figure 8-1 provides historic and forecast DRAM pricing in North America in millicents per bit over the first years of the product life cycle for densities of 64K, 256K, 1Mb, 4Mb, and 16Mb DRAMs. Note

Figure 8-1
North American DRAM Life Cycle Stage (Millicents per Bits; Volume: 100,00 Units)



Source: Dataquest (August 1992)

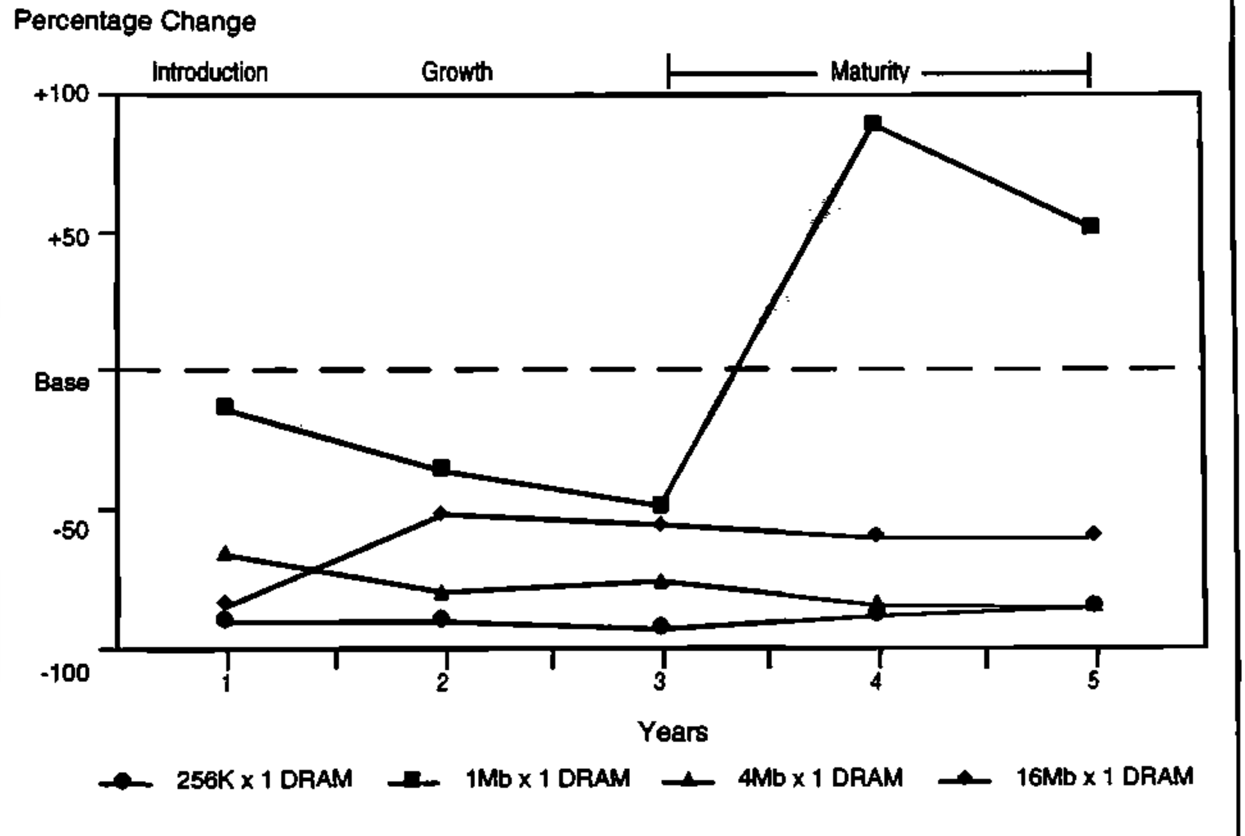
that the 16Mb DRAM price curve rests at the bottom of Figure 8-1. Based on the information in Figure 8-1, Figure 8-2 presents the rate-of-price decline in North America for each density of DRAM relative to the prior-generation device at each stage of the life cycle.

Forward Stage 16Mb DRAM Price Analysis

For users, a keynote DRAM supply base issue has become the 16Mb DRAM price outlook during the early volatile years of the product's life cycle.

In regard to the early life cycle (forward stage) 16Mb DRAM price outlook for North America, Figure 8-2 shows that during 1992—the first year of the 16Mb life cycle—Dataquest expects that millicent-per-bit pricing for the 16Mb part to be 84 percent lower than millicent-per-bit pricing for 4Mb DRAMs during the first year of their life cycle, which was 1989. It is important to note that the first-year life price curve for 16Mb DRAMs most closely

Figure 8-2
DRAM Pricing: Rate of Decline at Each Stage in Life Cycle Relative to Prior Density (64K DRAM = Base)



Source: Dataquest (August 1992)
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approximates the first-year curve for 256K DRAMs (1983), which in part led to U.S. allegations of dumping against Japan-based suppliers in the mid-1980s.

The 1993 Scenario

Prices in 1992 for 16Mb DRAMs in regions such as North America and Europe should be somewhat erratic and vary widely because suppliers are at different stages in terms of sampling, initial volume production, and full volume production. For 1993, however, the information in Figure 8-2 can be used to provide a forecast of the estimated high and low range of North America 16Mb DRAM pricing.

The information in Figure 8-2 historically depicts this range of percentage declines in DRAM pricing at the second year of any given product density relative to the prior-generation device, from a low of a 35 percent decrease for 1Mb DRAM in its second year compared with 256K DRAM in its second year, to a high of a 90 percent decline for 256K DRAM versus 64K DRAM.

The Estimated 1993 Range of 16Mb DRAM Pricing

Four assumptions guide this analysis. First, the 256K scenario is unlikely to recur, not only because of trade friction but also because 16Mb DRAM require much larger capital outlays than did earlier-generation devices, including 256K DRAM. The second assumption is that, if trade friction recedes dramatically during 1993 and supplier competition increases, millicent-per-bit prices for 16Mb DRAM on the low side of the range will be 70 percent lower than the 4Mb DRAM price at the second year of its life. The third assumption is that, if trade friction does not recede during 1993, millicent-per-bit prices for 16Mb DRAM on the high side will still be lower than the 4Mb DRAM price in its second year, but only 30 percent lower. The final assumption is that the U.S. government will avoid in any legal action a repetition of increased DRAM prices for North American buyers, whether measured in dollars or millicents per bit. (Should that scenario unexpectedly unfold, users could expect a flat 16Mb DRAM price profile for 1993).

Using the assumptions outlined above, Table 8-3 predicts that 1993 North American 16Mb DRAM pricing should range from a low of

Table 8-3
Estimated 16Mb DRAM Pricing—North American Bookings (Volume: 100,000-200,000)

Part	4Mb×4 DRAM, 70ns, SOJ 400 mil
Estimated Low Price ($)	44.00
Forecast for Market Average ($)	70.20
Estimated High Price ($)	102.50

Source: Dataquest (August 1992)

$44, which represents a millicent-per-bit price that is 70 percent lower than 4Mb DRAM pricing during its second year, to a high of $102.50, which represents a millicent-per-bit price that is 30 percent lower than 4Mb DRAM pricing during its second year.

Chapter 9
Dataquest Perspective

DRAM cost management represents a priority challenge again for users during 1992, and will again during 1993. Eight years ago, one author of this report worked with the Korea Trade Center, which alerted the world that Korean-based companies such as Samsung were intent on achieving world leadership in DRAMs—a ludicrous thought at the time. Today, Samsung ranks among the very top suppliers in the DRAM world, with Goldstar and Hyundai aiming to join it as a member of this exalted rank. Looking ahead eight years from today, readers of this report should start preparing now to manage anticipated major changes in the DRAM supplier base by the year 2000.

For purchasers, component engineers and other users of DRAM interested in working toward that objective, this guide couples DRAM life cycle analysis with a supplier base evaluation as a strategy for cost-effective DRAM demand management during the 1990s, incorporating demand- and supply-side perspectives as key parts of the strategy. A critical element of the strategy calls for users to assess system migration paths against Dataquest's DRAM life cycle forecasts.

During the remainder of this decade, DRAM users will continue to confront periodic supply and demand mismatches, such as 256x4K VRAMs during the middle of 1992, which typically recede after one or two quarters. Users in North America and Europe, however, face the specter of fundamental long-term market changes that should make life quite challenging.

First, new technologies such as flash memory aim to displace DRAMs from system applications. Second, DRAM/VRAM/SIMM supply and demand mismatches could become more drastic as some suppliers reconsider their long-term strategy for profitably serving demand, which may mean some market withdrawals. For example, Chapter 5 notes the ominous delay by Japan-based suppliers of the scheduled opening of 4Mb/16Mb DRAM fabs. Another example is that packaging technology might be a barrier to future market evolution, and package shortages might prove more enduring and longer-term than is experienced in today's market. Third, IBM will be a key wild card in the entire worldwide DRAM business, not only in terms of demand and technology trends but also as a merchant market supplier. Fourth, users must manage continuing sharp shifts in the supplier base, as exemplified by Samsung's dramatic rise from the mid-1980s to worldwide DRAM market leadership by the early 1990s. Fifth, supplier survival means more DRAM alliances—alliances that will change, evolve, or terminate over time, meaning work and worry for users—as exemplified by recent shifts of the IBM-Siemens agreements.

Even so, the ever-volatile DRAM market is huge and will not disappear. At the end of this decade, users most likely will still be grappling with DRAM management strategies, although their concern in the year 2000 will be with suppliers of then state-of-the-art 256Mb DRAMs. And some of those suppliers are nonexistent today.

Appendix A

Ronald A. Bohn
Senior Industry Analyst
Semiconductor Procurement Service

Mr. Bohn is a Senior Industry Analyst for Dataquest's Semiconductor Procurement service. He is responsible for research and analysis in semiconductor pricing trends and lead times. He assesses semiconductor life cycles and the supplier base from a purchasing and component engineering perspective. He has developed a database listing the top-ranked electronic equipment producers' purchasing locations by application market, which serves as the survey base for Dataquest's Supplier of the Year awards. Mr. Bohn also has tracked analog, discrete, and power IC markets. In addition to his six years experience with Dataquest, he has seven years of business and legal experience. Prior to joining Dataquest, Mr. Bohn was with a market research company involved in analysis of worldwide markets for electronic components and systems. He was International Market Research Manager for the Korea Trade Center in the United States. Mr. Bohn received a B.A. degree in History/Government from Cornell University, an M.B.A. degree from the University of California at Berkeley, and a J.D. degree from the Hastings College of Law.

Rebecca Burr
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Ms. Burr is a Market Research Analyst from the Research Operations group. She has more than six years' experience in the industry. Ms. Burr focuses on wafer fabrication facilities databases, semiconductor equipment manufacturers' market share, silicon manufacturers' market share, and semiconductor equipment and materials forecasts. Prior to joining Dataquest, she was with Siemens. Ms. Burr holds B.A. degrees in Economics, Marketing, and Commercial German from Eastern Michigan University.

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Mr. Charlton is a Senior Market Research Analyst in the Research Operations group. He is responsible for analysis and forecast of the personal computer market. Before joining Dataquest, Mr. Charlton was a Product Manager at Alcatel Information Systems. He also served as Training Manager at ITT. Mr. Charlton holds B.S. degrees in Electronics and Chemistry and an M.B.A. from Golden Gate University.

Janet E. Cole
Industry Analyst
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Ms. Cole is an Industry Analyst for Dataquest's Computers and Peripherals group. In addition, she provides cross-industry support to Dataquest's subscription clients. Ms. Cole performs literature searches, gathers data, and prepares reports for presentations, publications, and client inquiries in the workstation and PC areas. Recent consulting projects that Ms. Cole has been involved with are a survey of direct-response PC vendors and an in-depth study of two PC vendors. Before joining Dataquest, Ms. Cole was a Manager in the Marketing Services Group at Symantec Corporation. Ms. Cole received her B.A. degree in Psychology and an M.S. degree in Communications from Boston University.

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Microprocessor Procurement Guide

Focus Report

Semiconductor Procurement Service
SPWW-SVC-FR-9201
July 20, 1992

Dataquest®

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Focus Report

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Chapter 1
Executive Summary

The microprocessor market is being pulled in many directions. The user community at the high end is being addressed one way, while the mass market personal computer (PC) segment sees a different picture. The difference between low-end workstations and high-end PCs continues to blur. The trends of the workstation market often lead the way for the rest of the computer industry because workstations are often used to design other electronic equipment that requires PCs. A healthy and growing market, the technical workstation segment continues to be very dynamic. With the majority of workstation users (60 percent) sharing machines and increasingly inexpensive machines continuing to come to market, the workstation user is in a good position to benefit from advances in technology and microprocessor competition. The choice of microprocessor engine that drives these workstations is becoming more critical as software applications specific to processor type become a key differentiating factor in market acceptance. Meeting the needs of a diverse customer base with various microprocessor platforms continues to be a challenge to the semiconductor industry.

The 80X86 microprocessor family is the largest segment of the market and is rapidly being populated by increasing numbers of suppliers supporting this platform. Intel controls 58 percent of worldwide microprocessor revenue, and it is aggressively protecting this coveted portion of the market. Now that the shift from 16- to 32- bit versions of the 80X86 market is nearly complete, the addition of competition is a breath of fresh air to this once sole-source world.

Intel's dominance in the 80X86 market has caused the market to react with alternate sourcing of these advanced microprocessors. The world of sole-sourced microprocessors is fast fading into history, yet the future of a multisourced market remains unclear because of legal ramifications. Good communication with suppliers of these strategic parts now more than ever is paramount in order to make the best sourcing decisions.

The long-term supplier base of microprocessors is in the midst of change, resulting in challenges for the user community in deciding which platform and, more recently, which supplier to choose from in order to be best served. The choice of microprocessor technology to a large extent determines system market acceptance and long-term market success or rejection, which in turn determines long-term growth or demise. As RISC-based and CISC-based processors vie for merging applications, the system designer and microprocessor buyer are caught in between. Internal communication of marketing design and procurement is mandatory for system companies that use advanced microprocessors because of the ever-reducing market window that each generation of system has to fit in. To quickly and accurately communicate end-user needs, system design requirements and supplier support capabilities are becoming the normal procedure and not a task force function. The life cycles of key microprocessor families included in this guide are key in helping to decide which technology processor to choose.

Chapter 2
Introduction

The intent of this guide is to have in one place the majority of microprocessor information needed by semiconductor procurement personnel in formulating sourcing and pricing decisions on a regular basis. The guide is divided into chapters that deal with specific areas of concern and interest to various segments of the microprocessor user population. Dataquest then concludes with a perspective on what microprocessor users need to consider when sourcing these key components.

Chapter 3 of this guide contains the demand-side perspective on what is affecting the microprocessor market. Dataquest looks at the trends of the technical workstation market and what the computer industry needs in the way of microprocessor power to support this driving force. The technical workstation was chosen as being representative of a high-growth market that demands the most from microprocessor suppliers and in many ways sets future trends for processor users.

Chapter 4 of this guide focuses on the microprocessor majority market share holder, the 80X86 product line. The rapid evolution/revolution of the 80X86 supplier base gives a general overview of what is driving this market from a macro perspective. Technical and legal developments continue to influence the 80X86 market almost on an equal basis. The future is expected to continue as a multisourced arena. However, the timing and exact product specifications have not been finalized at the time of this writing.

Chapter 5 deals with Dataquest's annually updated Microprocessor Life Cycle Curve that notes where specific MOS microprocessors are in their respective life cycles. To gain an historical perspective on this topic the reader is directed to Appendix A, a May 1990 chapter addressing the once sole-source world of 32-bit microprocessors. Chapter 5 also deals with the major suppliers to this market and their plans for the near and long term. A review of supply base management is also included in this chapter for those companies that compare microprocessor technology and supplier compatibility. Chapter 5 then covers a review of microprocessor design and production trends that affect the industry and closes with an overview of life cycle price analysis.

Chapter 6 highlights the results of Dataquest's Third Quarter 1992 Price Survey for MOS Microprocessors for both short- and long-range time spans. This survey is conducted quarterly, combining both supplier and user price estimates as a basis for Dataquest's forecast.

Chapter 7 includes a Dataquest Perspective on the overall microprocessor market.

Chapter 3
Technical Workstations: A Key Application for Advanced Microprocessors

Technical Workstation Market Overview

Because this market segment often leads the data processing market in technological requirements, the rest of the computer industry is often indirectly impacted by this leading-edge application. This chapter is included because it reviews a key computer market that is influencing microprocessor technology and application trends. The technical workstation computer is one of the most demanding applications a microprocessor can be set in. This chapter looks at where the workstation is headed and what is needed to support this market.

The workstation market continued to show signs that it is healthy and growing. The growth from 1990 to 1991 slowed slightly from the previous years, primarily because of the global economic weakness.

The workstation market continues to be driven by price/performance gains within the technical markets. But movement toward client/server computing is aiding the entrance of workstations into business applications.

The workstation market continues to be very dynamic. Those who would be major players in the workstation market must have the ability to react quickly to competitive pressure and to be proactive in driving the fundamental direction of the industry.

