Global Market Insight for Information Technology Companies

1995 RESEARCH PROGRAMS

From semiconductors to systems, software to services, telecommunications to document management, Dataquest's scope of expertise provides clients with a clear view of the relationships between information technology segments – relationships that can have a profound impact on making strategic business decisions.

Computer Systems and Peripherals

Computer Systems
- Client/Server Computing *Worldwide*
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- Government Agencies
- IT Business Strategy and Planning Organizations
- Publishing, Media, and Consulting Firms
- IS and Purchasing Organizations
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- Printers
- Computer Markets

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- Asia/Pacific
- Latin America

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SEMICONDUCTOR PROCUREMENT WORLDWIDE

Dataquest's Semiconductor Procurement Worldwide program responds to the quick information needs of semiconductor users. Dataquest provides users with indispensable information needed to make solid, intelligent, and timely procurement and design-in decisions.

Partnering to Provide Solutions

As a client, you have direct access to experienced analysts who can provide insights and advice on market dynamics, industry events, and competitive issues.

Inquiry Support

Personalized inquiry support is a primary component of your Dataquest annual subscription program.

Through an interactive approach, Dataquest analysts work with you to tailor the program to meet the unique needs of your organization.

Electronic Delivery

A variety of electronic delivery options that have the power to deliver Dataquest insights directly to your desk are available.

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Clients have unlimited access to Dataquest's extensive print and online resource libraries worldwide.

Optional Custom Research

Should your needs exceed the scope of this program, Dataquest also offers extensive primary research and consulting services.

Market Coverage

Quarterly Price Forecasts

Dataquest publishes short- and long-term forecasts for more than 200 products in the following semiconductor product families:

- DRAMs
- SRAMs
- EPROMs
- Flash memory ICs
- ROMs
- Microprocessors
- Gate arrays/CBICs
- Communications ICs
- Standard logic

Quarterly Procurement Pulse Survey Results

Based on surveys of procurement managers, this quarterly update tracks critical issues and market trends, including:

- Average semiconductor orders
- Average semiconductor lead times

Monthly Price/Lead-Time Updates

Dataquest publishes monthly price and lead-time updates on 25 products, 3 volume levels, and 6 regions worldwide.

Market Statistics

This program also provides a top-level view of the products, markets, and companies of the worldwide semiconductor industry.

Statistics include:

- Semiconductor market share estimates
- Worldwide consumption forecasts by region

Communications ICs

New for 1995, Dataquest has added communications ICs to the list of products tracked each quarter.

Dataquest

Worldwide Semiconductor Group

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Pricing Trends

North American Semiconductor Price Outlook: Quarterly and five-year price forecasts for more than 200 semiconductor products in the following product families: DRAMs, SRAMs, EPROMs, flash memory ICs, ROMs, microprocessors, gate arrays, cell-based ICs, CMOS PLDs, and standard logic ICs. Beginning in 1995, Dataquest will add 15 to 20 communications ICs to the quarterly survey.

Updated Quarterly

Market Statistics

Worldwide Semiconductor Consumption and Shipment Forecast: Five-year revenue forecasts for the global semiconductor market by region.

Published in the Second and Fourth Quarters

Worldwide Semiconductor Market Share: Market share by company for total semiconductors; total ICs; bipolar digital, memories, and logic; MOS digital, memories, microcomponents, and logic; analog ICs; discrete semiconductors; and optoelectronic semiconductors.

Available in the First Quarter

Focus Studies

Each report examines an issue of importance to equipment OEMs. Each report delivers a forward-looking assessment of procurement issues and their potential impact on short-term and long-term pricing before they affect your business.

Clients receive three focus reports published throughout the year:

- **Capital Spending** — ***First Quarter***
- **Low-Voltage ICs** — ***Second Quarter***
- **Benchmarking** — ***Fourth Quarter***

Perspectives

Procurement Pulse: Based on surveys of semiconductor procurement managers, Dataquest publishes a quarterly update on critical issues and market trends. Concise analysis and four easy-to-read graphs explain what inventory and order rate corrections mean to both semiconductors users and manufacturers.

Published Quarterly

Product Analysis: Comprehensive newsletters presenting analysis on product markets and procurement issues such as product life cycles, market dynamics, and alliances.

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Dataquest Predicts: In these hard-hitting reports, Dataquest takes a bold, opinionated, often controversial look at key issues, products, and trends shaping the industry today. The reports make predictions, backed with data and intelligent analysis, about why, when, and how events will happen and what impact these events will have on worldwide pricing.

Published in the Second and Fourth Quarters

Alerts

News and analysis, delivered by fax, for fast-breaking events. Dataquest Alert bulletins are published throughout the year on an event-driven basis.

Published on an Event-Driven Basis

The DQ Monday Report

Weekly news and commentary on semiconductor industry events and issues with a monthly snapshot of regional semiconductor pricing for 25 key semiconductors in 6 regions (United States, Japan, Europe, Taiwan, Korea, and Singapore). ***Weekly via Internet***

Conferences

Dataquest hosts the industry's preeminent semiconductor conferences in the United States, Europe, Japan, Taiwan, and Korea. For more information contact Dataquest's Conference Desk. Clients receive special discounts on conference fees.

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SEMICONDUCTOR PROCUREMENT WORLDWIDE 1995

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Intel Drops the Pentium Price Hammer Sooner than Later; Next Watch for a 486 Slugfest

Intel Formally Announces First-Quarter Pentium Price Cuts

Intel dropped its published low-volume Pentium microprocessor prices 7 percent to 40 percent, effective February 1, 1995. Re-emphasizing that 1995 will be "the year of the Pentium," Intel also plans to make the older 486 processors cheaper, but not as attractive on a cost-per-function basis as its flagship Pentium. Table 1 shows the old and new low first-quarter 1995 volume prices from Intel and Dataquest's December 1994 and revised 20,000-unit first-quarter 1995 contract price estimates for the affected parts.

Table 1

Pentium Price Comparisons--Old and New First-Quarter 1995 Pricing

Model Number	Intel Jan. 3, Q1 1K Unit Price ($)	Intel Jan. 30, Q1 1K Unit Price ($)	Price Reduction (%)	DQ 12/94, Q1 20K Price Est. ($)	DQ Feb. 1, Q1 20K Price Est. ($)
Pentium-60	383	273	28.7	280	200
Pentium-66	479	289	40.0	362	215
Pentium-75	495	301	39.2	Not surveyed	250
Pentium-90	587	546	7.0	Not surveyed	450
Pentium-100	905	673	25.6	816	605
80486DX4-75	356	184	48.3	280	145
80486DX4-100	449	245	45.4	Not surveyed	195

Source: Intel, Dataquest (February 1995)

Dataquest Perspective

As mentioned during our October 1994 conference, we expected a step function price cut for the Pentium product line by mid-1995. The two main factors pushing for an abrupt price reduction were yield improvements and increased 486 competition. Dataquest estimated that competing 486 devices from AMD and Cyrix, among others, would begin to erode average 486 pricing by the middle of the second quarter of 1995 (overall 486 revenue divided by overall 486 units equals average selling price, or ASP). By then Pentium yield improvements would profitably allow Intel a sharp price cut, thus leapfrogging 486 and Pentium-class competition.

The unchanged variable in this scenario is competitive production capacity. Capacity is still ramping up, but not to the extent that affects overall first-quarter 486 ASPs. The other variable, yield improvement, may have occurred earlier than expected (otherwise Intel is leaving Pentium money on the table because competition is not yet forcing the price cuts). The only other factor, demand, would have to soften to cause these price adjustments. Demand for 486 and Pentium devices remains strong at this time.

If cost improvements caused this latest round of pricing, the percentage of price decline hints at where most of the improvements exist--the 66-, 75-, and 100-MHz speeds. Is it also coincidental that these speeds are the key target areas where AMD and Cyrix aim to make inroads? With this pre-emptive price strike, Intel will make the Pentium a more popular product and again keep competition at bay. It is yet too soon to record the impact on 486 pricing, but rest assured that the ripple-through effect will quickly occur there as well. Intel is a master at the "cannibalize your young" school of marketing, and this is but another example of how a market leader stays the leader.
Mark Giudici

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Second Quarter Procurement Pulse: Constrained Supply Continues

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers. Based on the results of a recent client

Figure 1
Averaged Monthly Semiconductor Orders

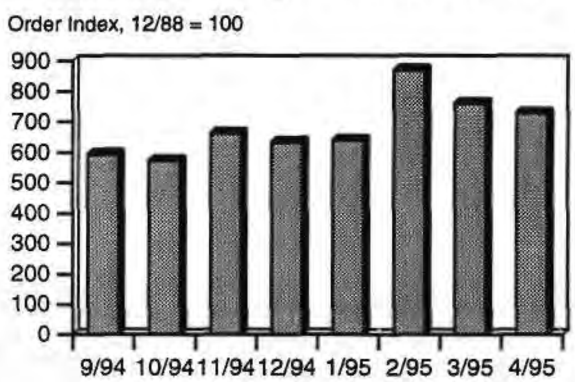


Figure 2
Averaged Semiconductor Lead Times

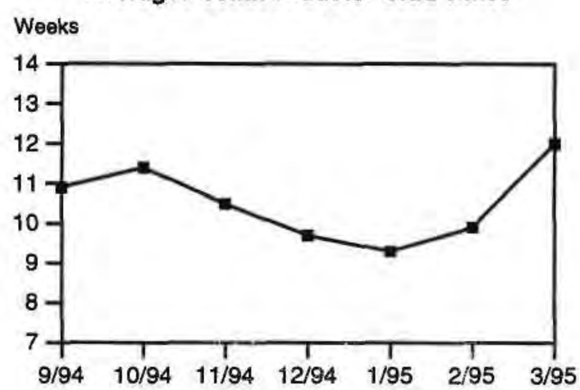


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

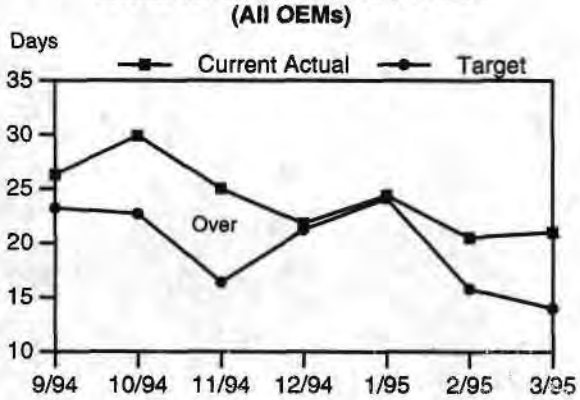
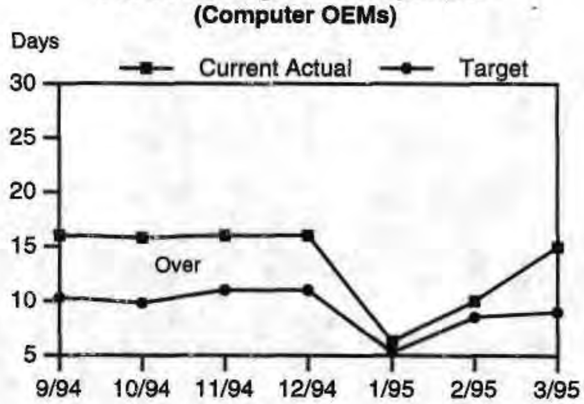


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



Source: Dataquest (April 1995)

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survey, we have decided that future *Procurement Pulses* will be updated on a quarterly basis unless dramatic market changes warrant an interim update. This is the second quarterly update for 1995. Last year we expanded our survey sample and added new procurement parameters that are of key concern. Price status by product family, package type, and contract manufacturing use are some of the newer parameters tracked. This article explains what changes to these parameters mean to semiconductor users.

Semiconductor Order Levels Drop Slightly

As shown in Figure 1, this month's sample of purchasing managers expect the April order level to be slightly lower than the order level for March. Both March and April are significantly lower than the order level for February. One explanation for the February order spike is that the usual postholiday slowdown was either nonexistent or very minimal, triggering a burst of purchasing in February.

Respondents indicated that current DRAM pricing was up more than 2 percent for all OEMs and up more than 5 percent for computer manufacturers. These prices reflect the general tightening of the memory market and, in part, the announcement that major Japanese DRAM suppliers intend to raise prices 5 to 10 percent to compensate for the falling dollar. First-tier U.S. -based computer manufacturers no doubt will resist this price hike. For example, Compaq officials recently were quoted in a leading Japanese newspaper saying that they will not accept the price hikes. The second- and third-tier users of DRAM do not have the same clout and probably will have to pay the 5 to 10 percent adder.

Increasing competition in the 486 and Pentium-like devices is forcing MPU pricing down. Overall MPU prices decreased 1 percent, while the computer group saw a price decline of 2.67 percent. All OEMs report an increase of 1.25 percent in standard logic, with the computer group reporting no change from the previous month. With the exception of some fast CMOS parts, the once tight market for standard logic is now more in balance.

Semiconductor Lead Times Stretching Out

Figure 2 shows that lead times have increased to a new recent high of 12 weeks for all OEMs; the figure is 10.67 weeks for the computer group. The continuing boom in electronic equipment, principally personal computers, workstations, servers, printers, and telecommunications, has created a lengthy growth cycle for the semiconductor market.

According to our survey respondents, a new concern is availability of discrete devices. Lead times for specific small-signal transistors, MOSFETs, power discretes, diodes, and tantalum capacitors are pushing out beyond 20 weeks. It would be wise for all OEMs to assess their risk and exposure in this area. The lack of a 10-cent diode can stop a production line just as easily as can a shortage of expensive ASICs or MPUs.

Semiconductor Inventories

Despite the lengthening lead times and firming memory prices, OEMs are managing inventory levels fairly well (see Figures 3 and 4). For example, computer OEMs report current actual at 15 days and target at 9 days, while all OEMs were at 21 days current actual and 14 days target.

Dataquest Perspective

Dataquest sees high demand for electronic products and therefore ICs through the late 1996 time frame. Until electronic equipment demand drops off or significant new fab capacity is ramped up, lead times will continue to be more than eight weeks, memory pricing will be firm, and inventory levels will not drop significantly.

The good news is that most large OEMs are managing their businesses very well in this generally difficult supply situation. There are spot shortages, but suppliers are working closely with their significant customers to keep the product rolling. Further, OEMs are keeping the reins on inventories, so supply and demand is not grossly out of balance. Dataquest sees this current tight but not impossible IC supply situation continuing for at least the next five to six quarters.

Scott Hudson

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May Procurement Pulse Data: Constrained Supply Continues

The *Procurement Pulse* is a monthly update of critical issues and market trends based on surveys of semiconductor procurement managers.

Figure 1
Averaged Monthly Semiconductor Orders

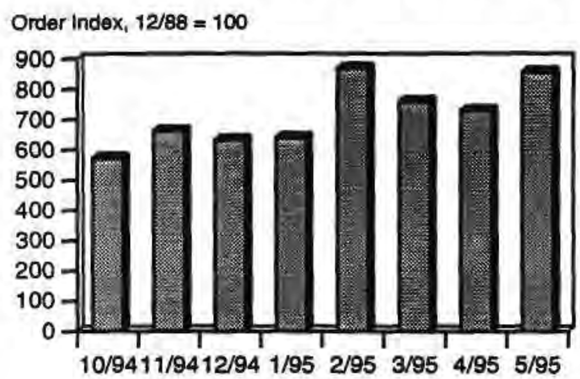
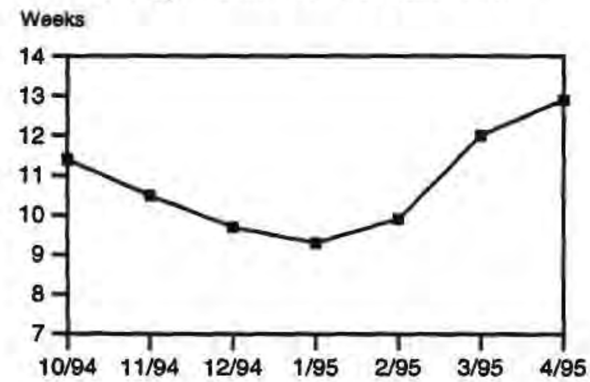


Figure 2
Averaged Semiconductor Lead Times



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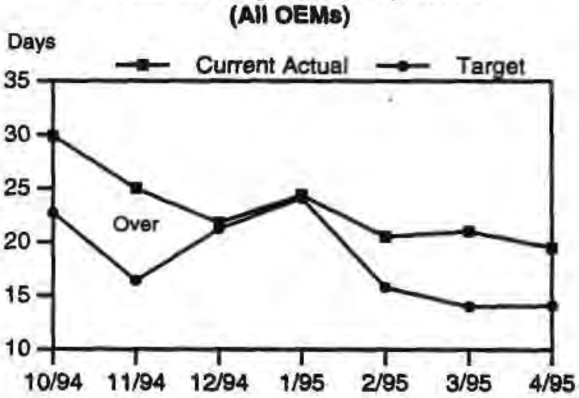

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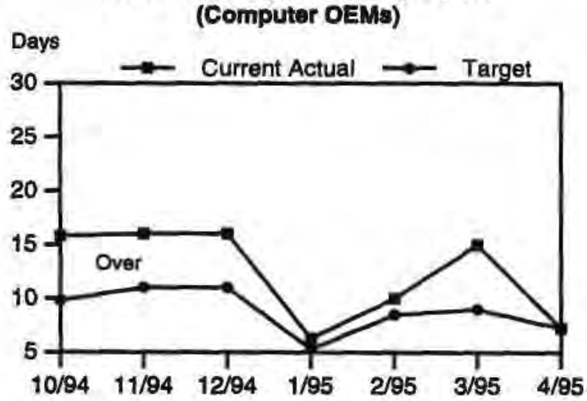

Source: Dataquest (May 1995)

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Dataquest Teleconference Alert

Topic: Midyear Semiconductor Price Forecast: Which Prices Will Decline, and When?

SCOPE: This telebriefing shows how supply/demand imbalances will affect pricing of critical memory and microprocessor ICs. DRAM price crossovers and Intel's Pentium/P6 product strategy are highlighted in this changing semiconductor price landscape. The session will open with comments by analysts from the following Dataquest services: Semiconductor Procurement Worldwide (SPSG) and Memories Worldwide. An interactive discussion with Dataquest clients will follow.

WHO: Discussion leaders will be Mark Giudici and Scott Hudson of SPSG; and Jim Handy and Ron Bohn of the Memories service. Invitees will be SPSG, Memories, and Cross Industry clients.

WHEN: Friday, June 2, 1995 at 8:30 a.m. PST.

HOW: To confirm your attendance, call or fax Jenny Williams at (408) 437-8263, or fax (408) 437-0292 ***no later than May 31, 1995.***

Clients that respond by the May 31 deadline will receive a set of figures (via fax) before the teleconference.

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Third Quarter Procurement Pulse: Orders and Lead Times Fluctuate while Inventories Remain Controlled

The *Procurement Pulse* is a quarterly update of critical issues and market trends based on surveys of semiconductor procurement managers in the North American region. Besides order

Figure 1
Averaged Monthly Semiconductor Orders

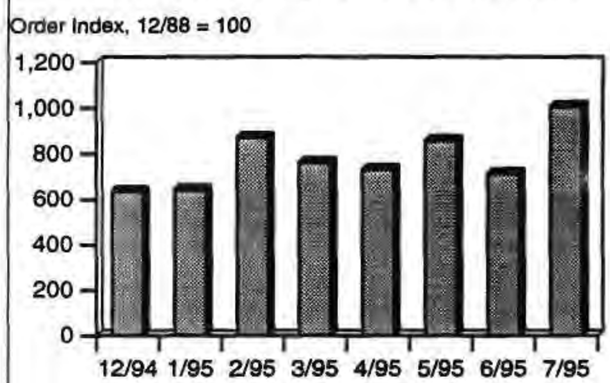
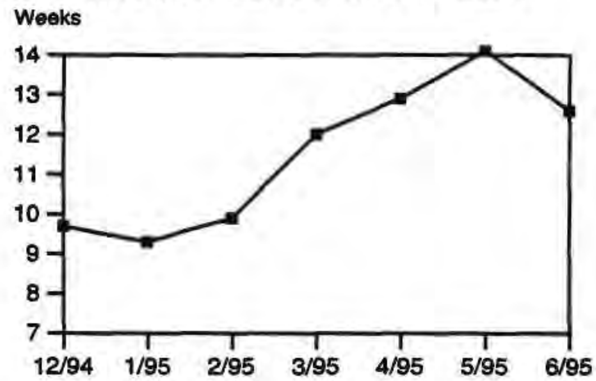


Figure 2
Averaged Semiconductor Lead Times



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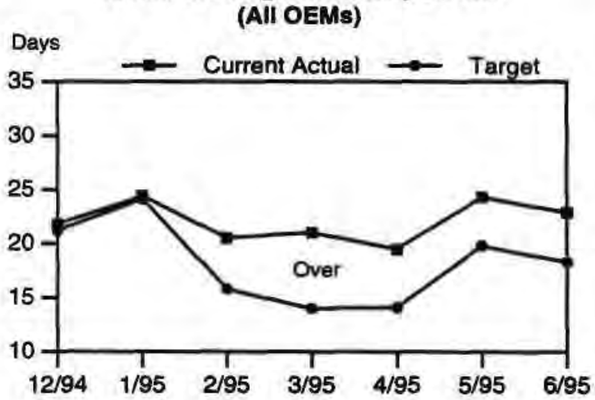

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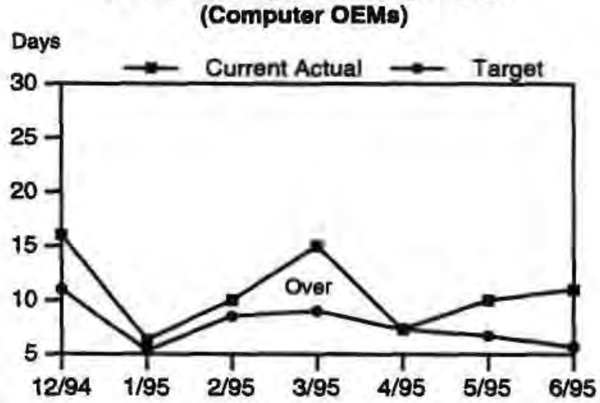

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Source: Dataquest (June 1995)

rate, lead time, and inventory information, this survey notes price status by semiconductor product family and package type; it also notes key problems facing semiconductor users. This article explains what changes to these parameters mean in relationship to the current market.

Semiconductor Order Rates Forecast to Reach Record High

As seen in Figure 1, the estimated semiconductor order rates for July are expected to exceed 1000 on the indexed scale. Semiconductor order activity continues to grow briskly, fueled by continued demand for PCs, cellular, and peripherals equipment. Although the index levels for May, June, and now July showed fluctuating demand forecasts, the overall outlook for semiconductor order levels remains strong, at least through the end of the year.

Respondents noted price increases for DRAM (3.8 percent) and standard logic (1.3 percent) for a fourth consecutive month. The well-reviewed supply/demand imbalance of the 1Mbx16 DRAM is the cause of current price hikes. Although the standard logic market was briefly in balance last quarter, logic price increases now affect most of the advanced product families and some of the very mature product lines because demand has again outpaced supply. Overall MPU pricing remains on the decline (down 1.6 percent) as the trickle-down effect of Intel's Pentium price cuts continues to keep all products competitive. The computer subset of respondents noted average MPU price declines of 2.7 percent, highlighting again where MPUs are mostly used.

Semiconductor Lead Times Ease a Bit

Figure 2 shows that, after four months of continually lengthening semiconductor lead times peaking in May, June lead times declined to an average 12.6 weeks. This by no means signals a turn to a buyer's market, but it does note that supplies have improved somewhat for selected MPU, discrete, and SRAM parts. Allocation still remains the norm for most DRAM, flash memory, and SOT23 discrete products. Lack of discrete semiconductors is causing many users' headaches as searches via alternative channels force close scrutiny of discretes once only an afterthought in strategic planning. Most problem products remain memory-related (DRAM, flash, and <15ns SRAM), plus the perennial SOT23 discrete package.

Semiconductor Inventories Remain Remarkably Controlled

Figures 3 and 4 illustrate that, despite strong demand, long lead times, and rising prices, inventory (read: COST) control is alive and well in the semiconductor procurement community. The overall targeted and actual semiconductor inventory levels for June were a respective 18.3 and 22.9 days, compared with May's like 19.8- and 24.3-day inventory levels. The computer subset is even more cost-conscious, with current target and actual inventory levels of 5.7 and 11.0 days, compared with May inventory levels of 6.7 days targeted and 10.0 days on-hand. By historical standards, semiconductor inventories are very controlled, again easing fears that any end-use demand fluctuations could cause an abrupt step function decline in semiconductor sales.

Dataquest Perspective

Demand for electronics and therefore semiconductors remains strong, and Dataquest expects this situation to remain through 1996. Even with the large increases in semiconductor fab capacity being brought online, the combination of lower-than-expected 1Mbx16 DRAM yields and higher-than-forecast demand for most end equipment continues to cause long lead times and overall firm IC prices. Until a break in either demand or 16Mb DRAM yield occurs within the next 12 months, expect to see a continuation of the current market. Continued vigilance of inventory levels, combined with regular review of critical component suppliers, is the best medicine for the times.

By Mark Giudici

Dataquest ALERT

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Midyear Semiconductor Price Forecast: Which Prices Will Decline, and When?

This *Dataquest Alert* is a transcript of a telebriefing held June 2, 1995 for Semiconductor Procurement Worldwide, Memories Worldwide, and Cross-Industry clients.

Hello and good morning. This is Scott Hudson of the Semiconductor Procurement Worldwide service. This telebriefing will cover the highlights of the Dataquest midyear semiconductor forecast, which addresses the issue of which prices will decline, and when. After an opening statement, we will take questions from the audience. Those with questions will be identified with a number. Please do not give out your name when asking questions. We are not recording this briefing.

First let me introduce the participants. In the room are Mark Giudici, principal analyst of the Semiconductor Procurement Worldwide service and Jim Handy and Ron Bohn of the Memories Worldwide service.

Before going into the market overview and the details of the pricing survey, some critical economic assumptions need to be mentioned:

- Despite all the negative economic news, Dataquest expects the electronics industry to remain strong.

- Worldwide PC demand, which drives the semiconductor business, will be strong through the 1995 to 1996 time frame.

- Fab capacity will continue to come on-stream but will not have a big market impact until early to mid-1996. For example, the critical 1Mbx16 DRAM will continue to be in a shortage situation throughout 1996, despite the tremendous ongoing build-up in fab capacity.

- Datquest pricing reflects average contract book pricing for large and medium-size companies. By contrast, the pricing on the so-called spot market now is much higher than some of the prices we report. Also, Dataquest pricing assumes a stable yen-to-dollar exchange rate of 84 yen to the dollar.

- o One of the major changes since our February forecast was the impact of the strong yen on DRAM price negotiations.

Market Environment

Before discussing the pricing details, the current market needs to be briefly explained. Two phrases characterize the current market: acute shortages and lengthening lead times. 2Mb and 4Mb flash devices, and 8-bit microcontrollers, for example, have lead times of more than 30 weeks. The lead times for even some discrete and passive devices, for example, certain capacitors, diodes, and crystals, are approaching 40 weeks, if available at all. There is even a general shortage of discretes available in the SOT-23 package.

This multiple-part shortage can make new product ramp-up a challenging experience. Some digital communications equipment companies recently reported difficulties in finding an adequate supply of DSP chips, flash memory, and capacitors.

PC Industry

Strong demand for PCs is primarily responsible for the semiconductor shortage situation. Not only does the PC industry use more than half of all memory production but also an incredible quantity of the various logic devices and discretes. Understanding PC demand can help us to predict the general market conditions for IC and discretes.

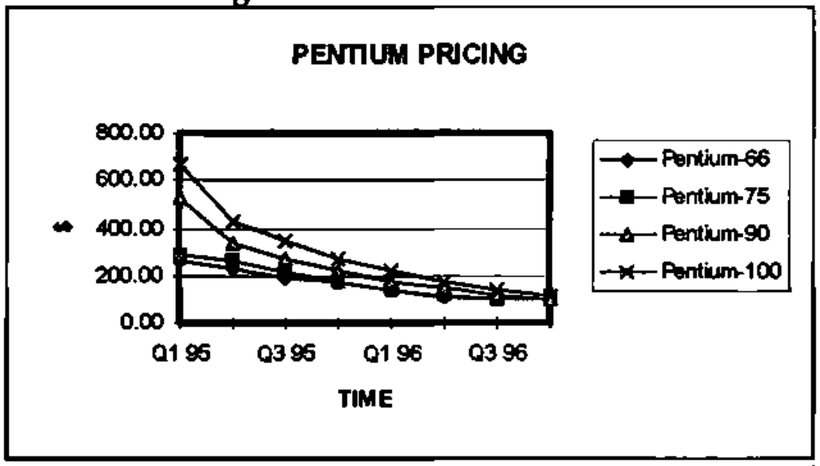
The current Dataquest PC forecast shows that 57 million PCs will be produced worldwide in 1995. This number represents a 19.5 percent increase over 1994 levels. Of these 57 million PCs in 1995, 26 million are expected to be built with Pentium-level MPUs. The forecast in 1996 shows total PCs at 68 million units, with 53 million containing a Pentium-level MPU. Clearly demand from the PC sector should be very strong through 1996. The forecast for 1997 is 77 million PCs.

MPUs

One assumption in these PC numbers is that Intel will aggressively ramp up production of the various Pentium chips and at the same time drastically bring down the price. In Figure 1, pricing is projected out through 1996 for the 66-, 75-, 90-, and 100-MHz devices. Currently, the 100-MHz is selling for $430, the 90-MHz at $340, the 75-MHz at $260, and the 66-MHz at $235. Of particular interest is that all devices will be selling for about $100 at the end of 1996. Essentially what Intel plans to do is shorten the life cycle of each product to two years. This not only gives Intel a strong competitive advantage but also creates an aggressive pricing scenario for all MPUs.

Figure 1

Pentium Pricing



Source: Dataquest (June 1995)

All the reports we have confirm that Intel's Pentium ramp-up is on or ahead of schedule. For those interested in calculating the price of future MPUs, a good rule (credited to one of Intel's prime rivals) is that the floor price for any MPU will be equal to one dollar per megahertz.

DRAMs

Let's now look at the DRAMs. The DRAM market will continue to be a sellers' market through this year. Prices are forecast to increase for all DRAMs during the second half of 1995 and to not begin to decline until the first half of 1996. This market of increasing prices is not only a major problem for system companies still seeing shrinking profit margins but also is highly unusual. In the classic IC life cycle, there is a negative correlation between volumes and prices. That is, as volume ramps up, prices should fall. We are now witnessing the incredible scenario where the 16Mb DRAM ramps up as the price is increasing.

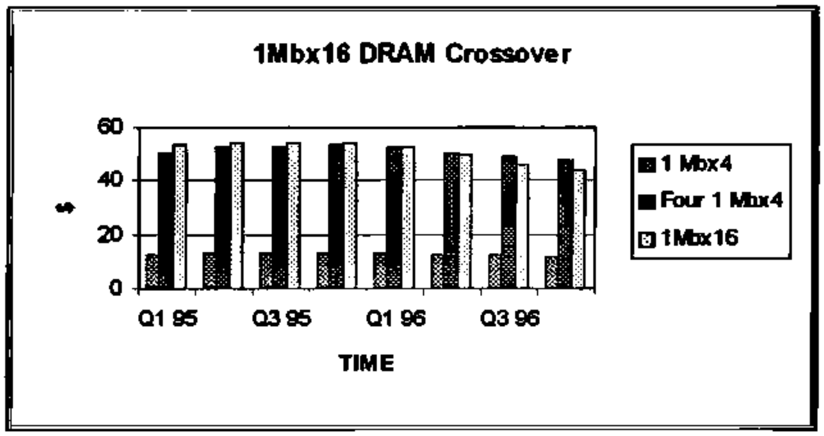
Let us look at some specific pricing. First we will discuss the 1Mbx4 DRAM. In the first quarter of 1995, the 1Mbx4 price was $12.66; the second quarter or current price is $13.10, with the fourth quarter price projected to be $13.35. In 1996, the 1Mbx4 price will decrease to $13.15 in the first quarter and is forecast to drop to $11.88 in the fourth quarter.

The 1Mbx16 price was $53.62 in the first quarter of 1995; the second quarter or current price is $53.90, with the fourth-quarter price projected to be $54.50. In 1996, the 1Mbx16 price will drop to $52.50 in the first quarter and is forecast to drop to $43.90 in the fourth quarter.

These price increases on the 1Mbx4 and the 1Mbx16 have had a dramatic effect on the much-watched crossover. The crossover shown in Figure 2 now occurs in the first half of 1996. The previous survey showed the crossover occurring in late 1995. To summarize, the new survey prices have pushed out the critical 1Mbx16 crossover to the first half of 1996.

Figure 2

1Mbx16 DRAM Crossover



Source: Dataquest (June 1995)

One more comment on the 1Mbx16: Because of the ongoing shortage of this part, some suppliers are seeing unanticipated high demand for the 4Mbx4 and the 2Mbx8 configuration. The 4Mbx4 can be used in 16MB SIMMs, and the 2Mbx8 is used in 8MB SIMMs.

SRAMs and Flash Memory

The final two parts to be covered are the SRAMs and the flash memory. The strong market for Pentium-class PCs is fueling demand for high-speed SRAMs used in cache memory applications. A very popular configuration is the 32Kx8, 15ns part. The pricing for this device is relatively flat at $4.00 for 1995. New suppliers here are helping to keep the price from going up. Also, there may be a market transition away from the 32Kx8 part by late 1995.

One last comment on the 32Kx8 SRAM: The 3V version of this part is in very short supply and is selling for $6.00. The next-generation part, the 128Kx8, is coming down in price as suppliers try to make this part attractive to large OEMs. The current price of the 128Kx8 is $18.31 in the 15ns version.

Flash memory prices are either increasing or firming up in the second half of 1995 and decreasing in the first half of 1996. The current second-quarter 1995 price for the 256Kx8 is $9.85, with a forecast price of $9.90 by the fourth quarter of 1995. The 512Kx8 or 4Mb sells for $11.30 in the second quarter of 1995, increasing to $12.30 by the fourth quarter of 1995. It is difficult to determine how long the current allocation situation will exist for the 2Mb and especially the 4Mb part. A key factor to monitor is the joint fab between AMD and Fujitsu known as FASL, which is ramping.

Thank you for your attention.
By Scott Hudson

SKS

Dataquest ALERT

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The Impact of Windows 95 on DRAM Demand

Dataquest's Semiconductor group analysts held the above-titled telebriefing on August 17, 1995. Dataquest's analysts that participated were Rob Enderle of the Client/Server Software Worldwide service; Ron Bohn of the Memories Worldwide service; Mark Giudici and Scott Hudson of the Semiconductor Procurement Worldwide Service; and Mario Morales of our Research Operations. This *Dataquest Alert* provides the opening statement and the figures and table used in the briefing.

Main Points

The telebriefing emphasized these key points:

- First, because of Windows 95 for the first time the new PC industry must confront the obsolescence of both its hardware and software.
- Second, for DRAM suppliers the introduction of Windows 95 is great news not only for the 1995-1996 period but for also for the rest of this decade.
- Third, because of Windows 95, PCs containing 16MB of DRAM will start to become common in both home and business markets during 1996. For the longer term, Windows 95 combined with Intel's Pentium/P6 ramp-up means that by the year 1997 10 percent or more of PCs will ship from the factory with 32MB of DRAM--a dramatic change versus the 1994 to 1995 period.

Dramatic Outlook for Windows 95

Windows 95 is finally arriving to a market that has been waiting for it for several years. Dataquest views Windows 95 as a significant step toward advancing today's software to take advantage of the enhancements in today's hardware.

Windows 95 marks the first time the new PC industry has had to face both the obsolescence of its hardware and software. Equipment that has been well out of date has at least been usable until now. With the advent of Windows 95, much of this equipment is now worth little more than the metals that make it up. Also, games and application providers will rapidly have to learn new skills to maintain and protect their customer base from competitors.

Although we have found upgrading to Windows 95 to be significantly less painful than any other significant operating system upgrade, there are some outstanding issues and precautions. A minimum of 8MB of memory is required and 16MB is preferred, along with Pentium performance, as 32-bit applications begin to pervade the market. Backward compatibility is strong, but obsolete hardware may not be supported by Windows 95. Testing is a requirement before installation of Windows 95, particularly in corporate environments.

Rapid Migration

Both in the home and in business, Microsoft's Windows 95 provides compelling reasons to drive a migration. At the very least it is a significant improvement over Windows 3.1, and can provide significant advantages for networked commercial desktop, mobile, and home environments.

Figure 1--which is titled"Actual and Projected Windows 95 Installed Base"--shows that Dataquest expects Windows 95 to move aggressively into the market with nearly 30 million units shipped by year-end 1995. Although initially this growth largely will be fueled by consumer demand, demand that is unprecedented for a software product, we expect it to move even more aggressively into the commercial market by the end of this year.

Microsoft's $150 million marketing program surrounding Windows 95 is unequaled. Microsoft will spend an estimated $100 million for direct marketing and an additional $50 million for channel development. Microsoft's Windows 95 budget compares to the entire budget for IBM's brand advertising--$100 million--and the estimated entire budget for Apple Computer's fourth quarter 1995 marketing--$60 million.

The total marketing dollars focused around Windows 95 by Microsoft and aligned vendors is estimated to $500 million to $750 million, which overwhelms the combined annual budgets of Apple Computer and IBM. This much money focused on a single calendar quarter and driven by a single product is unparalleled. We are likely to be overwhelmed with Windows 95 promotions in the fourth of quarter 1995. This should result in the most dramatic event to date in the history of PC marketing.

The enhancements for multimedia in Windows 95 target both home users and corporate users. Multimedia capabilities in Windows 95 provide a look into future PC games. Games such as "Fury Cubed," the first 32-bit game from Microsoft, have given us a view of just how dramatic this platform can be for home entertainment. Although some features are still lacking in the platform, such as native signal processing support and soft MPEG, the overall improvement of capabilities should be attractive to both consumer and corporate markets that need access to educational programs. For instance, there are a few game makers now writing games that will not run on machines with less than 16MB of memory.

Specific Windows enhancements in the product cover a range of areas, but none are more visible than those for mobile workers. Much of the pain of supporting mobile workers has been mitigated by Windows 95, and specific enhancements for corporate IS managers appear to have been well thought-out.

The Microsoft Network capabilities in Windows 95 are likely to bring a whole new group of users to the network, and the inclusion of an Internet Browser as standard with the product also should add significantly to the number of people using the Internet.

With the release there will be clear winners and losers in the fourth quarter. Intel, properly aligned PC hardware vendors such as Dell and Packard Bell, and software vendors such as Symantec will lead the winner's list. Compaq's matching campaign highlights its role in the development of and commitment to Windows 95.

We expect those companies positioning against both Intel and Microsoft to lead the loser's list. These companies will be followed closely by companies that have not adequately positioned themselves to take advantage of the launch, and these companies likely will lose market share to better-positioned competitors.

Windows 95 Implementation

Figure 2 is titled "Windows 95: Average Planned Implementation Versus Beta Tester Planned Implementation." This figure shows the results of separate surveys by Dataquest and Computerworld on Windows 95 implementation plans.

In early 1995 Dataquest surveyed 200 companies to determine their plans for implementing Windows 95 within a 12-month period. Recently Computerworld surveyed 100 beta sites to determine their respective plans for implementation over the same period. The Computerworld results shown in Figure 2 are more indicative of what most IS organizations will likely find when they begin testing the final Windows 95 version in the fourth quarter of 1995. This reflects a significant shift in perception between those that have the Windows 95 product and those that do not. This builds on our premise that Windows 95 is a substantial improvement over Windows 3.1 and a better general-use platform than Windows NT. Windows 95 can be justified on this improvement alone.

Competitively, Windows 95 embodies much of the advantages of OS/2, Mac OS, and, most important for existing applications and hardware, DOS/Windows 3.1. Although it has to make compromises in some areas, Dataquest testing has found it superior to anything else now on the market. Additional supporting tests were reported in the August publications of PC World and PC Computing. The PC World usability lab preferred Window 95 by a 5 to 1 ratio over OS/2 Warp. PC Computing's usability tests gave Windows 95 three-and-a-half stars. By contrast, it gave Windows for Workgroup's three stars and OS/2 Warp 3 two-and-a-half stars. Unfortunately the Mac OS is hampered by both the inability to run on standard hardware and a lack of native applications. Strangely enough Windows NT is the only perceived strong competitor to Windows 95 and will likely also enjoy strong growth in the fourth quarter of 1995.

To summarize our software outlook, Dataquest research has indicated that Windows 95 will be accepted at a rapid rate. The industry will likely look back at this event as one of the most significant in the history of PC and information technology. IS managers that have strong plans surrounding Windows 95 deployment will likely be praised, while IS managers that have put off dealing with Windows 95 are likely to find themselves in disfavor with their management. Hardware and software vendors that have strong programs to take advantage of Windows 95 will move past competitors that do not. Dataquest believes that a large number of dissatisfied Windows users will become both more satisfied and more productive on the new platform.

As it was with DOS and Windows 3.1, the landscape will never be the same after the Windows 95 launch, and there will be few that are not touched and changed in some way by this event.

Impact on DRAM Demand

A DRAM market shortage has existed since the end of 1992, and Dataquest expects this shortage to persist throughout 1996. From our perspective, Intel's Pentium and P6 ramp-up alone could drive long-term DRAM demand. Windows 95 now adds a second powerful long-term blast to DRAM demand.

Table 1--titled "Scenarios for Windows 95's Impact on DRAM Demand"--provides a structure for assessing the impacts of Windows 95 on DRAM demand for both the near term and through the 1997 to 1998 time frame.

The table assesses the impact (on DRAM demand) at both the PC factory and the so-called upgrade market. By memory upgrade market Dataquest means any postfactory installation of DRAMs.

Memory Upgrade versus Obsolescence

Regarding the memory upgrade market, Dataquest believes that Windows 95 will quickly render into obsolescence most PCs that contain just 4MB of DRAM. For example, many 486 PCs originally shipped in prior years with 4MB of DRAM and they still contain just 4MB. The owner's blunt choices are as follows--to install Windows 95 and upgrade to 8MB of DRAM, or remain at 4MB and forgo Windows 95. The latter choice--not upgrading--reflects both hardware and software obsolescence. Although there are always market laggards, Dataquest expects that most PCs will run Windows 95 using a minimum of 8MB of DRAM by mid-1996.

For this reason the memory upgrade market should be quite strong during the September to October 1995 time frame and also during early 1996. These periods could become "mega markets" in terms of memory upgrades because people drawn to retail stores by Microsoft's Windows 95 advertising campaign will buy other products as well. At a minimum, the memory upgrade market should be robust for the next six to nine months.

Table 1

Scenarios for Windows 95's Impact on DRAM Demand

DRAM Demand Source	Time Frame	Strong Impacts from Windows 95	Related Factors
Upgrade Market (postfactory installation)			
--All PCs	Sept.-Oct., 1995; Early 1996	4MB PCs must upgrade to 8MB	Alternative: PC obsolescence
--Desktop PCs	First half 1996	Some 8MB PCs will upgrade to 16MB or more	
From PC Factory			
--Desktop PCs	Second half 1995	Minimum: 8MB	32-bit PCs: Shifting to 16MB
--Notebooks	First half 1995	4MB PCs move to minimum of 8MBs	Via factory installation or upgrade
--Desktop PCs	Second half 1996	Minimum: 16MB?	
--Desktop PCs	1997	10 percent to 15 percent will ship with 32MB from the PC factory	Will help absorb 4Mbx4 supply

Source: Dataquest (August 1995)

Also, many PCs that ship this year with 8MB of DRAM will eventually upgrade to 16MB in part because of Windows 95.

More and More DRAM From the PC Factory

Regarding the amount of DRAM installed at the PC factory by the PC OEMs, the advent of Windows 95 already has started a near-term trend in which PCs must ship from the PC factory with a minimum of 8MB of DRAM. As of midyear 1995, most desktop PCs ship from the factory with 8MB. This trend toward the 8MB minimum should soon apply to notebooks PCs and become prevalent in this segment by mid-1996 or sooner.

Most major PC OEMs have long-term contracts with major DRAM suppliers, so the PC OEMs seem in good position to ship systems during 1995 and 1996 with at 8MB of DRAM, despite the current shortage.

Windows 95, however, might mean even stronger DRAM demand. Windows 95 could start a long-term trend in which PCs must ship from the PC factory with minimum of 16MB of DRAM. For example, Dataquest's Asian offices report that many 486 PCs and Macintoshes now ship with 16MB of DRAM--using the 4Mbx4 DRAM. By contrast, at year-end 1994, many 486 PCs shipped in the Asia region with just 4MB.

During the first half of 1996--in part because of Windows 95--PCs containing 16MB of DRAM will start to become common in both home and business markets. For example, the weekly advertisements at major PC retailers such as Circuit City now include several, somewhat higher-priced PCs that contained 16MB of DRAM. These ads certainly capture customers' attention. Next year at this time PC OEMs quite likely will be under market pressure to ship their PCs from their factory with a minimum of 16MB of DRAM. Because of DRAM pricing, PC OEMs might remain at a granularity of 8MB of DRAM for the second half 1996, but because of Windows 95 they will be under pressure to ship from the PC factory with 16MB.

More Bullish PC Forecast

D uring mid-July Dataquest revised upward the worldwide PC forecast, especially for the long term. The primary reason for the upward revision was a stronger outlook in the European and Asia/Pacific markets. The positive long-term outlook for Windows 95 was an important related factor.

The current Dataquest PC forecast shows that 58 million PCs will ship worldwide in 1995. This represents a 20 percent increase over the 1994 level. We still expect 26 million PCs to use Pentium-level MPUs during 1995. Dataquest expects worldwide PC unit shipments to increase by nearly 20 percent in 1996. The forecast in 1996 shows total PCs at 69 million units; 54 million of these PCs will contain a Pentium-level MPU during 1996. The worldwide forecast for 1997 is now 79 million PCs--which represents a 15 percent growth rate. We expect worldwide PC shipments to reach 107 million units during the year 1999. This increases our prior 1999 forecast--which was 100 million PCs--by 7 percent.

Also, there are board-level products that incorporate microprocessors and use DRAMs. These products include upgrade motherboards and industrial boards. In aggregate, worldwide shipments of these board-level products will total about 7 million units in 1995. For the 1996 to 1997 period, shipments of these boards should total about 8 million units per year.

A Major Event in PC DRAM History

Figure 3--which is titled"Worldwide PC and DRAM Growth Rates, 1984-1999"--illustrates the relationship between the worldwide growth rates in PC unit shipments and DRAM revenue. As the figure shows, historically any upturn or downturn in the PC market has had a pronounced effect on the DRAM market.

The figure includes notations that highlight other significant events that have had a strong impact on the DRAM market--which include Windows 3.1 earlier this decade and now Windows 95.

There are two striking things about Figure 3. First, the worldwide PC unit growth has been remarkably stable since the late 1980s. The annual PC unit growth rate has ranged from slightly more than 10 percent to slightly more than 20 percent during this period--and Dataquest expects a similar scenario for the rest of this decade.

Second, Figure 3 shows the tremendous historic volatility of the DRAM market. For example, during the 1980s the DRAM market went through an incredible sequence of upward spikes and downward plummets. In the context of DRAM history, the 1993 upward spike in the DRAM market shown in Figure 3 was impressive--but far less dramatic than what happened during the 1980s.

Going forward, what Figure 3 does not show is equally impressive. The figure shows that Dataquest expects no sharp downturn in the DRAM market for the rest of this decade. As Figure 3 shows, Dataquest expects a large amount of new DRAM capacity for the 1997 time frame. In the last DRAM telebriefing, we expressed concern about a potential large oversupply of 4Mbx4 DRAMs during 1997 in the very midst of a continuing shortage of wider-configuration DRAMs.

Windows 95 should trigger some relief for DRAM suppliers that plan to focus on the 4Mbx4 DRAM during the late 1996-to-1998 period. Windows 95 should help set the stage so that for the year 1997 10 percent or more of PCs will ship from the factory with 32MB of DRAM. This scenario assumes that the 4Mbx4 DRAM will be priced at less than $30 during the second half of 1997. In addition to paving the way to 32MB PCs, the August 24 rollout of Windows 95 should also ultimately set the stage for PCs that use 64MB of DRAM during the post-1997 period.

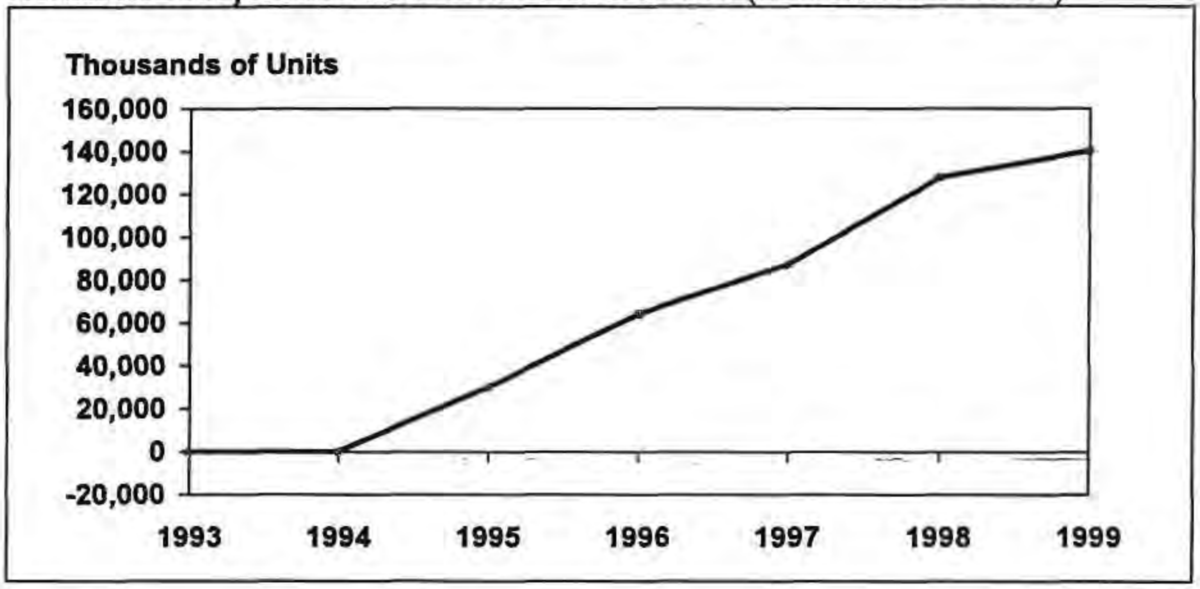
This leads to the last significant thing about Figure 3. The figure reflects Dataquest's expectation that the DRAM market will grow in a more stable fashion later this decade in part because of Windows 95. The DRAM market will remain more volatile than many markets. However, DRAM volatility should moderate later this decade versus the past 20 years of DRAM market history.

(That concluded the opening statement. A live question-and-answer session followed between the telebriefing audience and Dataquest analysts.)
Rob Enderle of Client/Server Software Worldwide service
Ronald Bohn of Memories Worldwide service
Mark Giudici, Scott Hudson of Semiconductor Procurement Worldwide service
Mario Morales of Research Operations

Note: For information on Dataquest's "DRAM Supply/Demand Quarterly Statistics," please call 800-419-DATA (800-419-3282).