Major Trends in the Workstation Market

Dataquest has identified the following major trends in the workstation market:

- The worldwide workstation market exceeded $8.7 billion in 1991, a 14.4 percent increase over 1990. The U.S. market for workstations achieved revenue of $3.474 billion in 1991 as compared with $3.147 billion in 1992, a 10.4 percent increase.
- Dataquest estimates that the worldwide market will equal $33.5 billion at year-end 1996, representing a five-year compound annual growth rate (CAGR) of 30.9 percent. The U.S. market will equal $13.7 billion, a CAGR of 31.6 percent.
- The product mix for workstations is shifting toward low-end workstations. However, the shift in 1991 was slower than expected with 282,371 units shipping in 1991, compared with our forecast of almost 310,000. We expect high growth in 1992

as every major workstation vendor now offers a workstation for less than $10,000.

- The traditional workstations achieved growth higher than anticipated in 1991 as compared with our forecast. The primary reason is the success of Hewlett-Packard's Series 700, IBM's RS/6000, and Sun Microsystems' SPARCstation 2, all of which were classified as traditional workstations.
- SPARC represented 39.9 percent of the units shipped in 1991, retaining its market leadership for microprocessors in the workstation market. Sun Microsystems represented 89.2 percent of the SPARC shipments.
- Even with the slow U.S. economy, the U.S. workstation market grew 10.4 percent in factory revenue, slower than the total market growth but double-digit growth nonetheless. The U.S. market grew 30.4 percent in unit shipments, exceeding the total market growth of 29.8 percent. This indicates that the United States is shifting toward lower-ASP systems. We expect this trend to continue as more vendors offer lower-ASP workstations, as indirect distribution channels open up, and as 586-based workstations enter the market.

Emerging Open Systems Alliances

In 1991, we saw the emergence of a new concept and a new way of doing business: open systems alliances. The common theme among these alliances was elimination of the distinction between personal computers and workstations and the movement of the computer industry toward client/server computing.

As systems move toward commodity status or at least to the point where profit margins are minimal, value and revenue stream will be derived from owning the chip (that is, the technology) and the operating environment. In the PC market, Intel and Microsoft are two of the most powerful companies and have profited handsomely off the growth of the PC market. In fact, according to our Microprocessor Group, for some aggressively positioned PC systems, Intel accounts for 70 percent of the profits derived from the sale of the PCs. We believe that these "open systems" alliances are an attempt to regain some of the control and thus the revenue stream from Intel and Microsoft. We have seen the major computer vendors start to jockey for position to have their technology and operating environment be the winner in the 1990s.

Although the microprocessor is a key component in the alliance, the operating environment will drive system sales and ultimately the recruitment of more vendors to an individual camp. For example, Microsoft's Windows/NT was clearly the driving force for the ACE Initiative and the reason many companies joined. Therefore, we see the strongest contenders being those with a strong operating environment. At this time, the two with the greatest potential for success are IBM/Apple with the PowerPC and the Taligent OS and PowerOpen and Microsoft's Windows/NT on Alpha, Intel, and MIPS.

Changing Product Mix Requires Changing Business Models

The workstation market has been shifting its product mix toward lower-ASP systems over the last few years. We expect this change in product mix to become more dramatic. As the product mix shifts, workstation vendors will have to contend with two different business models and two different sets of users.

One set of users is very price-sensitive. The business model must accommodate intense price competition and be able to survive on very low margins. The workstation vendor that wants to compete in this arena will be required to compete aggressively with the higher-performance Intel-based workstations. The price competition is guaranteed to be intense and business models and pricing models will transition to resemble the current PC market.

The expected price slide of the 586 is an excellent example of the pricing trends to be expected. Assuming that the 586 is configured with the same features as a workstation, the major components driving lower prices will be the cost of the 586 and the cost of the operating system. We expect the 586 to initially cost about $1,300 and Windows/NT to cost $600 retail with the OEM price conceivably costing from $25 to $100. We expect the 586 to be in the $150 range by 1996 while an OEM price for Windows/NT will be $5 to $15. This represents a ninefold drop in price over four years, equivalent to a negative 42.3 percent CAGR. This type of pricing erosion will definitely put pressure on workstation vendors to either meet prices or offer additional value to justify a higher cost.

The second set of users, the traditional workstation users, are still driven by performance, although other factors do arise in the final purchasing decision. We believe that the workstation vendors will maintain their leadership for this customer set. They have the expertise in developing advanced systems and pushing performance capabilities to the limit. PC-based vendors in general have not had the systems design experience nor the necessity to spend a lot on R&D. Typically, a PC manufacturer will spend about 4 percent on R&D, whereas a typical workstation vendor will spend between 10 and 14 percent on R&D. Instead of R&D, the PC vendor has focused its attention on volume manufacturing capabilities and distribution, skills not appreciated by the technical user.

Processor Market Share Still a Competitive Hotbed

Operating environments are definitely the future battleground, but the battle is still strong in the microprocessor arena. SPARC maintained its leadership with 39.9 percent of the units shipped in 1991, mainly because of the strength of Sun.

The volatility and the uncertainty in the processor forecast is at an all-time high. Last year, the ACE Initiative gave MIPS the potential for being a major contender. Now the loss of Compaq, the introduction of Alpha by Digital, and the loss of vendor neutrality with the purchase of MIPS Computers by Silicon Graphics has left the MIPS architecture with a less-than-rosy picture of its ability to effectively compete against the giants.

The ability to drive volume is key in the success of a microprocessor. We believe that Intel and the POWER chip have the greatest potential for driving volume. We believe that Intel has the ability based on its existing installed base and the likelihood that PC vendors will sell in volume. We believe that the POWER chip also has a high probability for driving volume because of backing by both IBM and Apple and the microprocessor design and manufacturing experience of Motorola. Bull and Cetia are the only other system vendors to have signed up to use the POWERchip, but we believe that more will come.

The SPARC market's performance, with the exception of Sun, has been less than stellar. Sun still represents 89.2 percent of the worldwide SPARC shipments. The primary reason for slow growth was the lack of demand in markets other than Sun's installed base and the inhibiting factors put in place by Sun (that is, Sun's exclusivity agreement with VARs and the lack of the latest SPARC technology).

Sun has attempted to correct some of these errors. In April 1992, SMCC announced that it will make its silicon designs, including SPARC CPU chips, ASICs, and other system support chips, available to selected semiconductor vendors, who will manufacture, sell, and support chips based on those designs worldwide. SMCC also announced its new distribution strategy. In this new strategy, a VAR will get an additional 1 percent discount for exclusivity. In addition, unless they have significant volume VARs must purchase through the master VAR. This indicates a backing away from the total exclusivity announcement of last year. Instead of trying to dominate the VAR, which could destroy key relationships, Sun is now using monetary incentives to encourage exclusivity for VARs strategically important to it (that is, the master VAR and VARs with large sales volume). The bottom line is that these announcements should have a positive impact on the SPARC market. The major drag factor now is the addition of vendors that can help drive volume, that is, someone like IBM, Apple, or Compaq.

The newer competitors for microprocessor dominance are PA-RISC and ALPHA. Both have potential because of the performance advantages and the financial investments HP and Digital have made and can make. However, neither offering has the critical desktop vendor to help drive volume. ALPHA has a greater potential to attract desktop vendors because of its relationship with Microsoft and the availability of Windows/NT on ALPHA. However, it will be late to market in comparison with other microprocessors and will be an expensive and power-consuming chip—not conducive in its first release for use in a PC replacement system.

Definitions

What Is a Workstation?

Workstations have been evolving fast and furiously. In the last year, we have seen workstation vendors offer server systems targeted at typical commercial midrange applications such as Sun with its 600 Series and IBM with its RS/6000 family, and Intel/DOS machines such as the Digital 433PC with integrated networking. The question then becomes: What is a workstation? Is it based on product features? Operating system? Usage?

Dataquest's Workstation Service has decided to classify workstations on their hardware, software, and product features and not by usage (that is, single-user, server, or multiuser). In general, a workstation must come standard with an integrated floating point coprocessor, integrated networking, and a 32-bit multitasking operating system, and offer a configuration that has high-resolution graphics capabilities (typically 1-megapixel display).

Once the system passes these criteria, we examine whether it is designed to be a server or if it was designed to be a workstation (that is, is the system marketed and sold with graphics capabilities?). If it is designed to be a server (examples are the SPARC-server 690 and RS/6000 950), the system is classified in Dataquest's midrange category. If it is marketed and sold with graphics capabilities, we further classify the workstation and its server configuration (for example, SPARCstation 2) into one of four categories.

Personal Workstation

The personal workstation is the combination of PC technology with workstation technology. The criteria for a personal workstation are that its product features include integrated floating point, integrated networking, high-resolution graphics, and a 32-bit multitasking operating system. Yet its processor technology and operating environment typically comes from the traditional PC market. The best example is the 586 system sold with Windows/NT that has integrated networking and improved graphics performance. It is always priced less than $10,000 and typically sells for less than $5,000. We expect the primary manufacturers of these systems to be the current PC vendors. We expect these systems to be sold through many of the same distribution channels in which current PCs are sold. The 586 performance is expected to be between 50 and 80 SPECmarks, with Intel claiming that it could be as high as 100 SPECmarks.

Entry-Level Workstation

Entry-level workstations have typical configurations costing less than $15,000 and usually have a base price of less than $10,000. They are targeted at the end user that is sensitive to price. Entry-level workstations mainly run two-dimensional graphics, although we are starting to see workstations with integrated 3-D graphics capabilities such as the IRIS Indigo; these are classified as entry-level systems. Typically entry-level workstations do not have the expandability of a traditional workstation or superworkstation and therefore cannot have as high a level of graphics performance or other features as do traditional workstations. In 1991, the performance ranged from 11 to 26 SPECmarks. In 1992, we expect new systems in this category to have performance of up to 50 SPECmarks.

Traditional Workstation

The traditional workstation classification is the original workstation. It is designed for the technical or power user who requires more power, better graphics, and more memory and storage. The systems typically have more expandability than the entry-level workstation. The price typically is between $15,000 and $60,000. In 1991, the performance ranged from 24 to 72 SPECmarks. We expect vendors to offer multiprocessor traditional workstations by the end of 1993. Today, traditional workstations are only uniprocessor.

Superworkstation

Superworkstations typically have the highest combination of CPU and graphics performance. They are designed to address scientific, engineering, and other computationally oriented problems. The systems can be acquired and run by a single user or as a server for a small group working on an individual project. Multiprocessing capabilities first appeared in this category and typically are the entry point for new technology into the workstation market. Base prices start at about $60,000 but can extend up to more than $200,000. In 1991, performance was typically greater than 50 SPECmarks.

Market Size and Share

In 1991, Sun maintained leadership in both revenue and unit shipments, with HP moving into the second position for both revenue and unit shipments. The vendor with the strongest growth was NeXT, with 380 percent growth over 1990, gaining almost 3 points in market share. IBM also gained almost 3 point in market share. It should be noted that IBM only shipped for six months in 1990. We expected IBM to at least double its unit shipments.

Sun's upward march has slowed. After experiencing a near-5-point gain in 1990, it barely maintained the same market share as in 1990, having grown at the same rate as the total workstation market. The growth between 1989 and 1990 was mainly because of Sun's push to lower price points with the SPARCstation 1^+, IPC, and SLC. In 1991, Sun did not drastically alter its product portfolio and competition increased significantly from HP and IBM at the high end and Digital at the low end.

HP has recovered from its problems of 1990 when Motorola was delayed in delivering the 68040 and HP had no low-end RISC offering. In 1991, HP introduced the 700 Series with great success but was plagued once again with chip component supply problems. As a result, HP did not gain significantly in market share. By 1992, it was able to recover from the TI floating point shortages and introduced the new low-end 705 and 710. We expect HP to introduce new products based on the 7100 chip in the third quarter of 1992. This should eliminate any outside dependence on chip supply. As a single-chip implementation, the 7100 will keep HP at the leading edge of performance and help reduce cost of manufacturing. Based on HP's current competitive position, we expect HP to gain market share in 1992.

Digital's difficulties also become apparent with a slide of about 7 points over the last three years. Digital's weaknesses can be attributed mainly to falling sales of the VAXstations combined with the inability to sell the DECstations. We expect that 1992 will be good for Digital in unit shipments but challenging in growing revenue. Digital introduced new low-end models of its VAXstations and DECstations at the end of 1991. Because of very competitive prices, these new models have had some success, with VAXstations growing 38.5 percent from the third quarter of 1991 to the fourth quarter of 1991. However, we do not expect the ramp-up to be enough to counter the lower ASPs. Hence, we anticipate a loss in market share based on revenue for Digital in 1992.

IBM did well, but not as well as could be desired. It continued to lack a low-end product and was plagued with announcement delays. The announcement finally occurred in January 1992 and will help IBM be competitive in the range of less than $10,000. Another plus for IBM in 1992 is its restructuring. It appears that RS/6000 can now be officially turned loose on the business accounts. In April, IBM announced the Model 970 and specifically targeted it at business applications. We expect further announcements from IBM, with focus on the business applications and announcements regarding high-availability and clustering options.

The most dramatic shift was that NeXT moved past both Intergraph and Silicon Graphics in unit shipments with 19,200 units shipped in 1991. The combination of more software applications, increased focus on commercial and government accounts, and the performance improvements derived from the 25-MHz 68040 put NeXT in a better competitive position. In 1991, NeXT increased its activity within the business and government accounts. More than 80 percent of its systems were sold into these two areas; the remainder was sold into higher education. The biggest question for NeXT is which RISC architecture it will support. NeXT has talked about the 88K and we have heard rumors of a two-processor 88K system in the works. Our initial response is "they have got to be crazy." NeXT's biggest problem has been that its look is too proprietary. If it goes with the 88K, it will continue down the path of a niche player. Our best guess as to which RISC processor NeXT will use is PA-RISC. HP could provide assistance in migration from Motorola to PA-RISC, and PA-RISC needs a desktop operating environment. Our second-best guess is the POWER chip. NeXT and Motorola have had excellent working relations and it could be a nice follow-on to the 68000. But once again, NeXT would be alone in promoting NeXTstep, while the rest of the POWER camp moved to PowerOpen or Taligent.

Another important note that should not be overlooked is the growth of the Japanese vendors, who now hold three of the five second-tier positions. Virtually all of this success has come in the Japanese market, but all Japanese vendors are quite interested in the lucrative and large U.S. market. The difficulty in the past for a Japanese vendor hoping to enter the United States has been getting ISVs to support its platform. As the open system alliances take shape, this should not be an issue for limiting market penetration within the United States The current market share leaders should keep an eye on the activities of Hitachi, NEC, and Fujitsu.

Driving Forces for Growth

The basic underlying driving forces for the adoption of workstation-class machines by both the commercial and technical end user are the drop in average selling price, the movement toward client/server computing, the requirement for increased functionality on the desktop, and the opening of indirect channels.

According to the 12-month cumulative results from our *Workstation Customer Satisfaction* survey, more than 60 percent of the respondents (3,201 end users surveyed) still share their workstation with a coworker. We believe that falling entry-level prices for workstations will enable more individuals to have their own workstation on their desk. The fact that the desktop market in the engineering and scientific community is not totally saturated will continue to be a driving force through the mid-1990s.

The movement toward client/server and distributed computing is a major driving force for the entry of workstations into commercial markets. Current PCs do not offer the advanced operating systems nor integrated networking features to easily implement a client/server architecture. The pending announcement of Windows/NT and the expected product enhancements will bring many PCs up to workstation-class levels and will help drive the acceptance of workstations in the commercial markets.

Although Windows/NT is the biggest threat that UNIX has had in many years, we see Windows/NT also as an aid to the acceptance of UNIX on the desktop. The multitasking, multiuser features that have been so widely publicized in Windows/NT have always been found in UNIX. In fact, we believe that Windows/NT's possession of some of these features will validate the need for an advanced operating system on the desktop. UNIX is a proven operating system, unlike Windows/NT, and therefore we believe that UNIX will be able to ride the wave into the commercial desktop and server markets.

We also believe that features and functionality currently available in workstation platforms will be requirements on the desktop in the near future. Among these features are multitasking operating systems, integrated floating point processor, integrated networking, and high-resolution graphics capabilities. Multitasking, multiuser operating systems and integrated networking are features needed for existing in a distributed environment. We expect to see integrated networking on high-end Intel-based machines at the end of 1992 and expect integrated networking to move down the price curve over the next two years. In surveys conducted by our Semiconductor Applications and Markets Group (SAM), major PC manufacturers indicated that a majority of PCs would have integrated networking. One major vendor indicated that 80 percent of its PCs would have networking on the motherboard by 1994.

The final driving force for positive growth in the workstation market is the opening of indirect distribution channels. In 1987, 58.6 percent of the workstations were shipped through direct channels, compared with 51.5 percent in 1991. With average selling prices plummeting, indirect channels have become necessary to reduce the cost of selling and to increase volume. Sun has been the leader in developing some dealer channels with its agreements with MicroAge and Intelligent Electronics. HP and IBM have followed Sun's lead and now have agreements with some of the same dealers. Although only 5.3 percent of the U.S. shipments went through dealers in 1991, we expect that the dealer channels will become a larger percentage as the installed base of workstations grows and as workstations become easier to use.

Why Include 586 Systems?

Many have asked why the 586 should be included when it is just another PC. Well, we differ in that opinion. For many systems, the 586 will be just another PC. If the 586 is just a replacement for the 386 and 486 and is sold with DOS, it will be classified as a PC. But a system with Windows/NT or Solaris or another advanced OS with integrated networking and high-resolution graphics will be a workstation. The reasoning for this distinction is as follows:

- Windows NT is a multitasking, multiuser operating system. It is being positioned by Microsoft at the high end to go directly against UNIX—that is, SunSoft's Solaris, USL's Destiny, and in the future PowerOpen and Taligent. All UNIX workstation vendors see Microsoft NT as their direct competitor and most significant competitor for the desktop and low-end servers.
- The growth and the definition of a workstation has not and will not be dependent on a single operating system. The features and functionality found in both the hardware and software are all criteria for the workstation status.
- In a survey completed by our SAM Group, a major company stated that 80 percent of its PC units will have embedded LAN connections by 1994. In addition, IBM is in joint development activity with National Semiconductor to produce a combined Token Ring and Ethernet controller chip. We expect this chip to end up on the motherboard of many of IBM's desktop systems, including those currently classified as PCs. This leads us to believe that integrated networking will no longer be a difference between PCs and workstations.

- We believe that Microsoft is trying to convince hardware vendors to produce "Windows PCs" by this fall's COMDEX. According to Microsoft, an ideal Windows/NT PC would be based on either a 586 or 486 running at 33 to 50 MHz, and have a minimum of 8MB RAM (although 32MB is recommended), a CD-ROM drive, and a 300MB or larger drive standard. MPC audio, multimedia, and networking capabilities would be built in. A high-end 19-inch display system would have 1280 x 1024 resolution. Assuming that vendors do follow Microsoft's guidance, the resulting system meets the criteria for the workstation definition and therefore should be classified as one.

Based on these reasons, we believe that there will be 586 systems running Windows/NT or another advanced operating system that will meet the criteria for workstations. We believe that most 586s will still run DOS, but that there will be a migration to Windows/NT or another advanced operating system over the forecast period. At this time, we do not include the 486-based systems because they do not meet all of the criteria for a workstation.

Uncertainty in the Forecast

As with every forecast, assumptions are made that may or may not come true. The main assumptions we are making that may cause us to understate or overstate the forecast are as follows:

- Acceptance and stability of Windows/NT. We expect Windows/NT to initially come out with many bugs and to not be a stable operating system for at least three years. However, we still believe that Microsoft will be able to sell many copies, even with the bugs. If it takes longer to fix the bugs, acceptance could be slowed. On the other hand, if there are fewer bugs and Microsoft is able to offer a stable new operating system more quickly than anticipated, the acceptance rate could be much higher.
- Global economic weakness. We expect the economy to recover by 1993. Continued global weakness will have a negative impact on workstation market growth.
- Aggressive pricing model by Intel. Typically, microprocessors have followed a pricing model that resulted in a 30 percent per year decline in price. With pressure from AMD and other semiconductor vendors cloning the 386, Intel may decided to be more aggressive on the 586 pricing in order to regain market share. If this is the case, the 586 forecast may be understated.
- Applications to take advantage of a workstation on the desktop. We believe that the operating systems and hardware will be there to entice users, but applications also need to be prevalent for a migration to occur. The desktop market is mature and many seat are already filled. As in the past, new applications were a major driver toward purchasing new systems. If the applications are too slow in coming, the forecast could be high.

Summary

The workstation market continues to offer great potential for growth. However, there is also intense competition. The major workstations vendors must attempt to achieve leading product price/performance, offer scalability from the desktop to data center, embrace standards, provide heterogeneous interoperability, and aggressively pursue other computer manufacturers to support their processor architecture and operating environments. For new entrants or small vendors, the best strategy is to target a niche, perhaps a vertical niche within the business applications, focus on embedded workstation applications, offer some product differentiation such as notebooks, or have distribution be a form of differentiation (for example, mail order). The strategy of being the price leader on the desktop is risky. It has been attempted by the SPARC clone vendors and profitability has been severely limited. Whatever strategy is chosen, a new vendor must align with a major vendor. Otherwise, the ability to attract software applications will be greatly hindered.

We see the workstation market as a central driving force for client/server computing and distributed computing. For the major computer vendors, workstations are a strategic product and a strategic focus. There are growth opportunities for vendors involved, yet competition will remain fierce. One certain factor in these dynamic times is that workstations will continue to be a major force in the computer industry.

Chapter 4
A Key Microprocessor Family: The 80X86

80X86 Processor Family Readies for Transition

This chapter is included because the way the 80X86 product family is evolving from a sole-sourced 32-bit market to a multisourced arena is very important to procurement managers. Intel is currently in an advantageous market position that, if abused, could force some users to alternate architectures and suppliers.

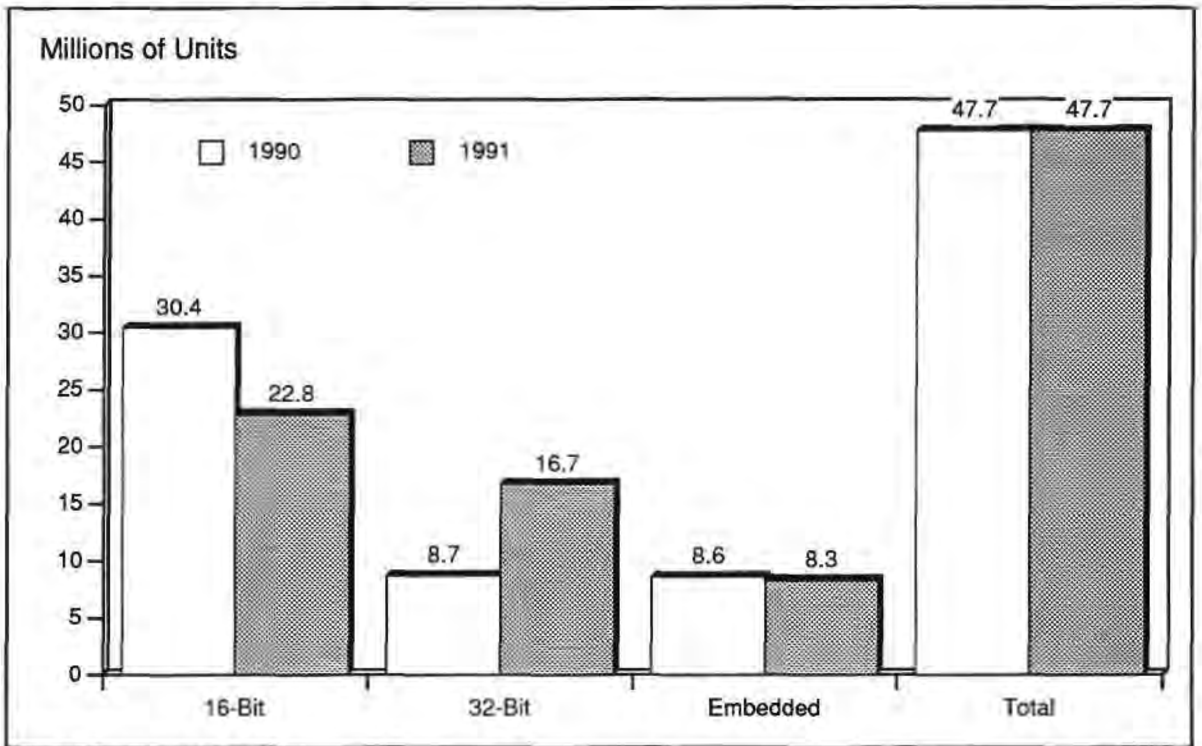
The 80X86 processor class is defined as all upward-compatible versions of the 8086 microprocessor, regardless of word length, instruction extensions, or level of integration. The following are also broken out as subsegments to enable a more focused analysis of market trends and competitive positions:

- 16-bit general versions—8086, 8088, 80286, and equivalents, for example, the V20 and others
- 32-bit general versions—80386, 80486, all versions
- Embedded versions—80186, 80188, 80376 and equivalents

The original 8086 was introduced by Intel Corporation in 1978, had 29,000 transistors (then state of the art), ran at under 5 MHz, had a die size of 51,000 square mils, and initially sold for nearly $200. It is now a $6 part. Now the 80486 has 1.2 million transistors, runs up to 50 MHz, has a die size of 261,000 square mils, and initially sold for nearly $800. What these parts have in common is the power of compatibility with more than 10,000 software applications, IBM's blessing, and chips and systems cloned by anyone that can make them. This power has driven volumes to more than 40 million units per year with increasing ASPs that have made the cloning of this golden goose a very hot target.

As of the end of 1991, Intel had about 50 percent of the 80X86 class volume (see Figure 4-1) with several vendors lining up to steal even more market share. The 80X86 market was originally opened up through second-source licensing agreements with Intel. After growing critical mass in the market, using the early 8088 and 80286 processors, both of which were widely second-sourced, the scene changed. Intel

Figure 4-1
80X86 Units by Subclass



Source: Dataquest (July 1992)
G2000865

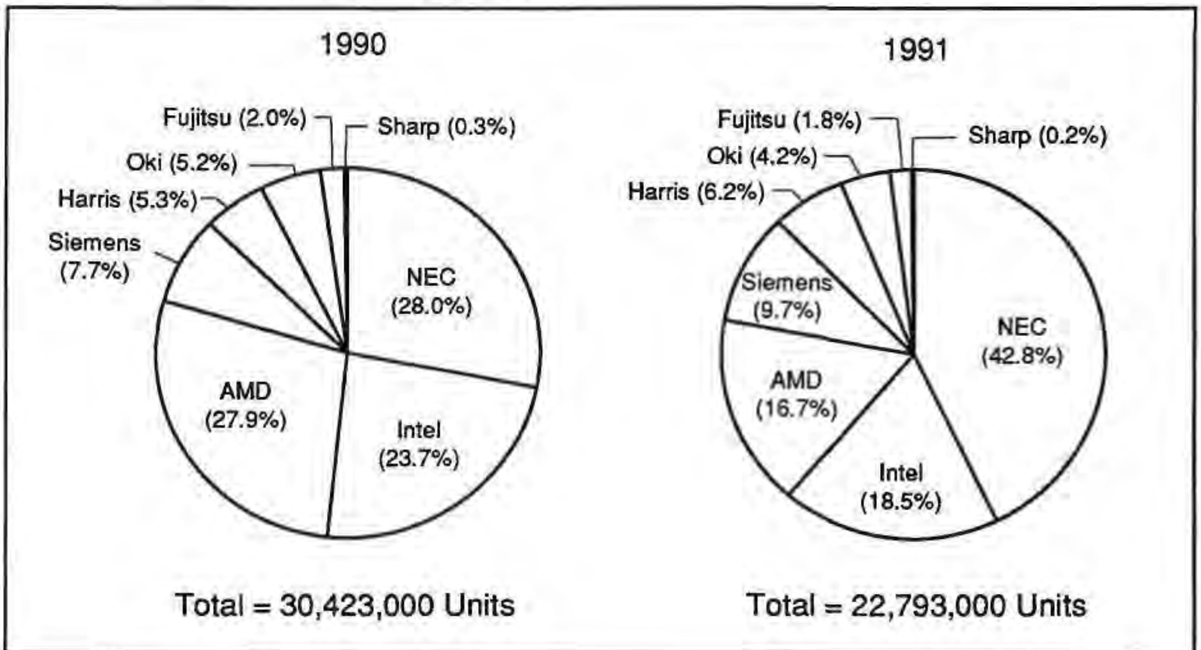
introduced the 32-bit generation of 80X86 processors intending to grow its business around a family of single-sourced, upward-compatible processors that would eventually reach workstation performance. Meanwhile, Intel used the older 16-bit core as the heart of an embedded processor family, the 80186/188, which has been very successful. As shown in this figure, the 16-bit family volume still dominates in unit volumes. However, at current growth rates, the 32-bit family will take the lead by the end of this year.

The 16-Bit Family Enters Its Twilight Years

Based on these preliminary estimates, it is not hard to imagine that we are at the beginning of a rapid decline for the 16-bit 80x86 processors—not including embedded versions. These processors were the lifeblood of the 1980s' PC, which is now dominated by the 386 processor and shows no signs of turning back. Although some contend that single-chip PC components, such as Chips & Technologies' new PC-chip product, will extend this family by living on in hand-held computers, Intel believes differently, focusing everything on the 386 and up.

As depicted in Figure 4-2, unit shipments for these processors decreased for all vendors except the leader, NEC Corporation. Unit shipments for both AMD and Intel declined sharply as they

Figure 4-2
80X86 16-Bit Processor Market Share



Source: Dataquest (July 1992) G2000866

focused on the 386/486 32-bit families. NEC markets the V-series 8086 equivalents and consumes many of them in its dominant Japanese PC family. Although primarily considered a PC microprocessor, a large percentage of 16-bit 80X86 processors have been used in other applications, including small systems, instrumentation, and certain embedded applications.

386/486 Processors Are the Target

In 1985, Intel introduced the 386, a superior part with much greater performance, advanced 32-bit features, and one other major change—Intel was the single source. In the years that followed, hundreds of system vendors built an endless stream of nearly identical 386-based clone PCs at ever-dropping prices to the point where up to 75 percent of the profit derived from each system made its way to Intel. Thus, the attraction to second-source this new 32-bit series of parts the hard way, without Intel's help or blessing. The key issue is whether anyone will be able to successfully grow and sustain a healthy portion of this incredibly profitable market.

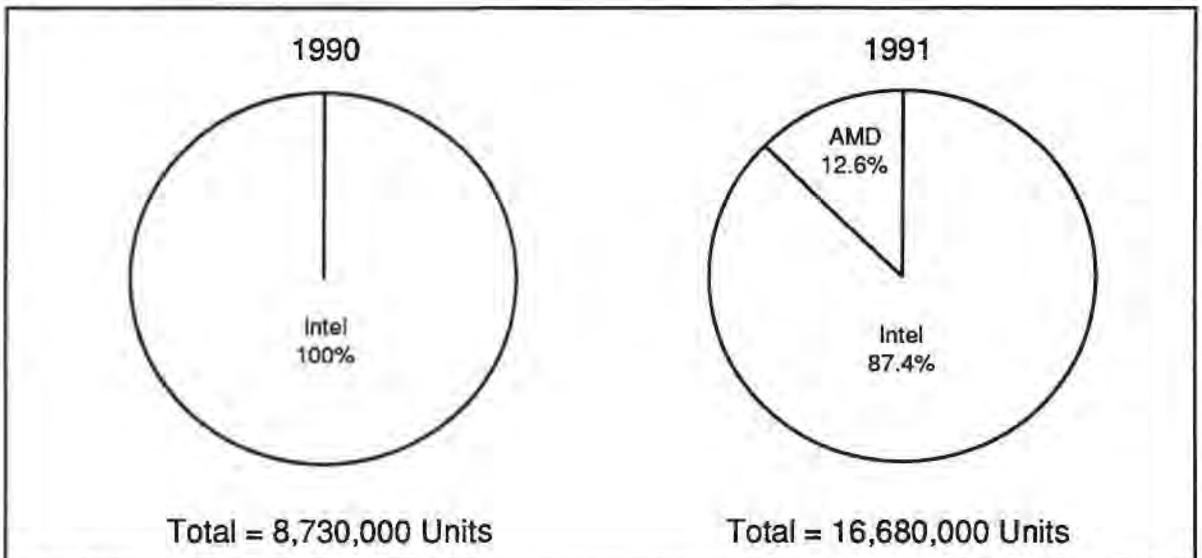
This processor family has two basic types and five total models, each of which shares the same basic 32-bit 386 core architecture. The primary versions and their characteristics are listed in Table 4-1. To date, only Intel ships every model listed, AMD ships versions of all 386 models (except SL Versions), and Chips & Technologies has introduced, but is not yet shipping,

Table 4-1
80X86 32-Bit Family Comparison

Model	386SX	386SL	386DX	486SX	486DX
Ext. Bus	16-bit	16-bit	32-bit	32-bit	32-bit
Clock Rate*	16-25	0-25	20-40	16-25	25-50
Coprocessor	387SX	387SX	387DX	487SX	Built-in
Cache Controller	Ext	Built-in	Ext	Built-in	Built-in

*Regarding clock rates: Intel just released a 25-MHz 386SX, and AMD is the only vendor shipping a 40-MHz 386DX.
Source: Dataquest (July 1992)

Figure 4-3
80X86 32-Bit Market Shares



Source: Dataquest (July 1992) G2000867

its 386 equivalents. Not incidentally, IBM internally ships some of its own versions of 386 processors and will be doing more so as the joint development with Intel at Noyce Development Center gets under way.

As shown in Figure 4-3, Intel had 100 percent market share until last year, when AMD entered the field. For 1991, AMD took about 12.5 percent of the total 386/486 market or 15 percent of the 386-specific market with a year-end run rate of nearly 30 percent of 386 unit volumes (90 percent of which is in the Asia/Pacific region).

Although three vendors are currently in this field and more are expected shortly, the structure of competition here is quite complex and involves legal, financial, technical, and marketing issues. Briefly, Intel sets the standards for all of these advanced 80X86 processors and has the financial, technical, and marketing means to remain a step ahead in new products for the foreseeable future. In fact, Intel will set a new high-water mark when it introduces the 586 in the second half of this year, beginning a new 64-bit family of X86 processors.

AMD achieved excellent success in 1991 as a second source for 386 processors and may enter the 486 market by the end of this year. This is because of the legal setback whereby a jury decided that AMD did not have the right to distribute Intel Corporation's microcode. AMD markets an identical 386 part to Intel's, right down to the microcode. Because these parts are identical, and AMD has been a credible and dominant supplier of 286s, it has had few technical hurdles in selling 386s. But its ability to continue selling these future-generation parts hinges primarily on winning the microcode-based lawsuit, filed by Intel, that AMD just lost. In essence, Intel could retain 386 dominance but drive its profit margins down to zero while switching demand to 486s before AMD can efficiently yield its 486s. Given AMD's current dependence on 386 profits, this strategy could have devastating consequences.