Figure 1

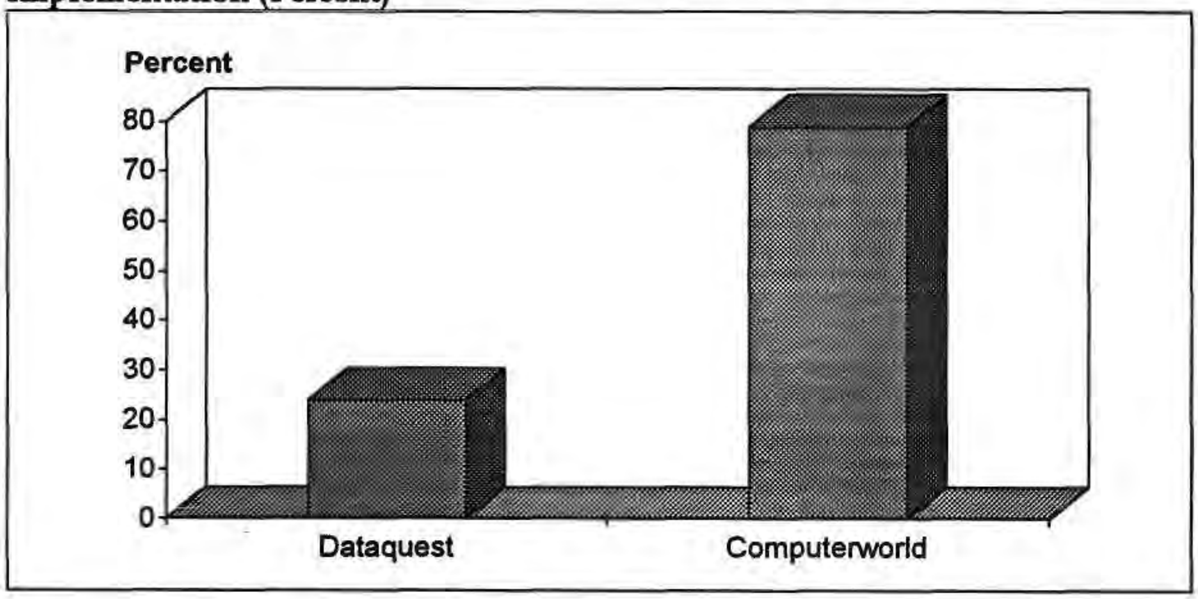
Actual and Projected Windows 95 Installed Base (Thousands of Units)



Source: Dataquest (August 1995)

Figure 2

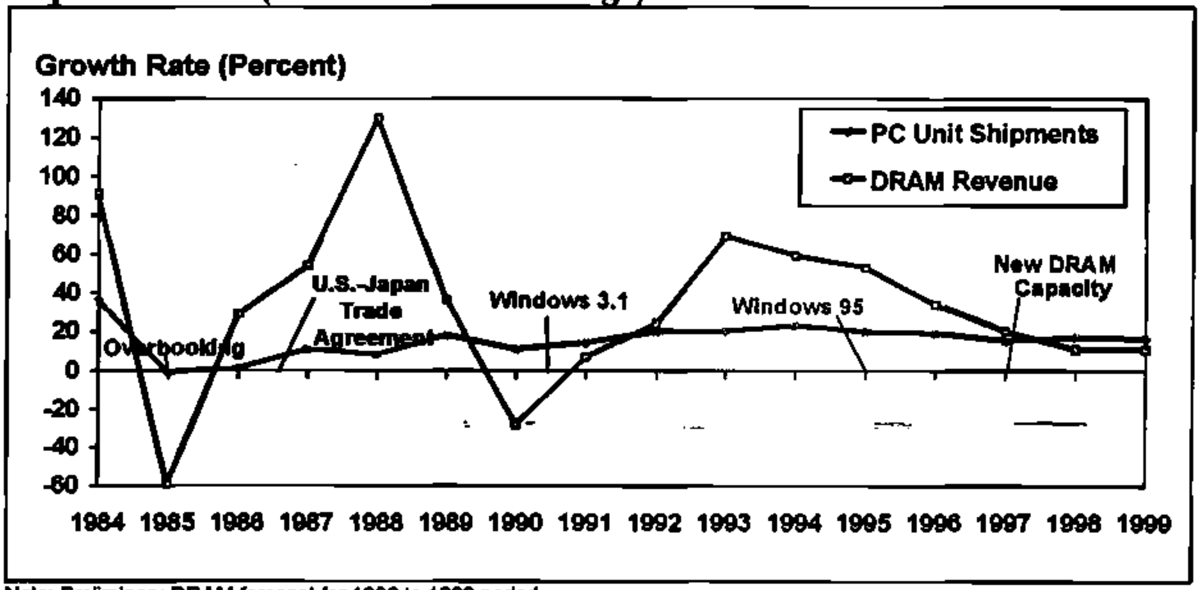
Windows 95: Average Planned Implementation Versus Beta Tester Planned Implementation (Percent)



Source: Dataquest (August 1995)

Figure 3

Windows 95: Average Planned Implementation Versus Beta Tester Planned Implementation (Growth Rate Percentage)



Note: Preliminary DRAM forecast for 1996 to 1999 period
Source: Dataquest (August 1995)

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Fourth Quarter Procurement Pulse: Orders Slow, Lead Times Slip, and Inventories Are Mixed

The *Procurement Pulse* is a quarterly update of critical issues and market trends based on surveys of semiconductor procurement managers in the North American region. Besides

Figure 1
Averaged Monthly Semiconductor Orders

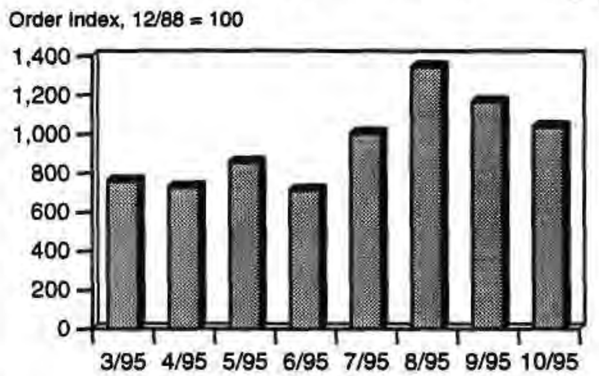


Figure 2
Averaged Semiconductor Lead Times

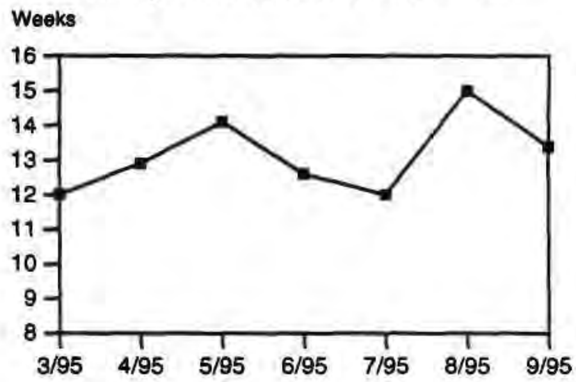


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

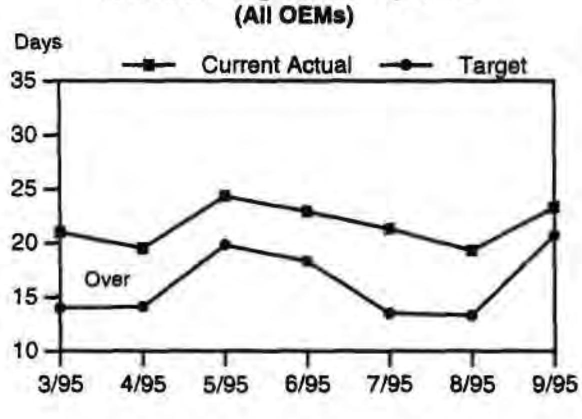
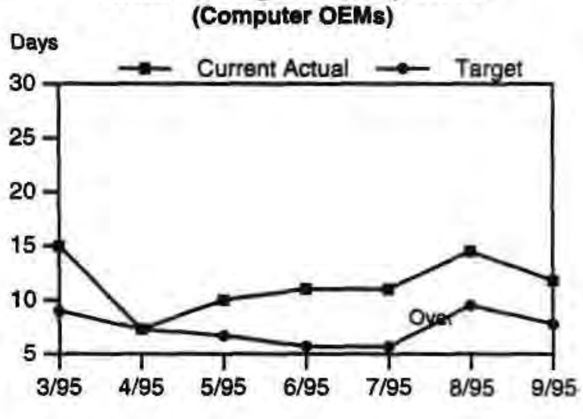


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



G2000304

Source: Dataquest (October 1995)

order rate, lead time, and inventory information, this survey also notes price status by semiconductor product family and package type, as well as key problems facing semiconductor users. This article explains what changes to these parameters mean in the current market.

Semiconductor Order Rates Forecast to Reach Record High

As shown in Figure 1, the estimated semiconductor order rates for October are expected to exceed 1,000 on the indexed scale of the graph. Semiconductor order activity continues to slow gradually despite continued strong demand for PCs, cellular, and peripheral equipment. Although the index levels for August, September, and October forecast slowing demand, the overall outlook for semiconductor order levels remains strong at least through the end of the year.

Respondents continue to note price increases for DRAM (over 2.6 percent), while standard logic and microprocessors show price declines of negative 0.3 percent and negative 3.6 percent, respectively. The thoroughly reviewed supply-demand imbalance of 1Mbx16 DRAM remains the primary cause of current price hikes. The computer subset of respondents noted average DRAM price increases of over 3.3 percent, highlighting once again where these parts are most often used. The standard logic market has come into balance, with manageable lead times and static pricing over the past three months. Overall MPU pricing remains on the decline as the trickle-down effect of Intel's Pentium price cuts continues to keep all products competitive (especially with the 486 supply).

Semiconductor Lead Times Rose and Now Ease A Bit

Figure 2 shows that after a summer of modulated lead times, peaking in August (15.0 weeks), September lead times declined to an average of 13.4 weeks. This by no means signals a turn to a buyer's market, but does show that supplies have improved somewhat for selected MPU, discrete, and SRAM parts. Allocation still remains the norm for most DRAM, flash memory, and SOT23 discrete products. The lack of discrete semiconductors continues to cause headaches for many users as searches through alternative channels force close scrutiny of discretes once considered only as afterthoughts in strategic planning. Most problem products are memory-related—DRAM, flash, and under-15ns SRAM, plus the perennial SOT23 discrete package.

Semiconductor Inventories under Control with Small Fluctuations

Figures 3 and 4 illustrate that despite strong demand, long lead times, and generally rising prices, inventory control (read: cost control) continues to rule the semiconductor procurement community. The overall targeted and actual semiconductor inventory levels for September were 20.7 and 23.3 days, respectively, compared with August's 13.3- and 19.3-day inventory levels. The computer subset is even more cost conscious, with current target and actual inventory levels of 7.7 and 11.8 days, compared with August inventory levels of 9.5 days targeted and 14.5 days on hand. By historical standards, semiconductor inventories are very controlled, which should ease fears that any end-use demand fluctuations could cause an abrupt decline in semiconductor sales.

Dataquest Perspective

Worldwide demand for electronics, and therefore semiconductors, remains strong despite some regional rumblings of oversupply and stock analysts' knee-jerk reaction that the sky is falling. (Dataquest's take: The Taiwan PC board market has had some perturbations because Intel has retained the lion's share of Pentium board business for itself and other key U.S. computer OEMs. The lack of Pentiums in Taiwan has had a temporary spillover effect on supplies of DRAM, SRAM, and other components tied to these boards in that demand has slipped and supplies are temporarily abundant. This additional supply will shortly be absorbed by astute regional buyers.) Dataquest expects worldwide demand to remain strong through 1996. Even with large increases in semiconductor fab capacity being brought online, the combination of lower-than-expected 1Mbx16 DRAM yields and higher-than-forecast demand for most end equipment continues to cause long lead times and firm IC prices. Until a break in either demand or 16Mb DRAM yield occurs, expect to see a continuation of the current market over the next 12 months. Continued vigilance over inventory levels and regular review of critical component suppliers is the best medicine for these times.

By Mark Giudici

Dataquest ALERT

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Procurement Pulse Flash

New Inputs Highlight Downward Trends in Expected Billings Activity; Lead Times, Inventories Rise Slightly

The *Procurement Pulse* is a quarterly update (with interval updates, if events warrant) of critical issues and market trends based on surveys of semiconductor procurement managers in the North American region. Besides order rate, lead time, and inventory information, this survey

Figure 1
Averaged Monthly Semiconductor Orders

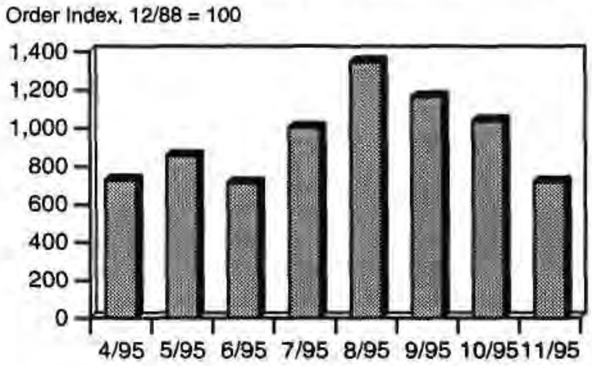


Figure 2
Averaged Semiconductor Lead Times

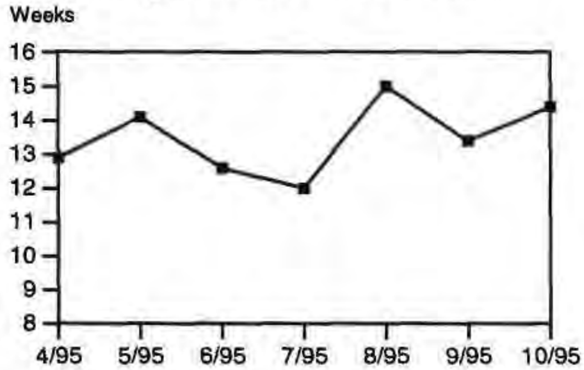


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

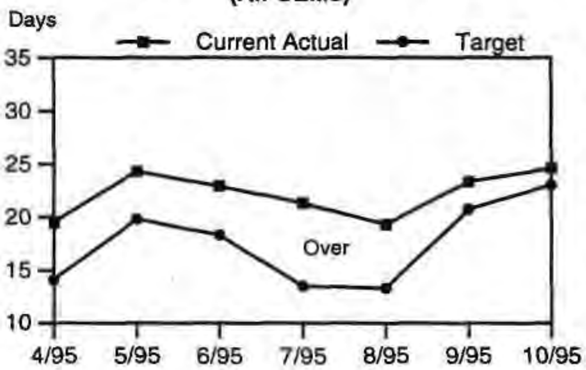
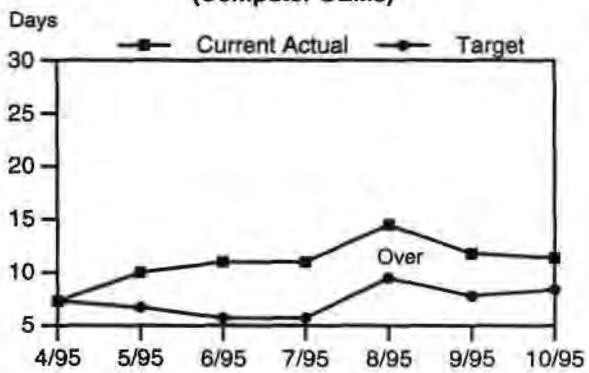


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



G2000304

Source: Dataquest (November 1995)

also notes price status by semiconductor product family and package type, as well as key problems facing semiconductor users.

This *Procurement Pulse* augments the standard quarterly update in light of Dataquest's latest survey, which drew a very large response rate, coupled with recent attention focused on the DRAM market-price situation.

Semiconductor Order Rates Expected to Slip for the Third Month in a Row

Figure 1 highlights a definite downward trend in average semiconductor order expectations for November, with the average index falling below the 1,000 mark for the first time since June of this year. Despite continued strong demand for PCs, cellular phones, and peripheral equipment, the level of semiconductor order activity appears to be declining, as reflected here and in the last two WSTS Semiconductor book-to-bill ratios. (See the *Semiconductor DQ Monday Report*, October 23, 1995, for the book-to-bill analysis.)

Another first is that all three product families (including DRAM) are expected to show price declines, ranging from negative 0.8 percent for DRAM to negative 1.9 percent for MPUs. Even with the ongoing supply-demand imbalance of 1Mbx16 DRAM, average DRAM prices are flattening out for this survey sample. This situation is also noted in our monthly *DQ Monday* pricing survey of suppliers and users (see the *Semiconductor DQ Monday Report*, November 20, 1995), which shows that average DRAM price ranges have fallen between 1 and 4 percent since September. Standard logic pricing continues to decline slowly; the supply-demand pendulum remains in the buyers' camp because additional capacity has temporarily overshot demand in the more mature product families. MPU pricing also remains on a negative slope because capacity is abundant and Intel's one-month-early Pentium price cut in October continues to ripple its way to competing processors.

Yet Semiconductor Lead Times Firm Up

Although order rates are expected to dip, the average lead time, as seen in Figure 2, increased slightly in October to 14.4 weeks compared with September's average 13.4-week level. The current uptick reflects a very wide range of average lead-time inputs, from five to 26 weeks for October compared with September's range of eight to 20 weeks. The main culprits in lengthening lead time remain 1Mbx16 DRAM, flash memory, EPROM, tantalum capacitors, and all SOT23 packaged parts. Also noted as problem products were linear/opto devices and selected MPUs. Allocation remains a given for 16Mb DRAM (all organizations), fast SRAM, and flash memory.

Overall Semiconductor Inventories Rise While Computer Companies Stabilize

Figures 3 and 4 show that the overall inventory level of on-hand semiconductors has continued to rise gradually, while the subset of computer company respondents continues to keep a close watch on tangible costs. The overall targeted and actual semiconductor inventory levels for October were 23.1 and 24.7 days, respectively, compared with September levels of 20.1 and 23.3 days. The computer subset remained relatively unchanged, with October targeted and actual levels of 8.4 and 11.4 days compared with September levels of 7.8 and 11.8 days. In historical terms, inventories are under control, and the continued upward trend in actual levels should soon be corrected, if the past is any guide. The slowdown in order activity noted may be a near-term remedy for inventory level control

Dataquest Perspective

Overall demand for electronics—PCs, telecommunications equipment, consumer products, or others—continues to push semiconductor suppliers to the maximum. The regional softness in the Taiwanese motherboard market has not migrated beyond Taiwan, yet the rumors of an impending soft market keep fleet-footed (but often short-sighted) stock analysts busy in their portfolio adjustment recommendations. All of this adds turmoil to a normally dynamic year-end market, which is a major reason why stock price movements have been erratic lately. Dataquest believes that the worldwide demand for electronics, and therefore semiconductors, will remain strong through 1996, even with the planned additional memory and MPU capacity that will come on line by next summer. Unless an unforeseen decline in end-user electronics occurs, expect to see much of the same supply-demand situation for DRAM, SRAM, flash memory, and high-end MPUs for the next 12 months.
By Mark Giudici

Dataquest

Perspective

Semiconductor Procurement Worldwide

Telebriefing

Will Cache and Flash Stay Hot in 1996?

Abstract: *Dataquest expects strong growth in the cache and flash memory markets. This report is based on a recent telebriefing and includes the telebriefing's question and answer session.*

By Ron Bohn, Jim Handy, Mark Giudici, and Scott Hudson

Dataquest's Semiconductor group analysts held a telebriefing on November 10, 1995. Dataquest analysts who participated were Mark Giudici and Scott Hudson of the Semiconductor Procurement Worldwide program, Dale Ford and Mark Gaare of the Semiconductor Applications Markets Worldwide program, and Ronald Bohn and Jim Handy of the Memories Worldwide program. This article provides the opening statement and several tables used in the briefing, plus a transcript of the key portions of the telebriefing's question and answer session.

Key Points

Dataquest expects the cache RAM and flash markets to remain hot during 1996 but for differing reasons. This telebriefing emphasized the following main points:

- First, the PC market migration to the Pentium processor's 64-bit bus has started to drive system manufacturers to use new cache RAM technologies. A key issue to monitor will be whether the supply of 32Kx32 synchronous burst cache RAM will meet demand in a timely fashion in 1996 and 1997.

Dataquest

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- Second, the uncertainty about the ramp-up of this 32Kx32 part stems from several factors, including the fact that most suppliers are still unfamiliar with wide-configuration devices. Despite Intel's effort to provide guidance to cache RAM suppliers as to how many 32Kx32 units will be required for the next several quarters, Intel cannot control how many 32Kx32 parts will actually be built by the suppliers.
- Third, in the flash market, flash memory will remain in a shortage throughout 1996, driven by demand from a wide range of applications, including communications, computing, transportation, and consumer electronics. By 1997, a large increase in flash capacity should restore supply-demand balance in the flash market.

PC Forecast

Before discussing cache RAMs, the analysts reviewed Dataquest's PC forecast. The current Dataquest PC forecast shows that 58 million PCs will ship worldwide in 1995. For 1996, Dataquest expects worldwide PC unit shipments to increase by nearly 20 percent. The 1996 forecast shows total PCs at 69 million units. The worldwide forecast for 1997 is now 79 million PCs.

Dataquest expects that 26 million PCs will use Pentium-class MPUs in 1995. Pentium-class processors include Pentium processors and other 586 processors as well as Pentium Pro and other 686 processors. During 1996, 54 million PCs will contain Pentium-class MPUs in 1995. By 1997, more than 70 million Pentium-class PCs will ship worldwide.

Vibrant Cache RAM Outlook

Dataquest views the SRAM market as a large market broken into three main segments: slow SRAM, PC cache, and high-end SRAM. The slow SRAM market is the largest and is expected to account for $2.6 billion of a total 1995 SRAM market of $5.8 billion. Second is the PC cache market. The smallest portion is the higher-priced SRAM versions at the high-performance end of the spectrum.

The 1Mb cache RAM market should vault into prominence during 1996. We just issued a new *Worldwide MOS Memory Forecast* (MMRY-WW-MS-9504, October 30, 1995) that covers the period from 1994 through 1999. This forecast shows that revenue for 1Mb cache RAM will increase from less than $1.4 billion in 1995 to $2.1 billion in 1996. This translates to a healthy 50 percent-plus growth rate for 1996.

Probably the most closely scrutinized portion of the SRAM market is the cache market. The big questions participants in this market have today are as follows:

- What will PCs use as cache memory in the next year and in the next several years?
- What will be the effect of the switch from the Pentium to the Pentium Pro?
- How can SRAM suppliers make sure that they do not rely too heavily on what might become on an oversupplied part?
- What must system vendors do to assure that they will have adequate supply?

32Kx32 Transition

Nothing drives cache like the advent of a new processor. PC purchasers appear to rationalize the need for cache by the fact that they are on the leading edge: If they are paying top dollar for the highest-performance CPU they can get, they had better buy a cache to avoid suffocating the expensive processor with a too-slow main memory. Add to this Intel's new thrust to replace existing processors with the next generation on a two-year rhythm rather than the older three-to-four-year cycle and you have a rapidly expanding PC cache market. This happened with the Pentium ramp, and the effect on the SRAM market is that there was no summer-season oversupply of SRAMs in Taiwan in 1995 as there had been in 1992, 1993, and 1994.

Pentiums PCs now use the 32Kx8 SRAM, in part because it is readily available at a reasonable price. Table 1, which lists the wide 1Mb SRAM offerings of several SRAM vendors, shows that many of these companies are gearing up to produce a 32Kx32 bursting pipelined synchronous cache device. The main reason for this is that Intel is pushing hard to make this the most widely used cache SRAM in Pentium systems. Intel is reported to be asking for more than 90 million of these in 1996, a number that would support over 85 percent of all Pentium-class systems sold.

Table 1
Wide Cache SRAM Sourcing

	16Kx16 Synchronous	32Kx18, 64Kx18 Synchronous Burst	32Kx32, 32Kx36 Synchronous Burst
Alliance			X
Cypress			X
Fujitsu			X
Hitachi			X
IBM		X	X
IC Works		X	
IDT			X
ISSI			X
Micron	X	X	X
Mitsubishi			X
Motorola	X	X	
NEC		X	X
Paradigm		X	
Samsung		X	X
SGS-Thomson			X
Sharp	X		X
Sony			X
Toshiba			X

Source: Dataquest (November 1995)

More than 16 SRAM companies have announced plans to support this part in one way or another. Samsung has announced that it plans to make 50 percent of all parts used. Sony has announced that it will build 1 million a month, starting in January. Micron is already making about 1 million units per quarter of the higher-priced version, a 32Kx36 that supports parity. Other manufacturers are keeping their projected run rates quiet, but if they are all able to ramp at the aggressive rates they have set their sights on, there should be a dramatic oversupply in the very near future.

Based on 1994 worldwide unit shipments, leading suppliers of fast 32Kx8 SRAM include (in ascending order) Winbond, Integrated Device Technology, Alliance Semiconductor, Cypress Semiconductor, and Motorola.

Dataquest also noted that there has been a continuing shortage of 3V cache RAM. We believe 3V cache RAM will remain in tight supply well into next year.

Potential 1996 Outcomes for 32Kx32

Table 2 shows that there appear to be three possible outcomes to this race. These three outcomes are not intended as a forecast but rather to provide an analytical framework for tracking this emerging technology.

Table 2
Synchronous Burst 32Kx32 Cache RAM Market Possibilities

Outcome	Potential Winners	Potential Losers	Related Factors
No. 1: "Timely" 1996 ramp-up	Early suppliers of synchronous burst 32Kx32 cache; suppliers with small 32Kx32 die size	Suppliers who over-commit to asynchronous 32Kx8 cache	1996 Pentium PC unit growth rate
No. 2: Supply ramps up much faster than demand	Suppliers committed to a broad range of SRAM types	Suppliers too narrowly focused on synchronous burst 32Kx32 cache	In which quarter of 1996 will 32Kx32 cache demand take a step function upward?
No. 3: Supply ramps up much more slowly than demand	Suppliers committed to asynchronous 32Kx8 cache, asynchronous 128Kx8 cache; early suppliers of synchronous burst 32Kx32 cache, until purchasers tire of limited supply	System OEMs who are unable to secure sufficient supply	Some suppliers of synchronous 1Mb cache market will focus on the 64Kx16/18 configuration

Source: Dataquest (November 1995)

The first possible outcome shown on Table 3 is that SRAM vendors will ramp at an acceptable rate to meet Intel's needs and that the 32Kx32 will quickly become a success story.

Table 3
Leading Suppliers of Flash Memory
(Based on 1994 Worldwide Revenue)

1994 Rank	Supplier	1994 Market Share (%)
1	Intel	50.9
2	Advanced Micro Devices	23.8
3	Atmel	7.4
4	Toshiba	5.7
5	SGS-Thomson	4.1
6	Fujitsu	1.6
7	Sharp	1.2
8	Catalyst	1.1
9	Mitsubishi	1.1
10	Texas Instruments	0.8
	Others	2.4

Source: Dataquest (November 1995)

The second possible outcome is that all 16 vendors will ramp the market into a very severe oversupply. Massive losses would be sustained as the price of the 32Kx32 SRAM dropped to well below $10.

The third possible outcome is that SRAM vendors, despite their aggressive ramp-up plans, will stumble. If they stumble badly, there will be a serious undersupply of the 32Kx32, which, if it lasted long enough, would cause Intel to look for other cache solutions to support the Pentium processor. From our perspective, should Intel drop the 32Kx32 SRAM it is unlikely that it would go back to this part.

In the first two possibilities—the oversupply outcome and the satisfactory ramp-up outcome—the cache of choice for 1996 would become the 32Kx32. In the third scenario—the undersupply—the 32Kx8 SRAM would maintain its current lead as the preferred PC cache component, with the 128Kx8 SRAM being the likely contender for 1997. Although top-level indications point to a 1996 oversupply of the 32Kx32 device, most vendors for this part have no experience in mass-producing synchronous 1Mb SRAMs, either because they do not have a production 1Mb process, or because they have never supported mass production of a synchronous product.

Note that none of the three potential outcomes counts on any decline in the PC market. Dataquest believes that the current strength of the PC market is sustainable for 1996 as well as the long term.

The next question is the effect of Intel's new Pentium Pro processor. Although the only version of the Pentium Pro that Intel has revealed to the general public uses a dual-cavity package with a multichip module approach, Dataquest believes that this is an interim approach, aimed solely at the high end. It is our understanding that a second version of the Pentium Pro will be used to support the desktop PC and that this version will use a dedicated cache bus to communicate with two upgraded 32Kx32 SRAMs. These devices are reported to run using a 2.5V version of the standard TTL interface and will need to meet tighter timing specifications than current versions of the 32Kx32.

Dataquest believes that this is why Intel is pushing so hard for widespread sourcing of today's 32Kx32. If Intel can help cultivate a ready supply of these parts, then the transition to the Pentium Pro follow-on SRAM—a 32Kx32 device—will run far more smoothly. The 32Kx32 SRAM would enable Intel to avoid the more expensive dual-cavity package. In other words, Dataquest believes that the Pentium Pro is already having a profound effect on the direction of SRAM suppliers. From our perspective, Intel needs the support of several strong SRAM vendors to cost-reduce future versions of its Pentium Pro. This need is driving Intel to create a 32Kx32 SRAM market for the Pentium PC.

So what should the cache RAM suppliers do? Specifically, how can cache RAM suppliers partake of this market without being caught in an oversupply? The only answer is to diversify. No matter how many of the 32Kx32 SRAMs sell, it will continue to be a good policy to maintain a share of the more standard business, that of the 32Kx8 and/or the 128Kx8 products. These devices should continue to be used in volume in non-PC applications like digital cellular phones, LAN cards, and modems. By keeping an interest in different parts for different markets, the supplier can respond more quickly to adverse pricing or an oversupply in the 32Kx32 SRAM market.

What should SRAM purchasers expect? They can look forward to a lot of 1996 competition in the 32Kx32 market. They should also monitor the 32Kx8 cache market. We do not anticipate any further tightening of the 32Kx8 market by vendors that would shift capacity to the 32Kx32. Although there is heightened interest in the 32Kx32, Dataquest believes that those vendors unwilling to continue to support the fast 32Kx8 have already gotten out of this market. The fab switch has been made by most suppliers.

Our key recommendation is that PC OEMs wanting to provide the best cache solution at the lowest cost should seriously consider using cache modules with an approach that supports both asynchronous and synchronous parts. The year 1996 will be a bad time to try to support caches that are soldered onto the main board. Synchronous/asynchronous cache modules have already been standardized, so the answer already exists and is simply waiting to be used.

The PC cache market is always changing. Dataquest sees a rapid swing from the 32Kx8 to the 32Kx32, driven by the needs of both the Pentium and the Pentium Pro. We believe that successful manufacturers and successful users will watch the market extremely closely and will position themselves to facilitate a quick response to any changes in the market.

1996 Flash Shortage

Worldwide flash memory revenue will reach or exceed $1.5 billion for 1995, which is a 50 percent increase over 1994. Flash memory revenue for 1996 will increase by 40 percent to exceed $2 billion. We expect worldwide flash revenue to increase by another 40 percent during 1997.

Table 3 shows the world's leading suppliers of flash memory in 1994.

Table 3 shows that Intel and Advanced Micro Devices (AMD) rank as the world's leading suppliers, by far. Several other companies, however, are also strongly committed to flash technology. By the end of 1995, we expect that more companies will become new members of what we will call the $100 million flash club. These suppliers include Atmel, Fujitsu, and Toshiba. Also, recently, Mitsubishi and Hitachi announced 16Mb 3V-only flash products that they will second-source. Meanwhile, SGS-Thomson has a strong long-term commitment to EPROM technology but also has a very active flash memory program. A host of other suppliers, such as Texas Instruments, Macronix, and others, have also announced flash memory strategies.

PCs, Wireless Drive Flash Market

A wide range of applications propels the flash market's growth. Applications range from desktop PCs and rigid disk drives to memory cards, cellular phones, and network devices. The mainstream densities are 1Mb, 2Mb, and 4Mb, followed by the 8Mb.

Our main observation regarding flash's role in PC applications is that, during 1995, flash has emerged as the technology of choice for the PC BIOS. During 1995, our teardowns of Pentium PCs have shown that the Pentium market is shifting to the use of flash for the BIOS. The emergence of plug-and-play PCs and the increased need for PC diagnostics to support home PC users contribute to flash's growth in the PC market.

Wireless communication and other mobile applications are driving the flash market to 3V technology. During 1995, worldwide unit shipments of cellular and related broadband Personal Communications Services (PCS) systems will total about 40 million units. By 1997, shipments will reach 65 million units. Low-voltage flash memory will compete against high-density low-voltage EEPROM technology in these markets. Worldwide unit shipments of digital cellular phones will be just over 10 million units during 1995 but will approach 40 million units by 1997. Not only will the digital cellular market expand, but the amount of flash used in cellular phones also can be expected to increase. Also, low-voltage flash is well suited to other wireless communication applications like Japan's Personal Handyphone System (PHS).

Dataquest expects that the current flash memory shortage will persist throughout most of 1996. The AMD-Fujitsu alliance and the Intel-Sharp team are increasing capacity; however, demand for flash will continue to outstrip supply for the next year. In the flash market, 1997 should be a transitional period. A lot of new capacity will become available—and a host of higher-density flash applications should start to emerge—with a supply-demand balance likely in 1997.

Telebriefing Questions and Answers

Dataquest analysts then answered audience questions.

Q: Could you share with us your quarterly pricing expectations in 1996 for the 32Kx32 as well as the 32Kx8, 3.3V?

MG (Mark Giudici): Right now we are conducting our quarterly survey. The preliminary price points we have for the 15ns 3.3V 32Kx32 indicate a first-quarter 1996 price of $27, going down very gradually by the fourth quarter of 1996 to $24. This is our current forecast; however, we do expect pricing to come down as the supplies increase over the first half of 1996. For 32Kx8 SRAM 3.3V pricing, on a preliminary basis, we expect a mild price decrease—from $4.60 for the fourth quarter of 1995 to $4.45 for late 1996.

RB (Ron Bohn): I would like to add something about the 32Kx32. Jim Handy and I have been talking a lot to the major suppliers. They are looking at the third quarter of next year as being sort of a potential time for a step function down-pricing of that device.

Q: What do you think of comments regarding a weak 32Kx8 pricing in Taiwan over the last few months?

RB: Jim Handy will probably have additional comments about this. Historically, we do not always view what happens in the Taiwan market as the best indicator of what happens in terms of North American contract-volume pricing. Taiwan does serve as an indicator, but our perspective is that the Taiwanese market had overheated. Pricing was much higher, extremely high over the past several years, than in other world regions. When suddenly the PC motherboard business started to shift away this year, the whole Taiwanese market went into a panic. It looks as if there is no demand there, or very little demand, so the pricing has tumbled to the other extreme. We do have an office in Taiwan, so we are really on top of this. We also have offices in Hong Kong, Japan, Korea, and Singapore. We do not always find what happens in Taiwan to be the best indicator of what will happen worldwide in fast SRAM markets, such as the North American market.

JH (Jim Handy): I will add something to that. You have to realize that Taiwan does march to the beat of a different drummer. It has a bunch of motherboard manufacturers whose business declined from Intel's entry into the motherboard business. Those motherboard manufacturers likely are among the lowest-ranked on Intel's allocation list. The manufacturers are not getting a whole lot of Pentiums. Pentiums are where the caches are going. Taiwanese motherboard manufacturers tend to use a different part because they can get it cheaper, so Taiwanese suppliers build those parts for Taiwanese motherboard manufacturers. This is a mixed-voltage 32Kx8 in which the power supply is 5V with the I/O pins guaranteed not to go high enough to burn out the Pentium's data input pins. North American manufacturers are quite reluctant to use a part like that, so they pay a premium to use a straight 3V part. When the Taiwanese market goes away for the mixed 32Kx8 part, there is no replacement market anywhere in the world for it. That part is really having the pricing catastrophe right now.

Q: I would like to know your projected production volume for 32Kx32 in 1996.

JH: The way that we forecast is by density more than by organization, so we do not have a set number on that. We believe the 1995 supply will total fewer than 4 million units. Starting with the 90 million units that we estimate Intel is targeting for 1996—which breaks down to 8 million units a month—we look at what we believe are suppliers' production capabilities. In the early part of next year, it likely will be on the order of 3 million to 4 million units per month. To ramp up to 3 million to 4 million units per month is a pretty aggressive ramp. Assuming a successful aggressive ramp-up—which remains uncertain—more than 10 million units might be built each month toward the end of 1996. If that does happen, that will cause the potential oversupply that I mentioned in the early part of the telebriefing.

Q: You mentioned earlier that, in 1996, the use of discrete components for cache might not be the best approach. You suggested modules might be a better solution than discrete SRAMs. Can you clarify this a little more?

JH: We are allowing for a level of uncertainty as to what is going to happen in the market. We sense there is going to be a pretty sudden transition away from the 32Kx8 to the 32Kx32. The precise timing of this transition is going to be a bit hard to call. Many suppliers who are professing to manufacture the 32Kx32 have never made a synchronous part in volume before. Some of the companies have never made a 1Mb density SRAM in volume before. So these are real uncertainties about the sources of supply.

You should position yourself to switch from the 32Kx8 to the 32Kx32 pretty rapidly once it becomes established in volume. However, it would not be too surprising if the volume picked up and then dropped off. Or that the supply and demand balance became a 32Kx32 oversupply and then became an undersupply—and then become an oversupply again. Rapid ramps like that tend to be somewhat unstable. In that case, you do not want to have a motherboard that counts on 32Kx8 and a different motherboard that counts on 32Kx32. You will never know how many of which blank of motherboard you will need to have in inventory at any one time. The way you can get around that is by using cache modules where the specifications will allow you to use either 32Kx8 or 32Kx32 devices on the cache module. There is that support for this. There is a standard SIMM specification that allows you to unplug an asynchronous module and plug in a synchronous module.

RB: By contrast, in the DRAM market, interchanging modules for asynchronous parts and synchronous parts still lack a standard. That is an action for which the market waits. What Jim Handy highlights is that, in the cache RAM market, there is a solution that is available already to manage the uncertainty as you make the transition next year.

Q: What do you think the percentage of PCs will be to use modules instead of discretes for cache?

JH: Most of them. What we see happening is that Intel is seeking to support 85 percent of Pentium PCs with cache. That percentage is kind of out of line with what is going on in the cache market right now. We know that, in 1994, 40 percent or fewer of all PCs contained caches, even though there were sockets for them in almost all PCs. We anticipate this year that the number is probably still under 60 percent, but for the number to climb to 85 percent in 1996 is still a pretty steep climb. We believe that what is going to happen instead is that nearly all PCs will have cache module sockets on them. However, probably somewhere on the order of 50 percent will actually ship with cache.

Q: This question is regarding flash. What do you see as pricing trends going from now through 1996 for the 2Mb, 4Mb, and 8Mb densities?

MG: Our survey is still in process. We start at our preliminary estimates for the 12V 256Kx8 product: Starting at the fourth quarter of 1995, the range runs from $9 to $10.50. For the first quarter of 1996, we expect a $10 price, declining gradually to $9.50 by the fourth quarter of 1996. These are relatively stable price points, reflective of the tight marketplace. The 5V-only part generally takes about a 50 cent-to-75 cent premium over the prices that I just gave.

Let us look at the 512Kx8 devices, starting with the 5V 4Mb part in the TSOP package. For the fourth quarter of 1995, the $16.50 price will stay flat into the first quarter of 1996 because of the tight market. By the third quarter of 1995, pricing could decline somewhat to $15.50. If you look at the 8Mb device, there is not much differential in price there because the 4Mb part is in such high demand now. The 8Mb device currently sells for $18 on some contract-volume orders. For the first quarter of 1996, the price might become $17. We expect more ample supply of 8Mb flash for next year.

Q: I think you mentioned that 60 percent of the PC systems in 1995 shipped with cache. Is that the right number?

JH: It was less than 60 percent.

Q: What was the percentage within the Pentium-system class?

JH: It would have been higher than that. We do not have an official 1995 statistic. This is kind of a raw estimate. We anticipate that a very high percentage of Pentium systems used caches this year, probably on the order of 80 percent.

Q: Would you expect that percentage to change within Pentium systems? It sounds like you think it is going to be coming down.

JH: Yes. When the Pentium represents a higher-priced processor, the cache becomes more cost-justified. As I said in the opening statement, new, high-priced processors justify a few extra dollars to make sure that that very expensive processor does not become throttled by a slow memory. The price of the Pentium continues to come down, so it finds itself in lower-priced systems. Then you are going to enter the realm of more cost-conscious buyers who are less willing to spend extra money to get the extra processor performance.

Q: Are you thinking that synchronous DRAM or burst EDO or any of these other main memory architectures are going to have an impact here? Or is that just kind of flavored into the whole?

JH: We actually pulled a part of the opening statement because it got too long. New technologies like synchronous DRAM and burst EDO will have a role in unified memory architecture (UMA) systems. UMAs will aim at the very low end of the PC spectrum—the very cost-conscious buyer. UMA ends up having severe bus conflicts between the processor and the graphics controller. There is a high likelihood that people will employ more cache in the cheaper UMA system to achieve more performance out of the cheaper system—rather than to use less cache. So we actually see synchronous DRAMs being used in a higher percentage of systems with cache (versus systems that use standard EDO).

Q: You mentioned that your PC forecast for next year is about 69 million units, and about 60 percent will be using cache. How does that square with Intel's pushing for 90 million units of SRAM next year?

JH: First of all, I believe that the 60 percent we were talking about was Pentium-class. So you are talking about 60 percent of 55 million units. Now 90 million SRAMs would cover 45 million PCs. That is a whole lot more than 60 percent of the 55 million Pentium-class PCs. So we do believe that manufacturers are being asked to build an abundance of these parts.

RB: I just want to point out a definition. Dataquest has a rather conservative definition of a PC. We define a PC as being a fully assembled box received by the end user. By contrast, some microprocessor and other semiconductor companies have another definition that is a little bit broader. The broader definition includes board-level products (industrial boards, upgrade motherboards). If you take Dataquest's total PC number for this year or 1996, you can add another 10 percent to 15 percent to our PC unit forecast. This provides you with some semiconductor companies' measurement of the PC total market. This is an important point of definition.

Q: Two questions on the flash market. You say that 1996 demand will outstrip supply. What is your percentage of how much more demand than supply? Second question: Do you see more acceptance of the Intel SmartVoltage design versus the AMD 5V design?

RB: I will begin by answering the second question. Predicting the outcome of the marketing war between AMD and Intel is sort of impossible. Intel's position is that they have certain major customers with whom they work closely regarding SmartVoltage. Intel is very supportive and service-oriented and pleased with its position with these customers. Now, AMD has quite an aggressive push for the 5V-only technology. The way we look at it, AMD and Intel are by far the market leaders. Both supply the NOR technology that is the lower-density de facto standard. We do not have a forecast, however, of AMD's 5V-only technology versus Intel's SmartVoltage.

Regarding the first question about the detailed supply/demand, we are adjusting our forecast because we have an application analysis that looks into that. We just changed our forecast on flash, and we are incorporating that information at this time for later publication.

Q: Regarding the flash configurations you mentioned for pricing, were they also the ones you see to be the industry sweet spots for 1996 to 1997?

MG: Yes. The x8 configuration in the TSOP package is the basic device, whether it be 1Mb, or 4Mb, or 2Mb, or 8Mb. The x8 configuration seems to be where the flash market is going. The TSOP package is fast becoming the standard package type for this part, too.

RB: Next year, you would expect a stronger market to emerge for the 16Mb density. So, in 1997, the 16Mb part should become important for higher-density applications. We continue to see the low-density flash, whether it is 1Mb, 2Mb, or 4Mb densities, having market vitality for the next couple of years. You should continue to monitor these parts well into 1997 or even 1998.

(This ended the telebriefing.)

Qty: 1

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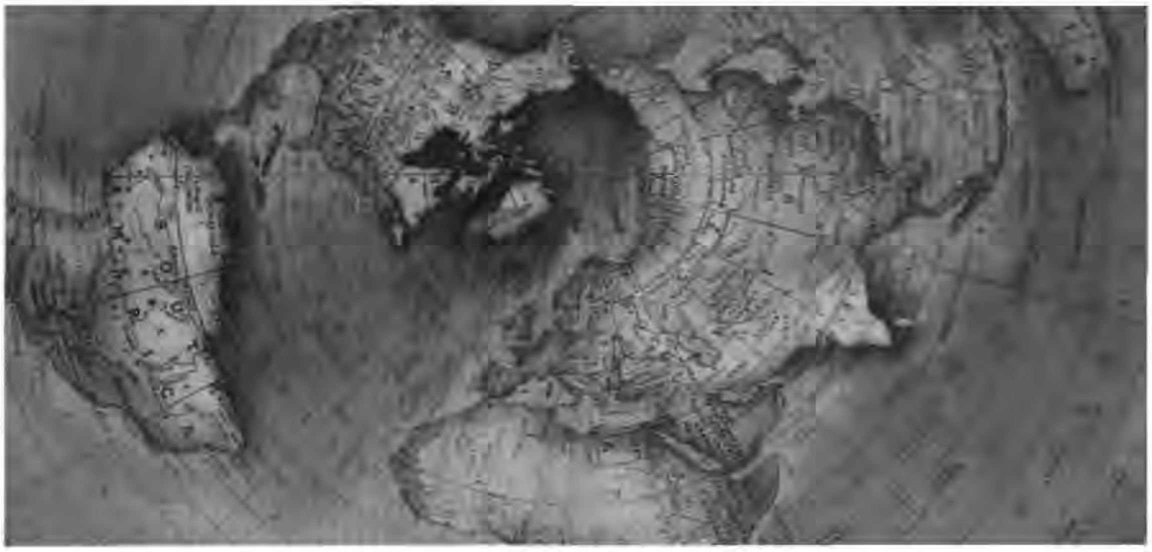
Perspective



Semiconductor Procurement Worldwide

Briefing

Midyear Semiconductor Price Forecast: Which Prices Will Decline, and When?

Abstract: *The results of the third-quarter semiconductor pricing survey were discussed in a teleconference held June 2, 1995, by the Semiconductor Procurement Worldwide service and Memories Worldwide service. This survey shows DRAM device pricing to be either firming up or increasing through the second half of 1995, with price decreases beginning in the first half of 1996. Certain other memories, for example, the 1Mb and 4Mb flash and the fast 32Kx8 SRAM, also are in short supply and now can demand a price premium. Microprocessors, particularly the Pentium-class devices, will see significant quarterly price decreases through 1996. This article is a transcript of highlights of that teleconference.*
By Scott Hudson

Midyear Semiconductor Forecast Highlights

Hello and good morning. This is Scott Hudson of the Semiconductor Procurement Worldwide service. This telebriefing will cover the highlights of the Dataquest midyear semiconductor forecast, which addresses the issue of which prices will decline, and when. After an opening statement, we will take questions from the audience. Those with questions will be identified with a number. Please do not give out your name when asking questions. We are not recording this briefing.

First let me introduce the participants. In the room are Mark Giudici, principal analyst of the Semiconductor Procurement Worldwide service, and Jim Handy and Ron Bohn of the Memories Worldwide service.

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Before going into the market overview and the details of the pricing survey, some critical economic assumptions need to be mentioned:

- Despite all the negative economic news, Dataquest expects the electronics industry to remain strong.
- Worldwide PC demand, which drives the semiconductor business, will be strong through the 1995 to 1996 time frame.
- Fab capacity will continue to come onstream but will not have a big market impact until early to mid-1996. For example, the critical 1Mbx16 DRAM will continue to be in a shortage situation throughout 1996, despite the tremendous ongoing buildup in fab capacity.
- Dataquest pricing reflects average contract book pricing for large and medium-size companies. By contrast, the pricing on the so-called spot market now is much higher than some of the prices we report. Also, Dataquest pricing assumes a stable yen-to-dollar exchange rate of ¥84 to the dollar.
- One of the major changes since our February forecast was the impact of the strong yen on DRAM price negotiations.

Market Environment

Before discussing the pricing details, the current market needs to be briefly explained. Two phrases characterize the current market: acute shortages and lengthening lead times. 2Mb and 4Mb flash devices, and 8-bit microcontrollers, for example, have lead times of more than 30 weeks. The lead times for even some discrete and passive devices, for example, certain capacitors, diodes, and crystals, are approaching 40 weeks, if available at all. There is even a general shortage of discretes available in the SOT-23 package.

This multiple-part shortage can make new product ramp-up a challenging experience. Some digital communications equipment companies recently reported difficulties in finding an adequate supply of DSP chips, flash memory, and capacitors.

PC Industry

Strong demand for PCs is primarily responsible for the semiconductor shortage situation. Not only does the PC industry use more than half of all memory production but also an incredible quantity of the various logic devices and discretes. Understanding PC demand can help us to predict the general market conditions for IC and discretes.

The current Dataquest PC forecast shows that 57 million PCs will be produced worldwide in 1995. This number represents a 19.5 percent increase over 1994 levels. Of these 57 million PCs in 1995, 26 million are expected to be built with Pentium-level MPUs. The forecast in 1996 shows total PCs at 68 million units, with 53 million containing a Pentium-level MPU. Clearly demand from the PC sector should be very strong through 1996. The forecast for 1997 is 77 million PCs.

MPUs

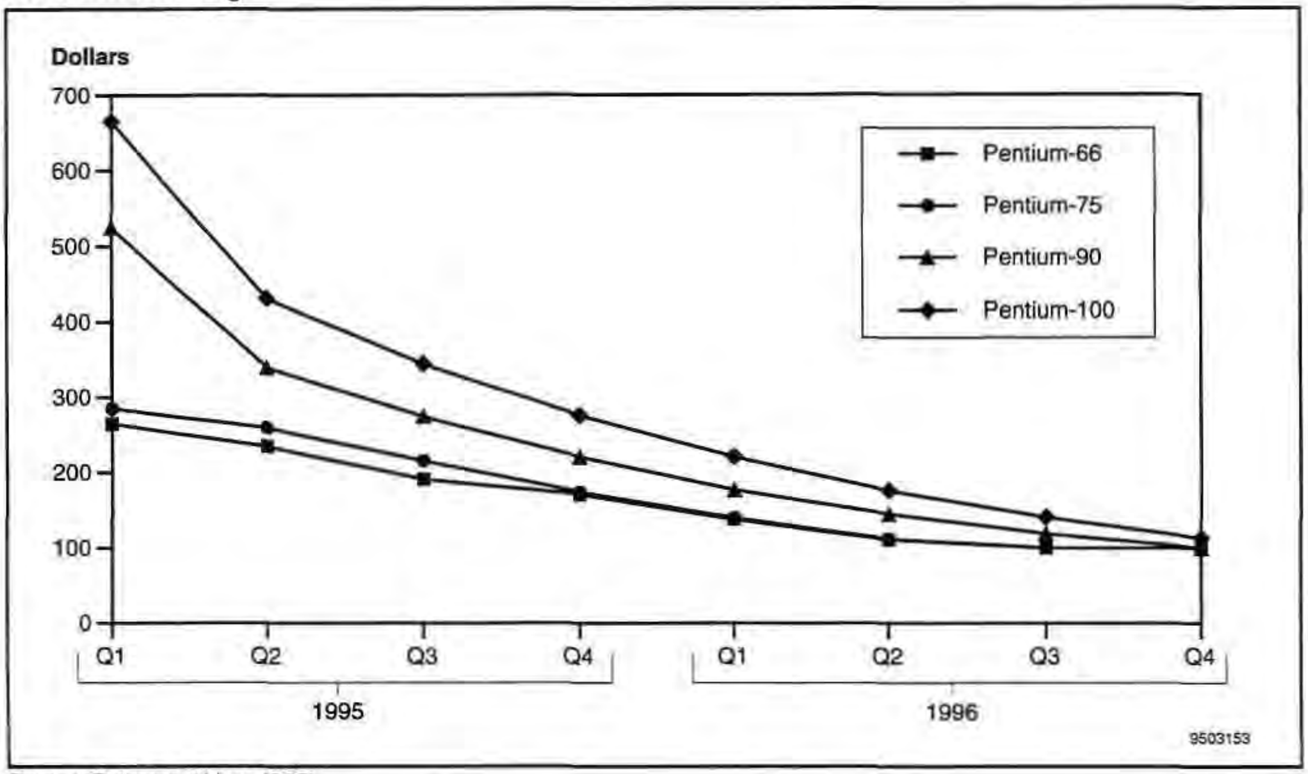
One assumption in these PC numbers is that Intel will aggressively ramp up production of the various Pentium chips and at the same time drastically bring down the price. In Figure 1, pricing is projected out through 1996 for the 66-, 75-, 90-, and 100-MHz devices. Currently, the 100-MHz is selling for $430, the 90-MHz at $340, the 75-MHz at $260, and the 66-MHz at $235. Of particular interest is that all devices will be selling for about $100 at the end of 1996. Essentially what Intel plans to do is shorten the life cycle of each product to two years. This not only gives Intel a strong competitive advantage but also creates an aggressive pricing scenario for all MPUs.

All the reports we have confirm that Intel's Pentium ramp-up is on or ahead of schedule. For those interested in calculating the price of future MPUs, a good rule (credited to one of Intel's prime rivals) is that the floor price for any MPU will be equal to one dollar per megahertz.

DRAMs

Let's now look at the DRAMs. The DRAM market will continue to be a sellers' market through this year. Prices are forecast to increase for all DRAMs during the second half of 1995 and to not begin to decline until the first half of 1996. This market of increasing prices is not only a major problem for system companies still seeing shrinking profit margins but also is highly unusual. In the classic IC life cycle, there is a negative correlation between volumes and prices. That is, as volume ramps up, prices should fall. We are now witnessing the incredible scenario where the 16Mb DRAM ramps up as the price is increasing.

Figure 1
Pentium Pricing



Source: Dataquest (June 1995)

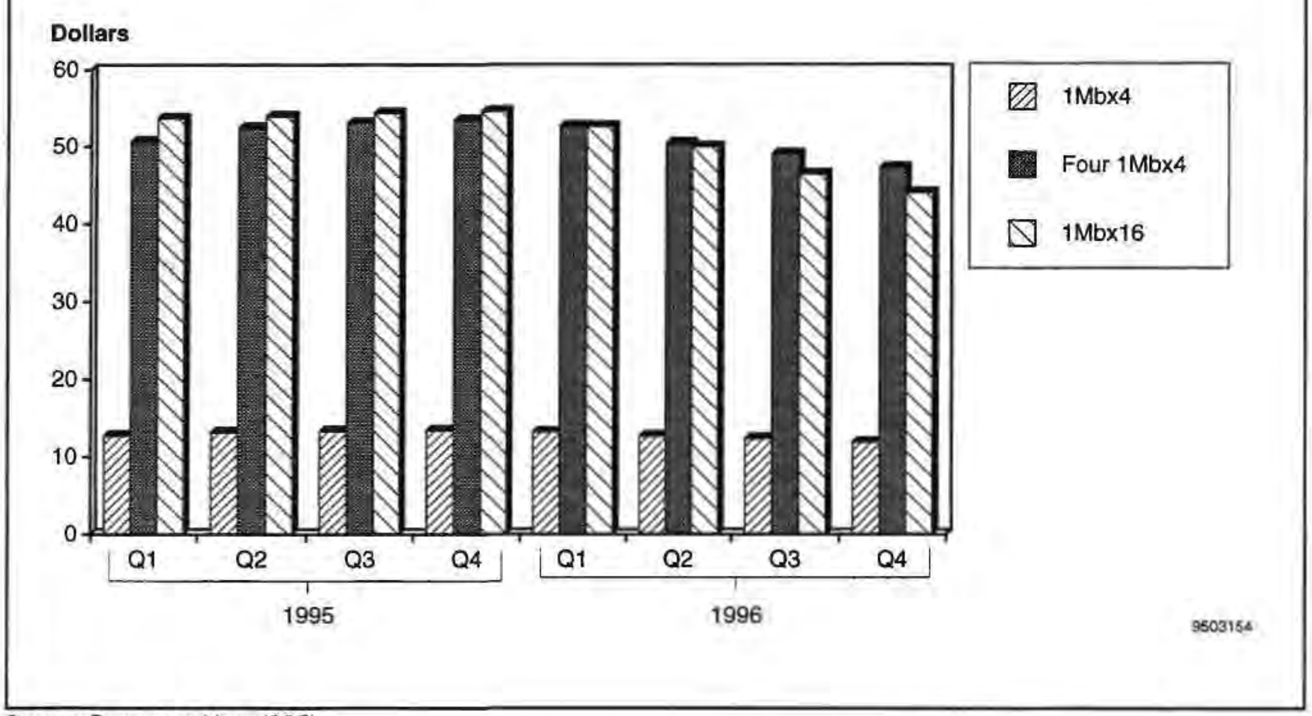
Let us look at some specific pricing. First we will discuss the 1Mbx4 DRAM. In the first quarter of 1995, the 1Mbx4 price was $12.66; the second quarter or current price is $13.10, with the fourth quarter price projected to be $13.35. In 1996, the 1Mbx4 price will decrease to $13.15 in the first quarter and is forecast to drop to $11.88 in the fourth quarter.

The 1Mbx16 price was $53.62 in the first quarter of 1995; the second quarter or current price is $53.90, with the fourth-quarter price projected to be $54.50. In 1996, the 1Mbx16 price will drop to $52.50 in the first quarter and is forecast to drop to $43.90 in the fourth quarter.

These price increases on the 1Mbx4 and the 1Mbx16 have had a dramatic effect on the much-watched crossover. The crossover shown in Figure 2 now occurs in the first half of 1996. The previous survey showed the crossover occurring in late 1995. To summarize, the new survey prices have pushed out the critical 1Mbx16 crossover to the first half of 1996.

One more comment on the 1Mbx16: Because of the ongoing shortage of this part, some suppliers are seeing unanticipated high demand for the 4Mbx4 and the 2Mbx8 configuration. The 4Mbx4 can be used in 16MB SIMMs, and the 2Mbx8 is used in 8MB SIMMs.

Figure 2
1Mbx16 DRAM Crossover



Source: Dataquest (June 1995)

SRAMs and Flash Memory

The final two parts to be covered are the SRAMs and the flash memory. The strong market for Pentium-class PCs is fueling demand for high-speed SRAMs used in cache memory applications. A very popular configuration is the 32Kx8, 15ns part. The pricing for this device is relatively flat at $4.00 for 1995. New suppliers here are helping to keep the price from going up. Also, there may be a market transition away from the 32Kx8 part by late 1995.

One last comment on the 32Kx8 SRAM: The 3V version of this part is in very short supply and is selling for $6.00. The next-generation part, the 128Kx8, is coming down in price as suppliers try to make this part attractive to large OEMs. The current price of the 128Kx8 is $18.31 in the 15ns version.

Flash memory prices are either increasing or firming up in the second half of 1995 and decreasing in the first half of 1996. The current second-quarter 1995 price for the 256Kx8 is $9.85, with a forecast price of $9.90 by the fourth quarter of 1995. The 512Kx8 or 4Mb sells for $11.30 in the second quarter of 1995, increasing to $12.30 by the fourth quarter of 1995. It is difficult to determine how long the current allocation situation will exist for the 2Mb and especially the 4Mb part. A key factor to monitor is the joint fab between AMD and Fujitsu known as FASL, which is ramping.

Thank you for your attention.

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Perspective

Semiconductor Procurement Worldwide

Telebriefing

When Will the DRAM Shortage End?

Abstract: *DRAMs have been in shortage since late 1992. At an aggregate level, the DRAM shortage should end during 1997. However, a recent telebriefing (June 23, 1995) highlighted the complexities of the DRAM supply-demand scenario when presented on a "product configuration" basis. For example, current trends signal a continued shortage of the x16 DRAM configurations during the very midst of the 1997 oversupply of the 4Mbx4 part.*
By Ronald Bohn

Introduction

This is Ron Bohn of the Memories Worldwide Service. In the room here at Dataquest are Jim Handy of the Memories service; Mark Giudici of the Semiconductor Procurement service; and Mario Morales of Dataquest's Research Operations group.

DRAM Supply/Demand Quarterly Statistics

Dataquest bases today's telebriefing on Dataquest's most recent assessment of worldwide DRAM supply-demand. In North America, we call this report the *DRAM Supply/Demand Quarterly Statistics*. The report links Dataquest's worldwide electronic equipment production forecast—the DRAM demand side—to our fab database, which is the DRAM supply side. From this we generate our worldwide 4Mb DRAM and 16Mb DRAM forecasts. The report presents the DRAM forecasts on a supplier-by-supplier, product-configuration-by-product-configuration basis.

Key Points

The telebriefing emphasizes three main points:

- First, at an aggregate level, the DRAM shortage should end during 1997—perhaps two years from now, in about second quarter 1997.

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- Second, even so, some wider configurations of DRAM will remain in shortage throughout the entire 1995, 1996, and 1997 period. For example, the current mismatch between 1Mbx16 DRAM supply and demand will remain severe over the next several years. Supply will not meet demand for the x16 devices until the post-1997 period.
- Third, 1997 looks like a year of transition for the worldwide DRAM market. Several "newly emerging" multimedia-type applications should accelerate their consumption of DRAMs during 1997. For example, during the second half of 1997, newer DRAM applications such as graphics-rich video game systems and digital set-top converter boxes quite likely will join PCs in absorbing some of the worldwide DRAM supply.

PC Forecast

At this point, we will review Dataquest's worldwide PC forecast. Dataquest defines a PC as being a fully assembled system when received by the end user. Other microprocessor-based board products will be described later.

The current Dataquest PC forecast shows that 57 million PCs will ship worldwide in 1995. This represents a nearly 20 percent increase over the 1994 level. We expect 26 million PCs to use Pentium-level MPUs during 1995. For 1996, Dataquest expects worldwide PC unit shipments to increase by 18 percent, at 68 million units. During 1996, 53 million of these PCs will contain a Pentium-level MPU. The worldwide forecast for 1997 is 77 million PCs; this represents a 14 percent growth rate. We expect worldwide PC shipments to reach 100 million units during the year 1999. (Note that subsequent to the telebriefing, Dataquest made some nondramatic changes in the PC forecast.)

Board-Level Products

As indicated, there are additional board-level products that incorporate microprocessors and use DRAMs. Dataquest's DRAM supply-demand database now includes two new categories: upgrade motherboards and industrial boards.

Upgrade motherboards are boards most often used to upgrade older PCs. Also, some end users use them to assemble their own PC. For the 1994-to-1995 period, worldwide shipments of upgrade motherboards totaled about 4 million units each year. For the 1996-to-1997 period, shipments should total about 5 million units per year.

Industrial boards are boards used in systems such as medical imaging equipment and factory automation systems. Some of these industrial boards are known in the market as VME boards or FutureBus boards. An example application is ultrasound imaging equipment. For the 1995-to-1997 period, worldwide unit shipments of industrial boards should total about 3 million units each year.

DRAM Supply-Demand

We will now look at Figures 1 through 3. These figures provide the DRAM supply-demand outlook for the years through 1997. The figures are based on information from the *DRAM Supply/Demand Quarterly Statistics* report.

Top-Level View

Figure 1 shows combined 4Mb and 16Mb DRAM supply expressed as a percentage of demand for the 1994-to-1997 period. Note that the areas below 0 percent in the figure show DRAM market shortage while areas above 0 percent indicate DRAM oversupply.

Figure 1 presents a top-level view of the supply-demand scenario by using 4Mb DRAM equivalents or 16Mb equivalents.

The key message from Figure 1 is that:

- For 1994, at an aggregate level, there was a nearly 20 percent shortage of 4Mb/16Mb DRAMs.
- For 1995, there is a 10 percent shortage.
- For 1996, the shortage narrows to about 5 percent.
- By contrast, for 1997 there could be an aggregate 20 percent oversupply of 4Mb/16Mb DRAMs.

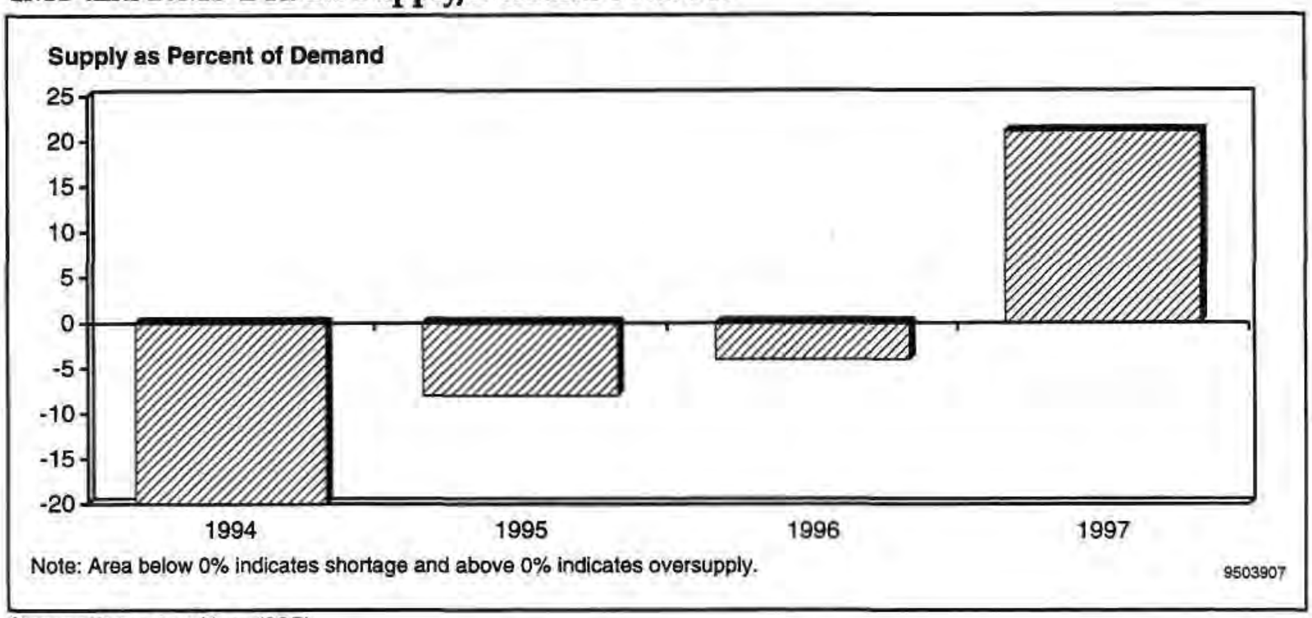
Note that the 64Mb DRAM will have little market impact until the year 1998.

DRAM Supply/Demand by Product Configuration

Figures 2 and 3 show differing scenarios for DRAM supply-demand in terms of specific product configurations.

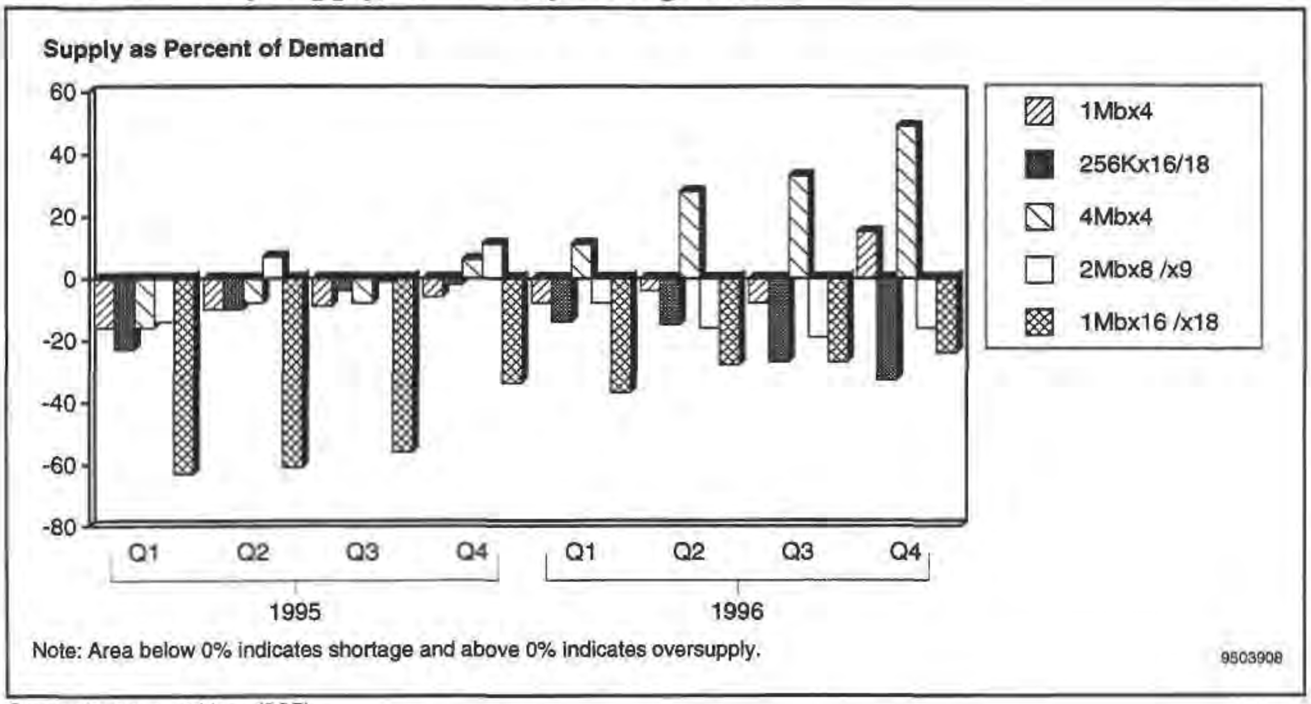
Figure 2 shows the quarterly 1995-to-1996 outlook for the 1Mbx4 configuration, the 256Kx16 organization, the 4Mbx4 device, the 2Mbx8 part, and the 1Mbx16 configuration.

Figure 1
4Mb and 16Mb DRAM Supply/Demand Scenario



Source: Dataquest (June 1995)

Figure 2
DRAM Quarterly Supply/Demand by Configuration



Source: Dataquest (June 1995)

Dataquest's outlook is as follows:

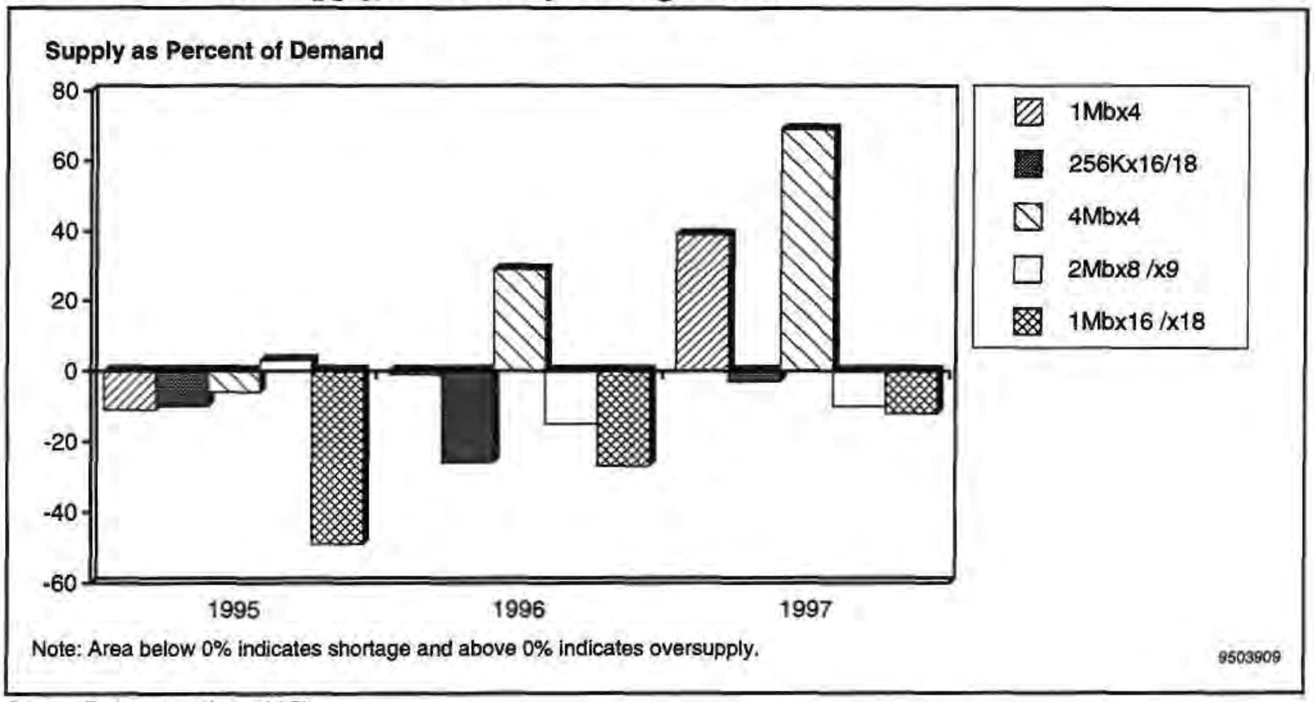
- 1Mbx16, 256Kx16 configurations—Figure 2 shows a continuing shortage of the 1Mbx16 DRAM and the 256Kx16 DRAM throughout the entire forecast period.
- 1Mbx4 device—Figure 2 shows a shortage that lasts throughout all of 1995 and most of 1996. The figure shows this 1Mbx4 shortage should end toward the end of 1996.
- 4Mbx4 organization—Figure 2 shows that this is the device that will move into oversupply most quickly and also to the greatest extent. Figure 2 shows an oversupply of 4Mbx4 DRAMs during the first half of 1996—which under current market conditions could become a large oversupply about one year from now.
- The 2Mbx8 device—Figure 2 shows a somewhat bouncy 1995 supply-demand scenario for the 2Mbx8 part. Figure 2 shows by early 1996 there will be a 2Mbx8 shortage.

Strong demand from the workstation market and very high end PCs right now means a 1995 shortage of the 4Mbx4 device. Many suppliers will ramp up the 4Mbx4 DRAM during 1995. However, the critical PC end market will not fully absorb this 4Mbx4 ramp-up during the 1996-to-1997 time frame.

Also, the 2Mbx8 is somewhat of a DRAM market anomaly as of midyear 1995. The background is that some major PC OEMs have pushed out their original schedule for use of this part until late 1995 or 1996. This means some extra 2Mbx8 parts are temporarily available. Figure 2 shows that, by early 1996, however, PC OEMs will ramp up demand, leading to a shortage.

Figure 3 shows the annual outlook through 1997 for the same configurations (1Mbx4, 256Kx16, 4Mbx4, 2Mbx8, and 1Mbx16).

Figure 3
1995-1997 DRAM Supply/Demand by Configuration



Source: Dataquest (June 1995)

The basic message of Figure 3 is that, under current market conditions, Dataquest expects an oversupply of 4Mbx4 DRAM to occur during 1996. The 4Mbx4 should remain in oversupply through 1997. The 1Mbx16 and the 256Kx16 devices will be in shortage throughout the 1995 to 1997 period. The 2Mbx8 devices will be in short supply during 1996 and 1997. Dataquest also expects strong long-term demand for Toshiba's newly announced 512Kx32 DRAM.

The 1Mbx4 device will be in oversupply during 1997. The 1Mbx16 and 2Mbx8 shortages could force some PC demand "back" to the 1Mbx4 DRAM. This would moderate any 1997 oversupply of the 1Mbx4 device. By contrast, unsatisfied PC demand for the x16 and x8 devices will do much less to moderate a 1997 oversupply of the 4Mbx4 DRAM.

Dataquest Perspective

The DRAM shortage will continue throughout 1995 and 1996. At an aggregate level, the DRAM shortage should end about two years from now. For this reason the year 1997 looks like a pivotal year of DRAM market transition.

The continuing emergence of multimedia-type applications including multimedia PCs, digital set-top boxes, and video games drives very strong demand for wide configurations of DRAM. This trend signals a continued shortage of the x16 DRAM and x8 DRAM configurations during the very midst of the 1997 oversupply of the 4Mbx4 part.

Transcript of Telebriefing "Questions and Answers" Session

This concluded the opening statement to the telebriefing. A live question-and-answer session followed between the telebriefing audience and Dataquest analysts. The identity of all callers remained confidential.

Q: Regarding Toshiba's newly announced 512Kx32 DRAM, where do you see the application for that part and do you see any followers into that market?

Ron Bohn (RB): We are not sure about any followers into the market at this time. A main application should be the set-top boxes. Partly for this reason, our opening statement made reference that we might see the set-top box finally blossoming into a significant consumer of DRAMs during late 1997. At this time, there is a lot of interest among set-top box manufacturers in the 256Kx16 DRAM. An alternative would be the 1Mbx16 DRAM. The 512Kx32 DRAM really fits the granularity requirements of set-top box applications. Right now, the market remains uncertain about which DRAM technology will best serve the set-top box market. The candidates include standard asynchronous (fast page mode), asynchronous Extended Data Out (EDO—a.k.a. hyper page mode) or synchronous DRAM. Regardless, we certainly see the 512Kx32 configuration as fitting very nicely with multimedia granularity requirements should the set-top boxes merge as a real strong consumer of DRAMs in several years.

Q: Looking at Figure 1 where you show the potential oversupply in 1997 caused by overbuilding of the 4Mbx4 DRAM, is this intended to be your projection of the way you think the way things will be? Or is it intended to portray what will happen if most of the DRAM manufacturers do what you think your survey says they are going to do?

RB: The latter. We are trying to send out a wake-up call that Dataquest's analysis shows that DRAM suppliers are very aggressively continuing to focus on the 4Mbx4 DRAM. DRAM suppliers may lack confidence in their ability to build the 1Mbx16 device. There is also uncertainty by DRAM suppliers about the future role of the 2Mbx8 part.

We believe DRAM suppliers will do several things to avoid the 4Mbx4 oversupply picture shown in Figure 1. One response is that they eventually could shift some capacity away from the 4Mbx4 DRAM to a 4Mb slow SRAM. Should the Japanese consumer electronics market rebound in a couple of years, those applications would use this slow SRAM part. Next, DRAM suppliers may want to unleash their capacity more slowly than they are currently planning. But the main thing they could do is to start focusing on building wider configurations of DRAMs. We want to mention again the 256Kx16 DRAM. Although the 4Mb DRAM is a relatively mature technology, the wide x16 version should remain in shortage throughout the 1995-1997 period. A main message today is that we still believe there would be DRAM revenue growth during 1997 as a result of a shortage of wide DRAM. We do not forecast any harsh cyclical downturn in the DRAM market but at this point in time our analysis indicates the shaping of oversupply of 4Mbx4 configuration.

Q: The last time we had this conference (March 1995), it appears that there was no DRAM oversupply in sight. What factors led you to change your opinion on this a couple of months later?

RB: We had not talked very much at any prior telebriefings about the year 1997. We certainly talked in prior telebriefings about a market shortage through 1996.

Every quarter we do a lot of analysis in terms of looking at DRAM supply and demand, and this telebriefing reflects the result of our most current analysis. One area of concern that we now have is the PC forecast for the year 1997. The PC unit growth rate worldwide that we mentioned in the opening statement is 14 percent. This 1997 rate is somewhat slower (than the 1995 PC worldwide growth). What is particularly slower in 1997 is the growth rate for the North American PC markets. The PC growth rate for the United States in 1997 is about 8 percent. So at this point, in terms of what we said before, we said we are not expecting a cyclical 1997 DRAM downturn. We are saying that our analysis at this point clearly indicates that some key configurations of 16Mb DRAMs confront a potential oversupply unless suppliers alter their strategy to better match the emerging demand patterns.

Q: We have two related questions about the 4Mbx4 that you are showing going into some surplus. First, what is the percentage of market share for the 3.3-volt and 5-volt parts? Second, what do you see happening in 1996, specifically if the United States starts to have an economic slowdown that is larger than forecast in the newspapers right now?

Jim Handy (JH): I am going to answer the question in reverse order, so the first shall be last and the last shall be first. First of all, what happens if there is a slowdown in the U.S. economy? That's always a wildcard in any kind of a forecast. We tap into The Dun & Bradstreet economists and ask for their help since we are a division of the Dun & Bradstreet Corporation. We do the best we can to figure out what is going on in the world economies, the exchange rates, and all of that. If terrible economic things were to happen that sent the U.S. economy (or any other major world economy) into a tailspin, it would have a profound influence on the spending pattern of PC buyers. This is not our forecast, but if these economic events were to occur, this could free up a lot of DRAM supply further up the food chain very quickly. The result would include reduced unit shipments of DRAM. There is room for a phenomenal downturn in the pricing for DRAMs. Our estimate is that that most DRAM suppliers could be selling the 1Mbx4 DRAM that today sells for $13 profitably for under $6.

With regard to the 3-volt question, DRAM manufacturers pushed most of the 3-volt requirements. Now that they have gotten to a point where they can produce 3-volt or 5-volt parts, they keep charging a premium for the 3 volt part.

What we see for the 3-volt DRAM's share is about a third (33 percent) of all shipments. This increases to about one-half (50 percent) in 1996.

RB: I would like to add one thing regarding your U.S. economic question. Dataquest's PC forecast for 1995 estimates that about 22 million PCs will ship in the United States. For 1996 we expect a 16 percent growth rate, which will push up shipments to about 26 million PCs in the United States. For 1997, Dataquest forecasts an 8 percent growth rate for the United States, translating into a total of under 30 million PCs. Right now our PC analysts are looking very carefully at any potential impact of a U.S. economic downturn and the impact on the PC market. In aggregate, they still feel comfortable with this U.S. forecast. They are expecting a softening of the U.S. economy sometime during the second half of 1996 or the first half of 1997. The current PC forecast assumes a 1996 or 1997 U.S. economic slowdown. So we are still comfortable with this PC forecast for the United States over the next couple of years. (Note that subsequent to the telebriefing, Dataquest made some nondramatic changes in the PC forecast.)

Q: How do you see the supply/demand mix by function—EDO DRAM versus standard synchronous DRAM versus Rambus DRAM?

JH: The supply/demand for those different devices is kind of a sketchy thing. EDO is something that is going to be a relatively simple switch for DRAM manufacturers. Most DRAM manufacturers have in place the mechanism where they can determine their mix of EDO product to fast page mode product (today's standard) at a very late level in production. This allows DRAM manufacturers to cater to the needs of the market till the last month or so of the production cycle.

By contrast, for synchronous DRAM, that is not the case at all. It looks as if there is going to be a very strong undersupply of synchronous 16Mb DRAMs for quite a while, probably for at least the next two years. However, for the 64Mb density, it looks as if most manufacturers are planning to produce a large portion of their product in some sort of a synchronous version. The manufacturer's votes are not all in yet as to which of the synchronous architectures are going to make up the bulk of the 64Mb DRAM sales. But since the peak shipments of the 64Mb DRAM will not happen until the end of our 1999 forecast cycle, there is plenty of time for DRAM manufacturers to respond to long-term demand.

RB: Just one more thing about Rambus. The synchronous DRAM technology that Jim just discussed includes the Rambus technology. The outlook for the Rambus technology depends in part on a business issue—the royalty rate charged by Rambus. Some DRAM companies we have talked to are quite comfortable with the royalty rate they pay. At the other extreme, some of them completely disfavor paying what they call another DRAM tax. Rambus is working on this, so that is one factor beyond technology that influences our analysis of the Rambus DRAM.

Q: You have given us some figures of different boards, the PC, the upgrade, and the industrial boards. How do you estimate the rest of this market demand for video and other applications?

RB: Dataquest has a very detailed worldwide electronic equipment production forecast. Our analysis has a unit shipment forecast of equipment production that we present in the report. These projections carry out over time. For the DRAM Supply/Demand report, the forecast extends to 1997.

For each of the electronic equipment types, with as much detail as possible, we estimate the DRAM demand from each equipment type. We aggregate these detailed demand estimates into our total demand forecast. That is a short description of our DRAM demand analysis.

Q: What is your average memory requirement for PCs for 1994 through 1997?

RB: First, we will start with DRAM installed as PC main memory at the OEM's factory. In 1994, the PC averaged just over 6.25MB of PC factory-installed DRAM. This average will not become a "round" number because we must factor in the shift from 486 PCs to Pentium PCs and later to P6 PCs. For 1995, 7.4MB were installed at the PC factory. For 1996, the PC average becomes 9.5MB, and for 1997, 11.4MB.

Now we turn to fully upgraded PCs. These are PCs that have had additional memory installed after leaving the PC factory. The memory "upgrade" occurs at the retail store, or end buyers might buy a module later at an electronics store. For 1994, the fully upgrade PC had just under 14MB of DRAM. For 1995, the upgrade becomes 16MB. For 1996, the upgrade increases to 22MB, and for 1997, 25MB.

Q: I have two questions. What specifically caused the market for 256Kx16 DRAM to go up recently? What are the current prices for each device listed in Figure 2?

RB: To understand the 256Kx16 DRAM, you have to go back into several years of 4Mb DRAM history. The prevalent 4Mb market interest during the early 1990s was for the 1Mbx4 device. There was an intermediate width part—the 512Kx8—that never really took off in terms of PC demand. Another part was the 256Kx16 DRAM, which tied into some graphics applications. Demand for the 256Kx16 device never seemed to really materialize either. In the midst of the continuing DRAM shortage, demand started to emerge from some video and set-top box applications that could use wide configuration parts like a 1Mbx16 or 256Kx16 DRAM. So the search by the video games and set-top box companies for any supply of DRAM at competitive price diverted attention to the 256Kx16 part. Instead of "winding down" and fading from market interest—which happened with the 512Kx8 DRAM—the 256Kx16 device has started to generate reasonably impressive demand. The continuing severe shortage of the 1Mbx16 DRAM means the 256Kx16 shortage will also persist.

Mark Giudici (MG): I will provide DRAM pricing based on the June 1995 forecast of North American marketplace for the parts shown on Figure 2. The 1Mbx4 device in second quarter 1995 sells for about $13. The price will increase by fourth quarter 1995 to $13.35. For the year 1995, the price averages to just under $13.10. For full-year 1996, the increased supply of 4Mb DRAM should lower the price to about $12.45.

The 256Kx16 DRAM sells as of second quarter 1995 for $14.80 in the North American market. The price increases to $15.57 in the fourth quarter of this 1995. The full-year 1995 averages at $15.17. The price for 1996 will be $14.68, a little bit of a decline versus the current price.

The next product in Figure 2 is the 4Mbx4 part. We will price the device that uses the 400 mil package, which is the highest volume runner today. The current price in the North American market is $41.50 for large volume buyers. The price will go down to about $34.20 in the fourth quarter of this year. The full-year 1995 price averages to $40. The 4Mbx4 price should decline to $30.65 for 1996, reflecting the start of an oversupply.

The 2Mbx8 device (300 mil package) is priced at $51.82 for the second quarter of 1995. By fourth quarter 1995, the price will increase to $52.26. The full-year 1995 price is $51.93 for this device. The 2Mbx8 price in 1996 is expected to be about $44.22 based on our survey.

The 1Mbx16 part sells as of second quarter 1995 for $53.90. By fourth quarter 1995, the price will be $54.50. For full-year 1995, the price is just over $54. For 1996, we forecast a price of just over $48. This 1996 price represents a 1Mbx16 price decline versus 1995. In retrospect of DRAM price history, however, the 1Mbx16 price decline for 1996 is far less than expected for the ramp-up of a new DRAM device.

Q: I am curious about the burst mode EDO DRAMs. Do you think those will have an impact on the market, or are they going to play a small role? Will producers be switching over to a fully synchronous part?

JH: From where we sit, we still do not find an awful lot of designers who are using, or planning to use, burst EDO. That could be because of the fact that it was announced so late, or could be that we are just not talking to the right people. Regardless, we are not finding an awful lot of sockets for burst EDO at this time. On the other hand, we do see that the standard asynchronous EDO DRAM has caused the acceptance of synchronous DRAM parts to become delayed by about one year. The reason is that system designers tend to stay with something that is not a big paradigm shift, if you will excuse my using the expression.

System designers like to stay with familiar technology for as long as they can. Fast page mode asynchronous DRAM started to run out of market steam some time ago. This technology could no longer meet the performance requirements at a certain system frequency (the frequency varies depending upon to whom you talk). The next logical step to take would be synchronous DRAM. However, EDO—or hyper page mode—asynchronous DRAM came onto the market scene. This delayed the timing at which the asynchronous technology would run out of performance steam. With that the acceptance of the synchronous architecture becomes delayed.

Burst EDO is an attempt to push things out just a little bit more. That could be very appealing to designers. So far we have not found system designers who have said resoundingly that they are going to use burst EDO, so we guard our bets on the success of burst EDO at this point.

Q: Could you tell me if you have any information concerning DIMMs versus SIMMs?

RB: Right now we are doing a study of the module market. We will be focusing on the worldwide and North America markets. We are getting some information on that now. What we plan to do is to have a report on the DRAM module market that will include an assessment of emerging module technologies like DIMMs. The report should appear during August 1995.

Q: What are the cost targets for 4Mbx4 EDO DRAMs in 1995 and 1996 in the 3-volt version?

JH: Our pricing usually reflects the high-volume devices in the more current market. We do not have a published forecast on this part because today's order volumes are far from high volume.

MG: Although we do not survey the price of a low-voltage EDO part, the price premium for a low-voltage part ranges from 10 percent to 15 percent at this time. The EDO technology should not command much of a price adder throughout its life. For a rough estimate of the 3V 4Mbx4 EDO DRAM pricing, add a 15 percent price adder over the prices given earlier for the 4Mbx4 DRAM.

Q: Our question concerns the supply side of the DRAM equation. We see some estimates that as much as $30 billion of spending on new DRAM plants in the next few years. In your forecast, going forward, do you assume that all the DRAM capital will be spent, or do you assume that some producers abort plans for a variety of reasons?

RB: In our DRAM Supply and Demand report, we do include a very careful look at DRAM fab by fab, so we try to factor in an expectation of what capacity yield utilization will be. We have one of our fab database people here, Mario Morales, in Research Operations group. He tracks all unit shipments of memory products. Mario also works closely with our fab analysts on worldwide fab database including DRAM fabs.

Mario Morales (MM): At this time, first I will give you our worldwide capital spending numbers for 1994 and also what we expect to see for 1995. For 1994, we had a total of $22.8 billion spent on semiconductor capital equipment. This capital goes toward running processing equipment, test and assembly, and also property and plant. This spending includes some computer equipment.

In 1995, we expect the worldwide spending to increase by over 50 percent. We estimate about $33 billion to $35 billion of capital spending in 1995.

JH: Let me add something to that. The way we relate capital spending to DRAM supply is not on a purely economic model of just looking at "dollars in" versus "DRAMs out." We are in constant communication with DRAM manufacturers. We keep a database of every fab that we can track down worldwide. For example, Mario Morales can generate the number of DRAM fabs from our database. It is a pretty large number. The result is a sharper focus on DRAM production (in Dataquest's DRAM report) than indicated by quickly comparing "dollars in" with DRAM "dollars out."

Q: On the 4Mbx4 DRAMs, do you have feeling for the demand breakdown of 2K refresh versus 4K refresh for the current year as well as for next year?

JH: In a word, "no." We have tried resolving that technical issue last year regarding the 2Mbx8 DRAM. We found then that not only is it hard to get a good deal on the supply side but also far harder on the demand side. This is not just a problem for Dataquest, this is also a problem for DRAM manufacturers, a pretty important problem. We will try to keep our clients posted on that battle, as it comes to a resolution, but the issue could not be any farther from resolution than it is right now.

Q: What are the major applications for each type of DRAM listed in Figure 2?

RB: The No. 1 application for DRAM would be the PC. For the 1Mbx4 device, the No. 1 application is the PC. For the 256Kx16, it would be graphics applications. For the 4Mbx4, it would be the workstation application. For the 1Mbx16, the No. 1 application is the PC. For the 2Mbx8 DRAM, the varied applications mix includes PCs, workstations, plus some others.

Q: Going back to your figures for the main memory PC content, I just want to get a little qualification. Is it an average of new systems being shipped, or is it an average across the total spectrum of installed base plus new shipments?

RB: At the first level—the PC "factory level"—that is an average of new PCs. It is much more complicated regarding the second level—the fully upgraded PC, which includes new PCs and the installed base.

For example, for the fully upgraded PCs, the "average" is going to be a really complicated mix of numbers. Some of the 1994 PC memory upgrades would occur in the same year when the PC shipped. Some of the fully upgraded PCs for 1994, however, might have shipped during 1993 or even 1992. Another complication: There may be some PCs that shipped back in 1993 that do not get fully upgraded until this year or next year. So for the PC main memory at the OEM level it is an average; but at the fully upgraded, it cuts across the spectrum of new PCs and the installed base.

Q: So how should we regard that number?

RB: Use it as a benchmark. If you have to get into deep analysis of it, you will have to contact us directly and we can talk about that.

Q: At the start of this conference, you mentioned that in 1997 there could be a big transition into multimedia applications like set-top boxes and video games. How confident are you really in those being a mainstay of demand, particularly video games? I would hate to see DRAMs as being driven by the whims of 13-year-olds playing games

RB: A couple of things. First of all, the multimedia trend is actually having an impact already in terms of the graphics application. Forget video games for a moment, and instead consider PC graphics applications. The video RAM highlights the impact of low-end multimedia PC on the DRAM market. Ultimately the video RAM faces replacement from PC graphics.

In terms of confidence level, at this point we recognize that DRAM consumption by applications like set-top box and video games is quite low. We do believe that in the longer term the set-top box market should start emerging. Regarding video games, DRAM demand (for games) does not mean that kids will ever drive DRAM market trends. These are just some areas of emerging DRAM demand that might become stronger during 1997. I think in the long term clearly the PC remains the king in terms of DRAM consumption. Tracking the PC market is the best way to plan spending on DRAM R&D and construction of DRAM fabs.

JH: Let me just add something to that. Maybe we are somewhat sweeping in how we define "multimedia" systems. We include set-top boxes as multimedia. This means when we count multimedia systems, we are counting high-end graphics applications in PCs for which Apple Computer is a very important multimedia provider.

Q: I have two questions. Both relate to 16Mb low-voltage DRAM. First question, you mentioned early on that 33 percent of 16Mb shipping during 1995 are 3-volt and that this is going to increase to 50 percent for 1996. Other than mobile computing products, what are the 3-volt applications? The second question, when do you expect that the 3-volt premiums on 16Mb DRAMs to diminish?

JH: Any low-energy applications could be a 3-volt application. That pretty much means all PCs. Any application of the newer version of the 486 from Intel or the P54C could be 3-volt applications. There are actually level translators between the processor and the DRAM to convert the processor's 3-volt signal into 5-volt DRAM signals. The reason why users are largely using 5-volt parts in portable application is because DRAM manufacturers are charging more for the 3-volt than they are charging for a 5-volt part.

The current supply and demand imbalance brought about the 3-volt price premium. If there were an oversupply of DRAMs, 3 volts would be a way for DRAM manufacturers to take market share away from each other (via lower 3-volt pricing). They do not need to do that right now. Because of that, they are capable of keeping the premiums up there. If suddenly the 3-volt premium went away because of an oversupply, 3-volt parts would make up a larger percentage of the devices shipped in all of the systems than mentioned before.

Q: Have you covered the 5-volt versus 3-volt DRAM markets today? What is the graph you have on this?

JH: We did not provide a graph on 5-volt versus 3-volt. All of the questions asked about 3-volt DRAMs fall outside the official scope of the telebriefing.

Q: The numbers on Figure 2—are those mostly 5-volt parts or are they mixed?

RB: The total market. It incorporates all 5-volt and 3-volt. The figure provides an aggregate look by configuration.

Q: How do you see the shortage in the DRAM supply affecting video RAMs?

RB: The video RAM market has been to some extent a separate market. The main memory is the key part of the PC. There is also what we call display memory, whether it is video RAM, Windows RAM (WRAM) or some newly emerging technologies like the Rambus part. This display memory segment has always been about 10 percent of the DRAM market. We see somewhat separate trends for display memory (versus main memory).

There is a lot more uncertainty regarding the emergence of the new display memory technologies. We believe that the video RAM will have a continued good life cycle for very high performance systems. But if you are talking about display memories for PCs, cost is a real big issue. Video RAM is typically much more expensive than the equivalent density of the standard DRAM. So there are several different competing architectures for display memory applications. The market is really not certain at all regarding which DRAM technology will prevail for display applications.

(This was the final question.)

Note: For additional information on the *DRAM Supply/Demand Quarterly Statistics,* please call 800-419-DATA (800-419-3282).

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Perspective

Semiconductor Procurement Worldwide

Briefing

Midyear Semiconductor Price Forecast: Which Prices Will Decline, and When?

Abstract: *The results of the third-quarter semiconductor pricing survey were discussed in a teleconference held June 2, 1995, by the Semiconductor Procurement Worldwide service and Memories Worldwide service. This survey shows DRAM device pricing to be either firming up or increasing through the second half of 1995, with price decreases beginning in the first half of 1996. Certain other memories, for example, the 1Mb and 4Mb flash and the fast 32Kx8 SRAM, also are in short supply and now can demand a price premium. Microprocessors, particularly the Pentium-class devices, will see significant quarterly price decreases through 1996. This article is a transcript of highlights of that teleconference.*
By Scott Hudson

Midyear Semiconductor Forecast Highlights

Hello and good morning. This is Scott Hudson of the Semiconductor Procurement Worldwide service. This telebriefing will cover the highlights of the Dataquest midyear semiconductor forecast, which addresses the issue of which prices will decline, and when. After an opening statement, we will take questions from the audience. Those with questions will be identified with a number. Please do not give out your name when asking questions. We are not recording this briefing.

First let me introduce the participants. In the room are Mark Giudici, principal analyst of the Semiconductor Procurement Worldwide service, and Jim Handy and Ron Bohn of the Memories Worldwide service.

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Before going into the market overview and the details of the pricing survey, some critical economic assumptions need to be mentioned:

- Despite all the negative economic news, Dataquest expects the electronics industry to remain strong.
- Worldwide PC demand, which drives the semiconductor business, will be strong through the 1995 to 1996 time frame.
- Fab capacity will continue to come onstream but will not have a big market impact until early to mid-1996. For example, the critical 1Mbx16 DRAM will continue to be in a shortage situation throughout 1996, despite the tremendous ongoing buildup in fab capacity.
- Dataquest pricing reflects average contract book pricing for large and medium-size companies. By contrast, the pricing on the so-called spot market now is much higher than some of the prices we report. Also, Dataquest pricing assumes a stable yen-to-dollar exchange rate of ¥84 to the dollar.
- One of the major changes since our February forecast was the impact of the strong yen on DRAM price negotiations.

Market Environment

Before discussing the pricing details, the current market needs to be briefly explained. Two phrases characterize the current market: acute shortages and lengthening lead times. 2Mb and 4Mb flash devices, and 8-bit microcontrollers, for example, have lead times of more than 30 weeks. The lead times for even some discrete and passive devices, for example, certain capacitors, diodes, and crystals, are approaching 40 weeks, if available at all. There is even a general shortage of discretes available in the SOT-23 package.

This multiple-part shortage can make new product ramp-up a challenging experience. Some digital communications equipment companies recently reported difficulties in finding an adequate supply of DSP chips, flash memory, and capacitors.

PC Industry

Strong demand for PCs is primarily responsible for the semiconductor shortage situation. Not only does the PC industry use more than half of all memory production but also an incredible quantity of the various logic devices and discretes. Understanding PC demand can help us to predict the general market conditions for IC and discretes.

The current Dataquest PC forecast shows that 57 million PCs will be produced worldwide in 1995. This number represents a 19.5 percent increase over 1994 levels. Of these 57 million PCs in 1995, 26 million are expected to be built with Pentium-level MPUs. The forecast in 1996 shows total PCs at 68 million units, with 53 million containing a Pentium-level MPU. Clearly demand from the PC sector should be very strong through 1996. The forecast for 1997 is 77 million PCs.

MPUs

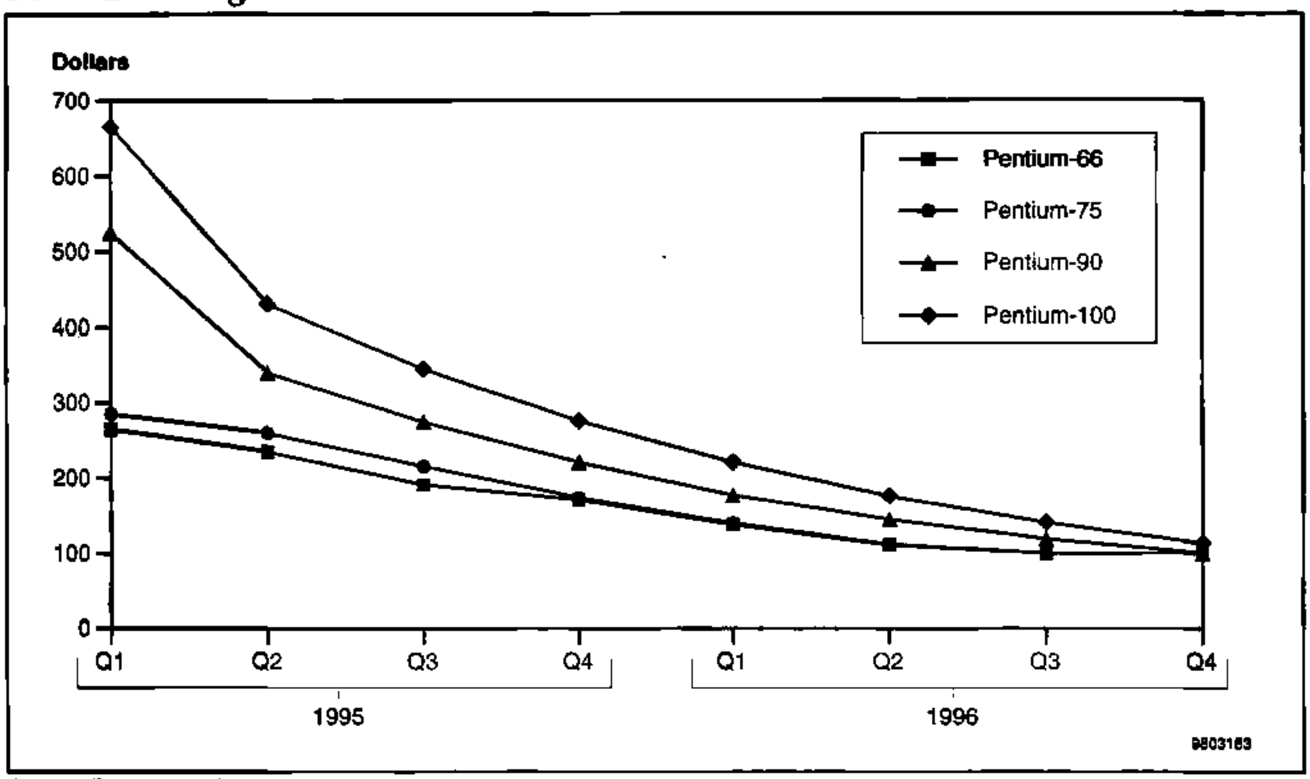
One assumption in these PC numbers is that Intel will aggressively ramp up production of the various Pentium chips and at the same time drastically bring down the price. In Figure 1, pricing is projected out through 1996 for the 66-, 75-, 90-, and 100-MHz devices. Currently, the 100-MHz is selling for $430, the 90-MHz at $340, the 75-MHz at $260, and the 66-MHz at $235. Of particular interest is that all devices will be selling for about $100 at the end of 1996. Essentially what Intel plans to do is shorten the life cycle of each product to two years. This not only gives Intel a strong competitive advantage but also creates an aggressive pricing scenario for all MPUs.

All the reports we have confirm that Intel's Pentium ramp-up is on or ahead of schedule. For those interested in calculating the price of future MPUs, a good rule (credited to one of Intel's prime rivals) is that the floor price for any MPU will be equal to one dollar per megahertz.