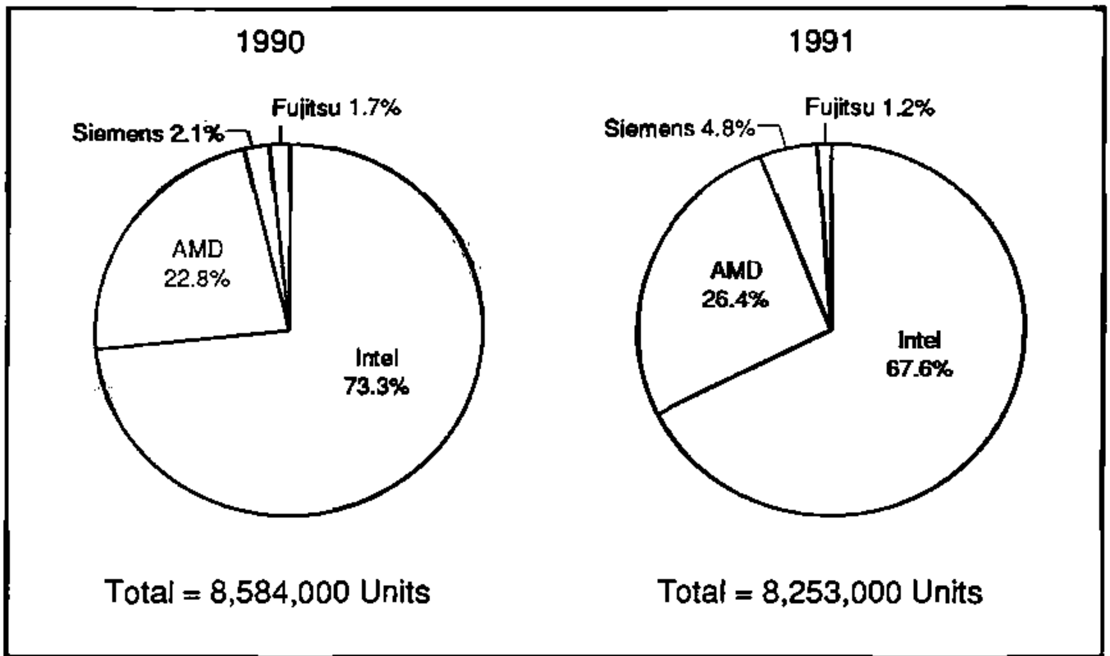
The remaining field of potential competitors falls under a different category because of forward engineering (not copying) their 386 or 486 equivalents. Although this prevents direct legal action from ensuing, it sets up a tremendous technical hurdle to overcome to qualify their parts. Because the microprocessor and its microcode have an infinitely large number of state changes, exhaustive compatibility testing becomes mandatory, which is almost unmanageable given the number of DOS applications.

Embedded 80X86 Processors Flatten Out

Embedded processing started showing up in the early 1980s and continued to grow into enormous proportions. During this period, the 186/188 family of integrated processors was introduced to capture this embedded market. Part of their appeal (to date) is their architectural commonality with the IBM PC and relatively rich set of tools available for programming and debugging. However, with the wide range of other processors available with equal or better development tools, demand for this family is nearing its decline.

As is evident in Figure 4-4, this segment is dominated by Intel, which still has over two-thirds of the market. However, Intel is the only vendor showing a decline in unit volumes, mainly because of the demand shifting to its proprietary i960 family. AMD also has a healthy and growing portion of this segment, but it is also migrating customers to its proprietary 29K family. As a final note, this category includes the 80376, an embedded version of the 386, which is only shipped by Intel and represents nominal demand in the 100,000-unit range.

Figure 4-4
80X86 Embedded Processors



Source: Dataquest (July 1992)

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Summary

It was clearly evident during 1991 that the future for the 80X86 class of processors lies in the 32-bit versions, leaving the real battle among Intel, AMD, and other potential entrants. Intel intends to migrate desktop computers to the increasingly fast 486s (and soon to be 586s) and portables to the increasingly integrated SL line of 386s (and soon to be 486s). Dataquest believes that Intel has the power to make this happen by 1993, which will impose increasingly high barriers to competition. However, Intel could win this battle and lose the war as a lack of competition has allowed it to take all the profits and push the premier PC vendors toward multisourced RISC architectures.

Chapter 5
Advanced Microprocessor Product and Supplier Assessment

This chapter deals with the procurement issues involved with microprocessors: technology trends, microprocessor product life cycles, and supplier analysis. Being the heart of many electronic systems, the choice of a microprocessor often directly affects the performance and market acceptance of a given product. Choosing the correct product, technology, and now supplier is becoming more critical with ever-decreasing system life cycles.

Dataquest's 1991 estimate of suppliers' microprocessor market shares showed a marketplace in the throes of change—which means challenge if not stress for the user community. Why such stress? By tying the company to the "right" MPU product technology, the supply base team can generate long-term growth and success; choosing a "wrong" processor engine could mean long-term demise. The MPU supply base outlook is for bruising supplier competition as workstation-based RISC technology drives downward and PC-based CISC technology migrates upward in the battle for system applications—with MPU buyers and system designers caught between.

This chapter contains five sections and its structure is similar to the annual supply base reports that the Semiconductor Procurement service (SPS) does for users on major IC product families. In addition, based on client recommendation, this chapter also looks at strategic alliances, fab networks, trends in process technology and die size, and forward pricing.

The first section serves as a guide to cost-effective procurement of MPUs through the use of product life cycle analysis. We then examine the strategies of the leading suppliers of MPU products and technology. Next we combine the analyses of the life cycles and the supplier base to support users of MPUs in assessing which supplier/technology direction to take over the long term. The fourth section examines trends in advanced MPU design and production, and the final section, on life cycle pricing—which can serve as a tool for "forward pricing" analysis—presents recent research results and advice for clients on how to make future use of this research.

It should be noted that, in terms of MPU word length, this chapter concentrates on 16/32-bit and 32-bit MPUs. In line with market evolution, Dataquest now tracks the MPU market by processor class—word length now serves as a secondary dimension. Within the new segmentation, the focus will be on the following processor classes: 80X86 family, 68XXX family, and platform RISC processors.

MOS Microprocessor Product Life Cycles

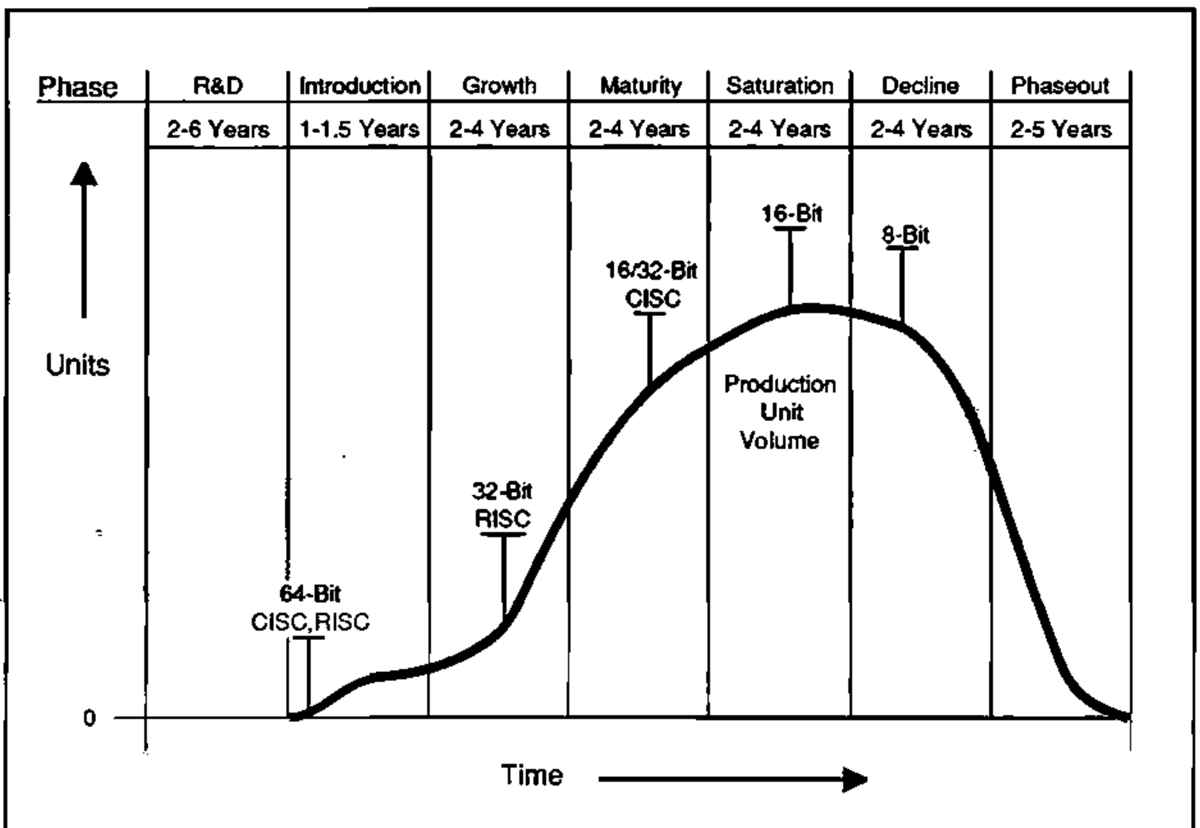
This section uses life cycle information as a guide to assist users in adjusting to forces that continue to reshape the worldwide MPU marketplace.

Typical Life Cycles for MPU Products

Figure 5-1 shows the MPU life cycle, including the time span for each stage of the cycle. An MPU family's life cycle typically lasts in excess of 10 years.

For users, the lengthy R&D stage provides a valuable opportunity to monitor the vendor's pace of technical achievement as well as the supplier's timetable for bringing the state-of-the-art device to the marketplace. Based upon inquiries to Dataquest, many users are evaluating these leading-edge MPUs among others for use in future systems: 80586; R4000; 21064 (ALPHA); and SuperSPARC.

Fig 5-1
Microprocessor Product Life Cycle As of May 1992



Source: Dataquest (July 1992)

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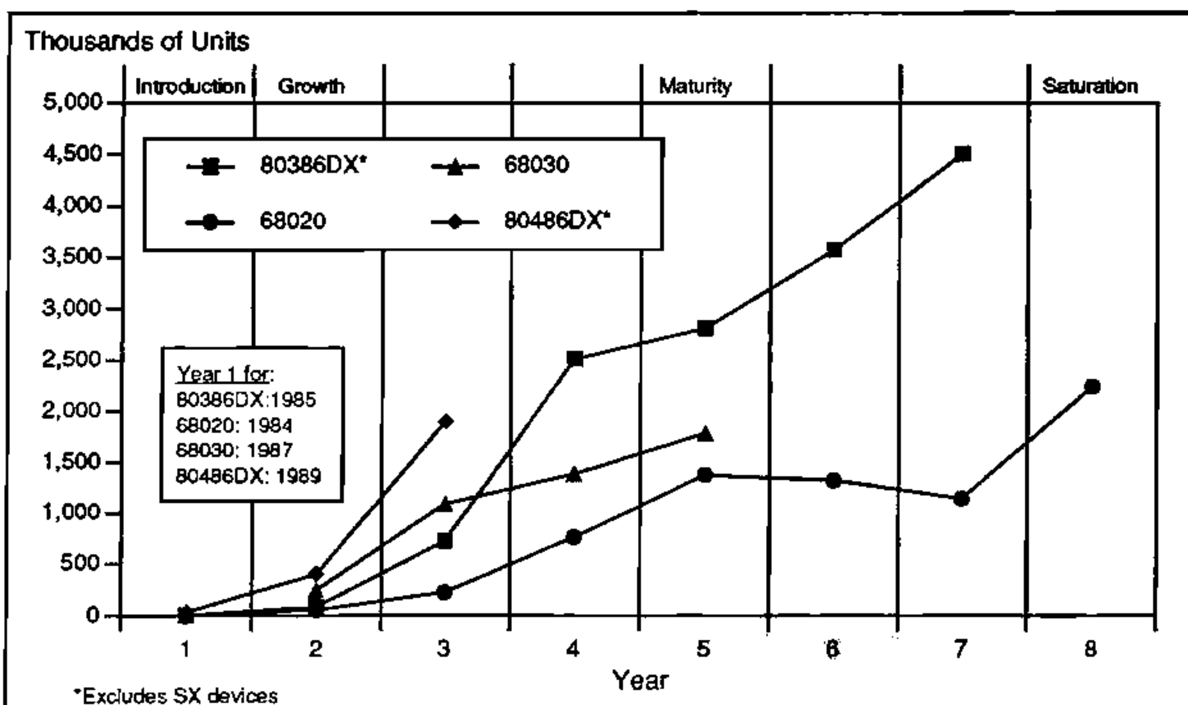
Figure 5-2 presents the product life cycle for select CISC 32-bit MPUs through 1991 using historical unit shipments data and shows that 1991 marked another year of growth in terms of unit shipments for 68020, 68030, 80386DX, and 80486DX products. The 1991 boost in the 80386DX shipment stemmed in part from the entry by AMD to this once sole-sourced market. The information in Figures 5-1 and 5-2 shows that users should *not* expect market saturation for any of these products to occur for several years.

Although life cycle expectations remain consistent in terms of product families, the dynamics of the life cycle curve are being reshaped by factors such as the increased pace of new product introductions (for example, device speed and packaging). Figure 5-3, which is based on the information in Figure 5-2, depicts the 80X86 and 68000 life cycles in terms of device speed.

Microprocessor Supplier Analysis

This section analyzes the product and market strategies of leading suppliers of MOS microprocessors. Because of the orientation of the SPS client base, this section focuses on suppliers that strongly serve demand in Europe and North America: Intel, Motorola, and AMD.

Figure 5-2
CISC MPU Life Cycles through 1991



Source: Dataquest (July 1992)

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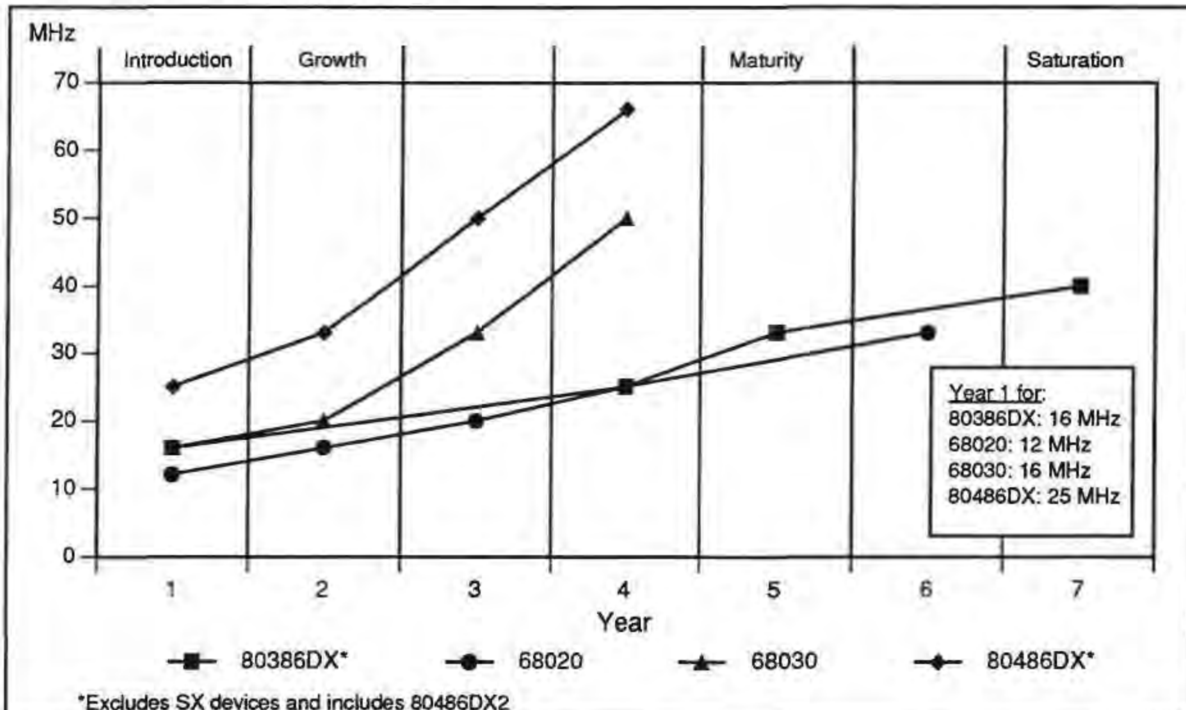
Figure 5-3
CISC MPU Life Cycles by Speed



Source: Dataquest (July 1992)

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As shown in Table 5-1, Intel remains the worldwide market leader by far with nearly 60 percent share. During 1991, the following suppliers outpaced the market's growth in terms of revenue: AMD, Cypress, and Intel. LSI Logic, National Semiconductor, and Motorola also achieved growth rates in excess of 20 percent for 1991.