DRAMs

Let's now look at the DRAMs. The DRAM market will continue to be a sellers' market through this year. Prices are forecast to increase for all DRAMs during the second half of 1995 and to not begin to decline until the first half of 1996. This market of increasing prices is not only a major problem for system companies still seeing shrinking profit margins but also is highly unusual. In the classic IC life cycle, there is a negative correlation between volumes and prices. That is, as volume ramps up, prices should fall. We are now witnessing the incredible scenario where the 16Mb DRAM ramps up as the price is increasing.

Figure 1
Pentium Pricing



Source: Dataquest (June 1995)

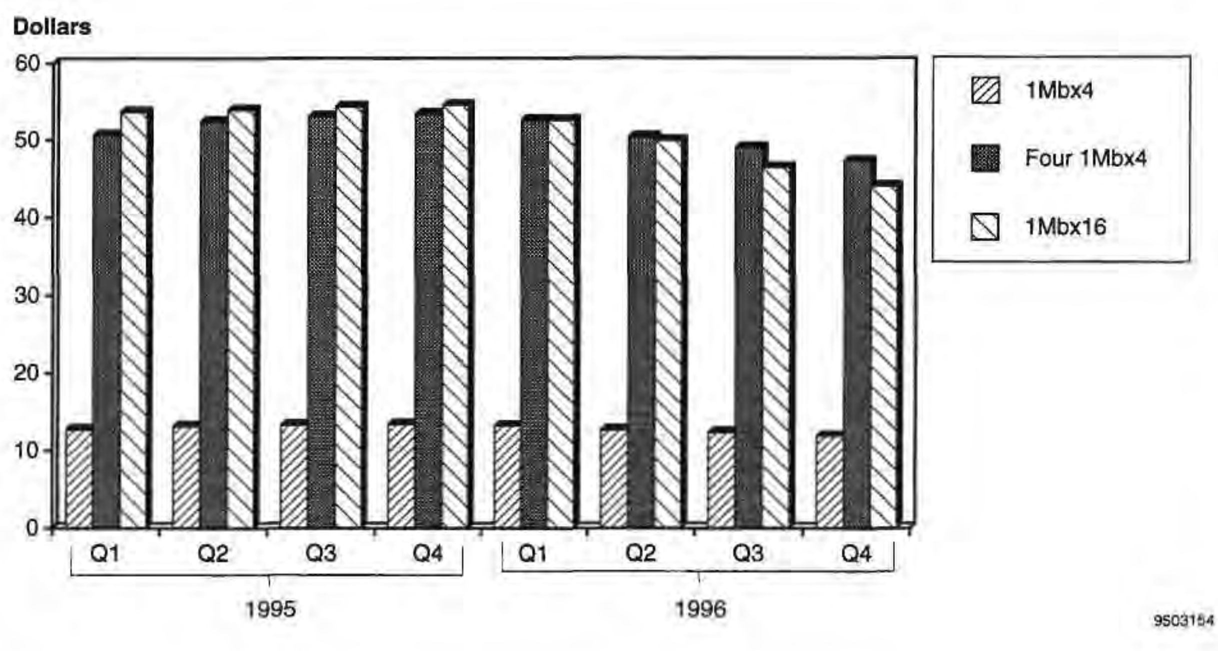
Let us look at some specific pricing. First we will discuss the 1Mbx4 DRAM. In the first quarter of 1995, the 1Mbx4 price was $12.66; the second quarter or current price is $13.10, with the fourth quarter price projected to be $13.35. In 1996, the 1Mbx4 price will decrease to $13.15 in the first quarter and is forecast to drop to $11.88 in the fourth quarter.

The 1Mbx16 price was $53.62 in the first quarter of 1995; the second quarter or current price is $53.90, with the fourth-quarter price projected to be $54.50. In 1996, the 1Mbx16 price will drop to $52.50 in the first quarter and is forecast to drop to $43.90 in the fourth quarter.

These price increases on the 1Mbx4 and the 1Mbx16 have had a dramatic effect on the much-watched crossover. The crossover shown in Figure 2 now occurs in the first half of 1996. The previous survey showed the crossover occurring in late 1995. To summarize, the new survey prices have pushed out the critical 1Mbx16 crossover to the first half of 1996.

One more comment on the 1Mbx16: Because of the ongoing shortage of this part, some suppliers are seeing unanticipated high demand for the 4Mbx4 and the 2Mbx8 configuration. The 4Mbx4 can be used in 16MB SIMMs, and the 2Mbx8 is used in 8MB SIMMs.

Figure 2
1Mbx16 DRAM Crossover



Source: Dataquest (June 1995)

SRAMs and Flash Memory

The final two parts to be covered are the SRAMs and the flash memory. The strong market for Pentium-class PCs is fueling demand for high-speed SRAMs used in cache memory applications. A very popular configuration is the 32Kx8, 15ns part. The pricing for this device is relatively flat at $4.00 for 1995. New suppliers here are helping to keep the price from going up. Also, there may be a market transition away from the 32Kx8 part by late 1995.

One last comment on the 32Kx8 SRAM: The 3V version of this part is in very short supply and is selling for $6.00. The next-generation part, the 128Kx8, is coming down in price as suppliers try to make this part attractive to large OEMs. The current price of the 128Kx8 is $18.31 in the 15ns version.

Flash memory prices are either increasing or firming up in the second half of 1995 and decreasing in the first half of 1996. The current second-quarter 1995 price for the 256Kx8 is $9.85, with a forecast price of $9.90 by the fourth quarter of 1995. The 512Kx8 or 4Mb sells for $11.30 in the second quarter of 1995, increasing to $12.30 by the fourth quarter of 1995. It is difficult to determine how long the current allocation situation will exist for the 2Mb and especially the 4Mb part. A key factor to monitor is the joint fab between AMD and Fujitsu known as FASL, which is ramping.

Thank you for your attention.

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Market Analysis

Dataquest

Market Analysis

Semiconductor Procurement Worldwide

Market Analysis

The Nonvolatile Memory Picture Becomes Clearer as Users Choose Long-Term Solutions

Abstract: *The nonvolatile memory market (ROM, EPROM, EEPROM, and flash) continues to grow at a healthy pace. While not as visible as its volatile cousins—DRAM and SRAM—the nonvolatile supply picture also remains in allocation as suppliers shift into and out of different offerings. This update focuses on the life cycles and future of these important, if underrepresented, memory devices.*
By Scott Hudson and Mark Giudici

Nonvolatile Devices

The nonvolatile market comprises four distinct devices: flash memory, EPROM, EEPROM, and mask ROM. The Dataquest definitions for these devices are given below along with some typical applications.

Flash memory: Includes nonvolatile product designed as flash EPROM/EEPROM that incorporates either 3V, 5V, or 12V programming supplies and one-transistor or two-transistor memory cells with electrical programming and fast bulk/chip erase. Flash memory can erase data only by bulk/chip, not by byte.

Flash is the newest nonvolatile memory and is stealing sockets from EPROM and EEPROM. For example, the newest generation of Pentium-based desktop computers uses flash instead of EPROM to hold the BIOS bootstrap program. New applications for flash devices are in handheld computing devices and cellular telephones.

EPROM: Erasable programmable read-only memory. This product classification includes ultraviolet EPROM (UV EPROM) and one-time programmable read-only memory (OTP ROM). EPROMs have memory cells consisting of a single transistor and do not require any memory cell

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refreshes. EPROMs are used to store code in applications both in embedded systems and in computers as the bootstrap or basic input/output subsystem (BIOS) in PCs.

EEPROM: Includes electronically erasable programmable read-only memory. Included are serial EEPROM (S-EEPROM), parallel EEPROM (P-EEPROM) and electronically alterable read-only memory (EAROM). EEPROMs have memory cells consisting of a minimum of two transistors and do not require memory cell refreshes. This product classification also includes nonvolatile RAM (NV-RAM), also known as shadow RAM. These latter semiconductor products are a combination of SRAM and EEPROM technologies in each memory cell. The EEPROM functions as a shadow backup for the SRAM when power is lost. EEPROMs are usually used in specialized applications where the minimal storage capability is acceptable and byte erase is required. One such application is code storage in printers.

Mask ROM: Includes mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step. Mask ROM is programmed in hardware rather than software. Mask ROMs are heavily used in the games industry and to hold font software in printers. Also, Apple Computer uses mask ROM to hold its BIOS software.

Nonvolatile Market and Pricing

In 1994, the total nonvolatile memory market was $5.383 billion, or about one-quarter the size of the 1994 DRAM market ($23 billion). The nonvolatile market in 1994 grew a respectable 18 percent from the 1993 market of $4.551 billion.

As shown in Table 1, mask ROM had the highest revenue in 1993 and 1994, followed by EPROM, flash, and EEPROM. As the primary application of mask ROM is in the game market, good growth in mask ROM revenue means that Nintendo, Sega, and Atari are in one of their up cycles.

EPROM had the second-highest growth at 29 percent, which came, in part, from customers unable to acquire flash memory. In many applications, especially at the 1Mb to 4Mb densities, flash and EPROM can both be used. EEPROM, because of its two-transistor architecture, are in volume production only in the relatively low densities of 16Kb and below.

Table 1
Worldwide Revenue from Shipments of MOS Nonvolatile Memory (Millions of U.S. Dollars)

Device Type	1993	1994	Change (%)
ROM	1,784	2,216	41
EPROM	1,460	1,545	29
Flash	746	884	16
EEPROM	561	738	14
Total	4,551	5,383	18

Source: Dataquest (September 1995)

Typical pricing trends for nonvolatile devices are shown in Table 2. This pricing data is from the most recent quarterly survey of both major users and suppliers of ROM, EPROM, and flash. Clearly, ROM is still the least expensive form of memory, but because of the masking or hardwired manufacturing process it is practical only for very high-volume applications that will never change. Also of interest is the price disparity between EPROM and flash at the same densities. EPROM has the price edge, but flash has the technological advantage with in-circuit programming.

Life-Cycle Curves

Besides pricing, another useful way to analyze the nonvolatile market is by assigning the different densities of flash, EPROM, ROM, and EEPROM into the seven stages of the IC life-cycle curve. In Figure 1, flash and EPROM are compared.

What is immediately obvious is that EPROM is stronger in the lower-density parts, while flash will dominate densities above 8Mb. Also, at the same densities, flash and EPROM are usually in different stages. At the 1Mb level, EPROM is in decline and flash is in saturation. At the 2Mb density, the flash device is entering the saturation stage at the same time the 2Mb EPROM is exiting. The 4Mb devices of flash and EPROM are together entering the maturity stage and the 8Mb flash is at least one year ahead of the 8Mb EPROM.

The other two nonvolatile devices, ROM and EEPROM, are exhibited in Figure 2. In some ways, these devices can be considered at opposite extremes. EEPROM tends to be at very low densities, while ROM includes some of the largest densities in production. In fact, the 64Kb EEPROM is in the same stage as the 64Mb ROM.

Nonvolatile Suppliers

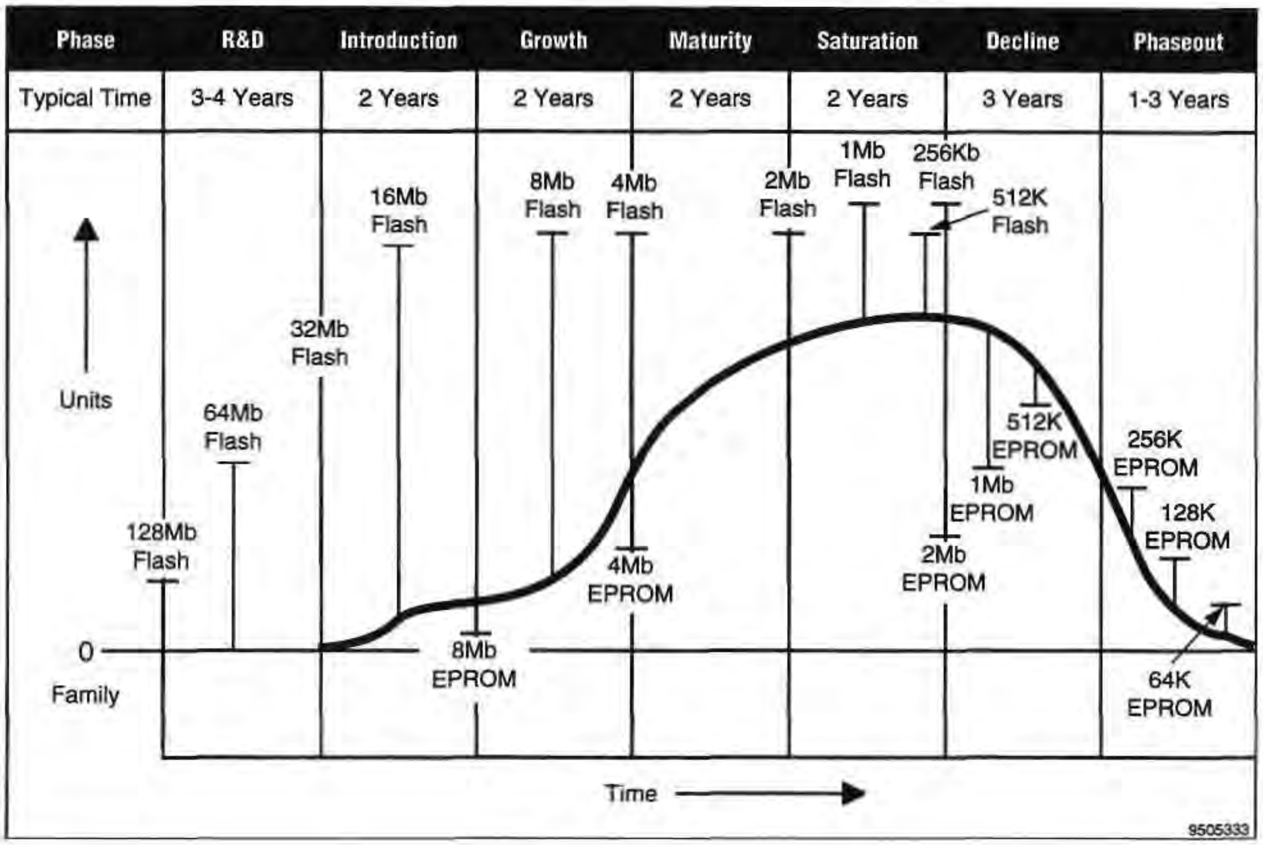
The primary suppliers of nonvolatile memory are a mixed lot: four Japanese companies, four U.S. companies, one European company, and one Korean company (see Table 3). Generally speaking, Asian-based companies are leaders in mask ROM and SGS-Thomson and other U.S. companies are market leaders in flash, EPROM, and EEPROM.

Table 2
Typical Pricing Trends for Nonvolatile Memory (Dollars)

Device	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96
1Mbx8 ROM	5.00	4.75	4.62	4.48	4.35
1Mbx16 ROM	7.80	7.59	7.44	7.25	7.16
128Kbx8 EPROM	2.63	2.60	2.55	2.50	2.50
512Kbx8 EPROM	8.20	8.20	7.96	7.36	6.82
128Kbx8 Flash	4.70	4.65	4.60	4.50	4.40
512Kbx8 Flash	13.10	13.00	13.00	12.00	11.50

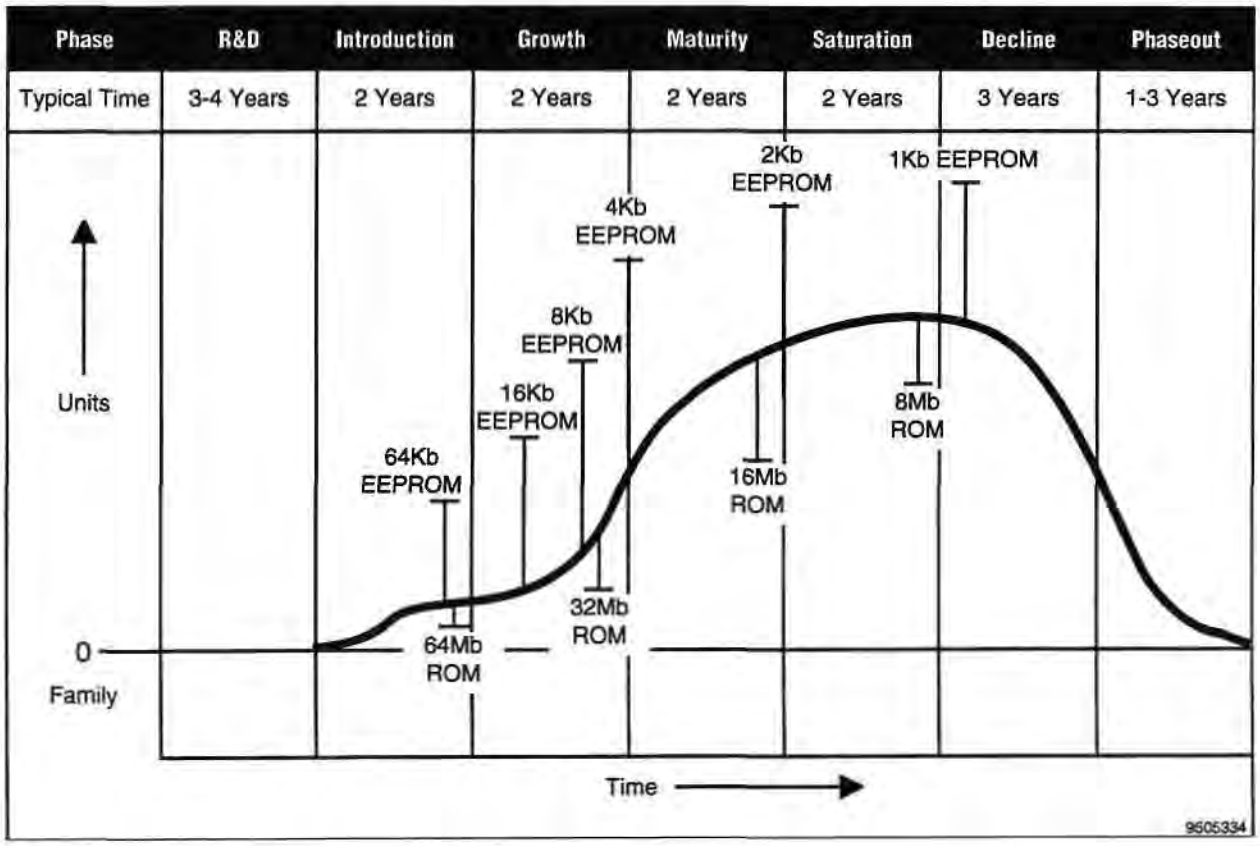
Source: Dataquest (September 1995)

Figure 1
Flash and EPROM Life-Cycle Stages by Density



Source: Dataquest (September 1995)

Figure 2
ROM and EEPROM Life-Cycle Stages by Density



Source: Dataquest (September 1995)

Table 3
1994 Top 10 Nonvolatile Market Leaders (Rank by Revenue)

			Rank by Device Type			
Rank	Company	1994 Revenue ($M)	Flash	EPROM	Mask ROM	EEPROM
1	Sharp	655	7	X	1	X
2	SGS-Thomson	546	5	1	X	2
3	Intel	458	1	X	X	X
4	AMD	425	2	2	X	X
5	Toshiba	387	4	9	3	X
6	NEC	336	X	X	4	7
7	Atmel	331	3	4	X	X
8	Samsung	315	X	X	2	X
9	Hitachi	241	X	8	5	X
10	Texas Instruments	240	10	3	X	10
	Others	1,449				
	Total	5,383				

Source: Dataquest (September 1995)

Analysis of the top five suppliers shows that leadership, if not dominance, in at least one area is critical. Sharp, the No. 1 supplier, is the largest manufacturer of mask ROM in the world. SGS-Thomson has bragging rights to the EPROM market and is moving aggressively into the flash area. Intel is the only company ranked in the top five that sells only one type of nonvolatile device, flash. AMD is very strong in both flash and EPROM, while Toshiba makes flash, EPROM, and mask ROM.

ROM Suppliers

The top five ROM suppliers are Sharp, Samsung, Toshiba, NEC, and Hitachi (see Table 4). Most of the ROM market is for relatively slow (over 100ns) and dense devices (greater than 8Mb) for the games industry. Other ROM applications for printers and select computers tend to be faster but less dense. Owing to the limited number of applications for fast ROM, suppliers tend to charge premiums (in some cases 10 percent to 15 percent over slower parts) for the same density.

EPROM Suppliers

The top five EPROM suppliers (in rank order) are SGS-Thomson, AMD, Texas Instruments, Atmel, and National Semiconductor (Table 4). Three of the top five, TI, AMD, and National, have recently announced that they are planning on scaling back EPROM production because of changing market ROI priorities/fab constraints. TI wishes to make more DSP chips, AMD wants to focus on flash, and National will produce application-specific standard products. In other words, these companies see more revenue in products other than EPROM. This situation should cause headaches for system companies that use EPROM, as long-term prices will firm and lead times could be stretched. The winners in this scenario are the other two leading EPROM suppliers, SGS-Thomson and Atmel. For long-term EPROM users, appropriate supplier realignments should be begun now.

Table 4
1994 Nonvolatile Market Leaders by Device Type

	ROM		EPROM		Flash		EEPROM	
Rank	Company	Market Share (%)	Company	Market Share (%)	Company	Market Share (%)	Company	Market Share (%)
1	Sharp	29	SGS-Thomson	26	Intel	51	Atmel	19
2	Samsung	13	AMD	14	AMD	24	SGS-Thomson	16
3	Toshiba	13	TI	14	Atmel	7	Xicor	12
4	NEC	11	Atmel	8	Toshiba	6	Siemens	10
5	Hitachi	7	National	7	SGS-Thomson	4	Microchip	8
	Others	27	Others	31	Others	8	Others	35
	Total ($M)	2,216		1,545		884		738

Source: Dataquest (September 1995)

Flash Suppliers

Intel, AMD, Atmel, Toshiba and SGS-Thomson are the top five producers of flash memory (Table 4). The two large U.S. companies, Intel and AMD, are truly kings of flash. In 1994, Intel and AMD together had 75 percent market share, despite the fact that numerous companies claim to be making and shipping flash parts. Most recently, the Taiwanese company Macronix and the Korean company Hyundai joined the list of flash suppliers.

In 1994 and 1995, 1Mb, 2Mb, and 4Mb flash devices have not been easy to procure. Just last month Dataquest heard that one major supplier is reneging on committed POs. There should be some relief in 1996 as new players enter the market and established suppliers expand capacity. The single biggest impact on flash supplies should be the ramp-up of the FASL (Fujitsu and AMD joint fab) facility in Japan.

EEPROM Suppliers

Atmel, SGS-Thomson, Xicor, Siemens, and Microchip are the leading suppliers of EEPROM (Table 4). In general, the EEPROM market is considered the most niche-like and will probably have the slowest growth rate for the foreseeable future.

Dataquest Perspective

For large system OEMs dependent on nonvolatile memory suppliers, the near-term availability news is not very good. Flash, being dominated by Intel and AMD, continues to be tight, with long lead times and high tags for 1Mb and above. The shift to flash memory, especially in the higher densities, at the expense of EPROM was made very evident in last year's shipments and continues to date. As a direct result, the EPROM scene just got much worse (from a user perspective) with the pullback of TI, AMD, and National from this aging market. Even venerable mask ROMs may be difficult to get if the customer is not a game manufacturer and requires faster but less dense devices. EEPROM has always been a specialized market with a limited supply base—no increase in supply seen here.

Dataquest makes the following recommendations to OEM supply base managers. Consider moving away from EPROM, as the supply base is shrinking. In flash, investigate newer suppliers like Atmel, SGS-Thomson, Macronix, and Hyundai. The flash market has the best potential for additional sourcing as suppliers seek to diversify product offerings with existing or similar technology. For mask ROM and EEPROM, monitor your primary suppliers for any changes in capacity, delivery, or price.

Overall, Dataquest sees a tight semiconductor market through 1996 (barring an abrupt decline in PC demand), so do not expect much relief from capacity constraints and firm pricing.

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Market Analysis

Semiconductor Procurement Worldwide

Market Analysis

Advanced Microprocessor Supplier and Product Update: Intel's Product-Life Compression Affects Entire Market

Abstract: *This article analyzes the events in the advanced microprocessor market from a user's perspective, focusing on products, suppliers, and the near-term direction of this critical market. We examine both major CISC and RISC architecture and supply bases in this annual update based on 1994 shipment data.*
By Mark Giudici

Intel Ratchets Up the Speed of MPU Product Life Cycles and Affects Entire Market

This article analyzes the developments of the advanced microprocessor market from a product- and supply-base perspective. Dataquest defines advanced microprocessors as those using 16/32-bit, 32-bit, 32/64-bit, and 64-bit I/O; both CISC and RISC processors as a group are labeled "32-bit-and-up MPUs." This category consists primarily of the 80x86/Pentium families, the 68xxx families, and open system RISC processors (Alpha, MIPS, PA-RISC, PowerPC, and SPARC). This market continues to change dramatically as suppliers play the game of price/performance one-upmanship at the hardware level, while application software support grows in importance as a user decision factor. These factors combine with others (especially memory availability since 1994) to accelerate the rate of change to higher-performance systems while reducing the system life cycles of many leading-edge products.

This article is divided into three sections. The first is a guide to the current state of microprocessor families relative to their position in the overall microprocessor product life-cycle curve, based upon the latest shipment data available. The second section examines the strategies of the top three suppliers of advanced MPU products and technology. The third section

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analyzes the current and future supply base for this critical semiconductor segment. Combining individual user company system data with this analysis provides good insight on the current and future supply base of this important product segment.

MOS Microprocessor Product Life Cycles

This section uses information on life cycles as a guide to assist users in adjusting to forces that continue to reshape the worldwide MPU marketplace.

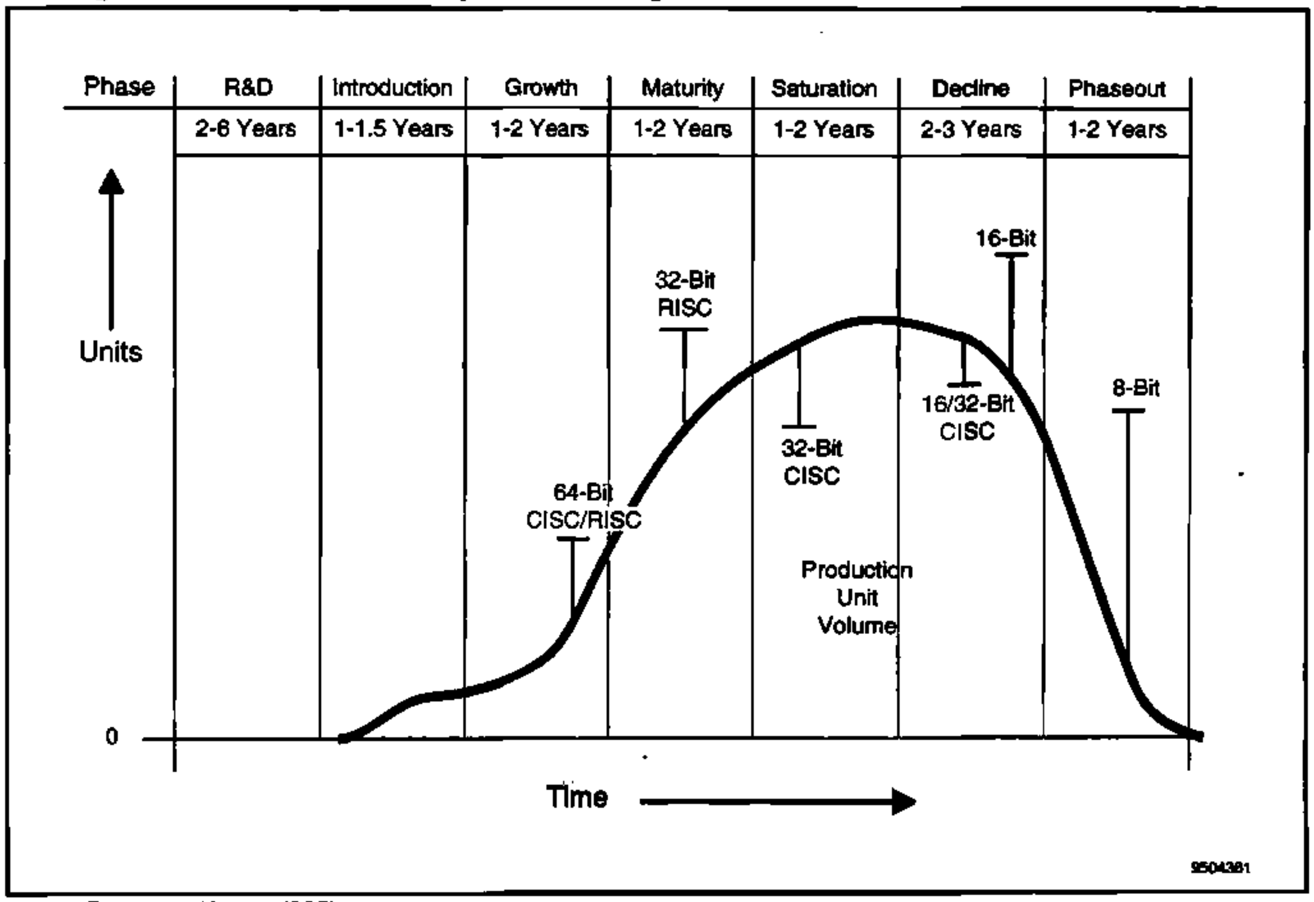
Typical Life Cycles for MPU Products Cut Almost in Half!

Figure 1 highlights the sea change undergone by microprocessor family life cycles. Intel's announced compression of its introduction of Pentium-and-beyond microprocessor products from four years to two years has affected not only the Pentium, but also all competing microprocessor products. This has resulted in a reduction in life cycle from the pre-1994 range of 13 to 28 years to the current range of nine to 18 years from initial R&D through obsolescence (phaseout). The typical MPU life cycle that involves production volumes (growth through decline) now generally exceeds six years (compared with the pre-1994 10-year range).

The lengthy R&D phase provides users a valuable opportunity to monitor a supplier's (or prospective supplier's) pace of technical achievement, legal standing (when applicable), and timetable for bringing a new, state-of-the-art device to market. The increasingly competitive 586-class market continues to bring price and availability relief as NexGen, Cyrix, and AMD compete legally with Intel. The 486 market remains strong despite Intel's announced plan to exit in December 1995, leaving this market to AMD, Cyrix, IBM, and TI. The 8-bit processor market remains solely with embedded applications and the 16-bit arena is also quickly ramping up into the embedded areas and in some handheld products. The 32-bit-and-up market remains fragmented. While a number of competitors vie for a piece of the Intel money pie, Motorola continues to support the aging 68020/030 products as the 68040 falls victim to the PowerPC. The quickly accepted Pentium and other 32-bit-and-higher RISC products are currently on the high end of the price-performance spectrum and are expected to come down the curve faster over the next two to three years than in the past.

Figure 2 highlights the product life cycle for select CISC 32-bit MPUs through 1994 using historical unit shipment data. It shows that 1994 continued to be a stellar year for the 486 product lines. The mature Motorola 68020 products continued to decline in unit volume, while the more advanced 68030 shipment growth compared favorably to the other 32-bit product growth rates. Continued use of the mature 68020, 68030, and 386 in embedded applications will keep unit shipments for these families resilient in the coming years, while the leading-edge MPU products win computer design-ins. Continued 486-competition prices, combined with Windows demand, kept the high-end 486DX2/4 market expanding and allowed Intel to remain the top semiconductor supplier in 1994. Figures 1 and 2 show that users should not expect market saturation for the majority of these products in the near term. The continued introduction of 75-MHz-and-higher non-Intel 486 products at close to $1 per megahertz has effectively made this family of products the baseline from which other processors are priced. Rapid acceptance of these economical 486DX2/4s devices has truncated the

Figure 1
Microprocessor Product Life Cycle as of August 1995



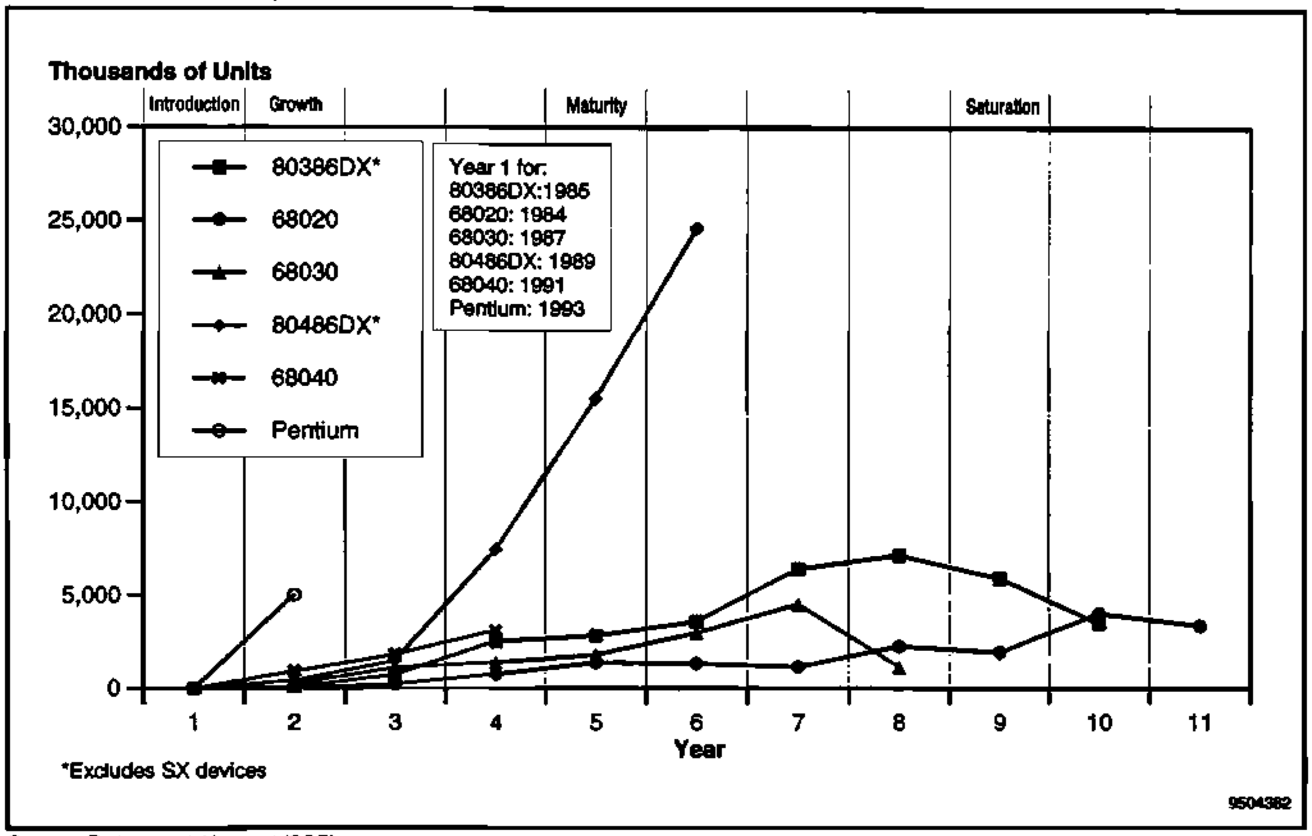
Source: Dataquest (August 1995)

life cycle of the 486SX and 386SX/DX as a primary PC engine but, as mentioned, prospects are still good for the 386 and 486 product families to become the embedded processors of choice because of the very large base of existing software expertise.

Microprocessor Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of advanced microprocessors. Because of the interest of the Semiconductor Procurement Worldwide service client base, this section focuses on suppliers with strength in the European and North American markets: Intel, Motorola, and AMD. Table 1 shows that Intel maintained its lead as the top semiconductor company in 1994, owning nearly three-fourths (73.2 percent) of the microprocessor market. Suppliers exceeding the average market growth rate of 30 percent (a good year for microprocessors) were: IBM (179 percent), Cyrix (143 percent), National (124 percent), Hitachi (103 percent), and AMD (93 percent). Although the growth rates for IBM, Cyrix, Fujitsu, and Hitachi are high, they started from a relatively small base. AMD's growth benefited more from the strong 486-based PC market because of its high output rate in 1994.

Figure 2
CISC MPU Life Cycle—1994



Source: Dataquest (August 1995)

Table 1
1994 Worldwide Microprocessor Market Share Ranking (Millions of U.S. Dollars)

1994 Rank	Company	Segment Revenue ($)	Market Share (%)	1993-1994 Change (%)
1	Intel	8,370	73.2	27
2	AMD	985	8.6	93
3	Motorola	597	5.2	-16
4	IBM	246	2.2	179
5	Cyrix	231	2.0	143
6	Texas Instruments	214	1.9	7
7	Hitachi	160	1.4	103
8	NEC	105	0.9	21
9	Toshiba	92	0.8	35
10	Fujitsu	56	0.5	124
	All Others	380	3.3	7
	Total	11,436	100.0	30

Source: Dataquest (August 1995)

Intel

Intel remained the No. 1 microprocessor (and semiconductor) supplier in the world in 1994 primarily because of the high growth of the 80486 product line. Intel's announced de-emphasis of the 486 product by the end of 1995 follows the formula of jumping to the next generation as competition heats up in the existing market. While Intel ceded the low-margin competitive 486 market as engine for computers, it focused on its mainstay high-end 486 and Pentium offerings.

Intel Strategy Modified: Take the High Road at Twice the Speed

Intel took its strategy of leapfrogging the industry with advanced technology one step further. The company recently announced plans for production of the next-generation P6 product in 1996—two years (not the traditional four) after the Pentium production introduction. Besides impacting the existing market, Intel has now put added pressure on competitive R&D efforts to keep up with the MPU technology treadmill. True to form, Intel flawlessly executed its formula of higher technology and higher price in 1994 and showed that staying ahead of the technology curve is very profitable. The rapid ramp-up of the Pentium superscalar processor and the approximately 20 new 486 products announced in 1993 continued to keep Intel ahead of the rapidly growing processor supplier pack. By aligning itself with key system companies, Intel keeps its favored customers on the leading edge with early market product allocations and also assures itself a steady revenue stream with which to fund the next generation (or two) of product families. Not one to leave money on the table, Intel will focus for the 386 on high-volume/low-cost embedded applications, ensuring a long life for this family. This jockeying for supply dominance has forced many of the smaller PC clone companies to seek other sources of 486s. In many ways the addition of competitors in the 486 market has benefited Intel's bottom line directly by siphoning away lower-volume customers that diverted attention away from the higher-profit, leading-edge products. The only potential competitive threats to the Pentium in the CISC world come from NexGen's nonpin compatible 586 part. Cyrix's M1 and AMD's K5 products are delayed until 1996 because of die size and customer compatibility issues, respectively. By that time, Intel plans on having its P6 in production, starting another technology cycle.

AMD

What a difference another year makes. In 1993, the short-term focus on the 386 market was expected to allow AMD some breathing room while it got its cleanroom Am486 into production. Although the clean Am486 didn't ship in 1993, the 1994 PC boom provided AMD with a needed—and readily met—boost in Am486 demand. Demand for the AM486 raised AMD to the No. 2 position in the 32-bit-and-higher microprocessor market. The legal vindication of the 486 that effectively allowed AMD to use Intel microcode (at least until the end of 1995) has improved its reputation and revenue stream. However, a clean 486 and K5 product design remain necessary to the long-term viability of AMD as a mainstream microprocessor supplier. The delay of the clean K5 processor into 1996 has given arch rival Intel another window of revenue opportunity. Making lemonade from lemons, this "setback" will allow AMD to focus on the very profitable high-end 486 product and should keep a solid revenue stream going into R&D efforts. AMD's stated strategy of using the K7 product to catch up with Intel in technology, while ambitious, should keep this lopsided battle going into the 21st century.

Motorola

Motorola's slip to No. 3 microprocessor supplier occurred largely because the company de-emphasized the 68030/40 while emphasizing the PowerPC, which then did not meet shipping expectations. Besides being the leading volume microprocessor for laser printers, the 68000 series is assured of continued growth as the processor of choice for the advanced Sega Genesis game. While the 68020/030 series focuses on declining Apple Macintosh shipments, laser printers, and other embedded applications, there are no new developments for this series because the integrated midrange 683xx family will take over embedded applications. The 68040 is being replaced by the PowerPC as the main engine for the current Apple Macintosh line. As the popularity of the PowerPC grows with Apple and others, Motorola will shift its energy to this fast-growing RISC computer market offering. The 68xxx computer-based applications portion of Motorola's portfolio will decline as Apple turns quickly to the PowerPC family, taking a large portion of revenue with it. However, overall unit shipments will grow because of Motorola's strength in winning high-volume embedded designs outside the computer systems market. Motorola's focus on the PowerPC will allow it to push the technology keeping the Pentium market competitive and will also allow the company to develop early growth for the PowerPC in embedded applications.

Advanced Microprocessor Supply Base Analysis

This section uses information on MPU product life cycles and suppliers to present a product-family evaluation of the supply base over the long term for CISC 32-bit and RISC 32-bit MPUs. This section also includes information on the global MPU fab network of key suppliers.

The advanced microprocessor market continued to be more competitive in many ways in 1994, yet it also remained monopolistic at the very high end of the technology spectrum. The result is an increased challenge for procurement managers, component engineers, and system designers of system companies in choosing products, let alone suppliers. This section combines product life-cycle and key-supplier analysis to summarize the expected MPU supply/supplier base from a user's perspective. The summary concludes with discussion of whether the user faces a favorable or critical supply base for each family/device. We now discuss factors affecting the supply base, such as supplier strategies and strategic alliances.

Table 2 shows the estimated 1994 worldwide MPU process technology and fab capability by geographic location for the following major MPU suppliers: AMD, Cypress, Fujitsu, Hewlett-Packard, Intel, Motorola, NEC, and TI. In most cases, the process technology is between 0.35 and 1.0 microns for these suppliers.

Supply Base for 32-Bit-and-Up MPUs

Table 3 shows the market size and predominant suppliers of the 32-bit RISC and CISC MPUs in 1994. Unit shipments of 32-bit-and-up MPUs in 1994 grew a healthy 22.7 percent following a phenomenal 74 percent growth rate in 1993. As noted in Figures 1 and 2, MPUs such as the 486 and 68030 should have life cycles extending out to the year 2000, although versions below 20 to 25 MHz will fade from mainstream production by the end of 1995.

Table 2
1994 Worldwide Microprocessor Market Share Ranking (Millions of U.S. Dollars)

	Intel	Motorola	AMD	Fujitsu	TI	IBM	NEC	HP
Number of Fab Lines								
North America	8	6	2	-	1	1	-	1
Europe	2*	2	-	-	-	1	-	-
Japan	-	-	-	5	1	1	9	-
Asia/Pacific and Rest of World	-	-	-	-	-	-	1	-
Total	10	8	2	5	2	3	10	1
Cleanroom (Sq. Ft.)								
North America	413,000	208,600	102,000	-	71,000	35,000	-	25,000
Europe	97,000*	62,000	-	-	-	20,000	50,000	-
Japan	-	-	-	142,300	36,000	-	360,075	-
Asia/Pacific and Rest of World	-	-	-	-	-	-	40,000	-

*Includes Intel Israel
Source: Dataquest (August 1995)

Table 3
Supply Base for 32-Bit Microprocessors—1994

Leading Product	Product's Share of Total 32-Bit-and-Up MPU Market (%)	Supplier	Supplier's Share of Product Segment (%)
68000	17	Motorola	83
		Hitachi	8
		Toshiba	6
		SGS-Thomson	3
80386SX/SL	3	AMD	56
		Intel	42
		Chips and Technologies	1
		United Microelectronics	1
80386DX	3	Intel	12
		AMD	85
		Chips and Technologies	3
80486SX	16	Intel	75
		IBM	8
		TI	5
		AMD	5
		Cyrix	7
80486DX	21	Intel	77
		AMD	16
		TI	3
		Cyrix	4
683XX	9	Motorola	100

(Continued)

Table 3 (Continued)
Supply Base for 32-Bit Microprocessors—1994

Leading Product	Product's Share of Total 32-Bit-and-Up MPU Market (%)	Supplier	Supplier's Share of Product Segment (%)
68040	3	Motorola	100
68030	1	Motorola	100
68020	3	Motorola	100
80960	4	Intel	100
AM29000	1	AMD	100
32X32	3	National	100
R3000/R4000	1	Performance	1
		IDT	35
		NEC	8
		LSI	52
		Toshiba	4
SPARC	1	Fujitsu	31
		TI	69
Pentium	4	Intel	100
Others	10		
Total	100		

Note: Total market size = 116.1 million units
Source: Dataquest (August 1995)

X86 Market Keeps Going and Going and Going ... (with Intel in the Driver's Seat)

We used this title in last year's update and it still remains applicable today. The growth in 1994 of the x86 market confirmed the obvious—the future of this product family lies with the 486- and Pentium-class series of processors. The addition of competition further strengthens an already strong market position for this family, resulting in a solid supply base of more competitively priced products for the future. AMD in 1994 became the big fish in the continually shrinking 80386 pond (the 80386 share of 32-bit shipments dropped from 10 percent in 1993 to 3 percent in 1994), with 85 percent of all shipments of this product. Now that no legal cloud shadows AMD's role in the 486 market, the company becomes another secure supply base of this important processor family. The current focus on the 486 market by the group of five competitors (Intel, AMD, Cyrix, TI, and IBM) promises to provide users with continued variety and price/performance improvements for the next two years as Intel leads the pack with its Pentium product line.

The Pentium processor ramped quickly into production in 1994 and jumped into a rapid growth phase during the second half of 1994 despite the infamous "Pentium problem" publicized in the fourth quarter of 1994. Both Cyrix (using IBM as a foundry) and AMD planned on shipping their Pentium-competitive offerings in the third and fourth quarter of 1994, but had cost or compatibility issues that have effectively delayed volume production until late 1995 or early 1996. The current price premiums enjoyed by the Pentium will decline over the next three years as competition from these two CISC products and rival RISC processors ramp up production. To date, dramatic Pentium price cuts against these competitors have been intended by Intel to "head 'em off at the pass," reducing the ability of competition to gain early profits (which equals high profits) from early product shipments.

Motorola Continues to Embed 68xxx Processors while Focusing on PowerPC Gold

Table 3 shows that Motorola's combined 68020/030/040 product offerings total only 7 percent of all 32-bit-and-up MPU shipments in 1994, while its advanced embedded 683XX family of parts totaled 9 percent of all MPUs in this class. Although not trivial, the nonembedded share of market has been eroding for Motorola since 1990, when the company held a 27 percent share of this market. As noted, the fastest-growing segment of Motorola embedded processors is the 683xx series, within which are three categories: the low-end 000 core, the midrange 020/030 cores, and the high-performance LC040 core. Motorola will continue to support existing customers of its 68020/30/40 products and offers an upward migration path for them with either the 68060 or the PowerPC, depending on the application. The continued emphasis on embedded MPU applications will continue to keep the fabs full, but prices will be lower than those enjoyed by the computer MPUs.

Balancing the embedded market is the PowerPC MPU, released in 1994. This jointly developed processor has the potential to become the largest-selling RISC product in its first year of production (barring any unforeseen difficulties in shipping PowerPC Macintoshes), overtaking the MIPS processor by a wide margin. Motorola realizes that as the shift to the PowerPC evolves, there will be a commensurate near-term revenue loss from the decrease in existing 68040 Macintoshes not made up by increased PowerPC shipments. Thus the company is accelerating its focus on embedded designs.

Open System RISC Processors

Dataquest segments the open system RISC (OSR) market to include the following processor families:

- SPARC
- MIPS
- PA-RISC
- PowerPC
- Alpha

These RISC processors garner the greatest number of inquiries from Semiconductor Procurement Worldwide service clients and therefore will be the focus of this segment. Dataquest defines this class as RISC-based microprocessors focused primarily on computing platforms (mainly technical workstations and PCs). While the computing RISC segment of the market accounted for only 7.6 percent of all 32-bit-and-up MPU shipments, this small segment of the market grew 116 percent compared with last year's shipments. These are the microprocessor products that continue to set performance standards for computer system engines.

Figure 3 shows that, although the Intel i960 embedded processor owns 45 percent of the RISC 32-bit-and-up market, the PowerPC family has taken over the No. 1 computing platform spot with 25 percent of the market, followed by the MIPS family (20 percent), the SPARC family (7 percent) the PA-RISC processor (2 percent), and the Alpha (1 percent).

PowerPC

The PowerPC product family quickly overtook the No. 1 RISC computing processor position, thanks largely to Apple Computer's successful switch to this new computing platform. IBM supplied most of this volume in 1994 but, as mentioned above, Motorola also has big plans for its newest microprocessor offering. Applications run the gamut from PCs to workstations to using the PowerPC as a high-performance platform for embedded processors for the 68xxx families. Although both Apple and Motorola have hitched their wagons to the PowerPC star, IBM continues to straddle the Intel/PowerPC fence. Dataquest acknowledges that changing MPU horses midstream is difficult (especially if the Intel-licensed horse isn't dead yet), but mixed signals continue to come from IBM and the PC Company regarding processor support. The quick adoption of the PowerPC as a standard processing platform could be at stake. Some of the significant PowerPC announcements in 1994 and 1995 were the following:

- Apple introduced its Power Macintosh 9500, which uses the high-performance PowerPC 604 processor, and the entry-level Quadra 630, which uses the PowerPC 603 processor.
- IBM introduced its Power Series 830 and 850 systems, based on the PowerPC 604, and the ThinkPad Power Series 830 and 850, based on the PowerPC 603e processors.
- Motorola and Microsoft announced the porting of the Windows NT 3.51 operating system for the PowerPC architecture.
- Motorola announced a series of its own PowerPC-powered midrange servers as part of its PowerStack product line.
- Companies developing PowerPC systems and subsystems include the following:
  - 3DO
  - Actebis
  - ADP
  - Amdahl
  - Apple
  - Canon
  - Datatech
  - DayStar Digital
  - Escom
  - Ford Motor
  - FirePower Systems

- Formosa Industrial Computing
- Groupe Bull
- Harris Computer Group
- Hitachi
- IBM
- ISG Technologies
- Mercury Computer Systems
- Motorola Computer Group
- Parsytec
- Power Computing
- Scientific-Atlanta
- Shannon Computer
- Tadpole Technologies
- Taiwan Auto Design
- Tatung
- Thomson-CSF
- Toshiba
- Umax
- YARC

- In March 1993, the initial PowerPC system companies (IBM, Apple, Bull, Harris, Thomson-CSF, Tadpole, and Motorola) formed an independent corporation, the PowerOpen Association. The PowerOpen Association's goal is to promote the PowerOpen Environment and provide software developers with services that support the development of PowerPC-based products.

Momentum for a price/performance competitor to Intel's Pentium continues to build, yet minimal operating system support and additional large computer company adoption still hinders the PowerPC. As Mac clones begin to enter the market and Apple begins to license its Mac OS, the consumer will have even more options in the search for the perfect computer. The big question now arises: "Is it too little, too late for the PowerPC?" We'll see.

MIPS Family

The MIPS family of processors rose to the No. 2 RISC OSR position, bypassing the SPARC product group in 1994, fueled by large shipments of chips from the top two suppliers, LSI Logic and IDT. Besides shipments to Silicon Graphics (the lone computer user), 1994 saw considerable MIPS product growth in embedded applications such as laser printers, X terminals, and advanced video games. Some of the more significant events that affected the MIPS world in 1994 and 1995 were the following:

- PCPI announced ColorImage laser printer/copier controllers that use a 64-bit Orion-class MIPS processor.