Intel

An increase in shipments of high-priced CISC MPUs—80386 and 80486—translated into nearly $2 billion in MPU revenue during 1991 for top-ranked Intel. The Intel product portfolio for these families includes the following devices: 80386SX 16-, 20-, and 25-MHz; 80386SL 20- and 25-MHz (with on-board cache controller); 80386DX 16-, 20-, 25-, and 33-MHz; 80486SX 16-, 20-, and 25-MHz (with on-board cache controller, plus low-power versions for each speed); 80486DX 25-, 33-, and 50-MHz (with built-in coprocessor and cache controller, plus low-power version for 25-MHz speed); and 80486DX2 25- and 50-MHz (with built-in coprocessor and cache controller).

The major long-term strategic issue concerns Intel's response to the move by AMD into the 386 market last year—with Chips & Technologies a prospective entrant—and the likely entry during this year or next year of suppliers such as AMD, Cyrix, and UMC into

Table 5-1
Preliminary 1991 Worldwide Microprocessor Market Share Ranking (Millions of Dollars)

Ranking	Company	Segment Revenue ($)	Market Share (%)	1990-1991 % Change
1	Intel	1,992	58.0	39
2	Motorola	359	10.8	23
3	AMD	251	7.6	130
4	Hitachi	90	2.7	10
5	NEC	86	2.6	8
6	National	85	2.6	29
7	SGS-Thomson	55	1.7	4
8	Toshiba	55	1.7	15
9	Cypress	46	1.4	254
10	LSI Logic	42	1.3	24
	All Others	321	9.7	16
	Total	3,312	100.0	36

Source: Dataquest (July 1992)

the 486 camp. Despite increased competition, key strands of the Intel's product strategy remain quite consistent with the plan of several years ago. Users must note, however, that the company now confronts a shift—from the mind of a monopolist to that of an oligopolist if not pure competitor—in terms of adhering to long-term strategic goals.

Consistent Elements of the Intel Strategy

As always, Intel aims at unparalleled technological leadership in the CISC MPU arena. A key element of the product strategy is to drive the 80X86 technology—via the soon-to-be-released 80586 device—upward into the RISC-based workstation marketplace. Intel continues its relentless push to develop and manufacture state-of-the-art MPUs in terms of density, functionality, and performance. Users can expect Intel to eventually make the 80586 device available in a multichip module (MCM). Intel will make massive expenditure on capital equipment and R&D during the 1990s in order to protect its leadership position. For example, Dataquest estimates the company's 1991 capital budget at nearly $1 billion while R&D expenditure should hit $750 million.

Another consistent is that Intel firmly grounds its current success and plans on aggressive legal protection of what it claims as its intellectual property. AMD has made a major advance in terms of undercutting Intel's ability to preserve its prior 80386 legal monopoly—at least vis-a-vis AMD if not other would-be suppliers. Intel's powerful legal team in turn faces a full calendar of cases against powerful legal teams at AMD, Cyrix, Texas Instruments (TI), and other companies. The legal battles could eventually take financial and other tolls on some litigants.

Intel's Migration Strategy: Some Risk for System Users

Intel consistently strives to adhere to its higher-performance/higher-priced MPU migration strategy—which carries some risk for system users. For example, except for first-tier customers, users can expect Intel to keep its product direction somewhat veiled in order to keep competitors off balance. Some users report concern to Dataquest regarding Intel's plans during the 1992 to 1993 period for the 80386, 80486, and 80586 families of MPUs. Intel's pace of technological advance has accelerated in response to the AMD competitive threat, catching some systems manufacturers off guard or behind schedule. Specifically, some system houses did not anticipate Intel's introduction during the first quarter of 1992 of the 80386SX 25-MHz device. Intel developed this part based on first-tier customer demand—and in the face of a direct competitive AMD product offering. This new part should become the 80386SX family's mainstream part through 1993.

Intel aims to migrate users soon—if not already—from the lower-priced 80386 family to the higher-priced 80486/80586 families. Intel has indicated that the 80586 device will be introduced during the second half of 1992. AMD has been successful in extending the growth stage of the 80386SX/SL family, which counters Intel's 80486DX/SX migration plans.

For some users, the Intel migration strategy carries risks at the 80486 level and higher. The first risk is that the 80486 device includes a processor enhancement slot (PES) that enables ultimate end users to upgrade systems without buying an entirely new system. In this trade-off between system user and ultimate end user, Intel—in line with strategic market dictates—gives the nod to the ultimate customer at the expense of *some* intermediate customers. Another risk is the system user's inability to timely migrate in synchronization with Intel's migration path. For example, Intel's first-half 1992 introduction of its 80486DX2 series could soon erode market demand for 80486DX devices. In effect, 80486DX systems face prospective displacement during 1992 and 1993 by the 80486DX2 IC.

What about the P5 (80586)?

During 1992 Dataquest will closely track any developments on Intel's P5 (80586) device. To date, the following estimates are available: speed—50 MHz to 66 MHz; number of transistors—3.1 million; package—CPGA, later—MCM; introduction date—second half of 1992.

Compaq Computer Corporation and Digital Equipment Corporation (DEC) separately indicated that they will ship 80586-based systems during the second half of 1992. For example, Compaq just received P5 engineering samples for use in technical evaluations.

Motorola

Motorola won Dataquest's Semiconductor Supplier-of-the-Year Award each year during the 1988 to 1991 period—in the large company category for the past two years. In general, Motorola will draw on its position as a vertically integrated captive manufacturer to generate a full range of microcomponents.

Second-ranked Motorola continues to target the MPU market as a key element of its long-term strategic plans. However, strategic alliances will play an increased role in the formulation and implementation of the company's MPU strategy.

Contrasting Scenarios: 68020/68030 MPUs and 68040/881000 MPUs

As shown in Figure 5-2, Motorola's penetration of the fast-growing technical workstation market meant a boost in demand during 1991 for its high-performance 68020 and 68030 32-bit MPUs. Motorola's delay during the 1990 to 1991 period in ramping the 68040 device, however, caused some key users (for example, Hewlett-Packard) to reevaluate long-term dependence on single-source suppliers for critical MPU technology. Market acceptance of Motorola's 88000 has been unimpressive.

Consequently, the life cycle expectations for the CISC 68040 and RISC 88000 architectures have become clouded. For example, the future role of the 68040 appears targeted over the long term for embedded applications. Users can expect the introduction of a 68EC040 series of parts during 1992 and 1993. Even so, Texas Instruments just announced an upgrade of its 1500 MP (multiprocessing computer) system, which uses Motorola's new 33-MHz 68040 MPU.

A Key Industry Alliance: RISC PowerPC MPUs

A crucial prong of Motorola's future MPU strategy is the alliance with Apple Computer and IBM on PowerPC RISC technology. First, the alliance keeps Motorola aligned with a key long-term MPU customer—Apple—and in turn enables Motorola and Apple to migrate to RISC MAC systems. Second, for Motorola, the alliance reduces some of the risky and expensive second-guessing associated with the development of a new MPU architecture that conforms to user wants and needs. Third, for Motorola, the alliance should enable Motorola to focus over the long term on its competitive strength—IC design and volume production at award-winning quality standards.

The latest word on the alliance is positive—including the development effort at the IBM-Motorola R&D (Somerset) facility in Austin, Texas. Although Silicon Valley sources report some uncertainty regarding the alliance strategy on multimedia objectives, the IBM-Apple team appears to be making consistent progress on the Taligent object-oriented operating system that will be necessary to run systems. The time frame for the IC/operating system remains consistent with original expectations—1994.

Advanced Micro Devices

As shown in Table 5-1, third-ranked AMD grew its MPU revenue by 130 percent during 1991—directly at the expense of Intel. For AMD, the introduction of the AM386 device during 1991 marked a rapid de-emphasis of the prior-generation 80286 MPU.

AMD Walks a Fine Legal Line

In staking its long-term MPU and corporate future on the 386/486 architectures, AMD continues to walk through a legal minefield, as shown by the recent loss in the 287 microcode legal case. For users in the 386 segment, AMD's position as a pure second source including identical microcode has been thrown into uncertainty. AMD and Intel still await a final legal decision on the microcode law case, which now is being appealed and subject to other legal challenge.

Critical Steps to AMD's Long-Term Survival

For 1992, the recent step-function decline in 386 pricing should extend the 386 product life cycle—meaning strong 1992 demand—much to AMD's pleasure and Intel's chagrin. This achievement marks the first step to AMD's long-term success. There are two other steps—which now shape as barriers.

The second step is that AMD's strategy calls for volume production of a 486 device by the fourth quarter of 1992. AMD's long-term MPU strategy is to dog Intel and take MPU revenue/profits at its competitor's expense. Slippage in the 486 schedule could mean closure of AMD's window of market opportunity. The microcode decision could delay AMD's 486 schedule by six months.

The third step—to withstand Intel's legal barrage—has been undercut by the microcode decision, which is subject as always to appeal.

Supply Base Analysis

This section uses information on MPU product life cycles and suppliers to present a product-by-product evaluation of the supply base over the long term for CISC 16/32-bit, CISC 32-bit, and RISC 32-bit MPUs. The section includes information on the global MPU fab network of key suppliers.

With the supply base trend toward multiple MPU sources, procurement managers, component engineers, and system designers face a challenge in terms of the selection of the most competitive and dependable long-term suppliers of these product technologies. The approach in this section is to mesh the product life cycle and supplier analyses so as to generate a summary assessment from a user's perspective on the anticipated MPU supply/supplier base. The summary includes a statement on whether the user faces a favorable or a critical supply base for each density. Building upon the prior sections, factors affecting the supply base such as supplier strategies and strategic alliances are discussed here.

Table 5-2 shows the size of the CISC 16/32-bit MPU market in terms of units shipped during 1991, the relative market shares of the predominant devices, and a ranking of the suppliers of these devices, including suppliers' shares in each product segment.

Table 5-2
Supply Base for 16/32-Bit Microprocessors (1991)

Leading Products	Product's Share of Total 16/32-Bit MPU Market (%)		Suppliers' Share of Respective Product Segment (%)
68000	60.59	Motorola	81.23
		Toshiba	8.84
		Hitachi	5.12
		SGS-Thomson	2.62
		Signetics	2.19
80386SX	36.83		
		Intel	86.97
		AMD	13.03
32000	2.58	National	100.00

Total Market Share = 27.085 million units
Source: Dataquest (July 1992)

Table 5-3 presents the information on the CISC/RISC 32-bit MPU market.

Although Tables 5-2 and 5-3 are based on Dataquest's prior segmentation of MPU word length, the analysis in this section conforms with Dataquest's new processor-class segmentation.

Table 5-4 shows the estimated worldwide MPU process technology and fab capability—including geographic locations—for the following suppliers: AMD, Cypress, Fujitsu, Hewlett-Packard (HP), Texas Instruments, Intel, Motorola, and NEC. The table shows that the process technology in most cases runs in the range of 0.7 microns to 0.8 microns.

Tables 5-2, 5-3, and 5-4 guide the analysis in this section.

Supply Base for 16/32-Bit MPUs

Unit shipments of 16/32-bit MPUs expanded at a 53 percent rate during 1991 to a total of 27.1 million devices. In terms of Dataquest's new MPU market segmentation, this arena includes elements of the 80X86 and 68XXX processor families.

The 68000 family accounts for more than 61 percent of the 16/32-bit market—and Motorola commands more than 80 percent of the 68000 segment. The 80386SX product accounts for 37 percent of the market—a gain of 10 percent over the 1990 share. Intel—the former market monopolist—now holds less than 90 percent of the 80386SX/SL segment—with more loss of share likely during the

Table 5-3
Supply Base for 32-Bit Microprocessors (1991)

Leading Products	Product's Share of Total 32-Bit MPU Market (%)		Supplier's Share of Respective Product Segment (%)
80386DX	30.14	Intel	82.2
		AMD	17.8
80486DX	16.74	Intel	100.0
68020	15.00	Motorola	100.0
68030	11.96	Motorola	100.0
32x32	3.35	National	100.0
SPARC	2.01	Cypress	36.67
		LSI	31.67
		Fujitsu	27.67
		Weitek	4.00
		Bit	0.33
R3000	1.22	Performance	29.67
		IDT	24.73
		NEC	21.98
		LSI	13.74
		Siemens	9.89
Others	19.58		

Total Market Share = 14.93 million units
Source: Dataquest (July 1992)

1992 to 1993 period. AMD gains at Intel's expense. National Semiconductor's 32XXX family holds just less than 3 percent share.

A Long Life Cycle for the 68000 Family, with Several Exceptions

Users can expect a long life cycle for the 68000 family of MPUs, especially the 68000 and 68HC00 devices. By contrast, the 68008 device is being displaced by the 68EC000 product. The 68010 should also decline over time, although not as rapidly as the 68008.

Users of these devices clearly should turn to Motorola for long-term support. Table 5-4 shows that Motorola's extensive worldwide fab network puts the industry giant in good position to serve demand from whatever world region for the long term. For

Table 5-4
Estimated Worldwide MPU Process Technology and Production Fab Capability

	Intel	Motorola	AMD	Fujitsu	TI	Cypress	NEC	HP
Process Technology	0.8 Micron CMOS	0.8 Micron CMOS	0.7 Micron CMOS	0.7 Micron CMOS	0.5 Micron CMOS	1.2 Micron CMOS	0.8 Micron CMOS	0.8 Micron CMOS
Geographic distribution of production and pilot lines by region of the world[1]								
Number of Wafer Fabrication Lines								
North America	8	5	2		5	2	1	2
Europe		2			1		1	
Japan		1		2	4		12	
Asia/Pacific-Rest of World	1[2]		1[3]		0			
Total	9	8	3	2	10	2	14	2
Geographic Distribution of Estimated Clean Room Space (in Square Feet)								
North America	211,000	126,800	30,700		144,500	26,000	40,000	40,000
Europe		59,600			10,000		19,500	
Japan		23,800		56,500[4]	98,000		372,935[4]	
Asia/Pacific-Rest of World	24,000[2]		40,000[3]					

[1] Facilities in production or slated to begin operation during 1992
[2] Intel Israel
[3] Fab line available to AMD through foundry relationship with TSMC, Taiwan
[4] Clean room square footage not available for each line
Source: Dataquest (July 1992)

example, Motorola has already positioned itself for Europe's evolving requirements on local "diffusion."

Table 5-2 reveals that Toshiba, Hitachi, SGS-Thomson, and Signetics also have stakes, albeit small, in this arena.

AMD Likely to Prolong 386SX Life Cycle

AMD's entry to the 386SX marketplace reduces supply base uncertainty for users. What is the backdrop to this statement? In the March 1991 version of this report we stated that users of the 80386SX faced an uncertain outlook regarding long-term supply, given Intel's monopoly position and the company's then stated goal of migrating users during 1992 to 80486 and above parts. AMD has changed the long-term supply base equation in favor of users of 386SX/SL devices. The entry of any other suppliers would strengthen the supply base outlook, although prospective entrants such as Chips & Technologies have not yet executed on original plans.

Intel should continue to lose market share, not because of 80386SX/SL manufacturing constraint but rather because of the company's strategic decision to shift focus during the 1992 to 1993 period to higher-priced 80486/80586 devices. Table 5-4 shows that Intel clearly has ample fab capability for supporting North American and European user demand. AMD has strong manufacturing capability in terms of serving European and North American demand—with AMD *aiming* to fulfill such demand. European users must continue to monitor trade-regulation trends because these North America-based suppliers have no fabs running at this time in Europe. Regardless, the combined fab capability of Intel and AMD as shown in Table 5-4 should adequately support user demand during the 1992 to 1994 period.

Under current market conditions, the life cycle of most 386SX and 386SL parts should extend through 1995, although slower-speed devices (for example, 16-MHz versions) likely will be de-emphasized during the 1993 to 1994 period. AMD certainly aims to migrate with the market, but it will continue to accommodate market demand for 386SX and 386SL parts for the next several years. In effect, multiple sourcing should translate into a 386SX life cycle curve in line with historic expectations shown in Figure 5-1.

Supply Base for 32-Bit MOS Microprocessors

Table 5-3 provides information on the market size and leading suppliers of the predominant 32-bit CISC and RISC MPUs as of 1991. In terms of Dataquest's new MPU market segmentation, this arena includes the lion's share of the 80X86 processor family, and the 68XXX processor family plus platform RISC MPUs.

Unit shipments of 32-bit MPUs grew to 14.9 million pieces during 1991, a 76 percent increase over 1990. As indicated in Figures 5-1 and 5-2, MPU products such as the 80486DX and 68030 have life cycles that should approach the end of this decade, although the life cycle for lower-speed versions likely will terminate by mid-decade.

Intel: Tremendous Manufacturing Capability

Intel is the sole source for 80486 devices, although that scenario should start to change by the end of 1992. As shown in Table 5-4, Intel's worldwide manufacturing capability puts the company in a strong position to protect its position in the 80486 market unless AMD timely and aggressively executes on plan.

Cracks in Intel's 80X86 Monopoly: Good News for Supply Base Managers

Intel's 80386/80486 architectures account for nearly 50 percent of unit shipments of 32-bit MPUs. Having broken Intel's 80386 monopoly during 1991, AMD must battle now in the legal courts to maintain its claim to 386 "rights" in the face of the microcode decision. Although the company likely will emerge as a second source for the 486 family of parts, the timing of the market impact should be delayed. Regardless, supply base managers must adapt to a market transition from yesterday's monopoly environment to an emerging two- or three-player oligopoly.

Under these market and legal conditions, the 386DX/486 supply base outlook remains favorable for users. For users in North America and Europe, however, Intel's legal victory against AMD in the litigation on microcode raises the spectre of the Intel-related "constrained MPU supply" scenarios of the recent past. Users should note that the U.S. Federal Trade Commission currently is investigating Intel's market activities. The market awaits a final decision on AMD's "rights" to the 386 product technology.

Users should note that strong growth in 80486DX/SX shipments during 1993 could push that MPU unit volume over the 80386 family volume by end of 1993.

Cloudy Outlook for Other 80X86 Market Entrants

The outlook is not clear regarding other prospective entrants such as Cyrix—which has formed an alliance with Texas Instruments—or UMC of Taiwan. Cyrix/Texas Instruments is waging a legal battle against Intel to secure manufacturing rights to this family of parts. Legal uncertainty notwithstanding, Cyrix and TI recently announced their 486 version—which in effect is a 386DX with a 487 device.

UMC faces the same scenario. Chips & Technologies continued to experience financial loss as of midyear 1992.

Motorola: A Shift to Embedded Applications

Table 5-3 shows that Motorola's 68020 and 68030 devices account for nearly 27 percent of 32-bit MPU unit shipments, down from 30 percent during 1990. Shipments of the 68040 MPU totaled less than 250,000 units, which is below original market expectations. Motorola's strategy calls for a shift to emerging embedded applications.

The information in Table 5-4 indicates that Motorola continues to be a worldwide manufacturing powerhouse among suppliers of CISC

MPUs. The Apple-IBM-Motorola alliance likely will strengthen and advance Motorola's RISC MPU manufacturing expertise. Under current market conditions, users should anticipate continuing support by Motorola for the 68020 and 68030 architectures—meaning lengthy life cycles. Users of these devices face a favorable long-term supply scenario.

Motorola's new 68ECXXX series is targeted for high-performance embedded applications. The parts are in effect 68020, 68030, and 68040 devices minus the FPU and MMU. Another newer series—the 683XX—is in effect a fully static MPU with integrated I/O and without internal EPROM, which targets hand-held instrument applications.

The 68040 strategy is to evolve in line with market demands—which carries some risk for users depending on intended application. Why? Although the full-blown 68040 device aims at workstation applications, market interest in the 68040 has shifted to other applications. For example, during 1991 Motorola introduced a low-cost 68LC040 part—which disables the FPU—that targets PC applications. During the second half of 1992, Motorola likely will start volume shipments of the 68EC040 device for embedded applications.

As noted earlier, Motorola's long-term thrust into the RISC camp will be via the Apple-IBM-Motorola alliance on the PowerPC MPU family. Some uncertainty exists regarding the outlook for the RISC 88XXX processor.

Platform RISC Processors

In terms of Dataquest's platform RISC processor segmentation, the discussion here will focus on these processors families: SPARC, MIPS, PowerPC, and PA-RISC.

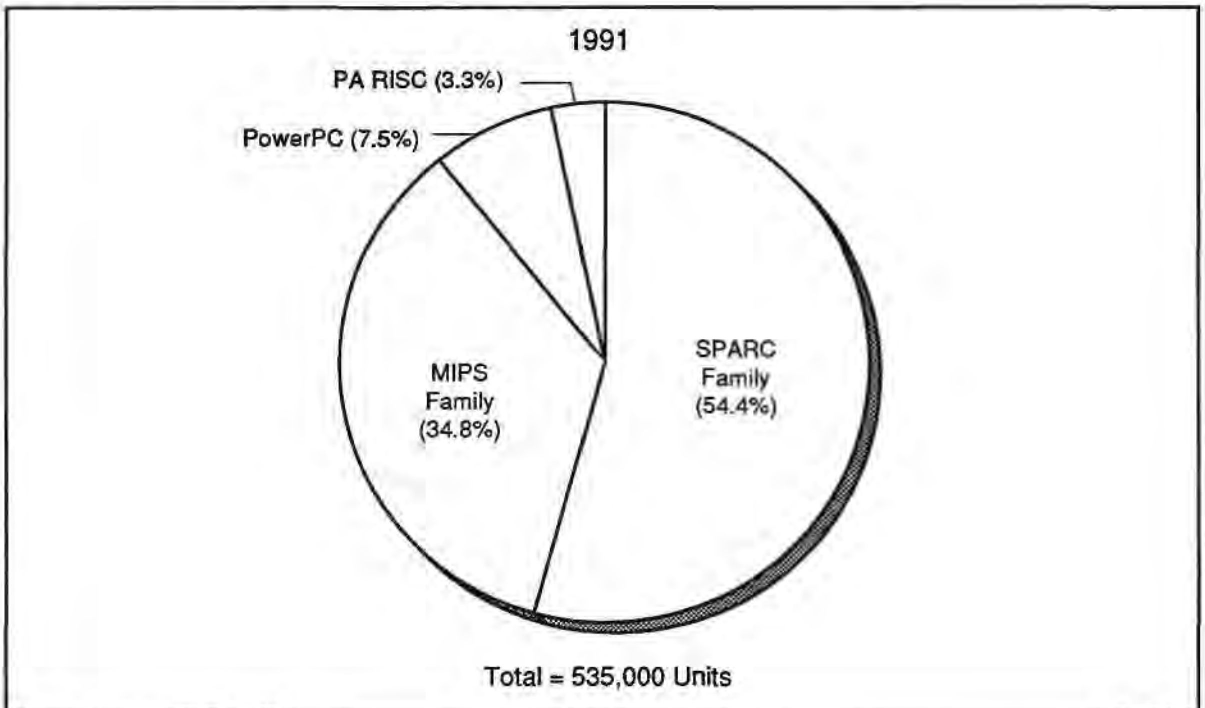
Table 5-3 reveals that RISC processors accounted for less than 5 percent of 1991 unit shipments of 32-bit MPUs—a gross understatement of the impact that these processors are having and will have on the entire MPU marketplace.

The impact of RISC technology in part can be shown through recent financial results. In terms of profitability for fiscal 1991, the following players in the RISC technology arena rank among the leaders among Silicon Valley companies: Hewlett-Packard (2nd ranking); Sun Microsystems (5th ranking via SPARC); and Cypress Semiconductor (15th).

The fact that RISC processor unit shipments and revenue remain dwarfed vis-a-vis the CISC marketplace requires somewhat different analysis to properly assess the supply base outlook. Because of the relative nascence of the RISC marketplace, the goal here will be to signal which RISC processor families are likely to emerge as long-term winners—and which suppliers most likely will be part of the long-term success paths.

For example, the goal here is not to assess each supplier's manufacturing capability—which tends to understate market positions—although Table 5-4 includes information for some suppliers of RISC

Figure 5-4
RISC Processor Shipments by Family



Source: Dataquest (July 1992) G2000872

MPUs. Another example is that this section does not directly assess Digital Equipment's yet-to-be-released ALPHA MPU family—which likely will become part of Dataquest's RISC processor class. However, information on the ALPHA processor is used to illustrate MPU design and manufacturing trends.

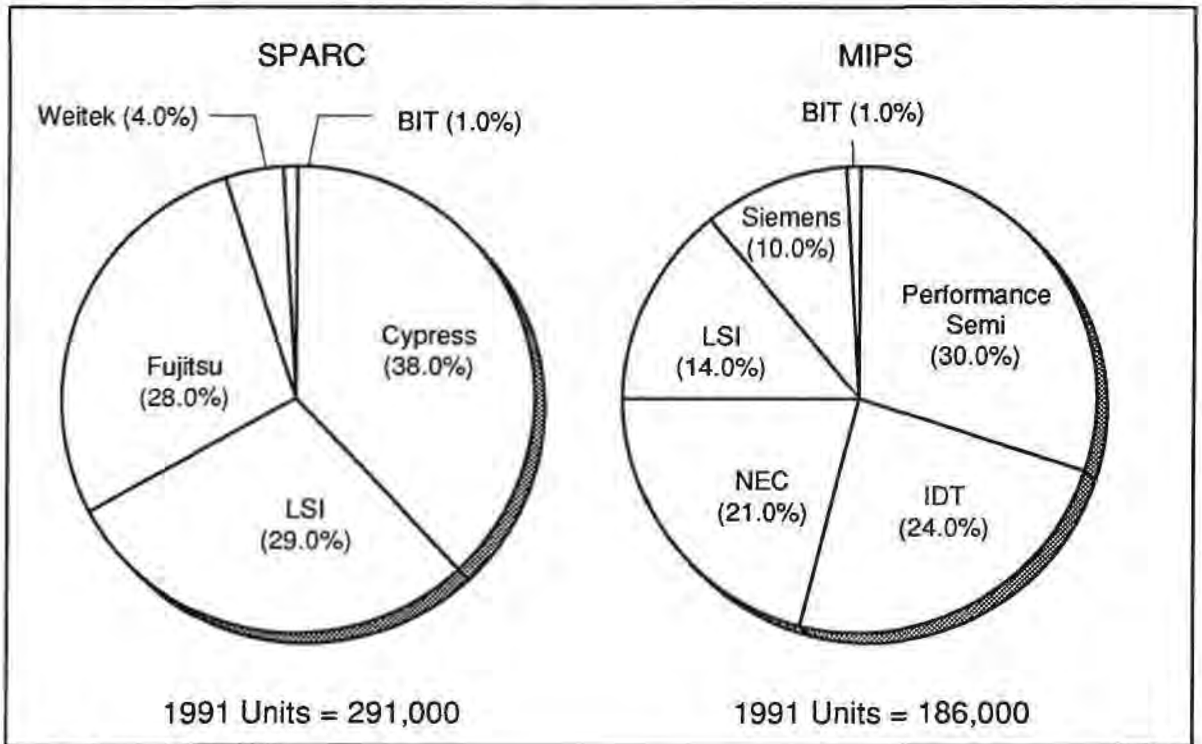
Figure 5-4 shows RISC processor shipments by class—with SPARC leading the market. During 1991 IBM's PowerPC was not sold on the merchant market. Besides internal consumption, Hewlett-Packard's PA RISC MPUs ship to merchant customers.

Figure 5-5 presents preliminary 1991 RISC market shares by IC supplier for the SPARC and MIPS processors.

RISC: A World of Multiple Sources and Long-Term Alliances

Two key factors distinguish the RISC 32-bit supplier base from the CISC 32-bit supplier base. First, in order to establish RISC devices as viable long-term competitors to well-established CISC 32-bit processors, the early leaders in the RISC arena—Sun/SPARC and MIPS Computers—strategically positioned themselves to prospective users as offering multiple sources vis-a-vis the Intel and Motorola monopolies. Second, to grow the market in the face of the CISC camp's enormous entrenched market power, players in the RISC camp have forged a series of key industry alliances among the

Figure 5-5
Final 1991 RISC Market Share (Units)



Source: Dataquest (July 1992)

G2000875

MPU inventors, prospective users, and chip suppliers. Each RISC processor class shown in Figure 5-4 in effect represents an industry alliance that aims to be a mainstream desktop computing system.

SPARC Processors

Figure 5-4 shows that Sun's SPARC family commands a 55 percent share of the RISC MPU marketplace. For SPARC processor suppliers, Figure 5-5 shows a three-way battle among LSI Logic, Fujitsu, and Cypress, with Cypress the new market leader based on outstanding 1991 results.

Sun's SPARC Strategy

As noted, Sun's alliance strategy won the company an impressive stream of revenue during 1991. A key element of the strategy, however, threatens to kill Sun's golden egg. Sun invited companies to clone the SPARC architecture but later—through domination of the distribution channel—in effect stifled meaningful growth of the clone competitors. Sun recently announced a policy that would mitigate this effect. However, the market must await year-end 1992 results. A possible outcome is that the SPARC alliance will become an alliance of one on the systems side.

SPARC Processor Supply Side

Regarding the IC supplier side of the SPARC alliance, Cypress and Fujitsu advanced during 1991 at the expense of LSI Logic, which formerly led the market. Regarding 1991 results and long-term trends, Cypress and Fujitsu supply integrated IU/FPU devices that are attractive for some users. Fujitsu advanced when Sun introduced new systems and via the emergence of an embedded applications marketplace (that is, SPARC-Lite series). Cypress' advance during 1991 stems from increased business with Sun, among other accounts. The RISC market is not risk-free, however. Early in 1992 Cypress reported lower earnings attributed in part to slower demand for SPARC processors.

Fujitsu might be best positioned for long-term market leadership. For example, Table 5-4 reveals that Fujitsu has strong SPARC MPU manufacturing capability. This vertically integrated supplier likely can withstand the RISC market volatility. Fujitsu should be well-positioned for success in the home Japan market and/or key regional markets such as North America as a supplier of either SPARC MPUs or SPARC-based systems, or both. Cypress and LSI Logic are relatively small vis-a-vis Fujitsu. However, the companies are aggressive, competitive, and well-managed.

For these suppliers, competition in the SPARC market has intensified with TI's recent market entry, although merchant customers will not receive TI's Viking SuperSPARC product until the fourth quarter of 1992 (Table 5-5 provides device/technology specifications).

Cypress aims to return the volley with its just-announced Pinnacle family.

MIPS Processors

Figure 5-4 shows that the MIPS processor family holds a 35 percent share of the RISC MPU marketplace. Among the suppliers of the mainstream R3000 device, Figure 5-5 reveals a five-way battle (in ascending order of ranking) among Performance Semiconductor, IDT, NEC, LSI Logic, and Siemens. BIT and Toshiba have also entered or will soon enter the marketplace.

ACE Initiative: Losing Momentum As a Key Player Departs?

The MIPS processor market had gained momentum during 1991 through the Advanced Computing Environment (ACE) initiative. The ACE/MIPS strategy was to compete against Intel's 80486/80586 family using the same NT-Windows operating system. The key alliance players (role) at that time were former MIPS Computer (architect); Microsoft (operating system); 75 system vendors—most notably Digital and Compaq Computer (users); and the MIPS MPU suppliers as shown in Figure 5-5.

The ACE/MIPS strategy confronts some challenging realities. In terms of market results, for 1991 MIPS processor platform sales—mainly workstations—totaled just over 100,000 units. Two users—Digital and Silicon Graphics—accounted for two-thirds of these platform units. Embedded applications accounted for 40 percent of shipments.

During the first half of 1992, the ACE/MIPS alliance encountered a series of momentum-draining events. First, Digital announced its ALPHA architecture, the result of a $1 billion R&D effort. Second, MIPS Computer—a key player—continued to lose money and was acquired by Silicon Graphics. The scenario here is akin to Intergraph's acquisition of Fairchild's Clipper architecture during the 1980s. The eventual result in that case was that the Clipper architecture became a good one-company processor—for Intergraph—with some prospective customers leery of using a processor owned by an actual or prospective competitor (that is, Intergraph). Some current and prospective users of the MIPS processor are uncomfortable with Silicon Graphics' acquisition of MIPS Computer.

Third—and perhaps most tellingly—Compaq Computer withdrew from the ACE consortium early in the second quarter of 1991. Compaq has delayed indefinitely workstation systems that were to use the MIPS processor. The news on Compaq's 80586-based system emerged shortly thereafter. Other systems manufacturers such as Convex and Groupe Bull have left the consortium in favor of other RISC alliances (Convex with Hewlett-Packard, Bull with IBM).

Nevertheless, the RISC market is quite young. Market players remain enthralled with the 64-bit R4000 processor. During the first half of 1992, Silicon Graphics and former MIPS Computer Systems kept performance pressure on competitors by introducing R4000-based systems that operate at speeds of 50 to 67 MHz.

MIPS Processor Supply Side

Performance Semiconductor and IDT maintained their leadership ranking of 1990 during 1991. These suppliers are not industry giants and earnings should continue to be uneven over time. For example, Performance Semiconductor—which announced a processor with on-board IU, FPU, and cache memory—to date depends largely on Digital in terms of its customer base. IDT has a more balanced customer base including workstation (Silicon Graphics), embedded, and system module (AT&T) applications. NEC jumped in ranking during 1991 by winning business from Digital. LSI Logic lost share. However, the supplier could rebound via an integrated processor that targets X Window terminal applications. Siemens gained 10 percent market share in its first year in the market. Recent entrants such as BIT and Toshiba aim for similar results.

In terms of embedded applications, the MIPS supplier base includes most of the suppliers shown in Figure 5-5—Performance Semiconductor, IDT, and Siemens. Macronix (Taiwan), NKK (Japan), Sony, and Toshiba have entered or likely will enter this segment during 1992. Macronix and NKK also have a flash memory alliance that uses NKK's new $1 billion 0.8-micron fab.

Of the MIPS suppliers shown in Figure 5-5, NEC might emerge as a long-term market leader. As shown in Table 5-4, this vertically integrated supplier should be positioned for success not only in Japan but also in North America and Europe. In the aggregate, the MIPS marketplace is fragmented in terms of the supplier base—with NEC a likely survivor in the event of eventual market consolidation.

For users in North America and Europe, the outlook regarding the viability of the MIPS architecture and the supplier base remains uncertain.

PowerPC Family

As noted in the analysis on Motorola, the PowerPC alliance links Apple Computer and Motorola—which have had a long-term business relation—with IBM, Apple's long-term competitor. The RISC PowerPC family will advance IBM's RS/6000 POWER architecture. As shown in Figure 5-4, this processor represented 7.5 percent of the RISC MPU market as measured in unit shipments. These shipments were for IBM's captive consumption. To date, Motorola will be the only merchant market supplier. Bull and Thomson-CSF recently joined the alliance as users.