- Tandem acquired the rights to market and support NeTpower's MIPS-based Windows NT servers and workstations.
- Ross Technology announced availability of 125-MHz HyperSPARC upgrades.
- MIPS Technologies and NEC announced the low-power VR4100 and the low-cost, very high-performance VR10000 products.
- AT&T, Network Systems, Philips, and Samsung announced their intention of supporting the Magic Carpet MIPS chipset for their communications and interactive consumer product lines.
- Time Warner Cable will use Magic Carpet chipset for its interactive applications.
- In 1994, Nintendo and SGI agreed to develop a 3-D Nintendo machine for home use, based on a version of the MIPS Multimedia Engine (a 64-bit MIPS RISC MPU chipset), which was planned for the 1995 Christmas season, but may be delayed into 1996.
- Toshiba supplied the R4400 processor for Silicon Graphics' Indigo 2 IMPACT Workstation.
- Sony Corporation released its advanced video game, the Playstation, which uses a MIPS R3000 core.

Strong growth in embedded applications will allow for continued growth of the product line, but there will be fewer suppliers.

SPARC Family

1994 saw the SPARC family of processors slip to the No. 3 RISC OSR ranking behind the PowerPC and MIPS families. In 1994, the SPARC processor group, which has been dominated by Sun Microsystems, attempted to disassociate itself from its largest benefactor and hindrance (Sun) by providing a technology road map targeting three design series. The low-end MicroSPARC targets embedded applications, the midrange SuperSPARC aims at PC business, and the high-end UltraSPARC (with more than 200 SPECint performance) shoots for advanced workstation designs. Some of the key events that impacted this market in 1994 and 1995 were the following:

- The SPARC vendor base was reduced by one when Fujitsu bought the ailing Ross Technology Division from Cypress.
- In April 1993, Sun announced SPARC Technology Business (STB), whose charter is to market Sun-developed SPARC processors, system product designs, and software. As part of STB, Sun entered the merchant semiconductor market by offering SPARC processors and supporting ASIC chipsets.
- Sun and Fujitsu formed a partnership to design and produce the next-generation MicroSPARC II, which began shipping in October 1994.
- TI released 50- and 60-MHz versions of the SuperSPARC and extended its partnership with Sun to development and production of the first UltraSPARC I product, a 64-bit processor designed to reach more than 200 SPECint performance.

- STB announced availability of the SuperSPARC II microprocessor (3.1 million transistor, 90 MHz, 148 SPECint, 143 SPECfp).
- STB introduced the UltraSPARC microprocessor (September 1994) and the UltraSPARC chipset (May 1995).

Although the SPARC family was the largest computer-volume OSR family, it continues to mirror market momentum lost by its largest computer user, Sun Microsystems. Despite the good efforts of the STB and recent design-wins by Fujitsu and LSI Logic, the overall outlook for large shipments of embedded processors in the near term is not high.

PA-RISC Family

The PA-RISC processor family, after some significant moves in 1993, remains a proprietary (fourth-ranked) high-performance workstation engine. Some of the major events in 1994 and 1995 were the following:

- Hewlett-Packard and Telecommunications Premium Services (TPS) announced an offering of next-generation value-added communications services via TPS' multimedia host environment based on PA-RISC servers.
- Hewlett-Packard announced two new HP9000 workstations based on the PA-RISC 7100LC processor.
- Hewlett-Packard announced availability of the next-generation PA-8000 64-bit microprocessor in the first quarter of 1996 (planned to exceed 360 SPECint92 and similar in architecture to Intel's P6 processor).
- Hewlett-Packard and Intel announced a joint development agreement to develop a P7-generation chip due out in 1997, in addition to Intel's independently planned successor to its P6 processor.
- The Precision RISC Organization (PRO), formed in March 1993 to cross-license PA-RISC technology, is still working hard to spread the PA-RISC gospel, with mixed success to date. Hewlett-Packard's agreement with Intel appears to be a hedge against lack of PRO success.

Hewlett-Packard's production model for the PA-RISC platform is based on systems profitability, while alliance suppliers appear to use a device-profitability model. In order for PA-RISC to become a viable architecture, Hewlett-Packard, as a leading computer supplier, must enter the RISC PC market and become the architecture standard-bearer. Except for captive embedded designs, embedded applications for this processor will grow slowly.

Alpha Family

Digital Equipment Corporation has carefully crafted the Alpha microprocessor into a high-performance core of its own PC and other computer businesses, while working on making the family a standard RISC architecture used by others. An early adopter of Windows NT, Digital's market position and aggressive independent software suppliers, plus its direct PC distribution channels, give it a good head start on other RISC-based Windows NT personal computer companies. Acknowledged to be the fastest microprocessor on the market, the Alpha is hindered by the lack of a large Windows NT user base. Another major disadvantage is the lack of alternate sources for the part, other than Mitsubishi, which has no experience in developing or marketing microprocessors. Some of the key 1994 and 1995 developments in the Alpha market were the following:

- Intelectronika (a wholly Russian-owned system manufacturer) contracted with Digital in a $2.5 million deal involving system manufacture (first-quarter 1995 delivery of 1,000 Alpha motherboards) and development of indirect technology channels in Eastern Europe.
- Just Imagine released the Alpha 64/233 workstation based on the Alpha 21064 processor that runs at 233 MHz.
- Digital shipped 100,000 Alpha microprocessor-based systems to Smith Kline Beecham.
- BTG released the superpowered AXP275 ULTRA personal supercomputer using an Alpha 21064A 275-MHz processor as its engine. Price: $17,000.
- Digital and Microsoft signed an OEM agreement allowing Digital to offer Microsoft BackOffice server products on AlphaServer systems and on Intel-based Prioris PC servers, while Microsoft is licensed to provide Digital's clustering technology for Windows NT.

Although Digital is going full tilt to promote the Alpha, the slow ramp of Windows NT as a mainstream desktop operating system is hindering its efforts. The new agreement with Microsoft may make this situation worse. Correctly focusing on computer applications, Digital now needs another licensed alternate processor supplier and a creative method of marketing this advanced product family.

Dataquest Perspective

Intel's 1995 accelerated introduction of the P6, following on the heels of the Pentium, will continue to reverberate throughout the microprocessor and PC markets for years to come. With the MPU treadmill cranked up to nearly double speed, both competitors and customers may have some changes imposed upon them. Although the RISC versus CISC distinctions once gave the RISC camp a performance advantage, the P6 architecture and initial performance specifications have narrowed the RISC/CISC gap dramatically. The Intel/Microsoft hardware/software duo will continue to rumble into the future, but in the long term, RISC processors will continue to make it glaringly obvious that both hardware and software are key factors in users' choices for high performance systems. The plethora of RISC processors promoting the openness of each processor's architecture in order to gain software support is evidence of this trend.

Growth in the x86 market continues at a very healthy clip, with Intel firmly in control of this technology-driven money-making machine. By playing technology leapfrog (now at a faster pace) with its increased number of competitors, Intel continues to control the lucrative high end of the market and simultaneously sows the seeds for additional x86 sales by ceding the low end, where price is the main decision factor, to its competition. Motorola's expected rocky transition from a 68xxx to a PowerPC customer base resulted in AMD's regaining the No. 2 advanced microprocessor supplier position. AMD's focus on the Am486 with faster clocks at attractive prices fit in well with the continued PC boom of 1994 and 1995. AMD's delay of its K5 product into 1996 may be a blessing in disguise. It will use its available fab space better by focusing on producing profitable high-end 486 processors while fine-tuning its K5 for later production. Motorola's balanced mix of embedded products and now a multisourced RISC core will continue to provide users with a wide selection of price/performance options rivaled only by Intel. IBM's Blue Lightning products received technological nods of approval but often got upstaged by Intel's marketing machine. Both Cyrix and TI gained ground in the 1994 MPU price war despite the two companies' falling out over foundry access. Both companies plan advanced x86-like designs to complement their current 386 and 486 products. TI plans to be one of the remaining low-cost providers of 486 processors.

The OSR market continues to focus rightly on price/performance advances over CISC alternatives. Many suppliers have put in place the infrastructure needed by mainstream system users (common advanced operating systems, second sourcing, among others) that will help facilitate market acceptance. The P6 and P7 architectures may somewhat blur this distinction, however. Software applications are critical elements of success in the conservative CISC versus RISC architecture selection process. The bottom line remains that if an end user can use a program that is interchangeable among competitively priced hardware options, the user will opt for the software-flexible hardware. Much of the infrastructure is now in place to allow users to make better comparisons. Marketing of the various processors and software attributes, along with processor/system technology road-map alliances, now appears to be the next challenge in the high-performance MPU marketplace.

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Market Analysis

Semiconductor Procurement Worldwide

Market Analysis

Static RAM Supply Becomes Critical

Abstract: *With the advent of faster and more powerful microprocessors, SRAMs are no longer an option, but a necessity. This article analyzes this high-demand and tight-supply situation in the context of the entire SRAM market. Along with historical data, a forecast, product life-cycle curve, supply base matrix, and strategic recommendations are provided. By Scott Hudson*

256Kb Shortages and 1Mb Questions

As highlighted in last year's SRAM update, "Cache Memory Energizes SRAM Market," (SPSG-WW-DP-9406, August 1994), the SRAM market is being driven by demand for cache memory for fast 486, Pentium, PowerPC, and other high-end microprocessors. Essentially, microprocessors with speeds above 66 MHz generally require some type of fast memory to minimize the wait states caused by the slower standard DRAM memory.

The computer industry has embraced 32Kx8 SRAMs as the current solution to the speed problem, causing lead times to stretch out and prices to stay firm. Prices for medium volumes (tens of thousands per year) of the 32Kx8, 15ns, 5V SRAM are now at $4, with prices not expected to decline until early 1996. Particularly difficult to get is the 3.3V part, the SRAM of preference for Pentium systems, now selling for $6 in medium volumes. Typically, fast 486 machines use four 32Kx8 SRAMs that provide a bus width of 32 bits and total memory of 128KB. Pentium and PowerPC systems with 64-bit buses require a minimum of eight 32Kx8 SRAMs or 512KB.

SRAM suppliers that also make DRAMs (Hitachi, Samsung, Toshiba, NEC, Fujitsu, Mitsubishi, and Hyundai, among others) realize that they must balance production so that enough SRAMs are produced to keep the computer industry pumping out product. There is no point in making only the higher

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priced DRAM if systems cannot be built. Along with the ongoing shortage issue of the 256Kb (32Kx8) part, there is another and potentially more challenging problem: What should be the configuration for the 1Mb part?

Currently, there are at least five different parts that could satisfy the need for the 1Mb. These are the 128Kx8 asynchronous, 32Kx32 synchronous, 32Kx36 synchronous, 64Kx16 synchronous, and the 64Kx18 synchronous. It now appears that the 128Kx8 and the 32Kx32 will be the most popular parts, but it is not absolutely clear which parts will be needed by system designers and which parts will be available in volume.

The 1994 cache SRAM market, defined as 256Kb and 1Mb devices at 10ns to 35ns, is valued at $1.3 billion and is forecast to be over $2 billion in 1996. Although the cache SRAM situation is most compelling, the total SRAM market includes many other devices at different configurations and access speeds. This article will cover the entire SRAM market, highlighting the technology trends, life-cycle product curve, and leading suppliers. The article will also show unit and dollar forecasts and provide a perspective.

Density and Speed Trends

The SRAM market comprises many micromarkets delineated by total density, configuration, and speed. In fact, specific applications (PCs, handheld devices, and consumer products, among others) drive demand for very particular devices. For example, the 64K SRAM is most popular at speeds over 70ns and at 20 to 44ns, with minimal demand for speeds of 45 to 70ns or less than 20ns.

The 1994 SRAM market is valued at $4.5 billion, up 16 percent from 1993 ($3.9 billion). Because of the recent demand for faster and denser parts, the average selling price has increased 18 percent, from $4.31 in 1993 to $5.10 in 1994. Dataquest expects this trend to continue as PC designs begin to require the 1Mb part.

In Figure 1, total units are shown for four speed ranges: greater than 70ns, 45 to 70ns, 20 to 44ns, and less than 20ns. From 1994 to 1998, devices at less than 20ns will grow from 8 percent of the market to over 20 percent. In the same period, the market for devices over 70ns will shrink from 62 percent to 37 percent.

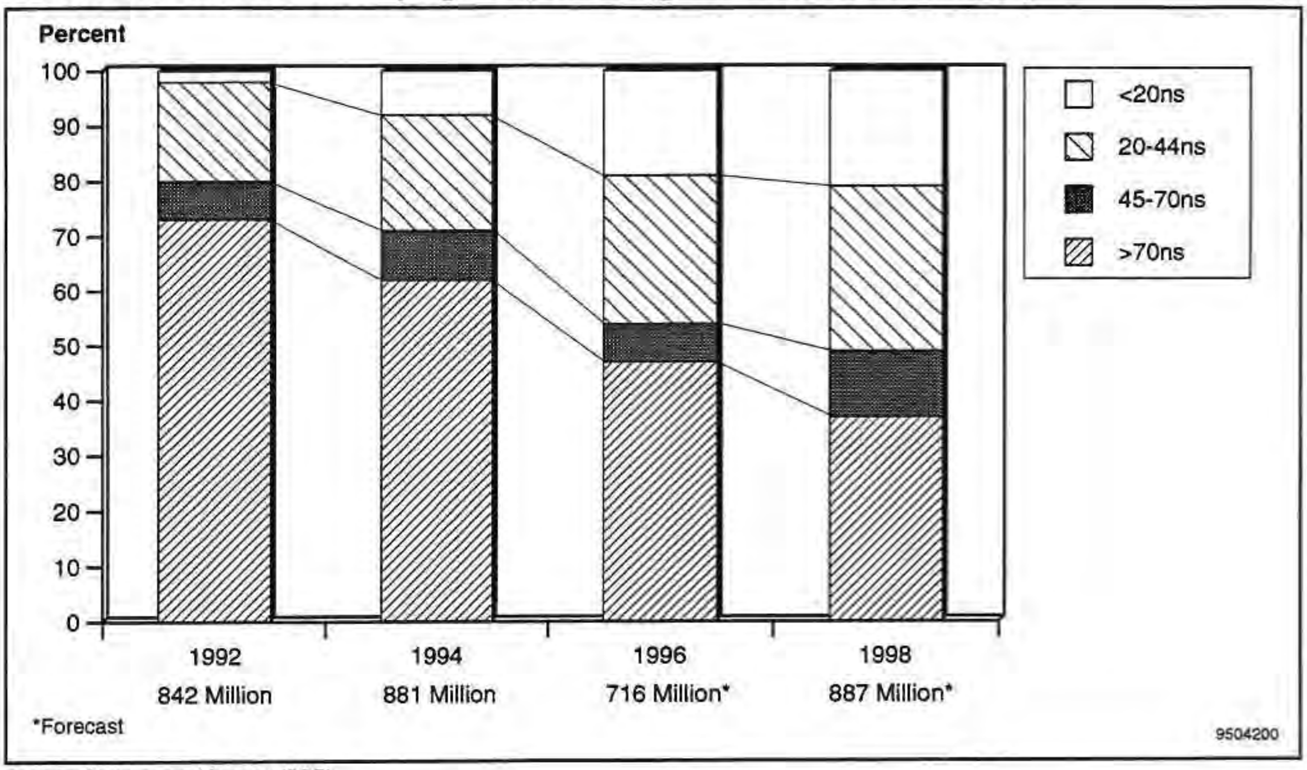
Devices in the 45 to 70ns speed range represent an interesting anomaly in the general trend of the fastest parts gaining market share at the expense of the slower parts. Dataquest forecasts that market share for these parts will grow from 7 percent in 1996 to 12 percent in 1998, because there will be significant demand for 4Mb devices at 45 to 70ns.

Figure 2 shows how SRAM density will change over time. In 1994, 85 percent of all SRAMs were at the 256K level or below, with a significant shift to 1Mb, 4Mb, and 16Mb later in the decade. By 1998, over 80 percent of all SRAMs will be above the 256K level.

SRAM Life Cycles

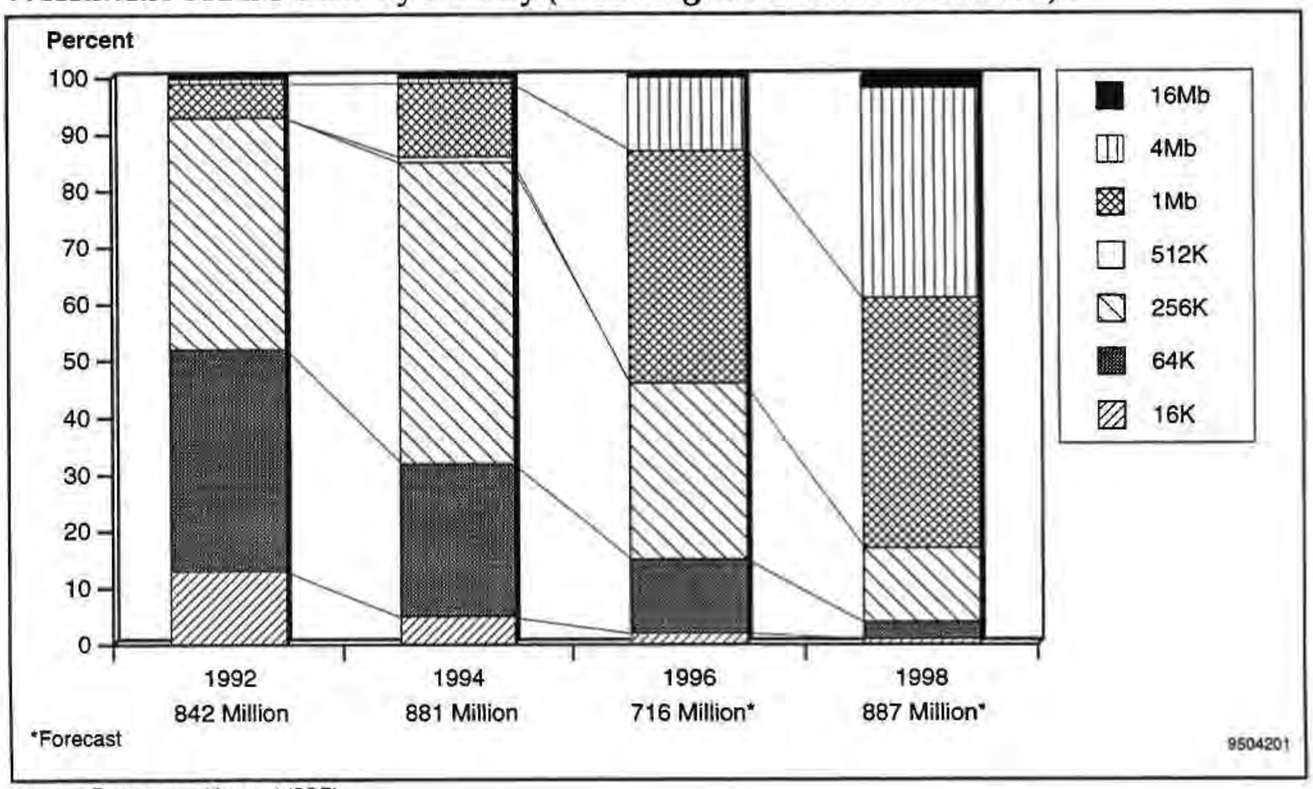
Another way of looking at the market is to place specific devices on the IC life-cycle curve. The IC life cycle has seven phases or stages: R&D, introduction, growth, maturity, saturation, decline, and phaseout. The SRAM life cycle is three times longer than that of DRAM, or about 15 years (see Figure 3).

Figure 1
Worldwide SRAM Units by Speed (Percentage of Worldwide Market)



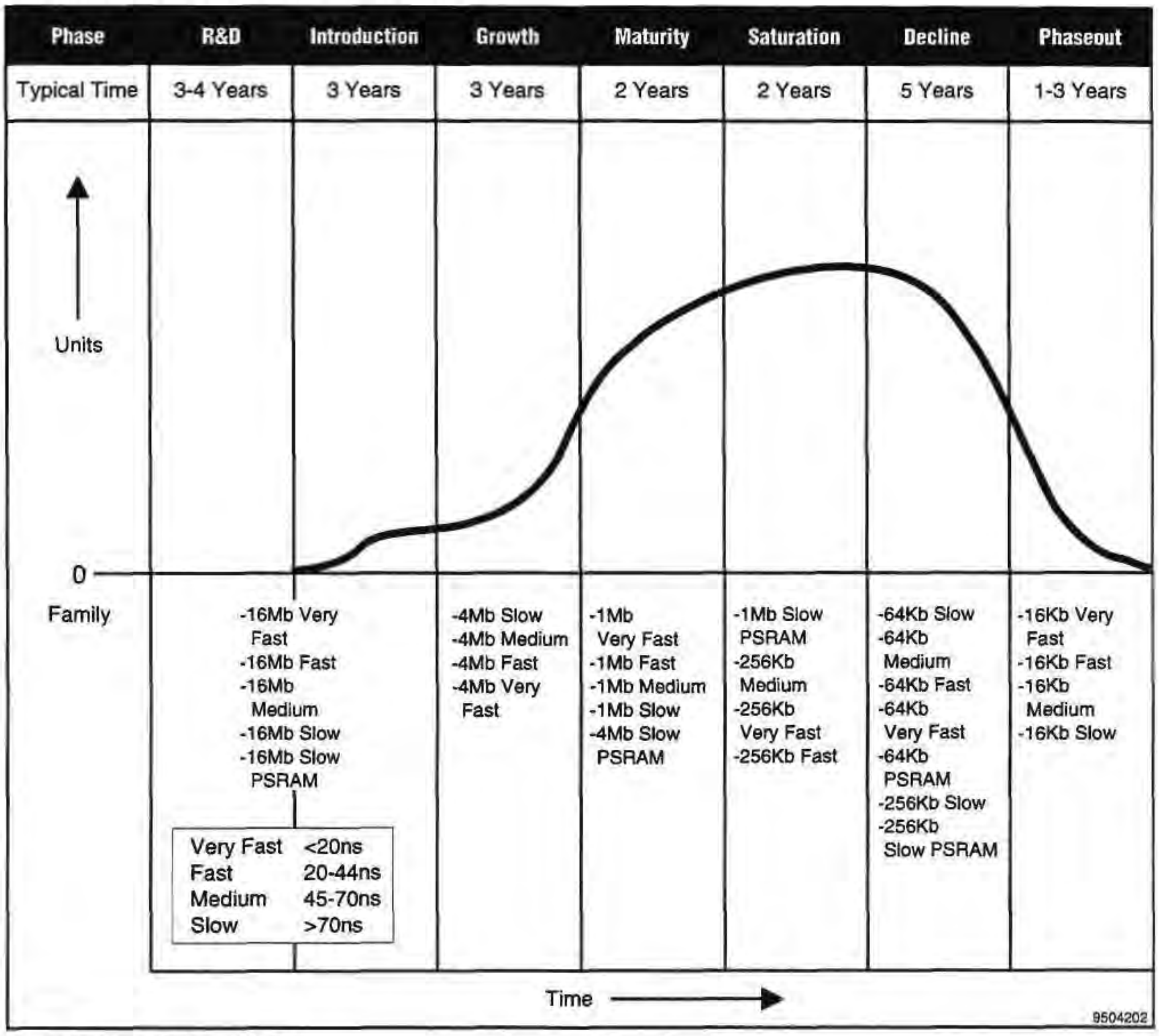
Source: Dataquest (August 1995)

Figure 2
Worldwide SRAM Units by Density (Percentage of Worldwide Market)



Source: Dataquest (August 1995)

Figure 3
SRAM Life-Cycle Stages by Density



Source: Dataquest (August 1995)

Understanding the position of a particular part on the life cycle curve is critical to the major IC users, the electronics system houses. Large system houses plan their volume production demands so that critical components are available in large quantities and at the best prices. This occurs when parts are in the maturity and saturation stages. Currently the fast and very fast versions of the 256Kb device are in the saturation stage, with the 1Mb following close behind in the maturity stage. If at all possible, system houses should avoid purchasing devices at either end of the life cycle, where availability is limited and pricing can be prohibitive.

Product/Supplier Matrix

With all the combinations of speed, density, and configuration available, it can be very difficult to keep track of the SRAM supply base. Also, SRAM suppliers typically cater to select segments of the market. Tables 1, 2, 3, 4, and 5 show who shipped what in 1994 and should relieve some of the confusion. A check mark indicates that a supplier shipped parts at the specified density and speed, while a dash means no parts were shipped.

Table 1
1994 Availability of 16K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Cypress Semiconductor	-	✓	✓	✓	-	-
Fujitsu	-	-	-	✓	-	-
Goldstar	-	-	-	-	✓	-
Hitachi	-	-	✓	✓	✓	-
Hyundai	-	-	-	-	✓	-
Integrated Device Technology	-	✓	✓	✓	-	-
MOSel-Vitelic	-	-	-	-	✓	-
Matra MHS	-	-	✓	-	-	-
Micron Technology	-	✓	✓	-	-	-
Mitsubishi	-	-	-	✓	-	-
Motorola	-	-	✓	-	-	-
OKI	-	-	-	-	✓	-
Rohm	-	-	-	-	✓	-
SGS-Thomson	-	-	-	-	✓	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
Sharp	-	-	-	✓	✓	-
Sony	-	-	-	-	✓	-
United Microelectronics	-	-	✓	-	-	-

— = Not available
✓ = Available
Source: Dataquest (August 1995)

Table 2
1994 Availability of 64K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	✓	-	-	-	-
Cypress Semiconductor	✓	✓	✓	✓	-	-
EDI	-	-	-	✓	-	-
Fujitsu	-	-	✓	✓	✓	-
Goldstar	-	-	-	-	✓	-
Hitachi	-	✓	✓	✓	✓	-
Hyundai	-	-	-	-	✓	-
Integrated Device Technology	-	✓	✓	-	-	-
MOSel-Vitelic	-	-	✓	-	✓	-
Matra MHS	-	-	✓	-	-	-
Matsushita	-	-	-	-	✓	-
Micron Technology	✓	✓	-	-	-	-
Mitsubishi	-	-	✓	✓	-	-
Motorola	-	✓	✓	-	-	-
NEC	-	-	-	✓	✓	✓
Rohm	-	-	-	-	✓	-
SGS-Thomson	-	-	✓	-	✓	-
Samsung	-	✓	✓	-	✓	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
Sharp	-	-	-	✓	✓	-
Sony	-	-	✓	-	✓	-
Texas Instruments	-	-	✓	✓	-	-
Toshiba	-	✓	✓	-	✓	-
United Microelectronics	-	-	✓	-	-	-
Winbond	-	-	-	✓	-	-

— = Not available
✓ = Available
Source: Dataquest (August 1995)

Table 3
1994 Availability of 256K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	✓	✓	-	-	-
Cypress Semiconductor	-	✓	✓	✓	-	-
EDI	-	-	-	✓	-	-
Fujitsu	-	-	✓	-	✓	-
Goldstar	-	-	-	-	✓	-
Hitachi	-	✓	✓	✓	✓	✓
Hyundai	-	-	-	-	✓	-
Integrated Device Technology	-	✓	✓	-	-	-
MOSel-Vitelic	-	-	✓	-	✓	-
Matra MHS	-	-	✓	-	-	-
Matsushita	-	-	-	-	✓	-
Micron Technology	-	-	-	✓	-	-
Mitsubishi	-	-	✓	✓	✓	-
Motorola	✓	✓	✓	-	-	-
NEC	-	-	-	✓	✓	-
OKI	-	-	-	-	✓	-
Paradigm	-	✓	✓	-	-	-
SGS-Thomson	-	-	✓	-	-	-
Samsung	-	-	✓	-	✓	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
Sharp	-	-	-	✓	✓	✓
Sony	-	-	✓	✓	✓	-
Toshiba	-	✓	✓	-	✓	✓
United Microelectronics	-	-	✓	-	✓	-
Winbond	-	-	-	✓	-	-

— = Not available
✓ = Available
Source: Dataquest (August 1995)

Table 4
1994 Availability of 1Mb SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	-	✓	-	-	-
Cypress Semiconductor	-	-	✓	-	-	-
EDI	-	-	✓	✓	-	-
Fujitsu	-	-	-	✓	✓	-
Goldstar	-	-	-	-	✓	-
Hitachi	✓	✓	✓	✓	✓	✓
Integrated Device Technology	-	✓	-	-	-	-
Micron Technology	-	✓	✓	-	-	-
Mitsubishi	-	-	-	✓	✓	-
Motorola	✓	✓	✓	-	-	-
NEC	-	-	✓	-	✓	✓
OKI	-	-	-	-	✓	✓
Paradigm	-	✓	✓	-	-	-
Rohm	-	-	-	-	✓	-
SGS-Thomson	-	-	✓	-	-	-
Samsung	-	✓	✓	-	✓	✓
Seiko Epson	-	-	-	-	✓	-
Sharp	-	-	✓	-	✓	-
Sony	-	-	-	✓	✓	-
Toshiba	-	✓	-	-	✓	✓

— = Not available
✓ = Available
Source: Dataquest (August 1995)

Table 5
1994 Availability of 4Mb SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Hitachi	-	-	✓	-	✓	✓
Mitsubishi	-	-	-	-	✓	-
Motorola	-	✓	✓	-	-	-
NEC	-	-	-	-	✓	-
OKI	-	-	-	-	-	✓
Samsung	-	-	✓	-	✓	-
Sony	-	-	-	-	✓	-
Toshiba	-	-	-	-	-	✓

— = Not available
✓ = Available
Source: Dataquest (August 1995)

Supply Base Profiles

In 1994, major Japanese firms accounted for six of the top 10 companies (see Table 6). The non-Japanese firms of Samsung, Motorola, and Winbond are providing tough competition and are moving up in the rankings. Samsung and Winbond had the most dramatic 1993 to 1994 sales growth, at 72 percent and 88 percent, respectively.

Clearly, Samsung is aiming for the No. 1 position, having moved from No. 6 in 1993 to No. 2 in 1994. Hyundai, which seems to follow Samsung's lead, is also targeting SRAMs and is currently at No. 14.

The Taiwanese companies of Winbond and United Microelectronics view SRAMs as the key to competing in the memory market without taking on the large DRAM producers directly. Winbond moved into the top 10 in 1994, from No. 16 in 1993.

Motorola, Cypress, and IDT, all United States-based companies, are targeting the fast, high-end market. Unlike the Japanese and Korean companies, or the United States-based Micron, these companies do not have to balance DRAM and SRAM production coming out of the same fab. Cypress and IDT do not make DRAMs, and Motorola uses dedicated fabs.

Table 6
1994 Worldwide Ranking of Top SRAM Suppliers

	1993 Revenue (U.S.$M)	1994 Revenue (U.S.$M)	Change (%)	1994 Market Share (%)
Hitachi	567	557	-2	12
Samsung	243	419	72	9
Toshiba	346	376	9	8
NEC	333	353	6	8
Sony	261	349	34	8
Motorola	239	329	38	7
Fujitsu	307	322	5	7
Mitsubishi	186	212	14	5
Cypress	165	194	18	4
Winbond	75	141	88	3
Sharp	139	140	1	3
IDT	104	139	34	3
Micron	130	132	2	3
Hyundai	116	129	11	3
United Microelectronics	114	118	4	3
Others	583	604	4	14
Total	3,908	4,514	16	100

Source: Dataquest (August 1995)

Hitachi

- Hitachi is still the No. 1 supplier of SRAMs in the world, controlling 12 percent of the market in 1994.
- The company is the No. 1 supplier of 256Kb devices slower than 35ns in North America.
- The company is shipping BiCMOS 256Kb and 1Mb at 10ns and below.

Samsung

- Samsung has moved aggressively to the No. 2 position.
- The company is converting 1Mb DRAM fabs and even some 4Mb capacity into SRAM fabs.
- The company is selling SRAM bare die through a third-party die distributor, Chip Supply.
- Samsung sells a broad line of 256Kb, 1Mb, and 4Mb in both CMOS and BiCMOS.

Toshiba

- Toshiba's sales grew 9 percent from 1993.
- In early 1995, the company announced two 3.3V, 1Mb devices (32Kx32 and 64Kx16) designed for Pentium and PowerPC Systems. The 100-pin LQFP devices are available with access times of 8, 10, and 12ns. Volume production slated for late summer 1995.

NEC

- NEC is investing $170 million for a 20 percent stake in Packard Bell Electronics. Packard Bell is now on the preferred customer list for cache SRAMs. Other SRAM customers may be affected.
- The company is spending $580 million for cache SRAM and DRAM line at the Hiroshima fab.
- NEC is developing 2Mb synchronous SRAM, with production planned for summer 1996.
- By spring 1996, it plans to be producing one million units per month of 8ns synchronous SRAM. At that time, total SRAM production will be six million units per month.

Sony

- Sony maintained No. 5 ranking from 1993 and, in 1994, increased its business 34 percent.
- The company offers a wide range of products in 256Kb and 1Mb densities and is targeting the 4Mb device.
- SRAMs are primary process drivers for Sony's entire IC program.
- In early 1995, Sony Semiconductor of America was formed to consolidate design, manufacturing, and marketing operations. Marketing and design are located in San Jose, California, and the wafer fab is in San Antonio, Texas (bought from AMD in 1990). Cache SRAM is a principal product.

Motorola

- In 1994, Motorola achieved the No. 6 position by increasing business 38 percent.
- Motorola marketing personnel see an SRAM shortage lasting at least through mid-1996.
- The company is sampling four asynchronous 1Mb SRAMs with access speeds as low as 6ns. The price for 500-piece quantities of 5V devices at 6ns, 128Kx8 or 256Kx4, is $150. The 3.3V, 8ns version is priced at $120.
- Motorola is also sampling the 3.3V, 32Kx36 synchronous device with access speeds as fast as 5ns. Volume prices are $52 to $75 for the pipeline version and $46 to $64 for the flow-through version. Production is planned for the third quarter.
- Motorola is considering constructing a large memory fab near Richmond, Virginia.
- The company is using second-sourced SRAMs for some SRAM modules.

Fujitsu

- Fujitsu is planning to expand its memory fab in Gresham, Oregon.
- The company increased business 5 percent and has 7 percent of the market.
- Fujitsu is setting up capacity to build fast pipelined parts for 75-MHz Pentium machines.

Mitsubishi

- Mitsubishi is shifting capacity away from low demand to 256Kb, 3.3V parts.
- The company has an ongoing yield improvement plan (including die shrinks, among other strategies).
- Its SRAM capacity is booked out through 1995.

Cypress

- Cypress introduced a Pentium PC chipset, containing 128KB of cache SRAM. The price is $48 in lots of 1,000.
- The company is producing high-speed SRAMs and specialty memories in a newly refurbished 8-inch wafer fab in Bloomington, Minnesota.

Winbond

- Winbond is the first Taiwanese company to be listed among the top 10 SRAM suppliers.
- The company increased sales by 88 percent in 1994, to $141 million.

Dataquest Perspective

256Kb fast SRAM will continue to be scarce through all of 1995 and will be tight through 1996. OEMs will get little relief in the near term because the options are extremely limited. Dataquest advises its clients to consider using alternate supply channels, for example, second-tier companies and distribution.

Trends to monitor include the switch to synchronous technology and the move to 1Mb densities. Micron Technology has already announced that it will cease providing asynchronous SRAMs, except for the popular 32Kx8 device. Beyond the 256Kb density, there are numerous configurations, especially for the 1Mb. Dataquest expects synchronous 32Kx32 and asynchronous 128Kx8 to be the most popular versions.

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Market Analysis

Semiconductor Procurement Worldwide

Market Analysis

DRAM Product/Market Update 1995: Allocations Remain, to User's Disdain

Abstract: *This newsletter provides insight to users of the volatile DRAM on how the current market and supply base is evolving to better meet demand. The latest market rankings by product density and an updated life-cycle chart for these products also are analyzed. By Mark Giudici*

The State of the Market

The current DRAM market remains one of allocation and long lead times, combined with flat to rising prices. This is one of the few times where rising prices for the next-generation density coincides with increased production volumes. Increased production historically translated into lower prices and shorter lead times. The market outlook for the near term remains guarded as the low-yielding 1Mbx16 device forces users to rely on the mature 1Mbx4 for much of the conventional memory used in personal computers and other applications. This situation has many unintended side effects that impact other semiconductors. As the PC market migrates to the high-memory-dependent "Pentium-class" systems, this shortfall of memory supply will become more acute until yields for the 1Mbx16 improve for the majority of suppliers.

The Demand Side

The current demand side situation is as follows:

- More than half of all DRAMs produced are put into PCs.
- The extremely fickle home market is now a solid portion of PC sales.

Dataquest

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- The PC industry is making a hardware technology leap to Pentium-based and PowerPC-based machines. The current 1995 forecast is for 19.6 percent worldwide growth.
- Windows 95 (the operating system that optimizes Pentium power) will be released later this summer. This software requires a minimum of 4MB (optimally 12MB) of RAM to run, let alone the megabytes needed for other applications.
- Powerful multimedia, graphics, and games applications are expanding the traditional roles of the PC beyond spreadsheets, word processing, and databases.
- Ongoing PC price wars are slashing margins at computer companies.
- There will be a strong semiconductor market for at least another one to two years.

The Supply Side

The current supply side situation is as follows:

- After holding back for several years, the major Japanese memory suppliers have invested and continue to invest heavily in semiconductor capital expenditure.
- Koreans, Taiwanese, and U.S. companies (especially Intel and Motorola) also are spending heavily.
- MPUs and memory are the key moneymakers and technology drivers.
- Semiconductor companies are enjoying healthy gross margins of greater than 30 percent. The worldwide 1995 semiconductor market is forecast to grow by 22.8 percent, using the constant exchange rate of ¥99.25 to the dollar (that is, the actual growth rate should top 30 percent at today's exchange rate of ¥84 to the dollar).
- Pricing on 4Mb has now started to rise as the shortfall of 1Mbx16 parts begins to be felt, effectively lengthening the 4Mb DRAM life cycle.

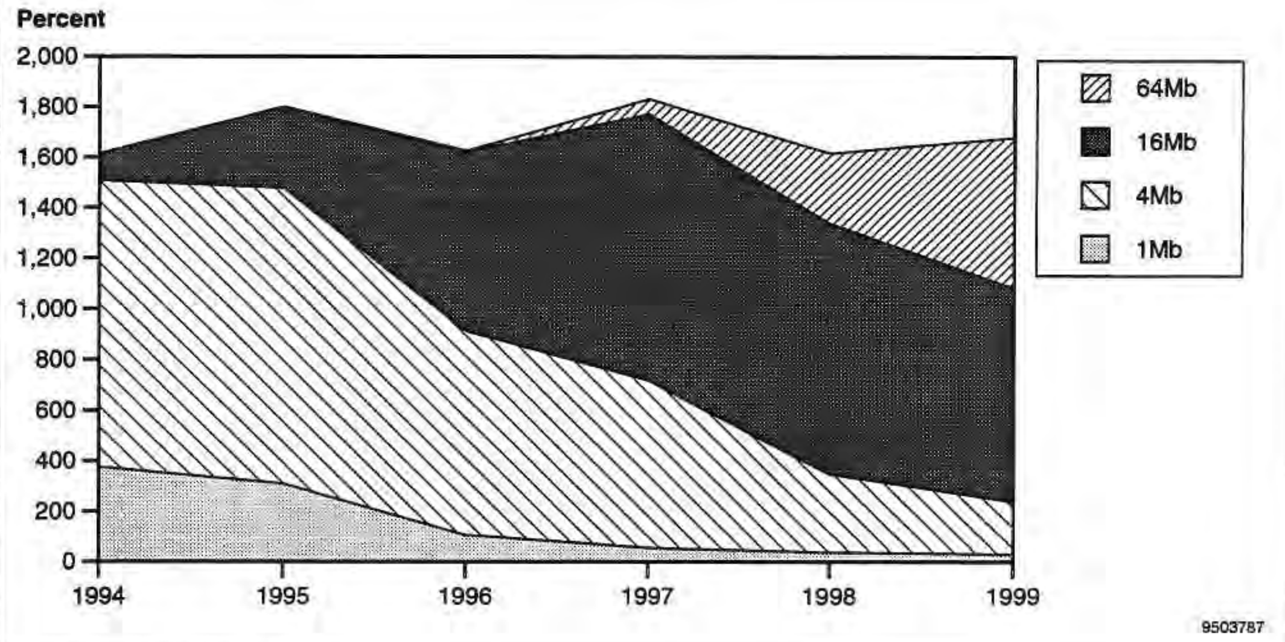
Given the scenario described, it is understandable how a continued memory shortage is likely to continue. Despite large increases in capital spending and fab capacity, the inability of many suppliers to produce large volumes of 1Mbx16 DRAM—combined with unprecedented end system demand—is forcing a market that has not occurred before.

Dataquest sees DRAMs being very tight through 1995, with the potential for shortage of 1Mbx16 DRAMs into the first half of 1996. Indications from our clients are that DRAM continues to be on allocation, yet those on long-term schedules still get agreed-to deliveries on time.

DRAM Unit Production and Life-Cycle Curve

Historic unit shipment and forecast data indicate that 4Mb DRAMs will be the memory of choice at least through 1995 and for much of 1996 (see Figure 1). Dataquest expects 4Mb production in 1995 to top out at about 1.2 billion units, followed by 1Mb at 310 million and 16Mb at 323 million. 256K devices are on the decline and now have a small supply base, which commands premium pricing.

Figure 1
DRAM Unit Shipments by Density



Source: Dataquest July 1995)

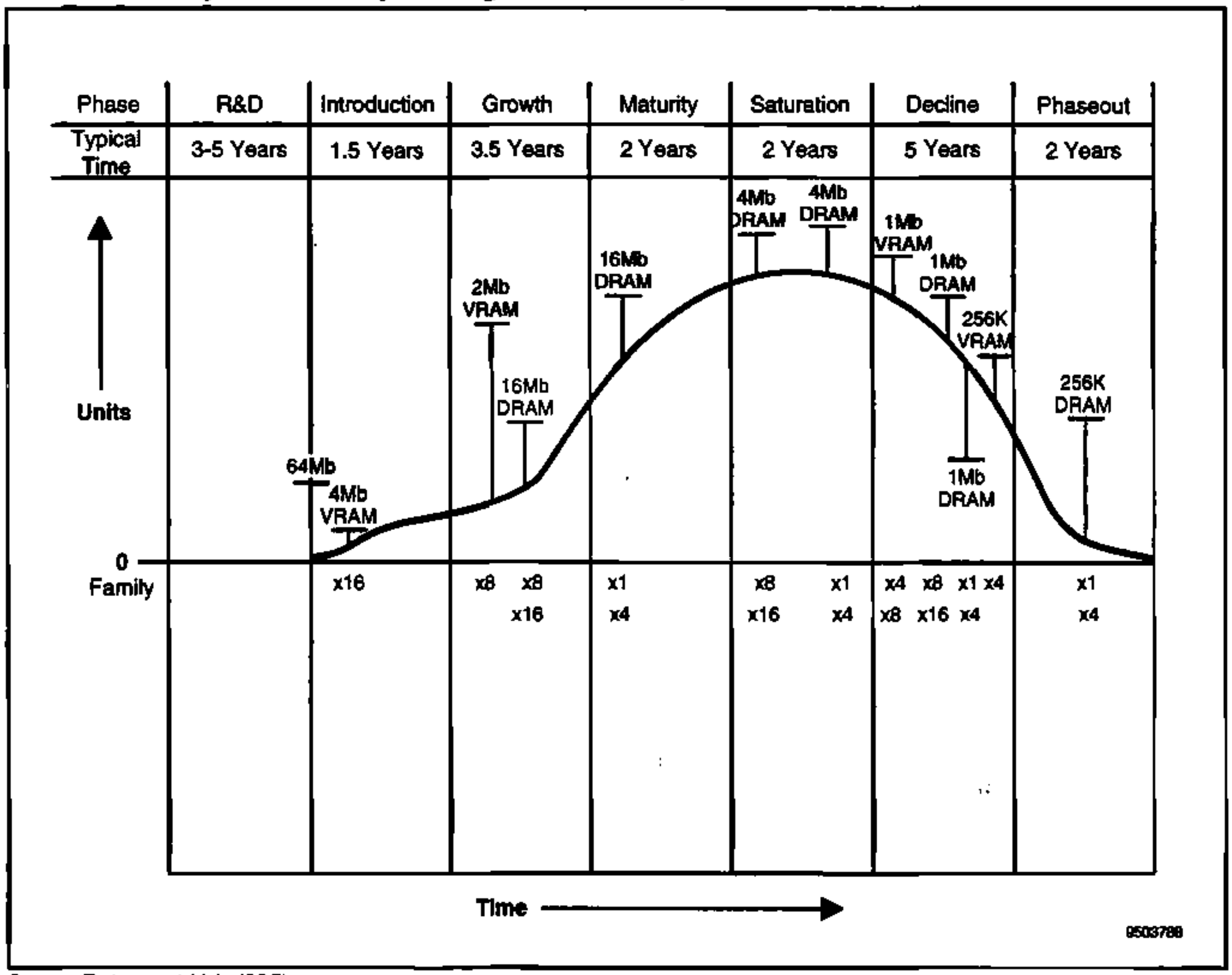
Figure 2 shows a broader perspective by placing the various DRAM density and configurations in a 15-year life-cycle curve. At the 1Mb density and above, the x1 and the x4 are produced first, with the x8 and x16 following on later. In 1995, the 512Kx8 and 256Kx16 join the 4Mbx1 and x4 organizations in the saturation stage, which is normally characterized by many suppliers and competitive pricing. Because of the current market dynamic, firm pricing remains the norm for all 4Mb densities.

The 1Mbx16 device is moving very slowly through the life cycle and is in the growth stage. Although earlier plans were to have the 4Mb to 16Mb crossover in late 1994, because of strong demand for the 1Mbx16 and the lack of supply the crossover for this part will not occur until early 1996. However, the market long ago reached the crossover point for the 4Mbx4 with the 1Mbx4. As a direct result of the supply/demand imbalance for the 1Mbx16 part, suppliers continue to receive a 12 percent premium for the 1Mbx16 part, compared with the 4Mbx4.

At the two edges of the cycle are the 256K DRAM at the middle of phaseout and 64Mb at the beginning of introduction stage. At this time, the 64Mb devices should only be a part of a new system design that will have an extremely long life.

VRAMs are always a generation or two behind DRAM. For example, the 1Mb VRAM is in decline and the 2Mb and 4Mb VRAM respectively are in the growth and introduction stages. It is not clear whether high-density VRAMs above 4Mb will ever make it to production because of other competing nonstandard RAM such as synchronous DRAM, Rambus, Mosys, and Window RAM offerings. These alternate RAMs will be discussed later in this newsletter.

Figure 2
DRAM Life-Cycle Curve by Configuration as of June 1995



Source: Dataquest (July 1995)

Top DRAM Suppliers

The 1994 ranking of top DRAM suppliers shows Samsung retaining the crown from 1993. Even more impressive is that Samsung grew by 69 percent and beat out second-ranked Hitachi by more than $1 billion. Hitachi grew sales 55 percent from 1993 and maintained its No. 2 position. NEC and Toshiba kept their respective third and fourth rankings in 1994. Regaining the No. 5 slot was Texas Instruments, which grew a healthy 65 percent in DRAM sales in 1994.

TI, at No. 5, is now the largest U.S.-based DRAM supplier. In addition to having strong DRAM sales, TI is also realizing a licensing revenue stream from its IC and packaging technology. No. 6 IBM slipped from its 1993 No. 5 position as its DRAM sales grew a disappointing 34 percent, compared with the 1994 DRAM market average growth of 60 percent. It appears that more focus on the merchant market is required, despite allocations and long lead times. IBM is developing a second-generation 64Mb and a 256Mb DRAM with Siemens and Toshiba.

Another Korean DRAM supplier, LG Semicon (Goldstar), rose to the No. 7 position of worldwide DRAM suppliers by focusing on production for the booming PC market. As a result, LG Semicon's 1994 DRAM sales grew an incredible 102 percent over 1993, the highest growth rate in the DRAM market. When a company grows its business by 48 percent, as No. 8 Mitsubishi did in 1994, it ordinarily would be seen as great news. Yet the overall market grew by 60 percent and as a result Mitsubishi slipped from its prior No. 7 position. U.S.-based Micron Technology sits at No. 9 and had the third-highest growth rate (72 percent) in the market. The second-highest growth in 1994 (93 percent) went to No. 10 Hyundai, which continues to make aggressive plans.

Strategic RAM Alliances

First-tier semiconductor companies are banding together to develop new chips, hoping to save money and shorten the design cycle (see Tables 1 and 2). The key areas companies are focusing on are the 16Mb and especially the 64Mb and 256Mb. TI is working separately with Hitachi and Acer at the 16Mb level, while Motorola and Toshiba have extended their partnership. Toshiba also is involved with IBM and Siemens to develop a second-generation 64Mb and a 256Mb device. Not to be left out, NEC and Samsung are discussing joint development of a 256Mb.

Supply Base

The following are some of the recent highlights of the top worldwide DRAM suppliers:

- Samsung
  - DRAM market leader; plans to be semiconductor market leader within 10 years
  - Offers full range of 16Mb DRAM architectures, speeds, packages; one of the few shipping 1Mbx16 product in sizable volume
  - Has enormous fab capacity and is well positioned for 1995 to 1996
- Hitachi
  - Market and technology leader
  - Offers wide range of 4Mb and 16Mb products
  - Pricing generally on conservative side
- NEC
  - Market and technology leader
  - Primary provider of current leading-edge 16Mb products; another supplier shipping the 1Mbx16 part in volume
  - Well positioned with worldwide regional fabrication support
- Toshiba
  - Was No. 1 supplier of the 1Mbx16 16Mb configuration
  - Continues to ramp up 16Mb and ramp down 4Mb densities in 1995
  - Alliance with Motorola masks North American presence; still a major "indirect" supplier

Table 1
Estimated Worldwide DRAM Technology Alliances as of June 1995

	1Mb DRAM	Alliances	4Mb DRAM	Alliances	16Mb DRAM	Alliances	256Mb DRAM Alliances
Supplier	Second Source Agreement	Fab Agreement	Joint-Venture Agreement	Fab Agreement	Joint Venture Agreement	Joint Development	Technology Development
Goldstar	Motorola	Vitelic-Mosel	Hitachi (FA)	Siemens			
Hitachi	Goldstar			Goldstar	Goldstar	TI	TI (includes 64Mb)
				Nippon Steel			
IBM			Micron (LA)	Kuroda Electric		Siemens	Siemens/Toshiba
Micron	NEC (Mutual OEM) Sanyo (64Kx16)		NEC (Mutual OEM)		NEC (Mutual OEM)	Samsung (Synchro-DRAM)	
Motorola	Goldstar (OEM)	Toshiba	Goldstar (OEM)	Toshiba	Toshiba		
NEC							AT&T
NMB			Ramtron (JD)	Hitachi	Ramtron		
OKI			SGS-Thomson	Vitelic-Mosel	Vitelic-Mosel		
Samsung				Sony	OKI (S-DRAM)	Sony	NEC
Sanyo			Mosaid				
TI	Mitsubishi		HP-Canon	Kobe Steel (KTI)	HP-Canon		Hitachi
			Acer	Acer			
			Samsung	Samsung			
Thorn-EMI	NMB (LA)						
Toshiba	Motorola		Motorola		Motorola		IBM/Siemens
	Siemens (LA)						

Definitions/Notes:
FA = Fab agreement: Supplier offers fab capacity for partner's 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 product, which may or may not be marketed separately.
JV = Join venture: The companies form a new joint-venture company to develop, manufacture, and market new products.
OEM = OEM arrangement: Supplier sells product to alliance partner, which is sold under partner's name.
SS = Second source agreement: The companies agree to develop consistent specifications to ensure a second source.
Source: Dataquest (July 1995)

Table 2
Recent DRAM Alliances

Companies	Devices	Notes
Canon-Mitsubishi	1Gb DRAM lithography technology	Joint development of technology
Mitsubishi/Kanematsu-Taiwanese company	16Mb DRAMs	
OKI-Mosel Vitelic	16Mb DRAM technology	
Rohm-Alliance Semiconductor	256K, 1Mb DRAMs	Joint development and fab agreement

Source: Dataquest (July 1995)

- Texas Instruments
  - 16 years ago DRAMs were 80 percent of revenue; 1993 DRAMs were 20 percent of sales; 1994 DRAMs were 29 percent
  - Plans to manage market volatility via supplier and customer alliances
  - Focuses on major accounts with long-term commitments
- IBM
  - Focus to date on SIMMs
  - Limited merchant market presence because of internal DRAM/processor fab allocations
  - Processors taking merchant fab priority with Cyrix and NexGen partners; long-term alliance with Toshiba and Siemens slower than planned
- LG Semicon
  - Alliance relies on Hitachi for 4Mb technology
  - Plans to focus more on customer requirements
  - Faces market challenges beyond 4Mb density without continued alliance support
- Mitsubishi
  - Despite making a major push in North America with its DRAM portfolio, went from No. 8 in 1993 to No. 8 in 1994
  - Strong focus on 2Mbx8 16Mb DRAM production
  - Emphasizes SIMM and cache DRAM offerings
- Micron
  - DRAMs represented 70 percent of total revenue in 1993; 1994 DRAMs were 91 percent of revenue
  - Manufacturing move to a 0.4-micron process; released 300-mil 16Mb offering in 1995; 16Mb process uses 13 masks, versus 18- to 20-mask industry standard
  - Stopped development of 4Mb VRAM and dropped WRAM with Samsung

- Hyundai
  - World leader yet wild card supplier in DRAM
  - Pushing 16Mb development for 1995 to 1996 production
  - Interested in emerging nonstandard DRAM (that is, synchronous DRAM)
- Others
  - Siemens to continue European focus with Dresden fab
  - Fujitsu strong effort in synchronous DRAM, especially in densities above 16Mb
  - Mosel-Vitelic and other Taiwanese DRAM suppliers plan to make push in 1995 to 1996 time frame with 16Mb parts

Supply Base Analysis

Table 3 shows market leaders by density. The five top suppliers hold about 50 percent of the mid-density 1Mb and 4Mb DRAM market. The top five suppliers hold at least 70 percent of the market at the very low and high end. Figures 3, 4, and 5 give more details on unit production by density.