The strategy is as follows: the alliance participants will jointly develop the processor at the billion-dollar Somerset R&D center. Later IBM and Motorola will separately manufacture the processors. Intended applications include the entire platform market: notebooks, PCs, workstations, and servers. As noted earlier, development of the Taligent operating system appears on schedule for introduction during 1994.

One alliance participant—Apple Computer—publicly shares its vision of the role that the alliance will play in the company's market evolution. For Apple, the alliance is the key for establishing itself in the corporate client/server marketplace. The PowerPC MPU should become critical as Apple makes the transition from CISC MACs—which were based on Motorola's 680X0 family—to RISC MACs.

Precision Architecture RISC (PA-RISC)

Hewlett-Packard first shipped this family during 1987 and advanced the technology during 1989. As shown in Figure 5-4, HP's PA-RISC processor represents 3.3 percent of the RISC MPU market—which understates its potential impact. The PA-RISC processor ranks as one of the performance leaders in the performance-intensive RISC arena—creating a threat for other RISC processors such as SPARC products. In addition to HP's captive production, other suppliers/users include Japan-based Hitachi and Korea-based Samsung, a potentially powerful global alliance.

HP has steadily if quietly grown this market. Although small today, the PA-RISC architecture already shows sign of emergence as a long-term winner. For example, during the first half of 1992 HP struck an alliance with Convex, a former member of the ACE/MIPS consortium.

Microprocessor Design and Production Trends

This section highlights trends in MPU design and production. Table 5-5 summarizes information on leading-edge 32-bit and 64-bit RISC/CISC processors regarding the following factors: architecture, speed, process technology, power supply voltage, design rule, transistors, and chip size. The table includes information on two devices developed by Digital, including ALPHA and one from Sun/TI (SuperSPARC). No R4000 papers were presented at ISSCC 1992.

Trends from ISSCC 1992

At ISSCC 1992, all microprocessor papers were presented by computer/workstation companies. Digital's Alpha RISC architecture and MIPS R4000 architecture (not presented at ISSCC/1992) herald the arrival of 64-bit computing. Leading-edge microprocessors are using CMOS technology with minimum lithography design rules in the 0.5- to 0.8-micron range. Extra-wide-field stepper lenses and other lithography innovations such as step-and-scan technology will be needed to print increasingly larger microprocessor chips. BiCMOS technology may be needed to implement the ECL-type low-level logic swings of high-speed microprocessors.

Microprocessors continue to drive multilevel interconnect technology. Three-level interconnect technology is rapidly becoming the standard in advanced 32/64-bit microprocessors, with four-level interconnect implementations looming on the horizon. Metal linewidth/space and contact feature sizes in the range of 0.5 to 0.8 microns rival the traditional transistor gate-length as a technology driver. In response, microprocessor manufacturers will increase the proportion of the wafer fab equipment capital budget spent on planarization, plug, interconnect deposition, and etch applications, relative to lithography applications.

The Impact of RISC

What is the potential MPU impact of the RISC technology? The semiconductor revolution is giving way to the semicomputer evolution. The design innovation pendulum is swinging away from traditional proprietary, merchant microprocessor houses such as Intel and Motorola toward system-knowledge-intensive, captive computer companies such as Digital, Hewlett-Packard, IBM, Sun, and Silicon Graphics. The evolution of RISC-based open-architecture computing and access to leading merchant CAD tools and global ASIC foundries has significantly leveled the silicon playing field between traditional merchant microprocessor companies and captive computer/workstation companies.

Table 5-5
Key Features of Microprocessor Technology at ISSCC/1992*

Company	Architecture	Speed (MHz)	Technology	Power Supply Voltage	Design Rule (Microns)	Transistors (Millions)	Chip Size (cm * cm)	Package
Digital	32-Bit/CISC	100	CMOS	3.3V	0.75	1.30	1.62 * 1.46	CPGA-339
Digital	64-Bit/RISC	200	CMOS	3.3V	0.75	1.68	1.68 * 1.39	CPGA-431
Sun/TI	32-Bit/RISC	40	BiCMOS	5V	0.80	3.10	1.60 * 1.60	CPGA-293

*All use three layers of metallization
Source: Dataquest, ISSCC/1992 (July 1992)

Microprocessor Life Cycle Pricing

This section extracts recently published work by SPS on forward-stage MPU pricing. The information can be used to generate estimates—based on MPU transistor counts and prior MPU price history—for next-generation parts. The example is Intel's 80586 processor.

There are two goals of this section: to explain the forward-pricing methodology, and to make clients aware that SPS can assist them via our inquiry service—along with published reports such as this—on forward-pricing analysis.

Methodology behind MPU Life Cycle Pricing Analysis

A number of SPS clients have requested a structured framework as they make the transition from today's predominantly CISC world to tomorrow's CISC/RISC marketplace. The following analysis was first published April 20, 1992 in a Semiconductor Procurement *Dataquest Perspective* article entitled "Buyer's Headache: Will IC Prices Stay Low if the Economy Turns Up?" This analysis marks a move toward that goal.

Figure 5-6 shows pricing measured in dollar-per-transistor for the early, or forward, stages of the product life cycle for 80286-10, 80386DX-16, and 80486DX-25 devices, and 68000-8, 68020-16, and 68030-25 parts. To construct this MPU life cycle pricing curve, we used information dating as far back as 1979 and 1980 on pricing, product introduction dates, and transistor counts.

Figure 5-7—which is based on the information in Figure 5-6—shows the rate-of-price decline for the 80X86 and 680X0 devices relative to the family's prior generation part over the life cycle. Although the objective is to estimate the forward price of the 80586 device from Intel, Motorola MPU price history serves as an analytical "check."

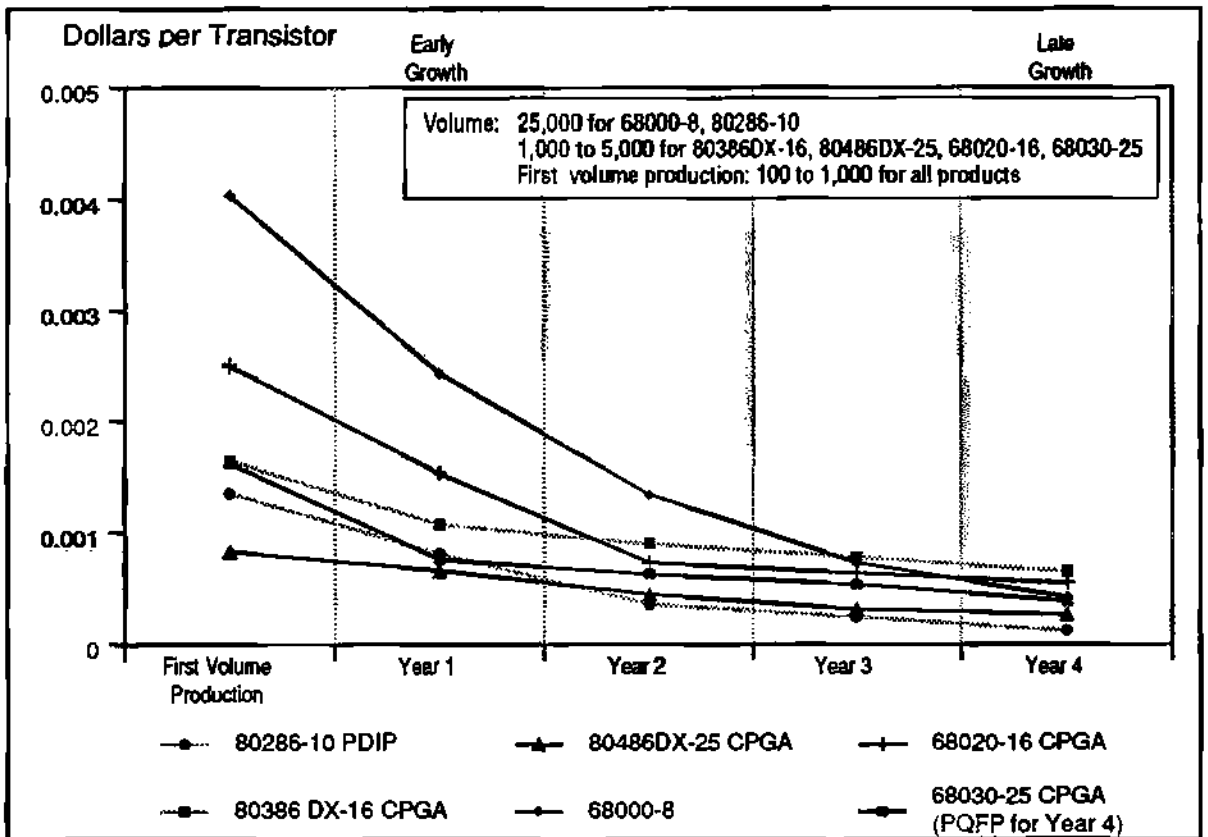
The rates of decline shown in Figure 5-7 are quite similar for the forward life cycle stages regarding 80486DX-25 pricing vis-a-vis the prior-generation 80386DX-16 product; 68020-16 pricing vis-a-vis the 68000-8 device; and 68030-25 pricing versus the 68020-16 part.

The Assumptions behind the 80586 Price Estimate

Dataquest clients require a statement of the assumptions for forward price estimates like the 80586 estimate shown in Table 5-6.

Table 5-6 states the critical assumptions. Clients who disagree with these assumptions can modify the estimated price in line with their differing assumption(s). The table shows several assumptions regarding specifications (for example, transistor count and package) but also an analytical assumption regarding the pricing environment/rates of price decline that Dataquest assumes. Again, clients may modify their estimate depending on the kind of competitive environment they assume.

Fig 5-6
North American MPU Pricing by Life Cycle Stage (Dollars per Transistor)

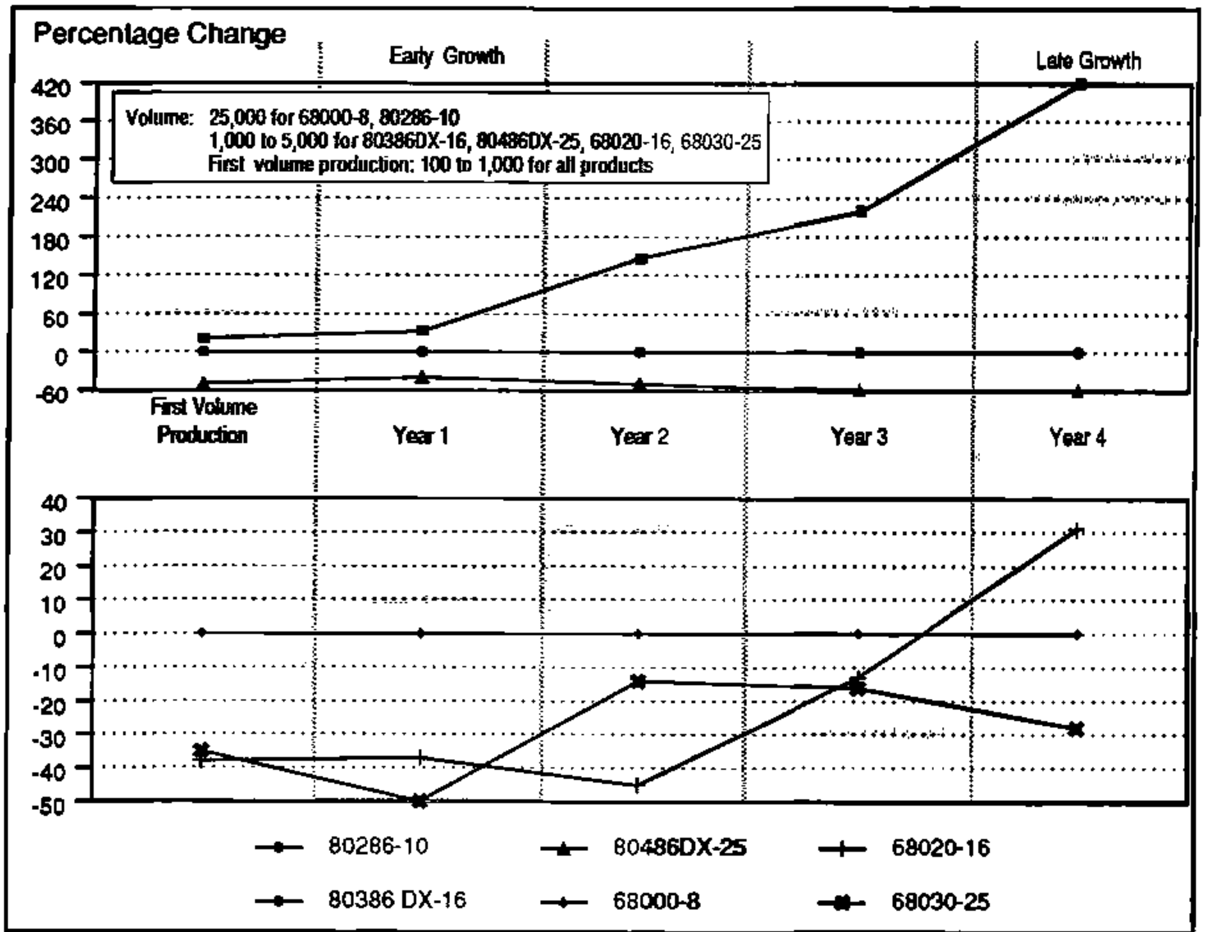


Source: Dataquest (July 1992) G2000876

Other Forward Prices

Dataquest also tracks forward-pricing via discussions with users and suppliers. For example, Digital's ALPHA 21064 200-MHz device (see Table 5-5) should be available during the third quarter of 1992 at an estimated price of $1,650 (1,000-unit volume). Another device shown in Table 5-5, the Sun/TI SuperSPARC processor (33 MHz, CPGA-293) should be priced during the first quarter of 1993 at less than $400 at 10,000-unit volume.

Figure 5-7
MPU Pricing: Rate of Decline at Forward Stages in Life Cycle Relative to Prior Generation (80286-10 and 68000-8 = Base of 0)



Source: Dataquest (July 1992)

G2000877

Table 5-6
Estimated P5 (80586) Pricing by Product Life Cycle Stage

Stage:	Price ($)
Introduction (Second Half 1992) First Volume Production[1]	1,268
Early Growth (1993) Price at First Full Year of Production[2]	788
Growth (1994) Price at Second Full Year of Production[2]	694

Assumptions: Specs: 3 million transistors; 50 MHz; CPGA (not multichip module). Intel's strategy: conforms more so with historic forward-pricing strategy associated with competitive market environment and less so with monopoly-pricing power. Life cycle: starts by fourth quarter of 1992.
[1]Volume of 100-1,000 units
[2]Volume of 1,000-5,000 units
Source: Dataquest (July 1992)

Chapter 6
Microprocessor Price Outlook

A procurement guide would not be complete without a chapter on price trends. The following price tables come from Dataquest's Semiconductor Procurement Service and are based upon survey results from suppliers and users of microprocessors.

Table 6-1 provides the estimated North American microprocessor quarterly price trends for 1992 and 1993. Table 6-2 provides a long-range estimate for North American microprocessor price trends through the year 1996.