Table 3
1994 DRAM Market Leaders by Product Density (Based on Unit Shipments)

Rank	1Mb	4Mb	16Mb
1	Mitsubishi	Samsung	Samsung
2	Toshiba	Hitachi	NEC
3	Samsung	NEC	Toshiba
4	Hyundai	Texas Instruments	Hitachi
5	OKI	Toshiba	Mitsubishi
Market Share of Top Five (Percent)	55	52	69

Source: Dataquest (July 1995)

Supply Base for 1Mb DRAMs

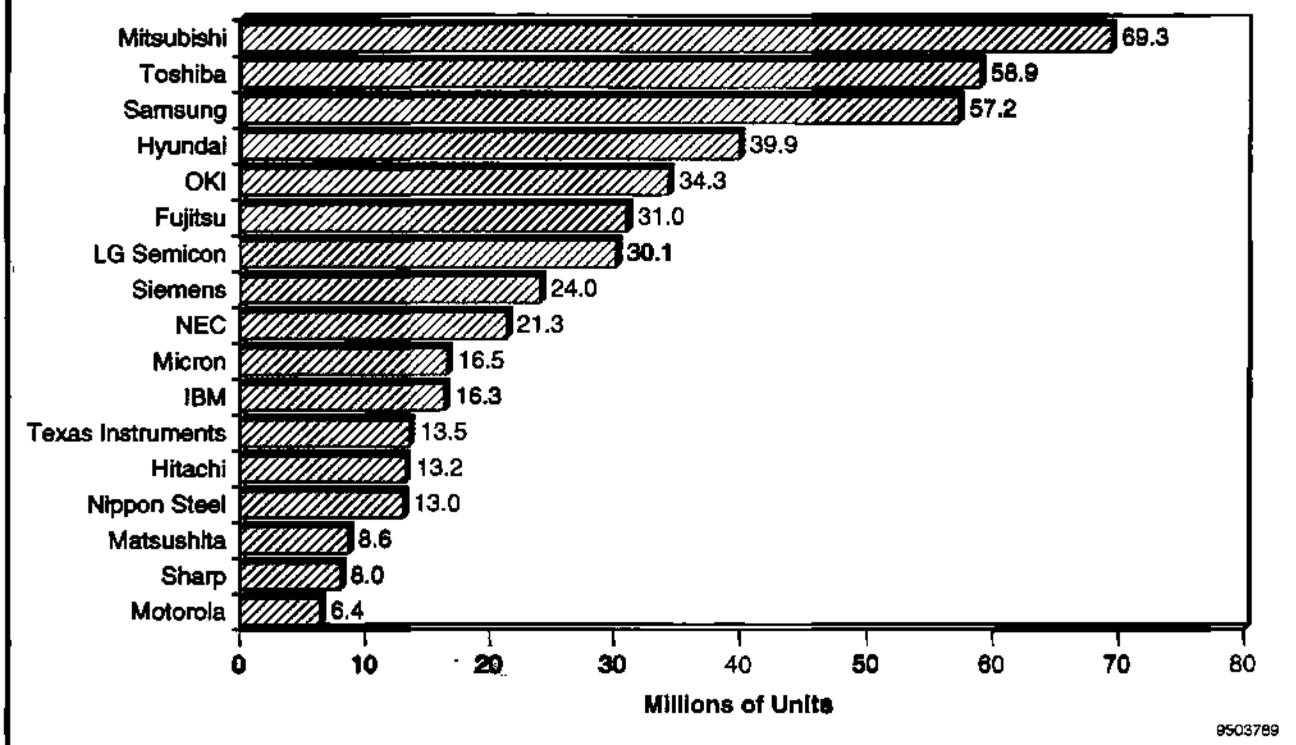
Figure 3 shows the rankings of 1Mb suppliers. Total units for 1994 were 469 million, down from 601 million in 1993. The peak year for 1Mb was 1991, with 831 million units shipped.

The year 1995 should see some of the top players greatly reduce their 1Mb production, but few if any will totally desert the density. The overall market for 1Mb should be viable through 1997, when the product will move into the phaseout stage.

Supply Base for 4Mb DRAMs

Total 4Mb units reached 1.14 billion in 1994, up from 859 million units in 1993. The year 1995 will see 1.2 billion units shipped; this year is expected to be the high-water mark for this density as the 16Mb part begins to ramp up. Figure 4 shows the ranking for 1994.

Figure 3
1994 1Mb DRAM Supplier Base



Source: Dataquest (July 1995)

Supply Base for 16Mb DRAMs

The 16Mb DRAM ramp-up began in 1993 with 22 million units, yet overall unit shipments of 108 million in 1994 are growing slower than expected because of lower than forecast yields for the 1Mbx16 organization in 1994. This is quite a contrast from 1992, when only three vendors shipped more than 350,000 units. Figure 5 shows the rankings for 1994.

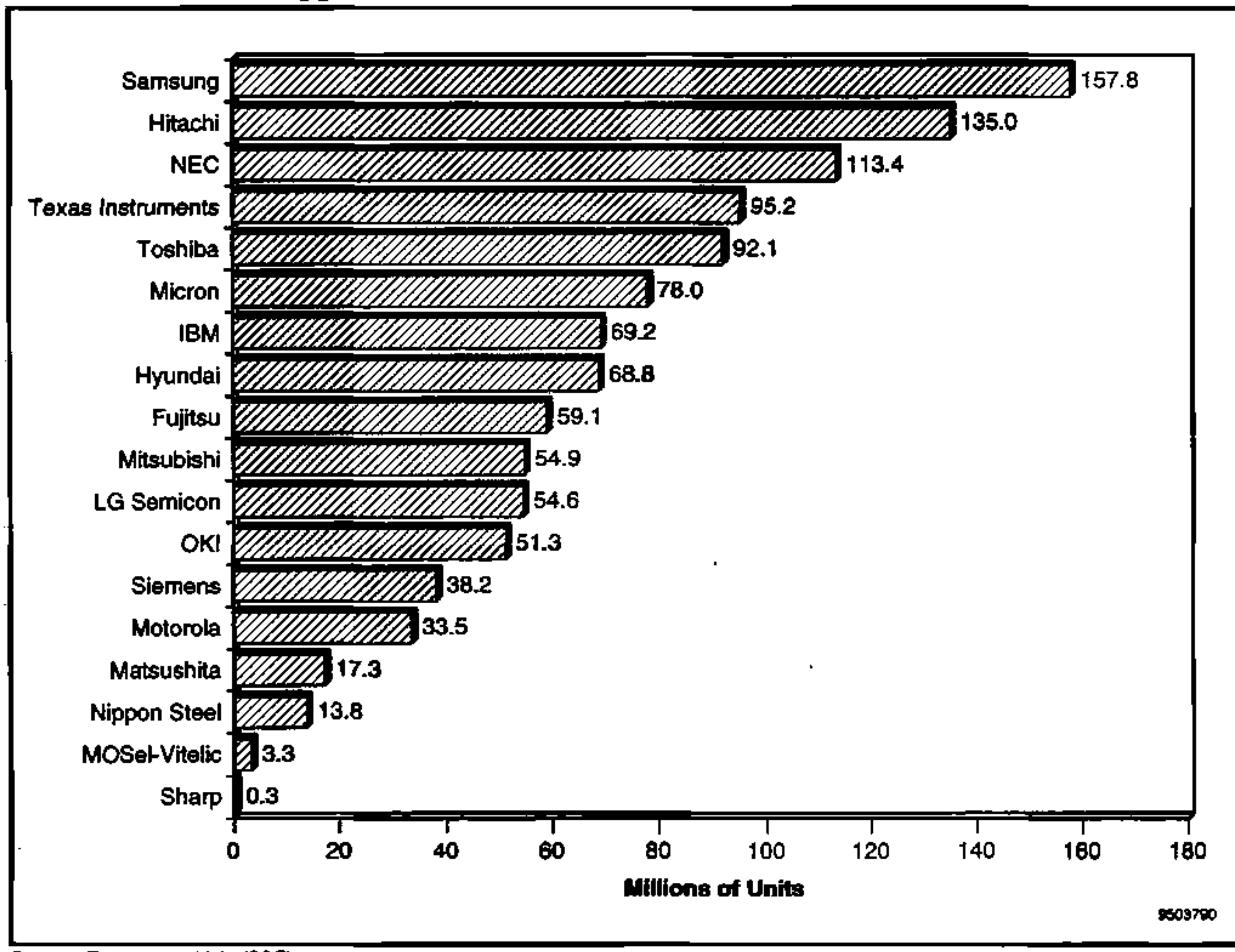
Nonstandard RAM

The push for nonstandard RAM is coming from multimedia and graphic applications that need memory capable of keeping up with fast 32- and 64-bit MPUs such as the Pentium, PowerPC, and other RISC-based systems. To date the answer to the speed question has been to add SRAMs and/or VRAMs. This solution, although effective, is expensive, compared to standard RAM, and takes up precious board space. Some nonstandard RAMs are described in the following paragraphs.

EDO RAM

Extended data out (EDO) RAM will become the next DRAM "standard" because it has no cost adder associated with it and most top-ranked suppliers plan to offer EDO products. Dataquest estimates that almost half of all 16Mb DRAMs 1996 and nearly all 1997 DRAMs will ship in EDO format. The EDO option is also the least revolutionary approach to the

Figure 4
1994 4Mb DRAM Supplier Base

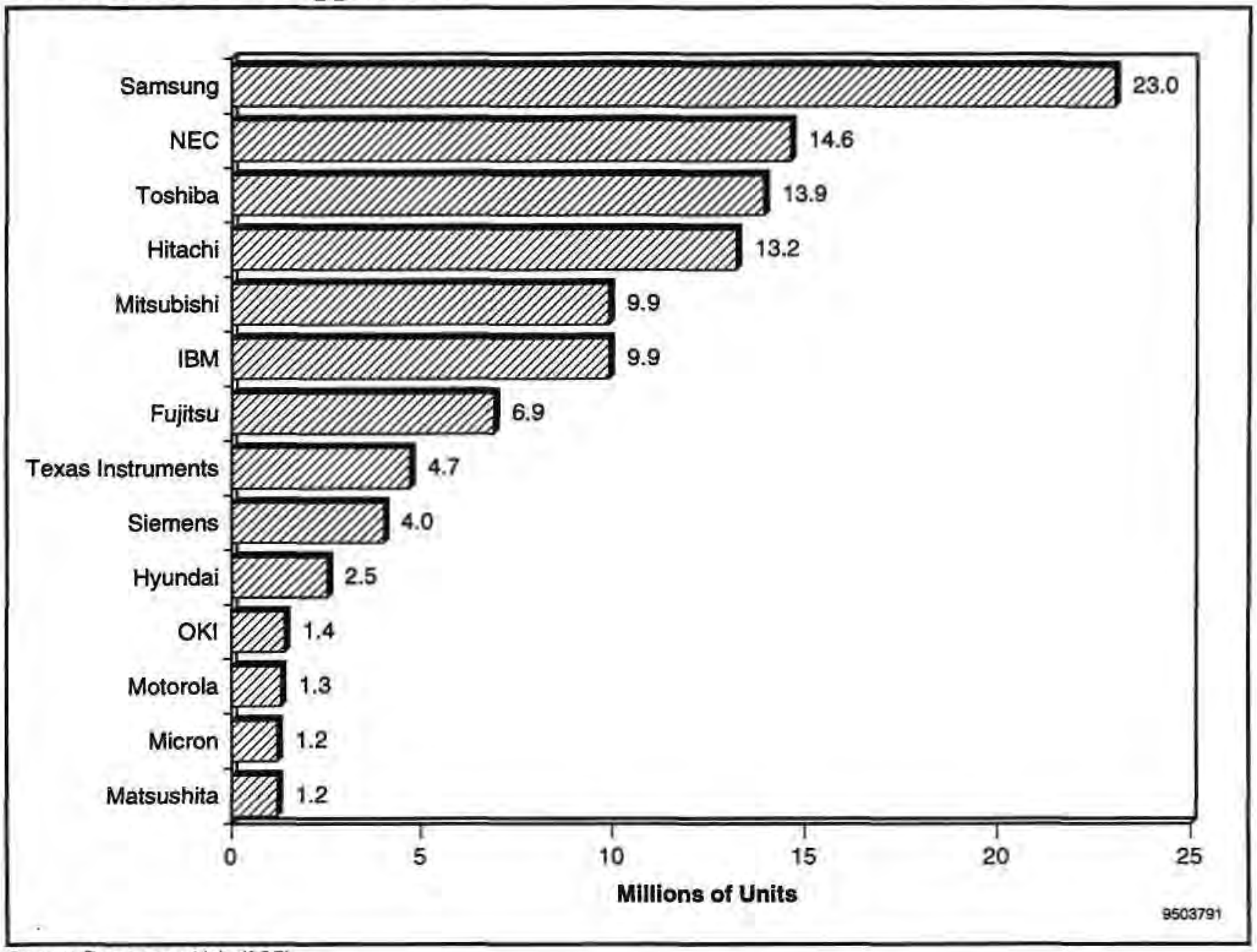


Source: Dataquest (July 1995)

high-speed/wide data bus problem. As speeds increase, however, EDO runs out of bandwidth and then the horse race begins regarding competing architectures. Some of the more hotly contested post-EDO options are as follows:

- Rambus: Licensed by 15 semiconductor companies and formally announced by Cirrus Logic, Hitachi, LG Semicon, LSI Logic, NEC, OKI, Samsung, and Toshiba. Pricing to be 20 percent greater than standard RAM. Access memory rated at 500 MB/sec.
- Synchronous DRAM: Much faster than conventional DRAM, 50- to 100-MHz. JEDEC standard established. Companies working on S-DRAMs include Fujitsu, NEC, IBM, Hitachi, and Matsushita.
- MoSys Multibank: Unique architecture with several companies reviewing. Access memory rated at 660 MB/sec.

Figure 5
1994 16Mb DRAM Supplier Base



Source: Dataquest (July 1995)

- Enhanced Memory Systems' (nee RAMTRON) enhanced DRAM: Taiwan-based Digicom selling fast memory for high-performance 486 PCs. IBM announced it is manufacturing enhanced DRAMs for Enhanced Memory Systems. Ocean Information Systems is the lone major customer because this technology has limited acceptance elsewhere.
- Window RAM: Similar to VRAM, with unused features removed. Samsung developing alone after the second source, Micron, dropped out in 1994.

At this time the jury is out as to which nonstandard RAM technology will actually take hold after EDO. However, synchronous DRAMs seem to have the most followers and are closest to production levels. Yet Rambus now has more potential than it did last year because Cirrus Logic announced in late June 1995 that it would support this architecture with its high-performance PC chipsets. This, along with Nintendo's prior announced implementation of Rambus in its future 64-bit machine, has the potential of a standard in the making.

Dataquest Perspective

The allocated market dynamic noted so far this year for DRAMs historically has preceded an overshoot in supply levels. The continued accelerated rate of capital spending begun in 1994 for DRAM equipment is now expected to be absorbed by a sea change in demand patterns for PCs. Because of a deliberate shrinking of a microprocessor's life from four down to two years, upgrades and new equipment demand is expected to remain robust for the foreseeable future.

The supply base for DRAM continues to revolve around a dozen or so key suppliers, each with specific strengths and plans. Users need to remain focused on their specific current and future system requirements and to continue to update their suppliers on these needs. Periodic review of competitive suppliers is also necessary to ensure that alternative sources are not overlooked.

Technology alliances continue to be the rule for most suppliers because the cost of equipment and research continues to escalate. Competition to DRAM on a cost-per-bit basis continues to emanate from flash memory advocates, where intriguing yet untried charge-retention schemes could actually make flash memory cheaper than down-in-the-dirt ROM, let alone DRAM. The question then arises: At what speed? DRAM is expected to retain its cost/bit/speed advantage over flash well into the 256Mb density, and possibly beyond. The 300-mil package constraint for the wide 16Mb architectures is a surmountable stumbling block for suppliers that continue to have enough work getting these parts to yield, let alone to fit into a shrunk package.

Specialty RAM suppliers continue to hail each other's virtues, yet as yet there is no predominant standard accepted by the market. Although each party/alliance points out how its product/architecture best solves the high-speed graphics problem, an agreement on a recognized standard probably will come down to cost/bit economics. A large design-win or en masse demand for a product could accelerate the shift to a "standard" for one of the many offerings now on the market.

Taken from two viewpoints, 1995 is both:

- The profitable market that will not appreciably change for the rest of 1995
- On the DRAM technology road map for users, a false start for the economic crossover to the 1Mbx16 DRAM as high demand compounds low-yielding device availability

Dataquest continues to see relatively tight supplies of critical DRAM (x8, x16 16Mb) on through the second quarter of 1996. Most suppliers are finding it difficult to ramp up these critical volume market devices, which is extending the expected life and volume of 4Mb parts. Users of x4 16Mb DRAM will see relatively good supplies and prices while the PC market hungers for the byte and word-wide variants.

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Market
Analysis

Semiconductor Procurement Worldwide

Market Forecast

Second Quarter Pricing Trends: Good News and Bad News

Abstract: *Dataquest has completed its North America Semiconductor Price Outlook: Second Quarter 1995 document (SPSG-WW-PT-9501, dated March 27, 1995). As with the price outlook for the fourth quarter of 1994 and the first quarter of 1995, the pricing survey shows two primary trends: The firming up of DRAM prices and the continual drop in the 80486 and Pentium-class MPUs.*
By Scott Hudson

The Party Continues

Consistent and continual PC demand is fueling one of the longest semiconductor growth cycles in recent memory. The home and home office channel drove demand for 80486 and particularly Pentium and PowerPC machines in 1994. Now, in 1995, major OEMs are aggressively pricing their PC offerings to attract the business and corporate customers that have not yet upgraded to the Pentium or PowerPC level.

When will the party end? The answer, of course, is when the PC consumers decide they have enough computing power and can wait for the next generation of machines. Dataquest believes that the demand for PCs will drive good growth in the semiconductor industry through 1995 and into 1996, barring any unforeseen economic catastrophe.

The impact that this strong PC market will have on IC pricing is detailed in the sections to follow.

DRAM Update (The Bad News)

Input from both suppliers and users suggest that DRAM pricing actually is increasing slightly from the our forecast published December 26, 1994 (*North American Semiconductor Price Outlook: First Quarter 1995*, SPSG-WW-PT-9404). For example, the average 1995 price for the 1Mbx4 DRAM has increased 6 percent from $11.61 to $12.34. The average 1995 price for the

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Filing: Market Analysis

1Mbx16 also increased slightly from $47.50 to $48.89. The critical 4Mb to 16Mb crossover point is still expected to occur in the second half of 1995 but could be pushed out further if the market continues to tighten for the 1Mbx16 or if the 1Mbx4 becomes aggressively priced. Table 1 shows the latest pricing on the 1Mbx4, 1Mbx16, 4Mbx4, and 2Mbx8 configurations taken from the second-quarter pricing survey.

Other Memory Highlights

SRAM pricing, in general, is tightening up slightly, especially in the 1996 time frame. SRAMs most in demand are devices with speeds faster than 25ns and densities of 256Kb and above. The primary new application is for cache tag memory in high-end PCs and workstations. Dataquest began tracking three new SRAMs starting this quarter, including one low-voltage part (see Table 2).

The other memories—mask ROM, EPROM, and flash—are showing less price volatility than are SRAM or DRAM. There are, however, some supply constraints in the lower-density flash below 4Mb, and some lead times have lengthened on the 1Mb-and-above EPROMs. Dataquest believes that these spot issues are not long-term problems because new fab capacity should be available soon. For example, the AMD-Fujitsu plant in Japan is ramping up for very high density flash parts. This should free up older fabs for lower-density flash devices. Moreover, SGS-Thomson is ramping up production of both flash and EPROMs.

Microprocessors (The Good News)

Intel cut prices on the 80486 and Pentium MPUs during the first quarter of 1995 from 7 percent to 39 percent, depending on the class (80486 and Pentium) and speed. Intel clearly plans for the Pentium to be the big runner and plans to ship at least 20 million units in 1995, up from 5 million in 1994.

Table 1
Estimated DRAM Pricing Trends, North American Bookings (Contract Volume; U.S. Dollars)

	Q1/95	Q2/95	Q3/95	Q4/95	1995 Average
1Mbx4 DRAM 60ns, SOJ	12.66	12.45	12.25	11.99	12.34
Four 1Mbx4 Crossover Multiplier	50.64	49.8	49.00	47.96	49.36
1Mbx16 DRAM 60ns, TSOP	53.62	50.13	47.37	44.42	48.89
4Mbx4 DRAM 70ns, SOJ	46.52	41.50	37.80	34.20	40.01
2Mbx8 DRAM 60ns, TSOP	51.38	46.52	43.57	40.32	45.45

Source: Dataquest (May 1995)

Table 2
New Fast SRAMs Tracked on a Quarterly Basis (20,000 per Year; U.S. Dollars)

	Q1/95	Q2/95	Q3/95	Q4/95	1995 Average
128Kx8 15ns	19.25	18.87	18.29	17.35	18.44
32Kx8 15ns, 5V	3.76	3.68	3.61	3.53	3.65
32Kx8 15ns, 3.3V	5.64	5.41	5.02	4.88	5.24

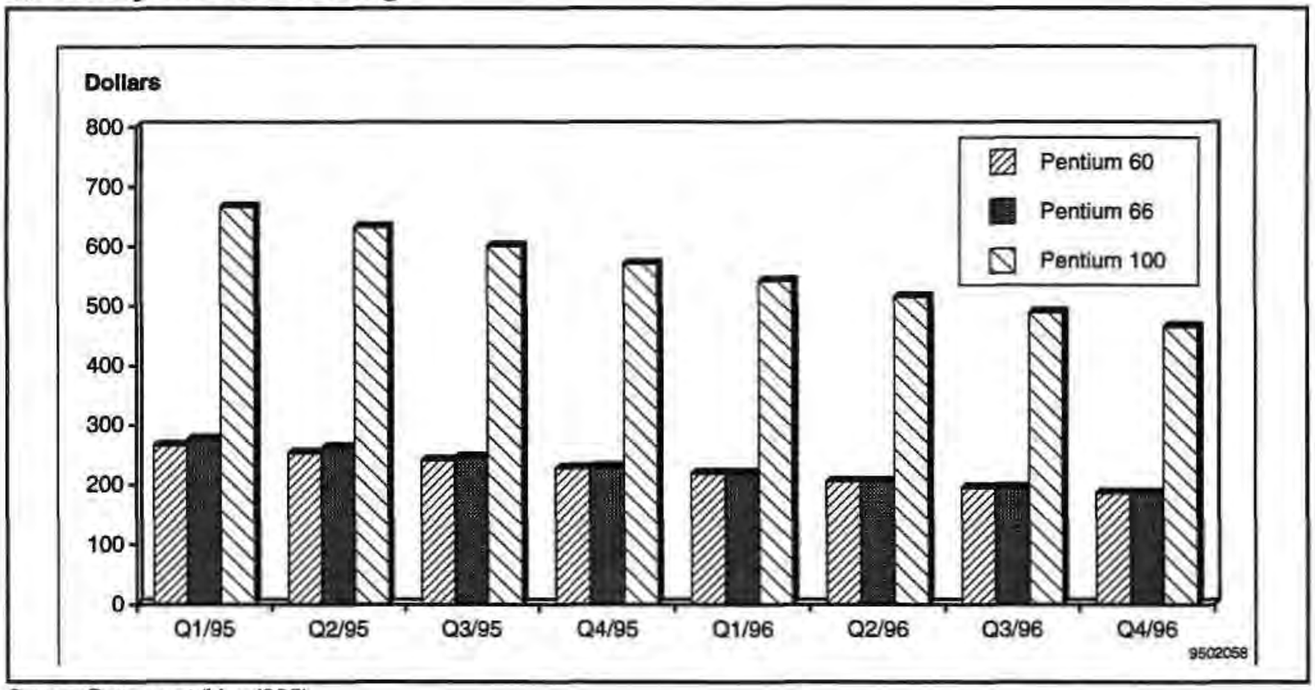
Source: Dataquest (May 1995)

Figure 1 shows quarterly prices for the Pentium 60, 66, and 100. There will be no premium for the 66-MHz device by the first quarter of 1996, compared to the 60-MHz. It should be noted that the pricing here is for volumes of 25,000 units per year and that the 1996 pricing is conservative.

80486 MPU pricing also is expected to drop precipitously. In 1996, for example, all 486 MPUs save the 75-MHz version will be well under $100 (see Table 3). With ongoing competition from 486 and Pentium-like devices from AMD, Cyrix, and NexGen, Intel is no longer totally in the driver's seat, and MPU pricing should be dropping on a quarterly basis.

The PowerPC MPU represents another threat to Intel's dominance of the MPU market. Apple, along with chip suppliers IBM and Motorola, is championing this technology. So far several OEMs—Radius, Power Computing, and Pioneer Electronic Corporation—have signed up to sell Macintosh clones. Apple expects three to nine more companies to join the PowerPC fold by the end of 1995.

Figure 1
Quarterly Pentium Pricing



Source: Dataquest (May 1995)

Table 3
Average Annual Pricing for 80486 MPUs (Dollars)

	1995	1996	Percentage Change
80486 DX-33	82.50	65.00	-21
80486 DX-50	148.75	85.00	-43
80486 DX2-50	82.50	65.00	-21
80486 DX2-66	111.00	73.75	-34
80486 DX4-75	171.00	139.00	-19

Source: Dataquest (May 1995)

Dataquest Perspective

Dataquest sees a challenging but not impossible semiconductor market for users for the rest of 1995 and early into 1996. Outside of MPUs, pricing in general looks to be firm and, in the case of memory, increasing.

However, as in any volatile market, change is a fact of life. Dataquest suggests that procurement professionals watch for the following scenarios, which will provide insight to future IC pricing trends:

- Downward price scenarios (possible but unlikely):
  - Sharp decline in demand for PCs and other high-volume electronic devices
  - Supply catches up to demand as new fabs come online
  - Yields dramatically improve on 1Mbx16 and new players enter market (for example, Hyundai)
  - Major memory suppliers break from the pack and slice prices
- Upward price scenarios (very possible):
  - Continued high demand for PCs and other high-volume electronic devices (telephones and set-top boxes, among others)
  - Less-than-optimal yields for 1Mbx16 keeping supply constrained
  - Weak dollar-to-yen exchange rate giving Japanese suppliers "excuse" to bump up prices
  - Various events unsettle market (Sumitomo explosion or Kobe earthquake, among others)

Dataquest believes that the upward pricing pressure is the more likely of the two scenarios. Already, major Japanese suppliers are asking for a 5 to 10 percent increase in DRAM prices to make up for the falling dollar. The larger U.S. DRAM users have some leverage and will try to resist these markups. For example, Compaq has already publicly announced that it does not intend to pay the currency price adder. The smaller DRAM users with little clout and limited alternate sources (for example, Korea- or Taiwan-sourced DRAMs) may have little choice but to pay the "tax."

In this generally tight semiconductor market, procurement and material managers must work closely with their suppliers and closely monitor any changes in price, lead times, and delivery.

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Dataquest

Final 1994 Worldwide Semiconductor Market Share

Market Statistics

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Filing: Market Analysis

Final 1994 Worldwide Semiconductor Market Share

Market Statistics

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Note: All tables show estimated data.

List of Tables (Continued)

Note: All tables show estimated data.

Final 1994 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:

- 1992-1994 market share estimates
- 1993-1994 market share rankings

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 this data is provided in other Dataquest documents.

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 is logical, appropriate to the industry in question, and immediately useful to clients.

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 (Including Hybrids)
- Total Semiconductor (Excluding Hybrids)
  - Total Integrated Circuit (Including Hybrids)
  - Total Integrated Circuit (Excluding Hybrids)
    - Bipolar Digital IC
      - Bipolar Memory
      - Bipolar Logic
    - MOS Digital IC
      - MOS Memory
      - MOS Microcomponent
      - MOS Logic
    - Monolithic Analog IC
    - Hybrid IC
  - Discrete Semiconductor
  - Optoelectronic Semiconductor

Definitions

This section lists the definitions that are used by Dataquest to present the data in this document. For a complete listing of all semiconductor market segments tracked by Dataquest, please refer to the *Dataquest Semiconductor Market Definitions Guide.*

Product Definitions

Total Semiconductor (Total Integrated Circuit + Total Discrete + Total Optoelectronic). Defined as an active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide, but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.

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

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 is stored and electronically retrieved. Includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, and first-in/first-out (FIFO) memory. Not included are products made with mixed bipolar CMOS (that is, BiCMOS) with TTL or ECL outputs, which are classified as MOS.

Bipolar Digital 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 (DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory). Defined as a MOS digital IC in which binary data is stored and electronically retrieved.

MOS Digital Microcomponent IC (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + Programmable Digital Signal Processor). Defined as a MOS digital IC that contains a data processing unit or serves as an interface to such a unit.

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

Total Analog IC (Amplifier/Comparator IC + Voltage Regulator/ Reference IC + Data Converter/Switch/Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special Function IC + Linear Array/ ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC + Smart Power IC). An 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 only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package.

Hybrid Integrated Circuit. Defined as a semiconductor product consisting of more than one die contained in a single package. A hybrid IC may perform 100 percent linear, 100 percent digital, or mixed-signal (both linear and digital) functions. Includes hybrid implementation of all monolithic IC functions described in the following categories. Includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies.

Total Discrete (Transistor + Diode + Thyristor + Other Discrete). A discrete semiconductor is defined as a unit building block performing a fundamental semiconductor function.

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

Merchant versus Captive Consumption. Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data excludes 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 Canada, Mexico, and the United States.

Japan: Japan is the only single-country region.

Western Europe: Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cyprus, Gibraltar, Liechtenstein, Monaco, San Marino, Vatican City, Iceland, Malta, and Turkey).

Eastern Europe: Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (Belarus, Russian Federation, Ukraine, Georgia, Moldavia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tadjikistan, Kyrgyzstan, and Turkenistan).

Asia/Pacific: Includes Asia/Pacific's newly industrialized economies (NIEs) and the Rest of Asia/Pacific regions. NIEs include Hong Kong, Singapore, Korea, and Taiwan. The Rest of Asia/Pacific region includes Australia, Brunei, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Rest of World: Includes Africa, Caribbean, Central America, Middle East, Oceania, and South America.

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its products. 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 uses 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 data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons

- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- 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 a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Analog Devices' revenue includes Precision Monolithics' revenue from 1991 forward.

2. Cirrus Logic's revenue includes Acumos and Crystal Semiconductor's revenue from 1992 forward.

3. Cypress Semiconductor acquired the logic division of Performance Semiconductor in 1993.

4. Dialog, Eurosil, Matra, Telefunken, and Siliconix are now known as TEMIC.

5. Fujitsu acquired Ross Semiconductor from Cypress Semiconductor in 1993.

6. IBM's merchant revenue were included in our Market Statistics beginning in 1993, which was the first complete year that IBM sold product on the merchant market.

7. IMP was formerly known as International Microelectronic Products.

8. Inmos' revenue is included in SGS-Thomson revenue.

9. Linfinity was formerly known as Silicon General.

10. Macronix revenue, beginning in 1991, was moved from the North American Companies area and is now included under the Asia/Pacific Companies section.

11. Mitsubishi's revenue includes Powerex's European revenue beginning in 1993.

12. MOSel and Vitelic merged in 1992 to form MOSel/Vitelic Corporation. In 1993, MOSel/Vitelic was moved to the Asia/Pacific-Rest of World region.

13. Nittetsu Semiconductor was formerly known as NMB Semiconductor.

14. Philips' revenue includes Signetics' revenue.

15. SGS-Thomson's revenue includes TAG in 1993.

16. Quality Technologies acquired Philips' Optocoupler Division in 1992.

17. Raytheon's revenue includes that of TRW's LSI Division from 1992 forward.

18. Thomson Semiconductors Specific (TCS) was formed through the merger of Thomson Composants Microndes (TCM) and Thomson Composants Militaires et Spatiaux (TMS).

19. Unitrode's revenue includes that of Microsemi's Semiconductor Products Division from 1992 forward.

20. Vertex's (formerly known as Integrated CMOS Systems) revenue is included in Toshiba's revenue from 1991 forward.

21. Xilinx acquired Plus Logic in 1992.

22. The following companies were added to worldwide market share tables starting in 1994, and may result in higher 1994 market growth rates in certain product areas:

- Integrated Silicon Solution Inc.
- Ramtron
- Quick Logic
- International CMOS Technology

23. In 1994, three-fourths of Intel's PLD Division's revenue is included in Intel's revenue, and the last quarter's revenue is included in Altera's revenue to accurately reflect the sale of the PLD Division.

24. Telcom was formerly known as Teledyne Semiconductor.

25. National Semiconductor, SGS-Thomson, and Siemens' revenue for 1993 was re-evaluated and restated.

26. Tektronix's revenue is now included with Maxim's revenue.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1 outlines these rates for 1992 through 1994.

Table 1
Exchange Rates

	1992	1993	1994
Japan (Yen/U.S.$)	126.45	111.20	101.81
France (Franc/U.S.$)	5.27	5.67	5.54
Germany (Deutsche Mark/U.S.$)	1.56	1.66	1.62
United Kingdom (U.S.$/Pound Sterling)	1.77	1.50	1.53

Source: Dataquest (March 1995)

Section 1: Final 1994 Semiconductor Market Share Worldwide

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	65,260	85,518	110,580	100.0	100.0	100.0
North American Companies	26,943	37,087	46,118	41.3	43.4	41.7
ACC Microelectronics	26	36	49	0	0	0
Actel	44	60	76	0.1	0.1	0.1
Adaptec	89	122	125	0.1	0.1	0.1
Advanced Micro Devices	1,514	1,660	2,134	2.3	1.9	1.9
Allegro MicroSystems	115	118	148	0.2	0.1	0.1
Alliance Semiconductor	13	41	90	0	0	0.1
Altera	102	140	199	0.2	0.2	0.2
Analog Devices	514	635	739	0.8	0.7	0.7
Appian Technology	10	10	7	0	0	0
Applied Micro Circuits Corporation	39	48	48	0.1	0.1	0
AT&T	911	1,110	1,307	1.4	1.3	1.2
Atmel	140	225	375	0.2	0.3	0.3
Brooktree	96	117	109	0.1	0.1	0.1
Burr-Brown	127	158	165	0.2	0.2	0.1
California Micro Devices	12	14	10	0	0	0
Catalyst	41	55	50	0.1	0.1	0
Cherry Semiconductor	46	55	77	0.1	0.1	0.1
Chips & Technologies	119	89	89	0.2	0.1	0.1
Cirrus Logic	275	451	781	0.4	0.5	0.7
Comlinear	15	16	16	0	0	0
Cypress Semiconductor	267	300	400	0.4	0.4	0.4
Cyrix	63	125	241	0.1	0.1	0.2
Dallas Semiconductor	97	112	154	0.1	0.1	0.1
DSP Semiconductor	10	8	18	0	0	0
Elantec	16	23	24	0	0	0
Electronic Designs	9	23	26	0	0	0
ETEQ Microsystems	20	19	6	0	0	0
Exar	123	158	169	0.2	0.2	0.2
General Instrument	220	239	262	0.3	0.3	0.2
Gennum	27	30	31	0	0	0
Gould AMI	79	101	136	0.1	0.1	0.1
Harris	559	605	665	0.9	0.7	0.6

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Hewlett-Packard	449	469	714	0.7	0.5	0.6
Honeywell	48	53	55	0.1	0.1	0
Hughes	37	40	40	0.1	0	0
IBM	NA	2,510	3,035	0	2.9	2.7
IMI	18	21	20	0	0	0
Integrated Circuit Systems	35	41	81	0.1	0	0.1
Integrated Device Technology	220	303	385	0.3	0.4	0.3
Integrated Information Technology	42	40	35	0.1	0	0
Integrated Silicon Solution	NA	NA	60	0	0	0.1
Intel	5,091	7,970	10,099	7.8	9.3	9.1
IMP	32	37	49	0	0	0
International CMOS Technology	NA	NA	12	0	0	0
International Rectifier	271	288	361	0.4	0.3	0.3
ITT	254	262	241	0.4	0.3	0.2
Kulite	24	24	20	0	0	0
Lattice	90	127	134	0.1	0.1	0.1
Linear Technology	132	173	225	0.2	0.2	0.2
Linfinity	29	37	44	0	0	0
Logic Devices	12	12	14	0	0	0
LSI Logic	615	719	901	0.9	0.8	0.8
Maxim	97	115	169	0.1	0.1	0.2
Micrel	15	18	25	0	0	0
Micro Linear	33	45	41	0.1	0.1	0
Micro Power Systems	22	23	23	0	0	0
Microchip Technology	83	140	212	0.1	0.2	0.2
Micron Technology	557	925	1,492	0.9	1.1	1.3
Microsemi	84	97	100	0.1	0.1	0.1
Mitel	52	69	100	0.1	0.1	0.1
Motorola	4,634	5,957	7,238	7.1	7.0	6.5
NCR	228	275	354	0.3	0.3	0.3
National Semiconductor	1,797	2,060	2,023	2.8	2.4	1.8
Novasensor	13	16	13	0	0	0
Oak Technology	50	50	62	0.1	0.1	0.1
Optek	57	56	56	0.1	0.1	0.1
OPTi	98	86	130	0.2	0.1	0.1
Paradigm	7	34	36	0	0	0
Performance Semiconductor	46	41	20	0.1	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Powerex	80	58	76	0.1	0.1	0.1
Q Logic	NA	21	45	0	0	0
Quality Semiconductor	18	22	22	0	0	0
QuickLogic	NA	NA	8	0	0	0
Quality Technologies	46	47	49	0.1	0.1	0
Ramtron	NA	NA	15	0	0	0
Raytheon	96	103	108	0.1	0.1	0.1
Rockwell	172	176	177	0.3	0.2	0.2
S3	31	113	130	0	0.1	0.1
SEEQ Technology	35	29	22	0.1	0	0
Semtech	20	19	25	0	0	0
Sierra Semiconductor	92	96	120	0.1	0.1	0.1
Silicon Systems	241	265	298	0.4	0.3	0.3
Sipex	20	20	16	0	0	0
Solitron	15	11	7	0	0	0
Standard Microsystems	40	47	100	0.1	0.1	0.1
Supertex	24	25	30	0	0	0
Symphony Laboratories	26	66	12	0	0.1	0
Teccor Electronics	46	45	60	0.1	0.1	0.1
Telcom	NA	NA	18	0	0	0
Teledyne	26	26	0	0	0	0
Tektronix	47	54	0	0.1	0.1	0
Texas Instruments	3,087	4,083	5,552	4.7	4.8	5.0
Trident Microsystems	80	60	87	0.1	0.1	0.1
Tseng Labs	74	71	83	0.1	0.1	0.1
Unitrode	76	78	88	0.1	0.1	0.1
Universal	14	14	13	0	0	0
VLSI Technology	429	517	588	0.7	0.6	0.5
VTC	45	70	70	0.1	0.1	0.1
WaferScale Integration	29	25	21	0	0	0
Weitek	26	33	28	0	0	0
Western Digital	190	218	184	0.3	0.3	0.2
Xicor	93	105	100	0.1	0.1	0.1
Xilinx	163	231	321	0.2	0.3	0.3
Zilog	146	203	222	0.2	0.2	0.2
Other North American Companies	406	100	78	0.6	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Japanese Companies	27,576	34,573	44,778	42.3	40.4	40.5
Fuji Electric	297	366	446	0.5	0.4	0.4
Fujitsu	2,553	2,928	3,869	3.9	3.4	3.5
Hitachi	3,851	5,015	6,644	5.9	5.9	6.0
Matsushita	1,942	2,344	2,896	3.0	2.7	2.6
Mitsubishi	2,213	2,823	3,772	3.4	3.3	3.4
NEC	4,869	6,141	7,961	7.5	7.2	7.2
New JRC	138	186	218	0.2	0.2	0.2
Nittetsu Semiconductor	120	148	160	0.2	0.2	0.1
Oki	956	1,187	1,471	1.5	1.4	1.3
Ricoh	93	143	182	0.1	0.2	0.2
Rohm	844	930	1,345	1.3	1.1	1.2
Sanken	426	533	608	0.7	0.6	0.5
Sanyo	1,385	1,843	2,321	2.1	2.2	2.1
Seiko Epson	230	252	273	0.4	0.3	0.2
Shindengen Electric	170	211	242	0.3	0.2	0.2
Sharp	1,354	1,760	2,188	2.1	2.1	2.0
Sony	1,103	1,398	1,876	1.7	1.6	1.7
Toko	59	81	91	0.1	0.1	0.1
Toshiba	4,675	5,727	7,556	7.2	6.7	6.8
Yamaha	201	317	382	0.3	0.4	0.3
Other Japanese Companies	97	240	277	0.1	0.3	0.3
European Companies	6,666	7,645	9,835	10.2	8.9	8.9
ABB-HAFO	40	34	40	0.1	0	0
ABB-IXYS	49	38	55	0.1	0	0
Austria Mikro Systeme	74	85	110	0.1	0.1	0.1
Elex	NA	NA	20	0	0	0
Elmos	NA	NA	15	0	0	0
EM Microelectronics Marin	45	50	65	0.1	0.1	0.1
Ericsson	72	72	113	0.1	0.1	0.1
Eupec	83	82	98	0.1	0.1	0.1
European Silicon Structures	30	36	40	0	0	0
Fagor	25	19	27	0	0	0
GEC Plessey	381	290	314	0.6	0.3	0.3
Micronas	10	14	20	0	0	0
Mietec	113	148	178	0.2	0.2	0.2

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Philips	2,113	2,300	2,920	3.2	2.7	2.6
Semikron	103	94	112	0.2	0.1	0.1
SGS-Thomson	1,605	2,038	2,640	2.5	2.4	2.4
Siemens	1,245	1,509	2,090	1.9	1.8	1.9
TEMIC	NA	625	720	0	0.7	0.7
TCS	53	65	78	0.1	0.1	0.1
Thesys	0	0	15	0	0	0
Westcode	35	35	41	0.1	0	0
Zetex	27	32	40	0	0	0
Other European Companies	563	79	84	0.9	0.1	0.1
Asia/Pacific Companies	4,075	6,213	9,849	6.2	7.3	8.9
Acer Labs	NA	50	70	0	0.1	0.1
Daewoo	24	31	38	0	0	0
Dongsung Semiconductor	11	2	0	0	0	0
Goldstar	642	946	1,697	1.0	1.1	1.5
Holtek	0	53	70	0	0.1	0.1
Hualon Microelectronics Corporation	75	83	89	0.1	0.1	0.1
Hyundai	556	853	1,521	0.9	1.0	1.4
Korean Electronic Co.	148	177	225	0.2	0.2	0.2
Macronix	69	144	221	0.1	0.2	0.2
MOSel/Vitelic	161	223	259	0.2	0.3	0.2
Samsung	1,900	3,044	4,832	2.9	3.6	4.4
Silicon Integrated Systems	40	71	101	0.1	0.1	0.1
United Microelectronics	198	309	418	0.3	0.4	0.4
Winbond Electronics	117	184	308	0.2	0.2	0.3
Other Asia/Pacific Companies	134	43	0	0.2	0.1	0

NA = Not available
Source: Dataquest (March 1995)

Table 1-2
Each Company's Factory Revenue from Shipments of Semiconductors to the World, Excluding Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	63,925	84,055	108,916	100.0	100.0	100.0
North American Companies	26,603	36,717	45,694	41.6	43.7	42.0
ACC Microelectronics	26	36	49	0	0	0
Actel	44	60	76	0.1	0.1	0.1
Adaptec	89	122	125	0.1	0.1	0.1
Advanced Micro Devices	1,514	1,660	2,134	2.4	2.0	2.0
Allegro MicroSystems	115	118	148	0.2	0.1	0.1
Alliance Semiconductor	13	41	90	0	0	0.1
Altera	102	140	199	0.2	0.2	0.2
Analog Devices	467	595	687	0.7	0.7	0.6
Appian Technology	10	10	7	0	0	0
Applied Micro Circuits Corporation	39	48	48	0.1	0.1	0
AT&T	911	1,110	1,307	1.4	1.3	1.2
Atmel	140	225	375	0.2	0.3	0.3
Brooktree	96	117	109	0.2	0.1	0.1
Burr-Brown	73	88	105	0.1	0.1	0.1
California Micro Devices	12	14	10	0	0	0
Catalyst	41	55	50	0.1	0.1	0
Cherry Semiconductor	46	55	77	0.1	0.1	0.1
Chips & Technologies	119	89	89	0.2	0.1	0.1
Cirrus Logic	275	451	781	0.4	0.5	0.7
Comlinear	7	8	9	0	0	0
Cypress Semiconductor	267	300	400	0.4	0.4	0.4
Cyrix	63	125	241	0.1	0.1	0.2
Dallas Semiconductor	97	112	154	0.2	0.1	0.1
DSP Semiconductor	10	8	18	0	0	0
Elantec	14	21	21	0	0	0
Electronic Designs	9	23	26	0	0	0
ETEQ Microsystems	20	19	6	0	0	0
Exar	123	158	169	0.2	0.2	0.2
General Instrument	220	239	262	0.3	0.3	0.2
Gennum	27	30	29	0	0	0
Gould AMI	79	101	136	0.1	0.1	0.1
Harris	559	605	665	0.9	0.7	0.6
Hewlett-Packard	449	469	714	0.7	0.6	0.7
Honeywell	48	53	55	0.1	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Hughes	37	40	40	0.1	0	0
IBM	NA	2,510	3,035	0	3.0	2.8
IMI	18	21	20	0	0	0
Integrated Circuit Systems	35	41	81	0.1	0	0.1
Integrated Device Technology	220	303	385	0.3	0.4	0.4
Integrated Information Technology	42	40	35	0.1	0	0
Integrated Silicon Solution	NA	NA	60	0	0	0.1
Intel	5,091	7,970	10,099	8.0	9.5	9.3
IMP	32	37	49	0.1	0	0
International CMOS Technology	NA	NA	12	0	0	0
International Rectifier	271	288	361	0.4	0.3	0.3
ITT	254	262	241	0.4	0.3	0.2
Kulite	24	24	20	0	0	0
Lattice	90	127	134	0.1	0.2	0.1
Linear Technology	132	173	225	0.2	0.2	0.2
Linfinity	27	34	41	0	0	0
Logic Devices	12	12	14	0	0	0
LSI Logic	615	719	901	1.0	0.9	0.8
Maxim	93	111	165	0.1	0.1	0.2
Micrel	15	18	25	0	0	0
Micro Linear	33	45	41	0.1	0.1	0
Micro Power Systems	22	23	23	0	0	0
Microchip Technology	83	140	212	0.1	0.2	0.2
Micron Technology	557	925	1,492	0.9	1.1	1.4
Microsemi	84	97	100	0.1	0.1	0.1
Mitel	39	55	70	0.1	0.1	0.1
Motorola	4,511	5,786	7,012	7.1	6.9	6.4
NCR	228	275	354	0.4	0.3	0.3
National Semiconductor	1,763	2,046	2,017	2.8	2.4	1.9
Novasensor	13	16	13	0	0	0
Oak Technology	50	50	62	0.1	0.1	0.1
Optek	57	56	56	0.1	0.1	0.1
OPTi	98	86	130	0.2	0.1	0.1
Paradigm	7	34	36	0	0	0
Performance Semiconductor	46	41	20	0.1	0	0
Powerex	80	58	76	0.1	0.1	0.1
Q Logic	NA	21	45	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Quality Semiconductor	18	22	22	0	0	0
QuickLogic	NA	NA	8	0	0	0
Quality Technologies	46	47	49	0.1	0.1	0
Ramtron	NA	NA	15	0	0	0
Raytheon	96	103	108	0.2	0.1	0.1
Rockwell	172	176	177	0.3	0.2	0.2
S3	31	113	130	0	0.1	0.1
SEEQ Technology	35	29	22	0.1	0	0
Semtech	18	19	25	0	0	0
Sierra Semiconductor	92	96	120	0.1	0.1	0.1
Silicon Systems	241	265	298	0.4	0.3	0.3
Sipex	3	3	2	0	0	0
Solitron	8	11	5	0	0	0
Standard Microsystems	40	47	100	0.1	0.1	0.1
Supertex	24	25	30	0	0	0
Symphony Laboratories	26	66	12	0	0.1	0
Teccor Electronics	46	45	60	0.1	0.1	0.1
Telcom	NA	NA	18	0	0	0
Teledyne	26	26	0	0	0	0
Tektronix	39	46	0	0.1	0.1	0
Texas Instruments	3,087	4,083	5,552	4.8	4.9	5.1
Trident Microsystems	80	60	87	0.1	0.1	0.1
Tseng Labs	74	71	83	0.1	0.1	0.1
Unitrode	62	64	73	0.1	0.1	0.1
Universal	14	14	13	0	0	0
VLSI Technology	429	517	588	0.7	0.6	0.5
VTC	45	70	70	0.1	0.1	0.1
WaferScale Integration	29	25	21	0	0	0
Weitek	26	33	28	0	0	0
Western Digital	190	218	184	0.3	0.3	0.2
Xicor	93	105	100	0.1	0.1	0.1
Xilinx	163	231	321	0.3	0.3	0.3
Zilog	146	203	222	0.2	0.2	0.2
Other North American Companies	401	95	78	0.6	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Japanese Companies	26,707	33,585	43,642	41.8	40.0	40.1
Fuji Electric	281	345	424	0.4	0.4	0.4
Fujitsu	2,496	2,866	3,753	3.9	3.4	3.4
Hitachi	3,754	4,913	6,508	5.9	5.8	6.0
Matsushita	1,942	2,344	2,896	3.0	2.8	2.7
Mitsubishi	2,111	2,717	3,663	3.3	3.2	3.4
NEC	4,786	6,043	7,863	7.5	7.2	7.2
New JRC	138	186	218	0.2	0.2	0.2
Nittetsu Semiconductor	120	148	160	0.2	0.2	0.1
Oki	945	1,175	1,458	1.5	1.4	1.3
Ricoh	93	143	182	0.1	0.2	0.2
Rohm	781	862	1,273	1.2	1.0	1.2
Sanken	273	331	368	0.4	0.4	0.3
Sanyo	1,236	1,677	2,147	1.9	2.0	2.0
Seiko Epson	230	252	273	0.4	0.3	0.3
Shindengen Electric	126	162	194	0.2	0.2	0.2
Sharp	1,354	1,760	2,188	2.1	2.1	2.0
Sony	1,070	1,362	1,835	1.7	1.6	1.7
Toko	51	73	83	0.1	0.1	0.1
Toshiba	4,622	5,669	7,497	7.2	6.7	6.9
Yamaha	201	317	382	0.3	0.4	0.4
Other Japanese Companies	97	240	277	0.2	0.3	0.3
European Companies	6,540	7,540	9,731	10.2	9.0	8.9
ABB-HAFO	40	34	32	0.1	0	0
ABB-IXYS	49	38	55	0.1	0	0.1
Austria Mikro Systeme	74	85	110	0.1	0.1	0.1
Elex	NA	NA	20	0	0	0
Elmos	NA	NA	15	0	0	0
EM Microelectronics Marin	45	50	65	0.1	0.1	0.1
Ericsson	72	60	94	0.1	0.1	0.1
Eupec	83	82	98	0.1	0.1	0.1
European Silicon Structures	30	36	40	0	0	0
Fagor	25	19	27	0	0	0
GEC Plessey	343	269	308	0.5	0.3	0.3
Micronas	10	14	20	0	0	0
Mietec	113	148	178	0.2	0.2	0.2

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Philips	2,041	2,245	2,866	3.2	2.7	2.6
Semikron	103	94	112	0.2	0.1	0.1
SGS-Thomson	1,605	2,038	2,640	2.5	2.4	2.4
Siemens	1,245	1,509	2,090	1.9	1.8	1.9
TEMIC	NA	623	720	0	0.7	0.7
TCS	53	65	78	0.1	0.1	0.1
Thesys	0	0	15	0	0	0
Westcode	35	35	41	0.1	0	0
Zetex	27	32	40	0	0	0
Other European Companies	547	64	67	0.9	0.1	0.1
Asia/Pacific Companies	4,075	6,213	9,849	6.4	7.4	9.0
Acer Labs	NA	50	70	0	0.1	0.1
Daewoo	24	31	38	0	0	0
Dongsung Semiconductor	11	2	0	0	0	0
Goldstar	642	946	1,697	1.0	1.1	1.6
Holtek	0	53	70	0	0.1	0.1
Hualon Microelectronics Corporation	75	83	89	0.1	0.1	0.1
Hyundai	556	853	1,521	0.9	1.0	1.4
Korean Electronic Co.	148	177	225	0.2	0.2	0.2
Macronix	69	144	221	0.1	0.2	0.2
MOSel/Vitelic	161	223	259	0.3	0.3	0.2
Samsung	1,900	3,044	4,832	3.0	3.6	4.4
Silicon Integrated Systems	40	71	101	0.1	0.1	0.1
United Microelectronics	198	309	418	0.3	0.4	0.4
Winbond Electronics	117	184	308	0.2	0.2	0.3
Other Asia/Pacific Companies	134	43	0	0.2	0.1	0

NA = Not available
Source: Dataquest (March 1995)

Table 1-3
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	54,417	73,429	95,928	100.0	100.0	100.0
North American Companies	24,309	34,384	42,881	44.7	46.8	44.7
ACC Microelectronics	26	36	49	0	0	0.1
Actel	44	60	76	0.1	0.1	0.1
Adaptec	89	122	125	0.2	0.2	0.1
Advanced Micro Devices	1,514	1,660	2,134	2.8	2.3	2.2
Allegro MicroSystems	104	108	139	0.2	0.1	0.1
Alliance Semiconductor	13	41	90	0	0.1	0.1
Altera	102	140	199	0.2	0.2	0.2
Analog Devices	514	635	739	0.9	0.9	0.8
Appian Technology	10	10	7	0	0	0
Applied Micro Circuits Corporation	39	48	48	0.1	0.1	0.1
AT&T	868	1,065	1,250	1.6	1.5	1.3
Atmel	140	225	375	0.3	0.3	0.4
Brooktree	96	117	109	0.2	0.2	0.1
Burr-Brown	127	158	165	0.2	0.2	0.2
California Micro Devices	12	14	10	0	0	0
Catalyst	41	55	50	0.1	0.1	0.1
Cherry Semiconductor	46	55	77	0.1	0.1	0.1
Chips & Technologies	119	89	89	0.2	0.1	0.1
Cirrus Logic	275	451	781	0.5	0.6	0.8
Comlinear	15	16	16	0	0	0
Cypress Semiconductor	267	300	400	0.5	0.4	0.4
Cyrix	63	125	241	0.1	0.2	0.3
Dallas Semiconductor	97	112	154	0.2	0.2	0.2
DSP Semiconductor	10	8	18	0	0	0
Elantec	16	23	24	0	0	0
Electronic Designs	9	23	26	0	0	0
ETEQ Microsystems	20	19	6	0	0	0
Exar	123	158	169	0.2	0.2	0.2
Gennum	27	30	31	0	0	0
Gould AMI	79	101	136	0.1	0.1	0.1
Harris	444	467	478	0.8	0.6	0.5
Hewlett-Packard	214	230	255	0.4	0.3	0.3
Honeywell	21	26	23	0	0	0
Hughes	37	40	40	0.1	0.1	0

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
IBM	NA	2,510	3,035	0	3.4	3.2
IMI	18	21	20	0	0	0
Integrated Circuit Systems	35	41	81	0.1	0.1	0.1
Integrated Device Technology	220	303	385	0.4	0.4	0.4
Integrated Information Technology	42	40	35	0.1	0.1	0
Integrated Silicon Solution	NA	NA	60	0	0	0.1
Intel	5,091	7,970	10,099	9.4	10.9	10.5
IMP	32	37	49	0.1	0.1	0.1
International CMOS Technology	NA	NA	12	0	0	0
International Rectifier	1	3	8	0	0	0
ITT	148	155	127	0.3	0.2	0.1
Kulite	24	24	20	0	0	0
Lattice	90	127	134	0.2	0.2	0.1
Linear Technology	132	173	225	0.2	0.2	0.2
Linfinity	29	37	44	0.1	0.1	0
Logic Devices	12	12	14	0	0	0
LSI Logic	615	719	901	1.1	1.0	0.9
Maxim	97	115	169	0.2	0.2	0.2
Micrel	15	18	25	0	0	0
Micro Linear	33	45	41	0.1	0.1	0
Micro Power Systems	22	23	23	0	0	0
Microchip Technology	83	140	212	0.2	0.2	0.2
Micron Technology	557	925	1,492	1.0	1.3	1.6
Mitel	52	69	100	0.1	0.1	0.1
Motorola	3,741	4,922	6,096	6.9	6.7	6.4
NCR	228	275	354	0.4	0.4	0.4
National Semiconductor	1,727	1,983	1,929	3.2	2.7	2.0
Novasensor	13	16	13	0	0	0
Oak Technology	50	50	62	0.1	0.1	0.1
Optek	0	0	7	0	0	0
OPTi	98	86	130	0.2	0.1	0.1
Paradigm	7	34	36	0	0	0
Performance Semiconductor	46	41	20	0.1	0.1	0
Q Logic	NA	21	45	0	0	0
Quality Semiconductor	18	22	22	0	0	0
QuickLogic	NA	NA	8	0	0	0
Ramtron	NA	NA	15	0	0	0

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Raytheon	89	95	100	0.2	0.1	0.1
Rockwell	172	176	177	0.3	0.2	0.2
S3	31	113	130	0.1	0.2	0.1
SEEQ Technology	35	29	22	0.1	0	0
Semtech	4	2	5	0	0	0
Sierra Semiconductor	92	96	120	0.2	0.1	0.1
Silicon Systems	241	265	298	0.4	0.4	0.3
Sipex	20	20	16	0	0	0
Solitron	7	0	2	0	0	0
Standard Microsystems	40	47	100	0.1	0.1	0.1
Supertex	15	15	19	0	0	0
Symphony Laboratories	26	66	12	0	0.1	0
Telcom	NA	NA	18	0	0	0
Teledyne	26	26	0	0	0	0
Tektronix	42	49	0	0.1	0.1	0
Texas Instruments	3,016	4,000	5,471	5.5	5.4	5.7
Trident Microsystems	80	60	87	0.1	0.1	0.1
Tseng Labs	74	71	83	0.1	0.1	0.1
Unitrode	66	78	88	0.1	0.1	0.1
Universal	14	14	13	0	0	0
VLSI Technology	429	517	588	0.8	0.7	0.6
VTC	45	70	70	0.1	0.1	0.1
WaferScale Integration	29	25	21	0.1	0	0
Weitek	26	33	28	0	0	0
Western Digital	190	218	184	0.3	0.3	0.2
Xicor	93	105	100	0.2	0.1	0.1
Xilinx	163	231	321	0.3	0.3	0.3
Zilog	146	203	222	0.3	0.3	0.2
Other North American Companies	201	36	9	0.4	0	0
Japanese Companies	21,610	27,550	36,288	39.7	37.5	37.8
Fuji Electric	51	73	89	0.1	0.1	0.1
Fujitsu	2,294	2,648	3,542	4.2	3.6	3.7
Hitachi	3,225	4,286	5,757	5.9	5.8	6.0
Matsushita	1,248	1,536	1,968	2.3	2.1	2.1
Mitsubishi	1,906	2,413	3,172	3.5	3.3	3.3
NEC	4,227	5,444	7,159	7.8	7.4	7.5

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
New JRC	123	170	205	0.2	0.2	0.2
Nittetsu Semiconductor	120	148	160	0.2	0.2	0.2
Oki	922	1,150	1,437	1.7	1.6	1.5
Ricoh	93	143	182	0.2	0.2	0.2
Rohm	391	438	643	0.7	0.6	0.7
Sanken	153	202	240	0.3	0.3	0.3
Sanyo	1,005	1,370	1,782	1.8	1.9	1.9
Seiko Epson	230	252	273	0.4	0.3	0.3
Shindengen Electric	44	49	48	0.1	0.1	0.1
Sharp	1,002	1,342	1,678	1.8	1.8	1.7
Sony	808	1,073	1,513	1.5	1.5	1.6
Toko	30	36	40	0.1	0	0
Toshiba	3,537	4,384	5,931	6.5	6.0	6.2
Yamaha	201	317	382	0.4	0.4	0.4
Other Japanese Companies	0	76	87	0	0.1	0.1
European Companies	4,747	5,614	7,278	8.7	7.6	7.6
ABB-HAFO	25	20	28	0	0	0
Austria Mikro Systeme	74	85	110	0.1	0.1	0.1
Elex	NA	NA	20	0	0	0
Elmos	NA	NA	15	0	0	0
EM Microelectronics Marin	45	50	65	0.1	0.1	0.1
Ericsson	72	72	83	0.1	0.1	0.1
European Silicon Structures	30	36	40	0.1	0	0
GEC Plessey	350	269	286	0.6	0.4	0.3
Micronas	10	14	20	0	0	0
Mietec	113	148	178	0.2	0.2	0.2
Philips	1,562	1,696	2,159	2.9	2.3	2.3
SGS-Thomson	1,270	1,654	2,207	2.3	2.3	2.3
Siemens	847	1,110	1,586	1.6	1.5	1.7
TEMIC	NA	396	391	0	0.5	0.4
TCS	32	43	51	0.1	0.1	0.1
Thesys	0	0	15	0	0	0
Zetex	0	2	3	0	0	0
Other European Companies	317	19	21	0.6	0	0

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Asia/Pacific Companies	3,751	5,881	9,481	6.9	8.0	9.9
Acer Labs	NA	50	70	0	0.1	0.1
Daewoo	24	31	38	0	0	0
Goldstar	631	946	1,697	1.2	1.3	1.8
Holtek	0	53	70	0	0.1	0.1
Hualon Microelectronics Corporation	75	83	89	0.1	0.1	0.1
Hyundai	556	853	1,521	1.0	1.2	1.6
Korean Electronic Co.	30	37	47	0.1	0.1	0
Macronix	69	144	221	0.1	0.2	0.2
MOSel/Vitelic	161	223	259	0.3	0.3	0.3
Samsung	1,781	2,897	4,642	3.3	3.9	4.8
Silicon Integrated Systems	40	71	101	0.1	0.1	0.1
United Microelectronics	198	309	418	0.4	0.4	0.4
Winbond Electronics	117	184	308	0.2	0.3	0.3
Other Asia/Pacific Companies	69	0	0	0.1	0	0

NA = Not available
Source: Dataquest (March 1995)

Table 1-4
Each Company's Factory Revenue from Shipments of Integrated Circuits to the World, Excluding Hybrids (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	53,082	71,966	94,264	100.0	100.0	100.0
North American Companies	23,969	34,014	42,457	45.2	47.3	45.0
ACC Microelectronics	26	36	49	0	0.1	0.1
Actel	44	60	76	0.1	0.1	0.1
Adaptec	89	122	125	0.2	0.2	0.1
Advanced Micro Devices	1,514	1,660	2,134	2.9	2.3	2.3
Allegro MicroSystems	104	108	139	0.2	0.2	0.1
Alliance Semiconductor	13	41	90	0	0.1	0.1
Altera	102	140	199	0.2	0.2	0.2
Analog Devices	467	595	687	0.9	0.8	0.7
Appian Technology	10	10	7	0	0	0
Applied Micro Circuits Corporation	39	48	48	0.1	0.1	0.1
AT&T	868	1,065	1,250	1.6	1.5	1.3
Atmel	140	225	375	0.3	0.3	0.4
Brooktree	96	117	109	0.2	0.2	0.1
Burr-Brown	73	88	105	0.1	0.1	0.1
California Micro Devices	12	14	10	0	0	0
Catalyst	41	55	50	0.1	0.1	0.1
Cherry Semiconductor	46	55	77	0.1	0.1	0.1
Chips & Technologies	119	89	89	0.2	0.1	0.1
Cirrus Logic	275	451	781	0.5	0.6	0.8
Comlinear	7	8	9	0	0	0
Cypress Semiconductor	267	300	400	0.5	0.4	0.4
Cyrix	63	125	241	0.1	0.2	0.3
Dallas Semiconductor	97	112	154	0.2	0.2	0.2
DSP Semiconductor	10	8	18	0	0	0
Elantec	14	21	21	0	0	0
Electronic Designs	9	23	26	0	0	0
ETEQ Microsystems	20	19	6	0	0	0
Exar	123	158	169	0.2	0.2	0.2
Gennum	27	30	29	0.1	0	0
Gould AMI	79	101	136	0.1	0.1	0.1
Harris	444	467	478	0.8	0.6	0.5
Hewlett-Packard	214	230	255	0.4	0.3	0.3
Honeywell	21	26	23	0	0	0
Hughes	37	40	40	0.1	0.1	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
IBM	NA	2,510	3,035	0	3.5	3.2
IMI	18	21	20	0	0	0
Integrated Circuit Systems	35	41	81	0.1	0.1	0.1
Integrated Device Technology	220	303	385	0.4	0.4	0.4
Integrated Information Technology	42	40	35	0.1	0.1	0
Integrated Silicon Solution	NA	NA	60	0	0	0.1
Intel	5,091	7,970	10,099	9.6	11.1	10.7
IMP	32	37	49	0.1	0.1	0.1
International CMOS Technology	NA	NA	12	0	0	0
International Rectifier	1	3	8	0	0	0
ITT	148	155	127	0.3	0.2	0.1
Kulite	24	24	20	0	0	0
Lattice	90	127	134	0.2	0.2	0.1
Linear Technology	132	173	225	0.2	0.2	0.2
Linfinity	27	34	41	0.1	0	0
Logic Devices	12	12	14	0	0	0
LSI Logic	615	719	901	1.2	1.0	1.0
Maxim	93	111	165	0.2	0.2	0.2
Micrel	15	18	25	0	0	0
Micro Linear	33	45	41	0.1	0.1	0
Micro Power Systems	22	23	23	0	0	0
Microchip Technology	83	140	212	0.2	0.2	0.2
Micron Technology	557	925	1,492	1.0	1.3	1.6
Mitel	39	55	70	0.1	0.1	0.1
Motorola	3,618	4,751	5,870	6.8	6.6	6.2
NCR	228	275	354	0.4	0.4	0.4
National Semiconductor	1,693	1,969	1,923	3.2	2.7	2.0
Novasensor	13	16	13	0	0	0
Oak Technology	50	50	62	0.1	0.1	0.1
Optek	0	0	7	0	0	0
OPTi	98	86	130	0.2	0.1	0.1
Paradigm	7	34	36	0	0	0
Performance Semiconductor	46	41	20	0.1	0.1	0
Q Logic	NA	21	45	0	0	0
Quality Semiconductor	18	22	22	0	0	0
QuickLogic	NA	NA	8	0	0	0
Ramtron	NA	NA	15	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Raytheon	89	95	100	0.2	0.1	0.1
Rockwell	172	176	177	0.3	0.2	0.2
S3	31	113	130	0.1	0.2	0.1
SEEQ Technology	35	29	22	0.1	0	0
Semtech	2	2	5	0	0	0
Sierra Semiconductor	92	96	120	0.2	0.1	0.1
Silicon Systems	241	265	298	0.5	0.4	0.3
Sipex	3	3	2	0	0	0
Standard Microsystems	40	47	100	0.1	0.1	0.1
Supertex	15	15	19	0	0	0
Symphony Laboratories	26	66	12	0	0.1	0
Telcom	NA	NA	18	0	0	0
Teledyne	26	26	0	0	0	0
Tektronix	34	41	0	0.1	0.1	0
Texas Instruments	3,016	4,000	5,471	5.7	5.6	5.8
Trident Microsystems	80	60	87	0.2	0.1	0.1
Tseng Labs	74	71	83	0.1	0.1	0.1
Unitrode	52	64	73	0.1	0.1	0.1
Universal	14	14	13	0	0	0
VLSI Technology	429	517	588	0.8	0.7	0.6
VTC	45	70	70	0.1	0.1	0.1
WaferScale Integration	29	25	21	0.1	0	0
Weitek	26	33	28	0	0	0
Western Digital	190	218	184	0.4	0.3	0.2
Xicor	93	105	100	0.2	0.1	0.1
Xilinx	163	231	321	0.3	0.3	0.3
Zilog	146	203	222	0.3	0.3	0.2
Other North American Companies	196	31	9	0.4	0	0
Japanese Companies	20,741	26,562	35,152	39.1	36.9	37.3
Fuji Electric	35	52	67	0.1	0.1	0.1
Fujitsu	2,237	2,586	3,426	4.2	3.6	3.6
Hitachi	3,128	4,184	5,621	5.9	5.8	6.0
Matsushita	1,248	1,536	1,968	2.4	2.1	2.1
Mitsubishi	1,804	2,307	3,063	3.4	3.2	3.2
NEC	4,144	5,346	7,061	7.8	7.4	7.5
New JRC	123	170	205	0.2	0.2	0.2

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Nittetsu Semiconductor	120	148	160	0.2	0.2	0.2
Oki	911	1,138	1,424	1.7	1.6	1.5
Ricoh	93	143	182	0.2	0.2	0.2
Rohm	328	370	571	0.6	0.5	0.6
Sanyo	856	1,204	1,608	1.6	1.7	1.7
Seiko Epson	230	252	273	0.4	0.4	0.3
Sharp	1,002	1,342	1,678	1.9	1.9	1.8
Sony	775	1,037	1,472	1.5	1.4	1.6
Toko	22	28	32	0	0	0
Toshiba	3,484	4,326	5,872	6.6	6.0	6.2
Yamaha	201	317	382	0.4	0.4	0.4
Other Japanese Companies	0	76	87	0	0.1	0.1
European Companies	4,621	5,509	7,174	8.7	7.7	7.6
ABB-HAFO	25	20	20	0	0	0
Austria Mikro Systeme	74	85	110	0.1	0.1	0.1
Elex	NA	NA	20	0	0	0
Elmos	NA	NA	15	0	0	0
EM Microelectronics Marin	45	50	65	0.1	0.1	0.1
Ericsson	72	60	64	0.1	0.1	0.1
European Silicon Structures	30	36	40	0.1	0.1	0
GEC Plessey	312	248	280	0.6	0.3	0.3
Micronas	10	14	20	0	0	0
Mietec	113	148	178	0.2	0.2	0.2
Philips	1,490	1,641	2,105	2.8	2.3	2.2
SGS-Thomson	1,270	1,654	2,207	2.4	2.3	2.3
Siemens	847	1,110	1,586	1.6	1.5	1.7
TEMIC	NA	394	391	0	0.5	0.4
TCS	32	43	51	0.1	0.1	0.1
Thesys	0	0	15	0	0	0
Zetex	0	2	3	0	0	0
Other European Companies	301	4	4	0.6	0	0
Asia/Pacific Companies	3,751	5,881	9,481	7.1	8.2	10.1
Acer Labs	NA	50	70	0	0.1	0.1
Daewoo	24	31	38	0	0	0
Goldstar	631	946	1,697	1.2	1.3	1.8

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Holtek	0	53	70	0	0.1	0.1
Hualon Microelectronics Corporation	75	83	89	0.1	0.1	0.1
Hyundai	556	853	1,521	1.0	1.2	1.6
Korean Electronic Co.	30	37	47	0.1	0.1	0
Macronix	69	144	221	0.1	0.2	0.2
MOSel/Vitelic	161	223	259	0.3	0.3	0.3
Samsung	1,781	2,897	4,642	3.4	4.0	4.9
Silicon Integrated Systems	40	71	101	0.1	0.1	0.1
United Microelectronics	198	309	418	0.4	0.4	0.4
Winbond Electronics	117	184	308	0.2	0.3	0.3
Other Asia/Pacific Companies	69	0	0	0.1	0	0

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	3,193	3,079	2,960	100.0	100.0	100.0
North American Companies	1,601	1,650	1,467	50.1	53.6	50.5
Advanced Micro Devices	247	199	143	7.7	6.5	4.9
Applied Micro Circuits Corporation	29	26	20	0.9	0.8	0.7
AT&T	60	60	63	1.9	1.9	2.2
Atmel	1	1	0	0	0	0
Chips & Technologies	3	3	0	0.1	0.1	0
Harris	22	13	6	0.7	0.4	0.2
Intel	1	1	0	0	0	0
Motorola	384	432	421	12.0	14.0	14.5
National Semiconductor	274	279	215	8.6	9.1	7.4
Raytheon	51	27	22	1.6	0.9	0.8
Texas Instruments	505	594	577	15.8	19.3	19.9
Other North American Companies	24	15	0	0.8	0.5	0
Japanese Companies	1,240	1,158	1,207	38.8	37.6	41.5
Fujitsu	413	371	395	12.9	12.0	13.6
Hitachi	425	391	465	13.3	12.7	16.0
Matsushita	11	26	29	0.3	0.8	1.0
Mitsubishi	66	63	23	2.1	2.0	0.8
NEC	214	201	194	6.7	6.5	6.7
Oki	33	31	33	1.0	1.0	1.1
Sony	1	0	0	0	0	0
Toshiba	77	75	68	2.4	2.4	2.3
European Companies	328	227	186	10.3	7.4	6.4
GEC Plessey	40	23	16	1.3	0.7	0.6
Philips	241	152	121	7.5	4.9	4.2
SGS-Thomson	3	7	12	0.1	0.2	0.4
Siemens	40	41	33	1.3	1.3	1.1
Other European Companies	4	4	4	0.1	0.1	0.1
Asia/Pacific Companies	24	44	46	0.8	1.4	1.6
Goldstar	24	44	46	0.8	1.4	1.6

Source: Dataquest (March 1995)

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 (%)		
	1992	1993	1994	1992	1993	1994
Total Market	318	244	198	100.0	100.0	100.0
North American Companies	88	59	43	27.7	24.2	21.7
Advanced Micro Devices	46	39	28	14.5	16.0	14.1
Harris	13	4	0	4.1	1.6	0
Motorola	3	2	1	0.9	0.8	0.5
National Semiconductor	8	5	4	2.5	2.0	2.0
Raytheon	10	6	5	3.1	2.5	2.5
Texas Instruments	3	3	5	0.9	1.2	2.5
Other North American Companies	5	0	0	1.6	0	0
Japanese Companies	203	182	141	63.8	74.6	71.2
Fujitsu	90	81	32	28.3	33.2	16.2
Hitachi	94	85	93	29.6	34.8	47.0
NEC	19	16	16	6.0	6.6	8.1
European Companies	27	3	14	8.5	1.2	7.1
Philips	27	3	14	8.5	1.2	7.1

Source: Dataquest (March 1995)

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 (%)		
	1992	1993	1994	1992	1993	1994
Total Market	2,875	2,835	2,708	100.0	100.0	100.0
North American Companies	1,513	1,591	1,424	52.6	56.1	52.6
Advanced Micro Devices	201	160	115	7.0	5.6	4.2
Applied Micro Circuits Corporation	29	26	20	1.0	0.9	0.7
AT&T	60	60	63	2.1	2.1	2.3
Atmel	1	1	0	0	0	0
Chips & Technologies	3	3	0	0.1	0.1	0
Harris	9	9	6	0.3	0.3	0.2
Intel	1	1	0	0	0	0
Motorola	381	430	420	13.3	15.2	15.5
National Semiconductor	266	274	211	9.3	9.7	7.8
Raytheon	41	21	17	1.4	0.7	0.6
Texas Instruments	502	591	572	17.5	20.8	21.1
Other North American Companies	19	15	0	0.7	0.5	0
Japanese Companies	1,037	976	1,066	36.1	34.4	39.4
Fujitsu	323	290	363	11.2	10.2	13.4
Hitachi	331	306	372	11.5	10.8	13.7
Matsushita	11	26	29	0.4	0.9	1.1
Mitsubishi	66	63	23	2.3	2.2	0.8
NEC	195	185	178	6.8	6.5	6.6
Oki	33	31	33	1.1	1.1	1.2
Sony	1	0	0	0	0	0
Toshiba	77	75	68	2.7	2.6	2.5
European Companies	301	224	172	10.5	7.9	6.4
GEC Plessey	40	23	16	1.4	0.8	0.6
Philips	214	149	107	7.4	5.3	4.0
SGS-Thomson	3	7	12	0.1	0.2	0.4
Siemens	40	41	33	1.4	1.4	1.2
Other European Companies	4	4	4	0.1	0.1	0.1
Asia/Pacific Companies	24	44	46	0.8	1.6	1.7
Goldstar	24	44	46	0.8	1.6	1.7

Source: Dataquest (March 1995)

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 (%)		
	1992	1993	1994	1992	1993	1994
Total Market	39,709	56,374	75,951	100.0	100.0	100.0
North American Companies	17,717	26,784	34,386	44.6	47.5	45.3
ACC Microelectronics	26	36	49	0.1	0.1	0.1
Actel	44	60	76	0.1	0.1	0.1
Adaptec	89	122	125	0.2	0.2	0.2
Advanced Micro Devices	1,157	1,307	1,804	2.9	2.3	2.4
Allegro MicroSystems	4	4	5	0	0	0
Alliance Semiconductor	13	41	90	0	0.1	0.1
Altera	102	140	199	0.3	0.2	0.3
Analog Devices	39	69	85	0.1	0.1	0.1
Appian Technology	10	10	7	0	0	0
Applied Micro Circuits Corporation	10	22	21	0	0	0
AT&T	533	671	785	1.3	1.2	1.0
Atmel	138	223	363	0.3	0.4	0.5
California Micro Devices	5	6	5	0	0	0
Catalyst	40	54	49	0.1	0.1	0.1
Chips & Technologies	116	86	89	0.3	0.2	0.1
Cirrus Logic	246	371	681	0.6	0.7	0.9
Cypress Semiconductor	267	300	400	0.7	0.5	0.5
Cyrix	63	125	241	0.2	0.2	0.3
Dallas Semiconductor	89	104	154	0.2	0.2	0.2
DSP Semiconductor	10	8	18	0	0	0
Electronic Designs	9	23	26	0	0	0
ETEQ Microsystems	20	19	6	0.1	0	0
Gould AMI	49	63	105	0.1	0.1	0.1
Harris	205	204	188	0.5	0.4	0.2
Hewlett-Packard	214	230	255	0.5	0.4	0.3
Hughes	25	24	21	0.1	0	0
IBM	NA	2,510	3,035	0	4.5	4.0
IMI	15	18	18	0	0	0
Integrated Circuit Systems	35	29	42	0.1	0.1	0.1
Integrated Device Technology	220	303	385	0.6	0.5	0.5
Integrated Information Technology	42	40	35	0.1	0.1	0
Integrated Silicon Solution	NA	NA	60	0	0	0.1
Intel	5,080	7,957	10,079	12.8	14.1	13.3
IMP	21	8	9	0.1	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 (%)		
	1992	1993	1994	1992	1993	1994
International CMOS Technology	NA	NA	12	0	0	0
ITT	130	132	103	0.3	0.2	0.1
Lattice	90	127	134	0.2	0.2	0.2
Logic Devices	12	12	14	0	0	0
LSI Logic	615	719	901	1.5	1.3	1.2
Micrel	5	5	7	0	0	0
Micro Linear	0	0	6	0	0	0
Microchip Technology	83	140	212	0.2	0.2	0.3
Micron Technology	557	925	1,492	1.4	1.6	2.0
Motorola	2,706	3,612	4,525	6.8	6.4	6.0
NCR	178	230	298	0.4	0.4	0.4
National Semiconductor	714	902	817	1.8	1.6	1.1
Oak Technology	50	50	62	0.1	0.1	0.1
OPTi	98	86	130	0.2	0.2	0.2
Paradigm	7	34	36	0	0.1	0
Performance Semiconductor	46	41	20	0.1	0.1	0
Q Logic	NA	21	45	0	0	0.1
Quality Semiconductor	18	22	22	0	0	0
QuickLogic	NA	NA	8	0	0	0
Ramtron	NA	NA	15	0	0	0
Rockwell	17	21	17	0	0	0
S3	31	113	130	0.1	0.2	0.2
SEEQ Technology	26	20	22	0.1	0	0
Sierra Semiconductor	7	6	35	0	0	0
Standard Microsystems	40	47	100	0.1	0.1	0.1
Supertex	5	5	6	0	0	0
Symphony Laboratories	26	66	12	0.1	0.1	0
Texas Instruments	2,019	2,789	4,052	5.1	4.9	5.3
Trident Microsystems	80	60	87	0.2	0.1	0.1
Tseng Labs	74	71	83	0.2	0.1	0.1
Universal	10	9	7	0	0	0
VLSI Technology	427	515	588	1.1	0.9	0.8
WaferScale Integration	29	25	21	0.1	0	0
Weitek	26	33	28	0.1	0.1	0
Western Digital	190	218	184	0.5	0.4	0.2
Xicor	93	105	100	0.2	0.2	0.1
Xilinx	163	231	321	0.4	0.4	0.4
Zilog	146	203	222	0.4	0.4	0.3
Other North American Companies	63	2	2	0.2	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 (%)		
	1992	1993	1994	1992	1993	1994
Japanese Companies	16,267	21,501	29,034	41.0	38.1	38.2
Fuji Electric	26	36	40	0.1	0.1	0.1
Fujitsu	1,709	2,093	2,876	4.3	3.7	3.8
Hitachi	2,461	3,513	4,799	6.2	6.2	6.3
Matsushita	834	1,037	1,328	2.1	1.8	1.7
Mitsubishi	1,423	1,867	2,584	3.6	3.3	3.4
NEC	3,599	4,768	6,361	9.1	8.5	8.4
New JRC	10	12	32	0	0	0
Nittetsu Semiconductor	120	148	160	0.3	0.3	0.2
Oki	862	1,085	1,365	2.2	1.9	1.8
Ricoh	86	135	168	0.2	0.2	0.2
Rohm	90	112	210	0.2	0.2	0.3
Sanyo	386	571	797	1.0	1.0	1.1
Seiko Epson	219	241	260	0.6	0.4	0.3
Sharp	938	1,255	1,582	2.4	2.2	2.1
Sony	435	612	1,007	1.1	1.1	1.3
Toshiba	2,879	3,636	5,015	7.3	6.4	6.6
Yamaha	190	304	363	0.5	0.5	0.5
Other Japanese Companies	0	76	87	0	0.1	0.1
European Companies	2,267	2,595	3,499	5.7	4.6	4.6
Austria Mikro Systeme	29	36	46	0.1	0.1	0.1
Elex	NA	NA	20	0	0	0
Elmos	NA	NA	15	0	0	0
Ericsson	15	15	15	0	0	0
European Silicon Structures	30	36	40	0.1	0.1	0.1
GEC Plessey	118	111	129	0.3	0.2	0.2
Mietec	22	25	32	0.1	0	0
Philips	646	737	1,027	1.6	1.3	1.4
SGS-Thomson	609	789	998	1.5	1.4	1.3
Siemens	632	687	1,007	1.6	1.2	1.3
TEMIC	NA	132	124	0	0.2	0.2
TCS	22	27	31	0.1	0	0
Thesys	0	0	15	0	0	0
Other European Companies	144	0	0	0.4	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 (%)		
	1992	1993	1994	1992	1993	1994
Asia/Pacific Companies	3,458	5,494	9,032	8.7	9.7	11.9
Acer Labs	NA	50	70	0	0.1	0.1
Daewoo	7	11	21	0	0	0
Goldstar	587	862	1,606	1.5	1.5	2.1
Holtek	0	38	70	0	0.1	0.1
Hualon Microelectronics Corporation	74	76	80	0.2	0.1	0.1
Hyundai	556	853	1,521	1.4	1.5	2.0
Macronix	69	144	221	0.2	0.3	0.3
MOSel/Vitelic	161	223	259	0.4	0.4	0.3
Samsung	1,664	2,731	4,409	4.2	4.8	5.8
Silicon Integrated Systems	40	71	101	0.1	0.1	0.1
United Microelectronics	198	309	418	0.5	0.5	0.6
Winbond Electronics	102	126	256	0.3	0.2	0.3

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	15,308	23,306	33,481	100.0	100.0	100.0
North American Companies	3,593	6,253	8,406	23.5	26.8	25.1
Advanced Micro Devices	282	427	442	1.8	1.8	1.3
Alliance Semiconductor	13	41	90	0.1	0.2	0.3
AT&T	33	10	3	0.2	0	0
Atmel	99	181	331	0.6	0.8	1.0
Catalyst	40	54	49	0.3	0.2	0.1
Cypress Semiconductor	187	235	285	1.2	1.0	0.9
Dallas Semiconductor	24	38	30	0.2	0.2	0.1
Electronic Designs	9	23	26	0.1	0.1	0.1
Gould AMI	15	23	44	0.1	0.1	0.1
Harris	20	19	12	0.1	0.1	0
IBM	NA	1,133	1,520	0	4.9	4.5
Integrated Device Technology	138	189	252	0.9	0.8	0.8
Integrated Silicon Solution	NA	NA	60	0	0	0.2
Intel	324	468	458	2.1	2.0	1.4
IMP	5	2	1	0	0	0
International CMOS Technology	NA	NA	0	0	0	0
ITT	8	11	10	0.1	0	0
Logic Devices	4	4	2	0	0	0
Microchip Technology	47	64	82	0.3	0.3	0.2
Micron Technology	557	925	1,492	3.6	4.0	4.5
Motorola	610	762	948	4.0	3.3	2.8
NCR	2	2	0	0	0	0
National Semiconductor	128	172	155	0.8	0.7	0.5
Paradigm	7	34	36	0	0.1	0.1
Performance Semiconductor	16	8	5	0.1	0	0
Quality Semiconductor	9	12	7	0.1	0.1	0
Ramtron	NA	NA	15	0	0	0
SEEQ Technology	21	16	5	0.1	0.1	0
Texas Instruments	874	1,275	1,931	5.7	5.5	5.8
WaferScale Integration	22	20	15	0.1	0.1	0
Xicor	93	105	100	0.6	0.5	0.3
Other North American Companies	6	0	0	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Japanese Companies	8,008	11,180	15,519	52.3	48.0	46.4
Fujitsu	927	1,135	1,692	6.1	4.9	5.1
Hitachi	1,519	2,369	3,232	9.9	10.2	9.7
Matsushita	217	305	396	1.4	1.3	1.2
Mitsubishi	878	1,206	1,652	5.7	5.2	4.9
NEC	1,422	2,173	3,096	9.3	9.3	9.2
Nittetsu Semiconductor	120	148	160	0.8	0.6	0.5
Oki	424	486	697	2.8	2.1	2.1
Ricoh	8	21	19	0.1	0.1	0.1
Rohm	27	39	56	0.2	0.2	0.2
Sanyo	95	155	183	0.6	0.7	0.5
Seiko Epson	36	38	42	0.2	0.2	0.1
Sharp	519	697	867	3.4	3.0	2.6
Sony	197	287	387	1.3	1.2	1.2
Toshiba	1,618	2,101	3,018	10.6	9.0	9.0
Yamaha	1	1	1	0	0	0
Other Japanese Companies	0	19	21	0	0.1	0.1
European Companies	724	1,089	1,484	4.7	4.7	4.4
GEC Plessey	5	3	0	0	0	0
Philips	40	32	14	0.3	0.1	0
SGS-Thomson	304	467	589	2.0	2.0	1.8
Siemens	336	556	858	2.2	2.4	2.6
TEMIC	NA	31	23	0	0.1	0.1
Other European Companies	39	0	0	0.3	0	0
Asia/Pacific Companies	2,983	4,784	8,072	19.5	20.5	24.1
Daewoo	1	1	0	0	0	0
Goldstar	557	804	1,525	3.6	3.4	4.6
Hualon Microelectronics Corporation	29	36	46	0.2	0.2	0.1
Hyundai	556	851	1,515	3.6	3.7	4.5
Macronix	57	129	200	0.4	0.6	0.6
MOSel/Vitelic	136	223	259	0.9	1.0	0.8
Samsung	1,516	2,512	4,194	9.9	10.8	12.6
Silicon Integrated Systems	21	5	0	0.1	0	0
United Microelectronics	64	146	191	0.4	0.6	0.6
Winbond Electronics	46	77	142	0.3	0.3	0.3

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	14,359	19,947	25,868	100.0	100.0	100.0
North American Companies	9,879	14,395	18,303	68.8	72.2	70.8
ACC Microelectronics	26	36	49	0.2	0.2	0.2
Adaptec	89	122	125	0.6	0.6	0.5
Advanced Micro Devices	642	563	1,021	4.5	2.8	3.9
Analog Devices	39	69	85	0.3	0.3	0.3
Appian Technology	6	7	7	0	0	0
AT&T	115	246	305	0.8	1.2	1.2
Atmel	5	5	5	0	0	0
California Micro Devices	5	6	5	0	0	0
Chips & Technologies	116	86	89	0.8	0.4	0.3
Cirrus Logic	246	371	681	1.7	1.9	2.6
Cypress Semiconductor	40	8	40	0.3	0	0.2
Cyrix	63	125	241	0.4	0.6	0.9
Dallas Semiconductor	55	56	22	0.4	0.3	0.1
DSP Semiconductor	10	8	18	0.1	0	0.1
ETEQ Microsystems	20	19	0	0.1	0.1	0
Harris	57	47	52	0.4	0.2	0.2
Hughes	2	3	3	0	0	0
IBM	NA	337	399	0	1.7	1.5
Integrated Device Technology	31	48	51	0.2	0.2	0.2
Integrated Information Technology	42	40	35	0.3	0.2	0.1
Intel	4,721	7,444	9,595	32.9	37.3	37.1
IMP	0	6	8	0	0	0
ITT	29	25	12	0.2	0.1	0
LSI Logic	51	77	78	0.4	0.4	0.3
Micro Linear	0	0	6	0	0	0
Microchip Technology	32	72	130	0.2	0.4	0.5
Motorola	1,464	2,065	2,363	10.2	10.4	9.1
NCR	71	63	81	0.5	0.3	0.3
National Semiconductor	383	477	409	2.7	2.4	1.6
Oak Technology	50	50	62	0.3	0.3	0.2
OPTi	98	86	130	0.7	0.4	0.5
Performance Semiconductor	21	18	15	0.1	0.1	0.1
Q Logic	NA	21	45	0	0.1	0.2
Rockwell	13	17	12	0.1	0.1	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
S3	31	113	130	0.2	0.6	0.5
SEEQ Technology	5	4	17	0	0	0.1
Sierra Semiconductor	1	0	35	0	0	0.1
Standard Microsystems	35	43	100	0.2	0.2	0.4
Supertex	2	2	1	0	0	0
Symphony Laboratories	26	66	12	0.2	0.3	0
Texas Instruments	530	781	1,006	3.7	3.9	3.9
Trident Microsystems	80	60	87	0.6	0.3	0.3
Tseng Labs	74	71	83	0.5	0.4	0.3
VLSI Technology	141	173	216	1.0	0.9	0.8
WaferScale Integration	6	5	3	0	0	0
Weitek	26	33	28	0.2	0.2	0.1
Western Digital	190	218	184	1.3	1.1	0.7
Zilog	146	203	222	1.0	1.0	0.9
Other North American Companies	44	0	0	0.3	0	0
Japanese Companies	3,649	4,585	6,137	25.4	23.0	23.7
Fuji Electric	1	1	2	0	0	0
Fujitsu	233	282	390	1.6	1.4	1.5
Hitachi	596	718	998	4.2	3.6	3.9
Matsushita	275	286	460	1.9	1.4	1.8
Mitsubishi	456	532	698	3.2	2.7	2.7
NEC	1,130	1,341	1,678	7.9	6.7	6.5
New JRC	0	0	2	0	0	0
Oki	124	180	217	0.9	0.9	0.8
Ricoh	56	89	83	0.4	0.4	0.3
Rohm	20	23	50	0.1	0.1	0.2
Sanyo	100	145	161	0.7	0.7	0.6
Seiko Epson	16	17	21	0.1	0.1	0.1
Sharp	129	170	192	0.9	0.9	0.7
Sony	73	112	194	0.5	0.6	0.7
Toshiba	440	540	718	3.1	2.7	2.8
Yamaha	0	149	273	0	0.7	1.1
European Companies	637	640	851	4.4	3.2	3.3
Elex	NA	NA	15	0	0	0.1
GEC Plessey	8	7	11	0.1	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Philips	287	305	403	2.0	1.5	1.6
SGS-Thomson	167	162	227	1.2	0.8	0.9
Siemens	116	107	128	0.8	0.5	0.5
TEMIC	NA	44	51	0	0.2	0.2
TCS	12	15	16	0.1	0.1	0.1
Other European Companies	47	0	0	0.3	0	0
Asia/Pacific Companies	194	327	577	1.4	1.6	2.2
Acer Labs	NA	50	68	0	0.3	0.3
Daewoo	4	7	17	0	0	0.1
Goldstar	14	12	29	0.1	0.1	0.1
Holtek	0	18	20	0	0.1	0.1
Hualon Microelectronics Corporation	10	10	0	0.1	0.1	0
Hyundai	0	0	2	0	0	0
Macronix	12	15	21	0.1	0.1	0.1
Samsung	24	46	44	0.2	0.2	0.2
Silicon Integrated Systems	19	26	101	0.1	0.1	0.4
United Microelectronics	69	113	227	0.5	0.6	0.9
Winbond Electronics	42	30	48	0.3	0.2	0.2

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	10,042	13,121	16,602	100.0	100.0	100.0
North American Companies	4,245	6,136	7,677	42.3	46.8	46.2
Actel	44	60	76	0.4	0.5	0.5
Advanced Micro Devices	233	317	341	2.3	2.4	2.1
Allegro MicroSystems	4	4	5	0	0	0
Altera	102	140	199	1.0	1.1	1.2
Appian Technology	4	3	0	0	0	0
Applied Micro Circuits Corporation	10	22	21	0.1	0.2	0.1
AT&T	385	415	477	3.8	3.2	2.9
Atmel	34	37	27	0.3	0.3	0.2
Cypress Semiconductor	40	57	75	0.4	0.4	0.5
Dallas Semiconductor	10	10	102	0.1	0.1	0.6
ETEQ Microsystems	0	0	6	0	0	0
Gould AMI	34	40	61	0.3	0.3	0.4
Harris	128	138	124	1.3	1.1	0.7
Hewlett-Packard	214	230	255	2.1	1.8	1.5
Hughes	23	21	18	0.2	0.2	0.1
IBM	NA	1,040	1,116	0	7.9	6.7
IMI	15	18	18	0.1	0.1	0.1
Integrated Circuit Systems	35	29	42	0.3	0.2	0.3
Integrated Device Technology	51	66	82	0.5	0.5	0.5
Intel	35	45	26	0.3	0.3	0.2
IMP	16	0	0	0.2	0	0
International CMOS Technology	NA	NA	12	0	0	0.1
ITT	93	96	81	0.9	0.7	0.5
Lattice	90	127	134	0.9	1.0	0.8
Logic Devices	8	8	12	0.1	0.1	0.1
LSI Logic	564	642	823	5.6	4.9	5.0
Micrel	5	5	7	0	0	0
Microchip Technology	4	4	0	0	0	0
Motorola	632	785	1,214	6.3	6.0	7.3
NCR	105	165	217	1.0	1.3	1.3
National Semiconductor	203	253	253	2.0	1.9	1.5
Performance Semiconductor	9	15	0	0.1	0.1	0
Quality Semiconductor	9	10	15	0.1	0.1	0.1
QuickLogic	NA	NA	8	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Rockwell	4	4	5	0	0	0
Sierra Semiconductor	6	6	0	0.1	0	0
Standard Microsystems	5	4	0	0	0	0
Supertex	3	3	5	0	0	0
Texas Instruments	615	733	1,115	6.1	5.6	6.7
Universal	10	9	7	0.1	0.1	0
VLSI Technology	286	342	372	2.8	2.6	2.2
WaferScale Integration	1	0	3	0	0	0
Xilinx	163	231	321	1.6	1.8	1.9
Other North American Companies	13	2	2	0.1	0	0
Japanese Companies	4,610	5,736	7,378	45.9	43.7	44.4
Fuji Electric	25	35	38	0.2	0.3	0.2
Fujitsu	549	676	794	5.5	5.2	4.8
Hitachi	346	426	569	3.4	3.2	3.4
Matsushita	342	446	472	3.4	3.4	2.8
Mitsubishi	89	129	234	0.9	1.0	1.4
NEC	1,047	1,254	1,587	10.4	9.6	9.6
New JRC	10	12	30	0.1	0.1	0.2
Oki	314	419	451	3.1	3.2	2.7
Ricoh	22	25	66	0.2	0.2	0.4
Rohm	43	50	104	0.4	0.4	0.6
Sanyo	191	271	453	1.9	2.1	2.7
Seiko Epson	167	186	197	1.7	1.4	1.2
Sharp	290	388	523	2.9	3.0	3.2
Sony	165	213	426	1.6	1.6	2.6
Toshiba	821	995	1,279	8.2	7.6	7.7
Yamaha	189	154	89	1.9	1.2	0.5
Other Japanese Companies	0	57	66	0	0.4	0.4
European Companies	906	866	1,164	9.0	6.6	7.0
Austria Mikro Systeme	29	36	46	0.3	0.3	0.3
Elex	NA	NA	5	0	0	0
Elmos	NA	NA	15	0	0	0.1
Ericsson	15	15	15	0.1	0.1	0.1
European Silicon Structures	30	36	40	0.3	0.3	0.2
GEC Plessey	105	101	118	1.0	0.8	0.7

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Mietec	22	25	32	0.2	0.2	0.2
Philips	319	400	610	3.2	3.0	3.7
SGS-Thomson	138	160	182	1.4	1.2	1.1
Siemens	180	24	21	1.8	0.2	0.1
TEMIC	NA	57	50	0	0.4	0.3
TCS	10	12	15	0.1	0.1	0.1
Thesys	0	0	15	0	0	0.1
Other European Companies	58	0	0	0.6	0	0
Asia/Pacific Companies	281	383	383	2.8	2.9	2.3
Acer Labs	NA	0	2	0	0	0
Daewoo	2	3	4	0	0	0
Goldstar	16	46	52	0.2	0.4	0.3
Holtek	0	20	50	0	0.2	0.3
Hualon Microelectronics Corporation	35	30	34	0.3	0.2	0.2
Hyundai	0	2	4	0	0	0
MOSel/Vitelic	25	0	0	0.2	0	0
Samsung	124	173	171	1.2	1.3	1.0
Silicon Integrated Systems	0	40	0	0	0.3	0
United Microelectronics	65	50	0	0.6	0.4	0
Winbond Electronics	14	19	66	0.1	0.1	0.4

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	10,180	12,513	15,407	100.0	100.0	100.0
North American Companies	4,651	5,580	6,604	45.7	44.6	42.9
Advanced Micro Devices	110	154	187	1.1	1.2	1.2
Allegro MicroSystems	100	104	134	1.0	0.8	0.9
Analog Devices	428	526	602	4.2	4.2	3.9
Applied Micro Circuits Corporation	0	0	7	0	0	0
AT&T	275	334	402	2.7	2.7	2.6
Atmel	1	1	12	0	0	0.1
Brooktree	96	117	109	0.9	0.9	0.7
Burr-Brown	73	88	105	0.7	0.7	0.7
California Micro Devices	7	8	5	0.1	0.1	0
Catalyst	1	1	1	0	0	0
Cherry Semiconductor	46	55	77	0.5	0.4	0.5
Cirrus Logic	29	80	100	0.3	0.6	0.6
Comlinear	7	8	9	0.1	0.1	0.1
Dallas Semiconductor	8	8	0	0.1	0.1	0
Elantec	14	21	21	0.1	0.2	0.1
Exar	123	158	169	1.2	1.3	1.1
Gennum	27	30	29	0.3	0.2	0.2
Gould AMI	30	38	31	0.3	0.3	0.2
Harris	217	250	284	2.1	2.0	1.8
Honeywell	21	26	23	0.2	0.2	0.1
Hughes	.12	16	19	0.1	0.1	0.1
IMI	3	3	2	0	0	0
Integrated Circuit Systems	0	12	39	0	0.1	0.3
Intel	10	12	20	0.1	0.1	0.1
IMP	11	29	40	0.1	0.2	0.3
International Rectifier	1	3	8	0	0	0.1
ITT	18	23	24	0.2	0.2	0.2
Kulite	24	24	20	0.2	0.2	0.1
Linear Technology	132	173	225	1.3	1.4	1.5
Linfinity	27	34	41	0.3	0.3	0.3
Maxim	93	111	165	0.9	0.9	1.1
Micrel	10	13	18	0.1	0.1	0.1
Micro Linear	33	45	35	0.3	0.4	0.2
Micro Power Systems	22	23	23	0.2	0.2	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Mitel	39	55	70	0.4	0.4	0.5
Motorola	528	707	924	5.2	5.7	6.0
NCR	50	45	56	0.5	0.4	0.4
National Semiconductor	705	788	891	6.9	6.3	5.8
Novasensor	13	16	13	0.1	0.1	0.1
Optek	0	0	7	0	0	0
Raytheon	38	68	78	0.4	0.5	0.5
Rockwell	155	155	160	1.5	1.2	1.0
SEEQ Technology	9	9	0	0.1	0.1	0
Semtech	2	2	5	0	0	0
Sierra Semiconductor	85	90	85	0.8	0.7	0.6
Silicon Systems	241	265	298	2.4	2.1	1.9
Sipex	3	3	2	0	0	0
Supertex	10	10	13	0.1	0.1	0.1
Telcom	NA	NA	18	0	0	0.1
Teledyne	26	26	0	0.3	0.2	0
Tektronix	34	41	0	0.3	0.3	0
Texas Instruments	492	617	842	4.8	4.9	5.5
Unitrode	52	64	73	0.5	0.5	0.5
Universal	4	5	6	0	0	0
VLSI Technology	2	2	0	0	0	0
VTC	45	70	70	0.4	0.6	0.5
Other North American Companies	109	14	7	1.1	0.1	0
Japanese Companies	3,234	3,903	4,911	31.8	31.2	31.9
Fuji Electric	9	16	27	0.1	0.1	0.2
Fujitsu	115	122	155	1.1	1.0	1.0
Hitachi	242	280	357	2.4	2.2	2.3
Matsushita	403	473	611	4.0	3.8	4.0
Mitsubishi	315	377	456	3.1	3.0	3.0
NEC	331	377	506	3.3	3.0	3.3
New JRC	113	158	173	1.1	1.3	1.1
Nittetsu Semiconductor	0	0	0	0	0	0
Oki	16	22	26	0.2	0.2	0.2
Ricoh	7	8	14	0.1	0.1	0.1
Rohm	238	258	361	2.3	2.1	2.3
Sanyo	470	633	811	4.6	5.1	5.3