Table 6-1
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1991	1992				1992	1993				1993
	Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year
68000-12	5.58	5.50	5.50	5.50	5.50	5.50	5.00	5.00	5.00	5.00	5.00
68EC000-8	NA	3.00	2.95	2.85	2.75	2.89	2.75	2.65	2.56	2.50	2.62
80186-8 PLCC	6.33	5.75	5.65	5.50	5.50	5.60	5.50	5.50	5.50	5.50	5.50
80C186-10 PLCC	NA	9.95	9.95	9.45	9.25	9.65	9.00	9.00	8.75	8.75	8.88
80286-10 PLCC	6.54	5.00	4.75	4.50	3.75	4.50	3.75	3.75	3.75	3.75	3.75
80286-16 PLCC	13.50	9.25	8.00	7.05	6.25	7.64	5.75	5.75	5.75	5.50	5.69
68020-16 PQFP	35.69	29.00	29.00	27.00	26.00	27.75	24.00	24.00	24.00	23.00	23.75
68EC020-16 PQFP	NA	17.00	16.00	15.75	15.50	16.06	15.00	14.20	13.50	13.00	13.93
68020-25 PQFP	NA	36.00	36.00	34.50	34.00	35.13	33.57	33.25	32.78	32.40	33.00
68EC020-25 PQFP	NA	21.00	20.20	19.75	19.00	19.99	18.00	18.00	18.00	18.00	18.00
68030-16 CQFP	NA	76.00	70.00	68.00	66.00	70.00	60.00	60.00	60.00	60.00	60.00
68030-25 CQFP	161.00	120.00	110.00	105.00	100.00	108.75	95.00	95.00	95.00	95.00	95.00
68EC030-25 PQFP	NA	37.00	36.50	35.25	35.00	35.94	34.65	34.30	33.96	33.79	34.18
68040-25	538.85	455.08	430.10	413.90	400.90	425.00	388.00	376.00	364.00	352.00	370.00
68EC040-25	NA	125.00	115.00	110.00	108.00	114.50	97.00	97.00	97.00	97.00	97.00
386SX-16 PQFP	57.74	53.82	49.00	45.12	42.00	47.49	39.00	36.00	35.00	34.00	36.00
386SX-20 PQFP	89.21	81.41	59.00	55.60	51.00	61.75	44.00	40.00	35.00	34.00	38.25
386SX-25 PQFP	NA	84.00	78.50	68.99	57.75	72.31	47.00	41.00	35.00	34.00	39.25
386SL-25 CPGA	NA	178.00	122.00	90.00	79.00	117.25	69.00	59.00	56.00	53.00	59.25
AM386-40	NA	180.00	150.00	92.50	78.20	125.18	69.88	66.15	62.10	58.43	64.14
386DX-25 PQFP[1]	157.61	148.00	99.00	74.00	68.00	97.25	65.00	63.00	60.00	57.00	61.25

(Continued)

Table 6-1 (Continued)
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1991 Year	1992 Q1	Q2	Q3	Q4	1992 Year	1993 Q1	Q2	Q3	Q4	1993 Year
80486SX-20 PQFP[1]	NA	237.00	201.00	99.00	96.00	158.25	93.00	90.00	86.00	82.00	87.75
80486DX-25	533.75	409.00	405.00	365.00	325.00	376.00	300.00	200.00	180.00	160.00	210.00
80486DX-50	NA	610.00	565.00	505.00	455.00	533.75	357.18	339.32	325.00	305.00	331.62
80486DX2-50	NA	550.00	517.00	465.00	415.00	486.75	375.00	266.67	236.25	224.00	275.48
29000-25[2]	111.25	92.00	85.50	81.00	78.00	84.13	76.00	71.00	67.00	65.10	69.78
88100-25[2]	76.06	69.50	68.05	67.45	67.00	68.00	64.50	62.20	60.20	58.10	61.25
R3000-25[2]	131.75	105.00	96.00	94.00	93.40	97.10	90.00	87.00	84.00	81.00	85.50
6-9SPARC-25[2]	88.74	75.62	72.30	69.51	66.55	71.00	64.50	62.88	61.60	60.60	62.40
80960CA-25	NA	95.30	91.30	90.30	89.25	91.54	88.35	87.45	84.30	81.20	85.33

NA=Not available
[1]CPGA for 1991, Q1-1992
[2]Pricing excludes accessory parts such as floating point and memory management
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (July 1992)

Table 6-2
Estimated Long-Range Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
68000-12	5.50	5.00	4.50	4.00	4.00
68EC000-8	2.89	2.62	2.35	2.30	2.30
80186-8 PLCC	5.60	5.50	5.30	5.30	5.30
80C186-10 PLCC	9.65	8.88	7.25	6.75	6.50
80286-10 PLCC	4.50	3.75	NA	NA	NA
80286-16 PLCC	7.64	5.69	5.00	4.50	NA
68020-16 PQFP	27.75	23.75	17.00	17.00	17.00
68EC020-16 PQFP	16.06	13.93	12.00	11.00	10.00
68020-25 PQFP	35.13	33.00	31.04	31.00	31.00
68EC020-25 PQFP	19.99	18.00	17.00	16.00	15.50
68030-16 CQFP	70.00	60.00	59.00	58.94	58.94
68030-25 CQFP	108.75	95.00	94.00	94.09	93.15
68EC030-25 PQFP	35.94	34.18	32.10	30.50	30.00
68040-25	425.00	370.00	332.50	325.00	325.00
68EC040-25	114.50	97.00	92.00	87.00	83.00
386SX-16 PQFP	47.49	36.00	28.00	24.00	20.00
386SX-20 PQFP	61.75	38.25	28.00	24.00	20.00
386SX-25 PQFP	72.31	39.25	28.00	24.00	20.00
386SL-25 CPGA	117.25	59.25	43.00	37.00	31.00
AM386-40	125.18	64.14	47.00	40.00	34.00
386DX-25 PQFP[1]	97.25	61.25	47.00	40.00	34.00
80486SX-20 PQFP[1]	NA	87.75	74.00	62.00	53.00
80486DX-25	376.00	210.00	112.75	94.86	80.19
80486DX-50	533.75	331.62	135.30	109.09	84.19
80486DX2-50	486.75	275.48	124.03	101.97	80.99
29000-25[2]	84.13	69.78	63.00	58.00	55.00
88100-25[2]	68.00	61.25	56.00	51.00	50.00

(Continued)

Table 6-2 (Continued)
Estimated Long-Range Microprocessor Price Trends—North American Bookings
(Volume: 8- and 16-Bit—25,000 per Year; 32-Bit—1,000 to 5,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; exceptions noted)

	1992 Year	1993 Year	1994 Year	1995 Year	1996 Year
R3000-25[2]	97.10	85.50	74.00	65.00	60.00
SPARC-25[2]	71.00	62.40	59.00	53.66	53.00
80960CA-25	91.54	85.33	77.14	75.21	75.21

NA = Not available
[1]CPGA for 1991, Q1-1992
[2]Pricing excludes accessory parts such as floating point and memory management
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. This forecast correlates with Dataquest's quarterly forecast for 1992-1993 dated June 1992.
Source: Dataquest (July 1992)

Chapter 7
Dataquest Perspective

The next two to three years should be especially challenging for users of MPUs. The rise of the RISC technology and AMD's entry to the 386 marketplace signal dramatic long-term market change. For example, as this report was being prepared, two RISC devices—TI's SuperSPARC and Cypress's HyperSPARC processor—hit the market, along with the CISC 486 device from Cyrix/TI.

For many users, the central MPU supply base issue is whether to maintain or break a long-standing buyer-seller bond with Intel. Regarding 80386 devices, AMD has a stronger strategic interest than Intel in serving long-term demand for this part. Depending on legal results, AMD and Cyrix-TI stand poised to smash Intel's 80486 monopoly. Other would-be entrants aim to do the same, although their prospects for successful market penetration appear more cloudy.

However, the long-term action in this provocative MPU world lies in the 32/64-bit CISC-versus-RISC battle that could completely reshape the IC business during this decade. Simply stated, systems houses such as Apple, Hewlett-Packard, and IBM could emerge as the key players in the MPU marketplace later this decade. But at press time—with news of Compaq systems that will be based on Intel's next-generation P5 (80586) CISC processor—old ways seem never to change.

Appendix A
Dateline May 1990: Semiconductor Users Still Eye the Risks of Sole-Sourced CISC 32-Bit MPUs

This article from May 1990 is included as a reference to highlight that issues regarding 32-bit microprocessors have been and are still vexing procurement managers. Many of the issues analyzed in this article have been resolved, some have not. By knowing the past, it is hoped that one can prepare for the future.

Systems manufacturers continue to confront tough decisions about which 32-bit complex-instruction-set computing (CISC) or reduced-instruction-set computing (RISC) microprocessor(s) to use and from which manufacturer. The broad strategic decision of whether to use single- or multisourced ICs will challenge systems manufacturers throughout the 1990s. Currently, although users reported to Dataquest a rising interest in future use of RISC MPUs, systems manufacturers remain largely committed to 32-bit CISC devices. Table A-1 shows that using single-sourced 32-bit CISC MPUs carries a special set of risk/benefit trade-offs—as illustrated by the recent stunning legal ruling on the 68030 microprocessor.

This appendix is based on the information presented in Table A-1, with focus on the risks associated with the use of single-sourced ICs—specifically, CISC 32-bit MPUs—and recommendations to users for reducing risk exposure. Table A-1 centers on two critical user issues: competitive component/system pricing and global availability of single-sourced ICs.

Strategic IC Pricing Risks

As shown in Table A-1, users typically pay higher prices for single-sourced ICs such as CISC 32-bit MPUs than for components that are available from multiple sources. In addition, all component buyers, whether of single- or multisourced ICs, confront other pricing/availability risks: inconsistent IC pricing, supply, and quality among the different world regions.

Higher-IC ASPs

Although the use of sole-sourced ICs in systems typically means higher IC pricing vis-a-vis multisourced devices, the use of these higher-priced components *can* translate into enhanced system performance and profitability. Users of sole-sourced ICs must realize,

Table A-1
A User View of Single-Sourced CISC 32-Bit Microprocessors

Prospective Benefits for Users	Possible Risks for Users
Enhanced system value and competitiveness by use of proprietary technology	Higher IC ASPs (versus second-sourced 32-bit MPUs)
Protection against shortages through long-term contracts	Inconsistent world regional IC supply, quality, and pricing
More accurate production forecasts per close user/supplier relationships	Periodic allocations to users in times of product scarcity
Clear system/technology road map	Inability to meet system production and life cycle plans
Improved supply/pricing of ICs used along with the 32-bit MPU	Legal uncertainty associated with patent enforcement and other claims

Source: Dataquest (May 1990)

however, that the long-term pricing trend for these higher-priced devices is likely to be different than the historical pattern.

IC Life Cycle Pricing

Historically, semiconductor users have grown accustomed to rapid attrition in IC pricing during the early (or forward) stages of the IC life cycle, especially for multisourced devices such as standard logic or memory products. This pattern of semiconductor pricing is called life cycle or forward pricing.

Users of sole-sourced 32-bit CISC devices should expect a somewhat different pricing structure. The huge expense (for example, R&D, fab construction, legal protection) of producing these complex chips motivates suppliers of 32-bit MPUs to resist stiff price declines during the early years of the IC's life cycle. Pricing for these devices typically declines between 5 and 9 percent per quarter during the growth stage. By contrast, pricing for multisourced devices often declines at a quarterly rate of between 10 and 30 percent during the forward stages.

Depending on the CISC 32-bit MPU supplier, product pricing *for major buyers* should either stabilize or continue to decline moderately during the later years of the life cycle. When pricing stabilizes, a higher-speed product typically costs no more than a lower-speed version for long-term customers (that is, 16-MHz and 20-MHz price parity).

World Regional Supply Risks

Inconsistent IC pricing among different world regions relates directly to global supply/demand trends. For systems manufacturers that develop coordinated international procurement/manufacturing/marketing plans, management of world regional IC supply/pricing trends should become a central concern. Over the long term, some *suppliers* might be able to sell ICs at uniform prices worldwide, but that remains a future goal.

For users of CISC 32-bit MPUs, global pricing management requires, at a minimum, that users monitor suppliers' worldwide manufacturing capabilities, preferably taking an active role in shaping the global fab plans of the sole-sourced supplier. This strategy can help reduce the likelihood of another risk associated with use of single-sourced products: periodic allocations to users in times of product scarcity, as is now occurring for users of Intel's 80386/80386SX devices. Depending on supply/demand trends, a product can be on allocation in one or more world regions but be more readily available in other areas.

Table A-2
32-Bit CISC MPU Worldwide Manufacturing Capability—Intel and Motorola (as of May 1990)

	Motorola 32-Bit CISC MPUs[1]	Regional Total	Intel 32-Bit CISC MPUs[1]	Regional Total
	Number of Fabs by World Region			
North America	2	4	3	7
Europe	1	3	1[3]	1[3]
Japan	1[2]	1[2]	0	0
ROW	0	0	0	0
Total number	4	8	4	8
	Square Feet of Clean Room by World Region			
North America	76,900	91,800	72,000	182,000
Europe	34,000	94,600	24,000[3]	24,000[3]
Japan	0	23,800[2]	0	0
ROW	0	0	0	0
Total	110,900	210,200	96,000	206,000

[1]Intel and Motorola fabs largely dedicated to 32-bit CISC MPUs
[2]Joint Motorola/Toshiba facility
[3]Israel
Source: Dataquest (May 1990)

The 32-Bit CISC MPU Global Fab Networks of Intel and Motorola

Table A-2 weighs the global manufacturing strengths of Intel and Motorola regarding production of 32-bit CISC devices. These components include Intel's 80386, 80386SX, and 80486 products and Motorola's 68020, 68030, and 68040 devices.

Manufacturing by World Region

Table A-2 reveals that Motorola and Intel are well positioned to serve long-term North American demand. Motorola's United Kingdom fab puts suppliers in a good position to supply European users. Intel currently supplies European users of 80386 partly with products from the Israel fab. The approach of 1992 could mean expanded capacity for that region.

Table A-2 also shows that users in Japan and Rest of World (ROW) know firsthand of the challenges involved in globally sourcing single-sourced ICs. Motorola's alliance and joint-fab arrangement with Toshiba should enable Motorola to serve the Japan market effectively over the long term.

The Risk of Allocation

Nevertheless, unexpectedly strong market demand can overwhelm the ability of the formidable single-source suppliers to meet all user needs, as is now occurring with Intel's 80386/80386SX products. Clients that forged long-term contracts with Intel for these products report little interruption of supply, unlike buyers that operate on the spot markets.

At the time of this writing, Dataquest had been informed that the supply/demand imbalance is not expected to improve in North America and Europe until the second or third quarter of 1990. The imbalance in Japan and ROW also should not improve until the third or fourth quarter of this year.

Legal Risks

Users of 32-bit CISC MPUs must be ready to confront another risk: potential legal uncertainty surrounding the validity of sole suppliers' patents and other intellectual property. For example, an invalid patent ultimately vitiates the benefits presented as rationales for using sole-source devices. As shown in Table A-1, these benefits include enhanced system value through use of proprietary MPU technology and clear long-term system/technology road maps.

68030 Litigation

The stunning decision in the Hitachi/Motorola case concerning microprocessor (and microcontroller) patent infringement claims shocked users of the 68030 microprocessor. Regarding the CISC 32-bit MPU arena, the case could have severe and unanticipated consequences for Motorola and users of this device.

Setback for Users?

Users continue to receive shipments of 68030 products from Motorola during the second quarter of 1990. In late June 1990, barring a prior settlement, Hitachi and Motorola will return to court. A major issue is whether or not Motorola should be allowed to continue shipments during the lengthy appellate process. If not (again, barring a settlement), users will experience major disruption of 1990 system production plans and long-term uncertainty regarding their systems' life cycles and technology road maps.

A Fairly Speedy Settlement?

Dataquest believes that both Hitachi and Motorola have good reasons for seeking a resolution to their litigation. In Motorola's case, the threat of injunction hangs over a product that Dataquest believes garnered revenue in the $120 million to $150 million range in 1989. As noted, of greater long-term significance is the fact that stopping the flow of 68030s represents a serious hardship to Motorola's customers. Succinctly, major users are dependent on the 68030 as the sole-source heart of significant portions of their systems sales.

Hitachi also is motivated to come to terms. Although U.S. sales of its H8 product may not be as monetarily significant as the 68030, sales of the H8 in Japan would be jeopardized if the final destination of domestic equipment was the United States. As has been demonstrated by Intel and Texas Instruments, invoking the powers of the International Trade Commission (ITC) in defense of one's intellectual property can empower customs to seize imports of equipment containing an offending product. Consequently, many of Hitachi's customers also probably want a hasty resolution of the issue.

Given the stakes involved for both Hitachi and Motorola, Dataquest anticipates a fairly speedy settlement and an end to the jitters felt by 68030 customers. The settlement may cost Motorola the millions of dollars it might have hoped to gain from Hitachi when it first pressed its lawsuit more than one year ago. Nevertheless, the current bottom line is that users of the sole-sourced 68030 remain waiting for a legal resolution that could occur as soon as tomorrow or not for several years.

A User Eye on Unresolved Legal Issues

Dataquest strongly recommends that users carefully monitor legal developments associated with *all* sole-sourced ICs—not only the 68030 MPU, but also 80386/80386SX products and application-specific ICs (ASICs).

Regarding the 68030 litigation, the resolution of the following issues could have a forceful impact on users' 1990 production schedules and long-term technology road maps, as follows:

- If Hitachi and Motorola do not settle the litigation, how long will users have to wait before the case is resolved?

- Would a cross-license deal, as part of a settlement, imply access to selected technologies or outright second-sourcing of the 68030?
- Is Hitachi at all interested in producing the 68030?
- If the 68030 were to be second-sourced to Hitachi, how would this affect Motorola's agreement with Toshiba, with which it has a DRAM/microprocessor joint venture?
- Will pricing for 68030 products be higher than originally expected (for example, pass-on of Motorola's royalty payments), unaffected, or lower (that is, Hitachi as second source)?

More Legal Shocks for Users of Sole-Sourced 32-Bit MPUs?

Dataquest will be tracking the 68030 case with an eye on these issues. The recent events surrounding the 68030 product augur future shocks for supply-base managers at systems companies that use single-sourced CISC 32-bit MPUs. For example, users of 80386 devices must monitor the arbitration case between AMD and Intel over 80286 products. AMD claims a right to produce *80386* devices. Should AMD win that argument—as stunning as the scenario seems—AMD might emerge as a supplier of 80386 products. The unresolved issues surrounding the 68030 litigation could become for users—with some modification—the unresolved issues surrounding *the 80386 case.*

Dataquest Conclusions and Recommendations

Dataquest believes that users of sole-sourced ICs such as CISC 32-bit microprocessors confront a challenging set of risks in terms of pricing, worldwide supply, and legal claims. Use of these proprietary processors can mean enhanced system value and competitiveness, provided that the risks are minimized. Generally, risks can be minimized through close user/supplier relations that include the mutual sharing of sensitive forecast information.

Specifically, Dataquest also makes the following recommendations:

- To manage pricing risks (higher prices, no life cycle pricing), users must actively monitor suppliers' R&D/capital equipment plans to make certain that these plans coordinate with users' long-term *worldwide* system production goals and technology road maps.
- To manage global supply risks, users must track their single-sourced suppliers' worldwide network of fabs *as well as* world regional demand patterns in order to gauge the periodic likelihood of limited allocation *on a world regional basis.*
- To manage legal risks, users must monitor any legal developments surrounding any single-sourced IC and require from suppliers information on any such products currently involved or likely to be involved in a legal dispute.

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