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Seiko Epson	11	11	13	0.1	0.1	0.1
Sharp	64	87	96	0.6	0.7	0.6
Sony	339	425	465	3.3	3.4	3.0
Toko	22	28	32	0.2	0.2	0.2
Toshiba	528	615	789	5.2	4.9	5.1
Yamaha	11	13	19	0.1	0.1	0.1
European Companies	2,026	2,687	3,489	19.9	21.5	22.6
ABB-HAFO	25	20	20	0.2	0.2	0.1
Austria Mikro Systeme	45	49	64	0.4	0.4	0.4
EM Microelectronics Marin	45	50	65	0.4	0.4	0.4
Ericsson	57	45	49	0.6	0.4	0.3
GEC Plessey	154	114	135	1.5	0.9	0.9
Micronas	10	14	20	0.1	0.1	0.1
Mietec	91	123	146	0.9	1.0	0.9
Philips	603	752	957	5.9	6.0	6.2
SGS-Thomson	658	858	1,197	6.5	6.9	7.8
Siemens	175	382	546	1.7	3.1	3.5
TEMIC	NA	262	267	0	2.1	1.7
TCS	10	16	20	0.1	0.1	0.1
Zetex	0	2	3	0	0	0
Other European Companies	153	0	0	1.5	0	0
Asia/Pacific Companies	269	343	403	2.6	2.7	2.6
Daewoo	17	20	17	0.2	0.2	0.1
Goldstar	20	40	45	0.2	0.3	0.3
Holtek	0	15	0	0	0.1	0
Hualon Microelectronics Corporation	1	7	9	0	0.1	0.1
Korean Electronic Co.	30	37	47	0.3	0.3	0.3
Samsung	117	166	233	1.1	1.3	1.5
Winbond Electronics	15	58	52	0.1	0.5	0.3
Other Asia/Pacific Companies	69	0	0	0.7	0	0

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	1,335	1,463	1,664	100.0	100.0	100.0
North American Companies	340	370	424	25.5	25.3	25.5
Analog Devices	47	40	52	3.5	2.7	3.1
Burr-Brown	54	70	60	4.0	4.8	3.6
Comlinear	8	8	7	0.6	0.5	0.4
Elantec	2	2	3	0.1	0.1	0.2
Gennum	0	0	2	0	0	0.1
Linfinity	2	3	3	0.1	0.2	0.2
Maxim	4	4	4	0.3	0.3	0.2
Mitel	13	14	30	1.0	1.0	1.8
Motorola	123	171	226	9.2	11.7	13.6
National Semiconductor	34	14	6	2.5	1.0	0.4
Semtech	2	0	0	0.1	0	0
Sipex	17	17	14	1.3	1.2	0.8
Solitron	7	0	2	0.5	0	0.1
Tektronix	8	8	0	0.6	0.5	0
Unitrode	14	14	15	1.0	1.0	0.9
Other North American Companies	5	5	0	0.4	0.3	0
Japanese Companies	869	988	1,136	65.1	67.5	68.3
Fuji Electric	16	21	22	1.2	1.4	1.3
Fujitsu	57	62	116	4.3	4.2	7.0
Hitachi	97	102	136	7.3	7.0	8.2
Mitsubishi	102	106	109	7.6	7.2	6.6
NEC	83	98	98	6.2	6.7	5.9
Oki	11	12	13	0.8	0.8	0.8
Rohm	63	68	72	4.7	4.6	4.3
Sanken	153	202	240	11.5	13.8	14.4
Sanyo	149	166	174	11.2	11.3	10.5
Shindengen Electric	44	49	48	3.3	3.3	2.9
Sony	33	36	41	2.5	2.5	2.5
Toko	8	8	8	0.6	0.5	0.5
Toshiba	53	58	59	4.0	4.0	3.5

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
European Companies	126	105	104	9.4	7.2	6.3
ABB-HAFO	0	0	8	0	0	0.5
Ericsson	0	12	19	0	0.8	1.1
GEC Plessey	38	21	6	2.8	1.4	0.4
Philips	72	55	54	5.4	3.8	3.2
TEMIC	NA	2	0	0	0.1	0
Other European Companies	16	15	17	1.2	1.0	1.0

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	8,155	9,083	10,758	100.0	100.0	100.0
North American Companies	2,139	2,180	2,534	26.2	24.0	23.6
Allegro MicroSystems	11	10	9	0.1	0.1	0.1
AT&T	4	4	6	0	0	0.1
General Instrument	220	239	262	2.7	2.6	2.4
Harris	115	138	187	1.4	1.5	1.7
Hewlett-Packard	48	49	99	0.6	0.5	0.9
International Rectifier	270	285	353	3.3	3.1	3.3
ITT	106	107	114	1.3	1.2	1.1
Microsemi	84	97	100	1.0	1.1	0.9
Motorola	857	994	1,097	10.5	10.9	10.2
National Semiconductor	70	77	94	0.9	0.8	0.9
Optek	2	2	1	0	0	0
Powerex	80	58	76	1.0	0.6	0.7
Raytheon	7	8	8	0.1	0.1	0.1
Semtech	16	17	20	0.2	0.2	0.2
Solitron	8	11	5	0.1	0.1	0
Supertex	9	10	11	0.1	0.1	0.1
Teccor Electronics	46	45	60	0.6	0.5	0.6
Texas Instruments	29	29	32	0.4	0.3	0.3
Unitrode	10	0	0	0.1	0	0
Other North American Companies	147	0	0	1.8	0	0
Japanese Companies	4,117	4,861	5,692	50.5	53.5	52.9
Fuji Electric	246	293	357	3.0	3.2	3.3
Fujitsu	142	157	192	1.7	1.7	1.8
Hitachi	566	662	798	6.9	7.3	7.4
Matsushita	379	450	511	4.6	5.0	4.7
Mitsubishi	284	380	424	3.5	4.2	3.9
NEC	532	579	652	6.5	6.4	6.1
New JRC	3	3	2	0	0	0
Oki	8	9	10	0.1	0.1	0.1
Rohm	343	380	524	4.2	4.2	4.9
Sanken	253	299	334	3.1	3.3	3.1
Sanyo	244	336	389	3.0	3.7	3.6
Shindengen Electric	126	162	194	1.5	1.8	1.8

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Sony	79	89	50	1.0	1.0	0.5
Toko	29	45	51	0.4	0.5	0.5
Toshiba	883	1,017	1,204	10.8	11.2	11.2
European Companies	1,623	1,767	2,178	19.9	19.5	20.2
ABB-HAFO	7	6	0	0.1	0.1	0
ABB-IXYS	49	38	55	0.6	0.4	0.5
Ericsson	0	0	15	0	0	0.1
Eupec	83	82	98	1.0	0.9	0.9
Fagor	25	19	27	0.3	0.2	0.3
GEC Plessey	31	21	28	0.4	0.2	0.3
Philips	551	604	761	6.8	6.6	7.1
Semikron	103	94	112	1.3	1.0	1.0
SGS-Thomson	335	384	433	4.1	4.2	4.0
Siemens	219	229	284	2.7	2.5	2.6
TEMIC	NA	175	235	0	1.9	2.2
TCS	1	1	1	0	0	0
Westcode	35	35	41	0.4	0.4	0.4
Zetex	26	29	36	0.3	0.3	0.3
Other European Companies	158	50	52	1.9	0.6	0.5
Asia/Pacific Companies	276	275	354	3.4	3.0	3.3
Dongsung Semiconductor	11	2	0	0.1	0	0
Goldstar	11	0	0	0.1	0	0
Korean Electronic Co.	110	130	167	1.3	1.4	1.6
Samsung	119	143	187	1.5	1.6	1.7
Other Asia/Pacific Companies	25	0	0	0.3	0	0

NA = Not available
Source: Dataquest (March 1995)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Total Market	2,688	3,006	3,894	100.0	100.0	100.0
North American Companies	495	523	703	18.4	17.4	18.1
AT&T	39	41	51	1.5	1.4	1.3
Hewlett-Packard	187	190	360	7.0	6.3	9.2
Honeywell	27	27	32	1.0	0.9	0.8
Motorola	36	41	45	1.3	1.4	1.2
Optek	55	54	48	2.0	1.8	1.2
Quality Technologies	46	47	49	1.7	1.6	1.3
Tektronix	5	5	0	0.2	0.2	0
Texas Instruments	42	54	49	1.6	1.8	1.3
Other North American Companies	58	64	69	2.2	2.1	1.8
Japanese Companies	1,849	2,162	2,798	68.8	71.9	71.9
Fujitsu	117	123	135	4.4	4.1	3.5
Hitachi	60	67	89	2.2	2.2	2.3
Matsushita	315	358	417	11.7	11.9	10.7
Mitsubishi	23	30	176	0.9	1.0	4.5
NEC	110	118	150	4.1	3.9	3.9
New JRC	12	13	11	0.4	0.4	0.3
Oki	26	28	24	1.0	0.9	0.6
Rohm	110	112	178	4.1	3.7	4.6
Sanken	20	32	34	0.7	1.1	0.9
Sanyo	136	137	150	5.1	4.6	3.9
Sharp	352	418	510	13.1	13.9	13.1
Sony	216	236	313	8.0	7.9	8.0
Toshiba	255	326	421	9.5	10.8	10.8
Other Japanese Companies	97	164	190	3.6	5.5	4.9
European Companies	296	264	379	11.0	8.8	9.7
ABB-HAFO	8	8	12	0.3	0.3	0.3
Ericsson	0	0	15	0	0	0.4
Siemens	179	170	220	6.7	5.7	5.6
TEMIC	NA	54	94	0	1.8	2.4
TCS	20	21	26	0.7	0.7	0.7
Zetex	1	1	1	0	0	0
Other European Companies	88	10	11	3.3	0.3	0.3

(Continued)

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

	Revenue			Market Share (%)		
	1992	1993	1994	1992	1993	1994
Asia/Pacific Companies	48	57	14	1.8	1.9	0.4
Korean Electronic Co.	8	10	11	0.3	0.3	0.3
Samsung	0	4	3	0	0.1	0.1
Other Asia/Pacific Companies	40	43	0	1.5	1.4	0

NA = Not available
Source: Dataquest (March 1995)

Section 2: Final 1994 Worldwide Semiconductor Market Share Rankings

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,970	10,099	27	9.1
2	2	NEC	6,141	7,961	30	7.2
3	4	Toshiba	5,727	7,556	32	6.8
4	3	Motorola	5,957	7,238	22	6.6
5	5	Hitachi	5,015	6,644	32	6.0
6	6	Texas Instruments	4,083	5,552	36	5.0
7	7	Samsung	3,044	4,832	59	4.4
8	8	Fujitsu	2,928	3,869	32	3.5
9	9	Mitsubishi	2,823	3,772	34	3.4
10	10	IBM	2,510	3,035	21	2.7
11	12	Philips	2,300	2,920	27	2.6
12	11	Matsushita	2,344	2,896	24	2.6
13	14	SGS-Thomson	2,038	2,640	30	2.4
14	15	Sanyo	1,843	2,321	26	2.1
15	16	Sharp	1,760	2,188	24	2.0
16	17	Advanced Micro Devices	1,660	2,134	29	1.9
17	18	Siemens	1,509	2,090	39	1.9
18	13	National Semiconductor	2,060	2,023	-2	1.8
19	19	Sony	1,398	1,876	34	1.7
20	22	Goldstar	946	1,697	79	1.5
21	25	Hyundai	853	1,521	78	1.4
22	24	Micron Technology	925	1,492	61	1.3
23	20	Oki	1,187	1,471	24	1.3
24	23	Rohm	930	1,345	45	1.2
25	21	AT&T	1,110	1,307	18	1.2
26	26	LSI Logic	719	901	25	0.8
27	33	Cirrus Logic	451	781	73	0.7
28	27	Analog Devices	635	739	16	0.7
29	28	TEMIC	625	720	15	0.7
30	32	Hewlett-Packard	469	714	52	0.6
31	29	Harris	605	665	10	0.6
32	30	Sanken	533	608	14	0.5
33	31	VLSI Technology	517	588	14	0.5
34	34	Fuji Electric	366	446	22	0.4

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
35	36	United Microelectronics	309	418	35	0.4
36	38	Cypress Semiconductor	300	400	33	0.4
37	37	Integrated Device Technology	303	385	27	0.3
38	35	Yamaha	317	382	21	0.3
39	47	Atmel	225	375	67	0.3
40	40	International Rectifier	288	361	25	0.3
		All Others	9,795	11,618	19	10.5
		North American Companies	37,087	46,118	24	41.7
		Japanese Companies	34,573	44,778	30	40.5
		European Companies	7,645	9,835	29	8.9
		Asia/Pacific Companies	6,213	9,849	59	8.9
		Total Market	85,518	110,580	29	100.0

Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,970	10,099	27	9.3
2	2	NEC	6,043	7,863	30	7.2
3	4	Toshiba	5,669	7,497	32	6.9
4	3	Motorola	5,786	7,012	21	6.4
5	5	Hitachi	4,913	6,508	32	6.0
6	6	Texas Instruments	4,083	5,552	36	5.1
7	7	Samsung	3,044	4,832	59	4.4
8	8	Fujitsu	2,866	3,753	31	3.4
9	9	Mitsubishi	2,717	3,663	35	3.4
10	10	IBM	2,510	3,035	21	2.8
11	11	Matsushita	2,344	2,896	24	2.7
12	12	Philips	2,245	2,866	28	2.6
13	14	SGS-Thomson	2,038	2,640	30	2.4
14	15	Sharp	1,760	2,188	24	2.0
15	16	Sanyo	1,677	2,147	28	2.0
16	17	Advanced Micro Devices	1,660	2,134	29	2.0
17	18	Siemens	1,509	2,090	39	1.9
18	13	National Semiconductor	2,046	2,017	-1	1.9
19	19	Sony	1,362	1,835	35	1.7
20	22	Goldstar	946	1,697	79	1.6
21	25	Hyundai	853	1,521	78	1.4
22	23	Micron Technology	925	1,492	61	1.4
23	20	Oki	1,175	1,458	24	1.3
24	21	AT&T	1,110	1,307	18	1.2
25	24	Rohm	862	1,273	48	1.2
26	26	LSI Logic	719	901	25	0.8
27	32	Cirrus Logic	451	781	73	0.7
28	27	TEMIC	623	720	16	0.7
29	31	Hewlett-Packard	469	714	52	0.7
30	29	Analog Devices	595	687	15	0.6
31	28	Harris	605	665	10	0.6
32	30	VLSI Technology	517	588	14	0.5
33	33	Fuji Electric	345	424	23	0.4
34	36	United Microelectronics	309	418	35	0.4
35	38	Cypress Semiconductor	300	400	33	0.4
36	37	Integrated Device Technology	303	385	27	0.4
37	35	Yamaha	317	382	21	0.4

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	47	Atmel	225	375	67	0.3
39	34	Sanken	331	368	11	0.3
40	39	International Rectifier	288	361	25	0.3
		All Others	9,545	11,372	19	10.4
		North American Companies	36,717	45,694	24	42.0
		Japanese Companies	33,585	43,642	30	40.1
		European Companies	7,540	9,731	29	8.9
		Asia/Pacific Companies	6,213	9,849	59	9.0
		Total Market	84,055	108,916	30	100.0

Source: Dataquest (March 1995)

Table 2-3
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,970	10,099	27	10.5
2	2	NEC	5,444	7,159	32	7.5
3	3	Motorola	4,922	6,096	24	6.4
4	4	Toshiba	4,384	5,931	35	6.2
5	5	Hitachi	4,286	5,757	34	6.0
6	6	Texas Instruments	4,000	5,471	37	5.7
7	7	Samsung	2,897	4,642	60	4.8
8	8	Fujitsu	2,648	3,542	34	3.7
9	10	Mitsubishi	2,413	3,172	31	3.3
10	9	IBM	2,510	3,035	21	3.2
11	14	SGS-Thomson	1,654	2,207	33	2.3
12	12	Philips	1,696	2,159	27	2.3
13	13	Advanced Micro Devices	1,660	2,134	29	2.2
14	15	Matsushita	1,536	1,968	28	2.1
15	11	National Semiconductor	1,983	1,929	-3	2.0
16	16	Sanyo	1,370	1,782	30	1.9
17	22	Goldstar	946	1,697	79	1.8
18	17	Sharp	1,342	1,678	25	1.7
19	19	Siemens	1,110	1,586	43	1.7
20	24	Hyundai	853	1,521	78	1.6
21	20	Sony	1,073	1,513	41	1.6
22	23	Micron Technology	925	1,492	61	1.6
23	18	Oki	1,150	1,437	25	1.5
24	21	AT&T	1,065	1,250	17	1.3
25	25	LSI Logic	719	901	25	0.9
26	29	Cirrus Logic	451	781	73	0.8
27	26	Analog Devices	635	739	16	0.8
28	30	Rohm	438	643	47	0.7
29	27	VLSI Technology	517	588	14	0.6
30	28	Harris	467	478	2	0.5
31	33	United Microelectronics	309	418	35	0.4
32	35	Cypress Semiconductor	300	400	33	0.4
33	31	TEMIC	396	391	-1	0.4
34	34	Integrated Device Technology	303	385	27	0.4
35	32	Yamaha	317	382	21	0.4
36	42	Atmel	225	375	67	0.4
37	36	NCR	275	354	29	0.4

(Continued)

Table 2-3 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World, Including Hybrids (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	40	Xilinx	231	321	39	0.3
39	47	Winbond	184	308	67	0.3
40	38	Silicon Systems	265	298	12	0.3
		All Others	7,560	8,909	18	9.3
		North American Companies	34,384	42,881	25	44.7
		Japanese Companies	27,550	36,288	32	37.8
		European Companies	5,614	7,278	30	7.6
		Asia/Pacific Companies	5,881	9,481	61	9.9
		Total Market	73,429	95,928	31	100.0

Source: Dataquest (March 1995)

Table 2-4
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World, Excluding Hybrids (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,970	10,099	27	10.7
2	2	NEC	5,346	7,061	32	7.5
3	4	Toshiba	4,326	5,872	36	6.3
4	3	Motorola	4,751	5,870	24	6.2
5	5	Hitachi	4,184	5,621	34	6.0
6	6	Texas Instruments	4,000	5,471	37	5.8
7	7	Samsung	2,897	4,642	60	4.9
8	8	Fujitsu	2,586	3,426	32	3.6
9	10	Mitsubishi	2,307	3,063	33	3.2
10	9	IBM	2,510	3,035	21	3.2
11	13	SGS-Thomson	1,654	2,207	33	2.3
12	12	Advanced Micro Devices	1,660	2,134	29	2.3
13	14	Philips	1,641	2,105	28	2.2
14	15	Matsushita	1,536	1,968	28	2.1
15	11	National Semiconductor	1,969	1,923	-2	2.0
16	22	Goldstar	946	1,697	79	1.8
17	16	Sharp	1,342	1,678	25	1.8
18	17	Sanyo	1,204	1,608	34	1.7
19	19	Siemens	1,110	1,586	43	1.7
20	24	Hyundai	853	1,521	78	1.6
21	23	Micron Technology	925	1,492	61	1.6
22	21	Sony	1,037	1,472	42	1.6
23	18	Oki	1,138	1,424	25	1.5
24	20	AT&T	1,065	1,250	17	1.3
25	25	LSI Logic	719	901	25	1.0
26	29	Cirrus Logic	451	781	73	0.8
27	26	Analog Devices	595	687	15	0.7
28	27	VLSI Technology	517	588	14	0.6
29	31	Rohm	370	571	54	0.6
30	28	Harris	467	478	2	0.5
31	33	United Microelectronics	309	418	35	0.4
32	35	Cypress Semiconductor	300	400	33	0.4
33	30	TEMIC	394	391	-1	0.4
34	34	Integrated Device Technology	303	385	27	0.4
35	32	Yamaha	317	382	21	0.4
36	42	Atmel	225	375	67	0.4
37	36	NCR	275	354	29	0.4

(Continued)

Table 2-4 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Integrated Circuits to the World, Excluding Hybrids (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	40	Xilinx	231	321	39	0.3
39	46	Winbond	184	308	67	0.3
40	37	Silicon Systems	265	298	12	0.3
		All Others	7,087	8,401	19	8.9
		North American Companies	34,014	42,457	25	45.0
		Japanese Companies	26,562	35,152	32	37.3
		European Companies	5,509	7,174	30	7.6
		Asia/Pacific Companies	5,881	9,481	61	10.1
		Total Market	71,966	94,264	31	100.0

Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Texas Instruments	594	577	-3	19.9
2	3	Hitachi	391	465	19	16.0
3	2	Motorola	432	421	-3	14.5
4	4	Fujitsu	371	395	6	13.6
5	5	National Semiconductor	279	215	-23	7.4
6	6	NEC	201	194	-3	6.7
7	7	Advanced Micro Devices	199	143	-28	4.9
8	8	Philips	152	121	-20	4.2
9	9	Toshiba	75	68	-9	2.3
10	11	AT&T	60	63	5	2.2
11	12	Goldstar	44	46	5	1.6
12	13	Siemens	41	33	-20	1.1
13	14	Oki	31	33	6	1.1
14	16	Matsushita	26	29	12	1.0
15	10	Mitsubishi	63	23	-63	0.8
16	15	Raytheon	27	22	-19	0.8
17	17	Applied Micro Circuits Corporation	26	20	-23	0.7
18	18	GEC Plessey	23	16	-30	0.6
19	20	SGS-Thomson	7	12	71	0.4
20	19	Harris	13	6	-54	0.2
		All Others	24	4	-83	0.1
		North American Companies	1,650	1,467	-11	50.5
		Japanese Companies	1,158	1,207	4	41.5
		European Companies	227	186	-18	6.4
		Asia/Pacific Companies	44	46	5	1.6
		Total Market	3,079	2,906	-6	100.0

Source: Dataquest (March 1995)

Table 2-6
Top 9 Companies' Factory Revenue from Shipments of Bipolar Digital Memory ICs to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Hitachi	85	93	9	47.0
2	2	Fujitsu	81	32	-60	16.2
3	3	Advanced Micro Devices	39	28	-28	14.1
4	4	NEC	16	16	0	8.1
5	8	Philips	3	14	367	7.1
6	5	Raytheon	6	5	-17	2.5
7	9	Texas Instruments	3	5	67	2.5
8	6	National Semiconductor	5	4	-20	2.0
9	10	Motorola	2	1	-50	0.5
		All Others	4	0	-100	0
		North American Companies	59	43	-27	21.7
		Japanese Companies	182	141	-23	71.2
		European Companies	3	14	367	7.1
		Asia/Pacific Companies	0	0		0
		Total Market	244	198	-19	100.0

Source: Dataquest (March 1995)

Table 2-7
Top 20 Companies' Factory Revenue from Shipments of Bipolar Logic ICs to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Texas Instruments	591	572	-3	21.1
2	2	Motorola	430	420	-2	15.5
3	3	Hitachi	306	372	22	13.7
4	4	Fujitsu	290	363	25	13.4
5	5	National Semiconductor	274	211	-23	7.8
6	6	NEC	185	178	-4	6.6
7	7	Advanced Micro Devices	160	115	-28	4.2
8	8	Philips	149	107	-28	4.0
9	9	Toshiba	75	68	-9	2.5
10	11	AT&T	60	63	5	2.3
11	12	Goldstar	44	46	5	1.7
12	13	Siemens	41	33	-20	1.2
13	14	Oki	31	33	6	1.2
14	15	Matsushita	26	29	12	1.1
15	10	Mitsubishi	63	23	-63	0.8
16	16	Applied Micro Circuits Corporation	26	20	-23	0.7
17	18	Raytheon	21	17	-19	0.6
18	17	GEC Plessey	23	16	-30	0.6
19	20	SGS-Thomson	7	12	71	0.4
20	19	Harris	9	6	-33	0.2
		All Others	24	4	-83	0.1
		North American Companies	1,591	1,424	-10	52.6
		Japanese Companies	976	1,066	9	39.4
		European Companies	224	172	-23	6.4
		Asia/Pacific Companies	44	46	5	1.7
		Total Market	2,835	2,708	-4	100.0

Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,957	10,079	27	13.3
2	2	NEC	4,768	6,361	33	8.4
3	3	Toshiba	3,636	5,015	38	6.6
4	5	Hitachi	3,513	4,799	37	6.3
5	4	Motorola	3,612	4,525	25	6.0
6	7	Samsung	2,731	4,409	61	5.8
7	6	Texas Instruments	2,789	4,052	45	5.3
8	8	IBM	2,510	3,035	21	4.0
9	9	Fujitsu	2,093	2,876	37	3.8
10	10	Mitsubishi	1,867	2,584	38	3.4
11	11	Advanced Micro Devices	1,307	1,804	38	2.4
12	17	Goldstar	862	1,606	86	2.1
13	12	Sharp	1,255	1,582	26	2.1
14	18	Hyundai	853	1,521	78	2.0
15	15	Micron Technology	925	1,492	61	2.0
16	13	Oki	1,085	1,365	26	1.8
17	14	Matsushita	1,037	1,328	28	1.7
18	20	Philips	737	1,027	39	1.4
19	22	Siemens	687	1,007	47	1.3
20	24	Sony	612	1,007	65	1.3
21	19	SGS-Thomson	789	998	26	1.3
22	21	LSI Logic	719	901	25	1.2
23	16	National Semiconductor	902	817	-9	1.1
24	25	Sanyo	571	797	40	1.0
25	23	AT&T	671	785	17	1.0
26	27	Cirrus Logic	371	681	84	0.9
27	26	VLSI Technology	515	588	14	0.8
28	28	United Microelectronics	309	418	35	0.6
29	31	Cypress Semiconductor	300	400	33	0.5
30	30	Integrated Device Technology	303	385	27	0.5
31	29	Yamaha	304	363	19	0.5
32	36	Atmel	223	363	63	0.5
33	33	Xilinx	231	321	39	0.4
34	34	NCR	230	298	30	0.4
35	32	Seiko Epson	241	260	8	0.3
36	37	MOSel/Vitelic	223	259	16	0.3
37	49	Winbond	126	256	103	0.3

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	35	Hewlett-Packard	230	255	11	0.3
39	50	Cyrix	125	241	93	0.3
40	40	Zilog	203	222	9	0.3
		All Others	3,952	4,869	23	6.4
		North American Companies	26,784	34,386	28	45.3
		Japanese Companies	21,501	29,034	35	38.4
		European Companies	2,595	3,499	35	4.6
		Asia/Pacific Companies	5,494	9,032	64	11.9
		Total Market	56,374	75,951	35	100.0

Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Samsung	2,512	4,194	67	12.5
2	2	Hitachi	2,369	3,232	36	9.7
3	3	NEC	2,173	3,096	42	9.2
4	4	Toshiba	2,101	3,018	44	9.0
5	5	Texas Instruments	1,275	1,931	51	5.8
6	7	Fujitsu	1,135	1,692	49	5.1
7	6	Mitsubishi	1,206	1,652	37	4.9
8	11	Goldstar	804	1,525	90	4.6
9	8	IBM	1,133	1,520	34	4.5
10	10	Hyundai	851	1,515	78	4.5
11	9	Micron Technology	925	1,492	61	4.5
12	12	Motorola	762	948	24	2.8
13	13	Sharp	697	867	24	2.6
14	14	Siemens	556	858	54	2.6
15	15	Oki	486	697	43	2.1
16	17	SGS-Thomson	467	589	26	1.8
17	16	Intel	468	458	-2	1.4
18	18	Advanced Micro Devices	427	442	4	1.3
19	19	Matsushita	305	396	30	1.2
20	20	Sony	287	387	35	1.2
21	24	Atmel	181	331	83	1.0
22	21	Cypress Semiconductor	235	285	21	0.9
23	22	MOSel/Vitelic	223	259	16	0.8
24	23	Integrated Device Technology	189	252	33	0.8
25	29	Macronix	129	200	55	0.6
26	28	United Microelectronics	146	191	31	0.6
27	26	Sanyo	155	183	18	0.5
28	27	Nittetsu Semiconductor	148	160	8	0.5
29	25	National Semiconductor	172	155	-10	0.5
30	31	Winbond	77	142	84	0.4
31	30	Xicor	105	100	-5	0.3
32	34	Alliance Semiconductor	41	90	120	0.3
33	32	Microchip Technology	64	82	28	0.2
34	NA	Integrated Silicon Solution	NA	60	NM	0.2
35	35	Rohm	39	56	44	0.2
36	33	Catalyst	54	49	-9	0.1
37	38	Hualon Microelectronics Corporation	36	46	28	0.1

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	42	Gould AMI	23	44	91	0.1
39	36	Seiko Epson	38	42	11	0.1
40	39	Paradigm	34	36	6	0.1
		All Others	278	209	-25	0.6
		North American Companies	6,253	8,406	34	25.1
		Japanese Companies	11,180	15,519	39	46.4
		European Companies	1,089	1,484	36	4.4
		Asia/Pacific Companies	4,784	8,072	69	24.2
		Total Market	23,306	33,481	44	100.0

NA = Not available
NM = Not meaningful
Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Intel	7,444	9,595	29	37.1
2	2	Motorola	2,065	2,363	14	9.1
3	3	NEC	1,341	1,678	25	6.5
4	6	Advanced Micro Devices	563	1,021	81	3.9
5	4	Texas Instruments	781	1,006	29	3.9
6	5	Hitachi	718	998	39	3.9
7	7	Toshiba	540	718	33	2.8
8	8	Mitsubishi	532	698	31	2.7
9	10	Cirrus Logic	371	681	84	2.6
10	13	Matsushita	286	460	61	1.8
11	9	National Semiconductor	477	409	-14	1.6
12	12	Philips	305	403	32	1.6
13	11	IBM	337	399	18	1.5
14	14	Fujitsu	282	390	38	1.5
15	15	AT&T	246	305	24	1.2
16	22	Yamaha	149	273	83	1.1
17	24	Cyrix	125	241	93	0.9
18	21	SGS-Thomson	162	227	40	0.9
19	26	United Microelectronics	113	227	101	0.9
20	17	Zilog	203	222	9	0.9
21	18	Oki	180	217	21	0.8
22	19	VLSI Technology	173	216	25	0.8
23	28	Sony	112	194	73	0.7
24	20	Sharp	170	192	13	0.7
25	16	Western Digital	218	184	-16	0.7
26	23	Sanyo	145	161	11	0.6
27	27	S3	113	130	15	0.5
28	31	OPTi	86	130	51	0.5
29	34	Microchip Technology	72	130	81	0.5
30	29	Siemens	107	128	20	0.5
31	25	Adaptec	122	125	2	0.5
32	52	Silicon Integrated Systems	26	101	288	0.4
33	47	Standard Microsystems	43	100	133	0.4
34	32	Chips & Technologies	86	89	3	0.3
35	39	Trident Microsystems	60	87	45	0.3
36	36	Analog Devices	69	85	23	0.3
37	30	Ricoh	89	83	-7	0.3

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	35	Tseng Labs	71	83	17	0.3
39	38	NCR	63	81	29	0.3
40	33	LSI Logic	77	78	1	0.3
		All Others	825	960	16	3.7
		North American Companies	14,395	18,303	27	70.8
		Japanese Companies	4,585	6,137	34	23.7
		European Companies	640	851	33	3.3
		Asia/Pacific Companies	327	577	76	2.2
		Total Market	19,947	25,868	30	100.0

Source: Dataquest (March 1995)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	NEC	1,254	1,587	27	9.6
2	3	Toshiba	995	1,279	29	7.7
3	4	Motorola	785	1,214	55	7.3
4	2	IBM	1,040	1,116	7	6.7
5	5	Texas Instruments	733	1,115	52	6.7
6	7	LSI Logic	642	823	28	5.0
7	6	Fujitsu	676	794	17	4.8
8	12	Philips	400	610	53	3.7
9	9	Hitachi	426	569	34	3.4
10	13	Sharp	388	523	35	3.2
11	11	AT&T	415	477	15	2.9
12	8	Matsushita	446	472	6	2.8
13	16	Sanyo	271	453	67	2.7
14	10	Oki	419	451	8	2.7
15	20	Sony	213	426	100	2.6
16	14	VLSI Technology	342	372	9	2.2
17	15	Advanced Micro Devices	317	341	8	2.1
18	18	Xilinx	231	321	39	1.9
19	19	Hewlett-Packard	230	255	11	1.5
20	17	National Semiconductor	253	253	0	1.5
21	28	Mitsubishi	129	234	81	1.4
22	23	NCR	165	217	32	1.3
23	26	Altera	140	199	42	1.2
24	21	Seiko Epson	186	197	6	1.2
25	24	SGS-Thomson	160	182	14	1.1
26	22	Samsung	173	171	-1	1.0
27	29	Lattice	127	134	6	0.8
28	27	Harris	138	124	-10	0.7
29	30	GEC Plessey	101	118	17	0.7
30	36	Rohm	50	104	108	0.6
31	60	Dallas Semiconductor	10	102	920	0.6
32	25	Yamaha	154	89	-42	0.5
33	32	Integrated Device Technology	66	82	24	0.5
34	31	ITT	96	81	-16	0.5
35	33	Actel	60	76	27	0.5
36	34	Cypress Semiconductor	57	75	32	0.5
37	48	Ricoh	25	66	164	0.4

(Continued)

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

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	54	Winbond	19	66	247	0.4
39	40	Gould AMI	40	61	53	0.4
40	38	Goldstar	46	52	13	0.3
		All Others	703	721	3	4.3
		North American Companies	6,136	7,677	25	46.2
		Japanese Companies	5,736	7,378	29	44.4
		European Companies	866	1,164	34	7.1
		Asia/Pacific Companies	383	383	0	2.3
		Total Market	13,121	16,602	27	100.0

Source: Dataquest (March 1995)

Table 2-12
Top 40 Companies' Factory Revenue from Shipments of Monolithic Analog ICs to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	SGS-Thomson	858	1,197	40	7.8
2	3	Philips	752	957	27	6.2
3	4	Motorola	707	924	31	6.0
4	2	National Semiconductor	788	891	13	5.8
5	6	Texas Instruments	617	842	36	5.5
6	5	Sanyo	633	811	28	5.3
7	7	Toshiba	615	789	28	5.1
8	9	Matsushita	473	611	29	4.0
9	8	Analog Devices	526	602	14	3.9
10	11	Siemens	382	546	43	3.5
11	12	NEC	377	506	34	3.3
12	10	Sony	425	465	9	3.0
13	13	Mitsubishi	377	456	21	3.0
14	14	AT&T	334	402	20	2.6
15	18	Rohm	258	361	40	2.3
16	15	Hitachi	280	357	28	2.3
17	16	Silicon Systems	265	298	12	1.9
18	19	Harris	250	284	14	1.8
19	17	TEMIC	262	267	2	1.7
20	21	Samsung	166	233	40	1.5
21	20	Linear Technology	173	225	30	1.5
22	25	Advanced Micro Devices	154	187	21	1.2
23	22	New JRC	158	173	9	1.1
24	23	Exar	158	169	7	1.1
25	30	Maxim	111	165	49	1.1
26	24	Rockwell	155	160	3	1.0
27	27	Fujitsu	122	155	27	1.0
28	26	Mietec	123	146	19	0.9
29	29	GEC Plessey	114	135	18	0.9
30	31	Allegro MicroSystems	104	134	29	0.9
31	28	Brooktree	117	109	-7	0.7
32	33	Burr-Brown	88	105	19	0.7
33	35	Cirrus Logic	80	100	25	0.6
34	34	Sharp	87	96	10	0.6
35	32	Sierra Semiconductor	90	85	-6	0.6
36	37	Raytheon	68	78	15	0.5
37	40	Cherry Semiconductor	55	77	40	0.5

(Continued)

Table 2-12 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Monolithic Analog ICs to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	38	Unitrode	64	73	14	0.5
39	36	VTC	70	70	0	0.5
40	41	Mitel	55	70	27	0.5
		All Others	1,022	1,096	7	7.1
		North American Companies	5,580	6,604	18	42.9
		Japanese Companies	3,903	4,911	26	31.9
		European Companies	2,687	3,489	30	22.6
		Asia/Pacific Companies	343	403	17	2.6
		Total Market	12,513	15,407	23	100.0

Source: Dataquest (March 1995)

Table 2-13
Top 10 Companies' Factory Revenue from Shipments of Hybrid ICs to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Sanken	202	240	19	14.4
2	2	Motorola	171	226	32	13.6
3	3	Sanyo	166	174	5	10.5
4	5	Hitachi	102	136	33	8.2
5	9	Fujitsu	62	116	87	7.0
6	4	Mitsubishi	106	109	3	6.6
7	6	NEC	98	98	0	5.9
8	8	Rohm	68	72	6	4.3
9	7	Burr-Brown	70	60	-14	3.6
10	10	Toshiba	58	59	2	3.5
		All Others	360	374	4	22.5
		North American Companies	370	424	15	25.5
		Japanese Companies	988	1,136	15	68.3
		European Companies	105	104	-1	6.3
		Asia/Pacific Companies	0	0		0
		Total Market	1,463	1,664	14	100.0

Source: Dataquest (March 1995)

Table 2-14
Top 40 Companies' Factory Revenue from Shipments of Discrete Semiconductors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Toshiba	1,017	1,204	18	11.2
2	2	Motorola	994	1,097	10	10.2
3	3	Hitachi	662	798	21	7.4
4	4	Philips	604	761	26	7.1
5	5	NEC	579	652	13	6.1
6	8	Rohm	380	524	38	4.9
7	6	Matsushita	450	511	14	4.7
8	7	SGS-Thomson	384	433	13	4.0
9	9	Mitsubishi	380	424	12	3.9
10	10	Sanyo	336	389	16	3.6
11	12	Fuji Electric	293	357	22	3.3
12	13	International Rectifier	285	353	24	3.3
13	11	Sanken	299	334	12	3.1
14	15	Siemens	229	284	24	2.6
15	14	General Instrument	239	262	10	2.4
16	16	TEMIC	175	235	34	2.2
17	17	Shindengen Electric	162	194	20	1.8
18	18	Fujitsu	157	192	22	1.8
19	19	Samsung	143	187	31	1.7
20	20	Harris	138	187	36	1.7
21	21	Korean Electronic Co.	130	167	28	1.6
22	22	ITT	107	114	7	1.1
23	24	Semikron	94	112	19	1.0
24	23	Microsemi	97	100	3	0.9
25	29	Hewlett-Packard	49	99	102	0.9
26	26	Eupec	82	98	20	0.9
27	27	National Semiconductor	77	94	22	0.9
28	28	Powerex	58	76	31	0.7
29	30	Teccor Electronics	45	60	33	0.6
30	32	ABB-IXYS	38	55	45	0.5
31	31	Toko	45	51	13	0.5
32	25	Sony	89	50	-44	0.5
33	33	Westcode	35	41	17	0.4
34	34	Zetex	29	36	24	0.3
35	35	Texas Instruments	29	32	10	0.3
36	36	GEC Plessey	21	28	33	0.3
37	37	Fagor	19	27	42	0.3

(Continued)

Table 2-14 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Discrete Semiconductors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
38	38	Semtech	17	20	18	0.2
39	NA	Ericsson	NA	15	NM	0.1
40	40	Supertex	10	11	10	0.1
		All Others	106	94	-11	0.9
		North American Companies	2,180	2,534	16	23.6
		Japanese Companies	4,861	5,692	17	52.9
		European Companies	1,767	2,178	23	20.2
		Asia/Pacific Companies	275	354	29	3.3
		Total Market	9,083	10,758	18	100.0

NA = Not available
NM = Not meaningful
Source: Dataquest (March 1995)

Table 2-15
Top 20 Companies' Factory Revenue from Shipments of Optoelectronic Semiconductors to the World (Millions of U.S. Dollars)

1994 Rank	1993 Rank		1993 Revenue	1994 Revenue	Percentage Change	1994 Market Share (%)
1	1	Sharp	418	510	22	13.1
2	3	Toshiba	326	421	29	10.8
3	2	Matsushita	358	417	16	10.7
4	5	Hewlett-Packard	190	360	89	9.2
5	4	Sony	236	313	33	8.0
6	6	Siemens	170	220	29	5.6
7	10	Rohm	112	178	59	4.6
8	19	Mitsubishi	30	176	487	4.5
9	7	Sanyo	137	150	9	3.9
10	9	NEC	118	150	27	3.9
11	8	Fujitsu	123	135	10	3.5
12	12	TEMIC	54	94	74	2.4
13	11	Hitachi	67	89	33	2.3
14	16	AT&T	41	51	24	1.3
15	13	Texas Instruments	54	49	-9	1.3
16	15	Quality Technologies	47	49	4	1.3
17	14	Optek	54	48	-11	1.2
18	17	Motorola	41	45	10	1.2
19	18	Sanken	32	34	6	0.9
20	21	Honeywell	27	32	19	0.8
		All Others	371	373	1	9.6
		North American Companies	523	703	34	18.1
		Japanese Companies	2,162	2,798	29	71.9
		European Companies	264	379	44	9.7
		Asia/Pacific Companies	57	14	-75	0.4
		Total Market	3,006	3,894	30	100.0

Source: Dataquest (March 1995)

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Market Analysis

Semiconductor Procurement Worldwide

Market Forecast

Second Quarter Pricing Trends: Good News and Bad News

Abstract: *Dataquest has completed its North America Semiconductor Price Outlook: Second Quarter 1995 document (SPSG-WW-PT-9501, dated March 27, 1995). As with the price outlook for the fourth quarter of 1994 and the first quarter of 1995, the pricing survey shows two primary trends: The firming up of DRAM prices and the continual drop in the 80486 and Pentium-class MPUs.*
By Scott Hudson

The Party Continues

Consistent and continual PC demand is fueling one of the longest semiconductor growth cycles in recent memory. The home and home office channel drove demand for 80486 and particularly Pentium and PowerPC machines in 1994. Now, in 1995, major OEMs are aggressively pricing their PC offerings to attract the business and corporate customers that have not yet upgraded to the Pentium or PowerPC level.

When will the party end? The answer, of course, is when the PC consumers decide they have enough computing power and can wait for the next generation of machines. Dataquest believes that the demand for PCs will drive good growth in the semiconductor industry through 1995 and into 1996, barring any unforeseen economic catastrophe.

The impact that this strong PC market will have on IC pricing is detailed in the sections to follow.

DRAM Update (The Bad News)

Input from both suppliers and users suggest that DRAM pricing actually is increasing slightly from the our forecast published December 26, 1994 (*North American Semiconductor Price Outlook: First Quarter 1995*, SPSG-WW-PT-9404). For example, the average 1995 price for the 1Mbx4 DRAM has increased 6 percent from $11.61 to $12.34. The average 1995 price for the

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Filing: Market Analysis

1Mbx16 also increased slightly from $47.50 to $48.89. The critical 4Mb to 16Mb crossover point is still expected to occur in the second half of 1995 but could be pushed out further if the market continues to tighten for the 1Mbx16 or if the 1Mbx4 becomes aggressively priced. Table 1 shows the latest pricing on the 1Mbx4, 1Mbx16, 4Mbx4, and 2Mbx8 configurations taken from the second-quarter pricing survey.

Other Memory Highlights

SRAM pricing, in general, is tightening up slightly, especially in the 1996 time frame. SRAMs most in demand are devices with speeds faster than 25ns and densities of 256Kb and above. The primary new application is for cache tag memory in high-end PCs and workstations. Dataquest began tracking three new SRAMs starting this quarter, including one low-voltage part (see Table 2).

The other memories—mask ROM, EPROM, and flash—are showing less price volatility than are SRAM or DRAM. There are, however, some supply constraints in the lower-density flash below 4Mb, and some lead times have lengthened on the 1Mb-and-above EPROMs. Dataquest believes that these spot issues are not long-term problems because new fab capacity should be available soon. For example, the AMD-Fujitsu plant in Japan is ramping up for very high density flash parts. This should free up older fabs for lower-density flash devices. Moreover, SGS-Thomson is ramping up production of both flash and EPROMs.

Microprocessors (The Good News)

Intel cut prices on the 80486 and Pentium MPUs during the first quarter of 1995 from 7 percent to 39 percent, depending on the class (80486 and Pentium) and speed. Intel clearly plans for the Pentium to be the big runner and plans to ship at least 20 million units in 1995, up from 5 million in 1994.

Table 1
Estimated DRAM Pricing Trends, North American Bookings (Contract Volume; U.S. Dollars)

	Q1/95	Q2/95	Q3/95	Q4/95	1995 Average
1Mbx4 DRAM 60ns, SOJ	12.66	12.45	12.25	11.99	12.34
Four 1Mbx4 Crossover Multiplier	50.64	49.8	49.00	47.96	49.36
1Mbx16 DRAM 60ns, TSOP	53.62	50.13	47.37	44.42	48.89
4Mbx4 DRAM 70ns, SOJ	46.52	41.50	37.80	34.20	40.01
2Mbx8 DRAM 60ns, TSOP	51.38	46.52	43.57	40.32	45.45

Source: Dataquest (May 1995)

Table 2
New Fast SRAMs Tracked on a Quarterly Basis (20,000 per Year; U.S. Dollars)

	Q1/95	Q2/95	Q3/95	Q4/95	1995 Average
128Kx8 15ns	19.25	18.87	18.29	17.35	18.44
32Kx8 15ns, 5V	3.76	3.68	3.61	3.53	3.65
32Kx8 15ns, 3.3V	5.64	5.41	5.02	4.88	5.24

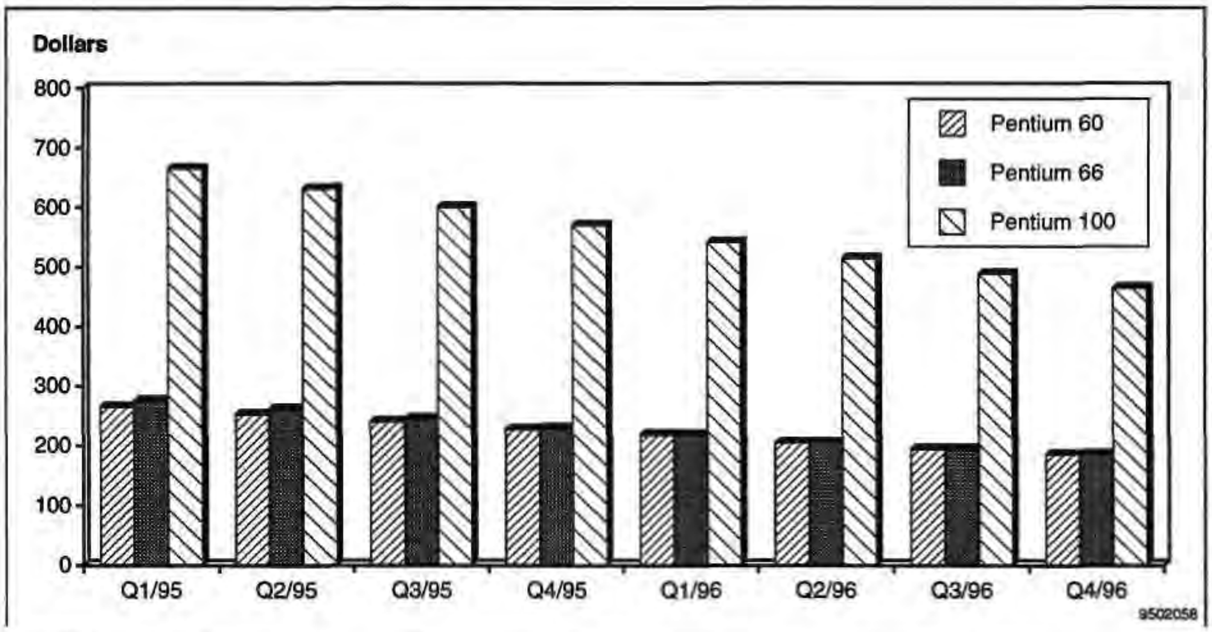
Source: Dataquest (May 1995)

Figure 1 shows quarterly prices for the Pentium 60, 66, and 100. There will be no premium for the 66-MHz device by the first quarter of 1996, compared to the 60-MHz. It should be noted that the pricing here is for volumes of 25,000 units per year and that the 1996 pricing is conservative.

80486 MPU pricing also is expected to drop precipitously. In 1996, for example, all 486 MPUs save the 75-MHz version will be well under $100 (see Table 3). With ongoing competition from 486 and Pentium-like devices from AMD, Cyrix, and NexGen, Intel is no longer totally in the driver's seat, and MPU pricing should be dropping on a quarterly basis.

The PowerPC MPU represents another threat to Intel's dominance of the MPU market. Apple, along with chip suppliers IBM and Motorola, is championing this technology. So far several OEMs—Radius, Power Computing, and Pioneer Electronic Corporation—have signed up to sell Macintosh clones. Apple expects three to nine more companies to join the PowerPC fold by the end of 1995.

Figure 1
Quarterly Pentium Pricing



Source: Dataquest (May 1995)

Table 3
Average Annual Pricing for 80486 MPUs (Dollars)

	1995	1996	Percentage Change
80486 DX-33	82.50	65.00	-21
80486 DX-50	148.75	85.00	-43
80486 DX2-50	82.50	65.00	-21
80486 DX2-66	111.00	73.75	-34
80486 DX4-75	171.00	139.00	-19

Source: Dataquest (May 1995)

Dataquest Perspective

Dataquest sees a challenging but not impossible semiconductor market for users for the rest of 1995 and early into 1996. Outside of MPUs, pricing in general looks to be firm and, in the case of memory, increasing.

However, as in any volatile market, change is a fact of life. Dataquest suggests that procurement professionals watch for the following scenarios, which will provide insight to future IC pricing trends:

- Downward price scenarios (possible but unlikely):
  - Sharp decline in demand for PCs and other high-volume electronic devices
  - Supply catches up to demand as new fabs come online
  - Yields dramatically improve on 1Mbx16 and new players enter market (for example, Hyundai)
  - Major memory suppliers break from the pack and slice prices
- Upward price scenarios (very possible):
  - Continued high demand for PCs and other high-volume electronic devices (telephones and set-top boxes, among others)
  - Less-than-optimal yields for 1Mbx16 keeping supply constrained
  - Weak dollar-to-yen exchange rate giving Japanese suppliers "excuse" to bump up prices
  - Various events unsettle market (Sumitomo explosion or Kobe earthquake, among others)

Dataquest believes that the upward pricing pressure is the more likely of the two scenarios. Already, major Japanese suppliers are asking for a 5 to 10 percent increase in DRAM prices to make up for the falling dollar. The larger U.S. DRAM users have some leverage and will try to resist these markups. For example, Compaq has already publicly announced that it does not intend to pay the currency price adder. The smaller DRAM users with little clout and limited alternate sources (for example, Korea- or Taiwan-sourced DRAMs) may have little choice but to pay the "tax."

In this generally tight semiconductor market, procurement and material managers must work closely with their suppliers and closely monitor any changes in price, lead times, and delivery.

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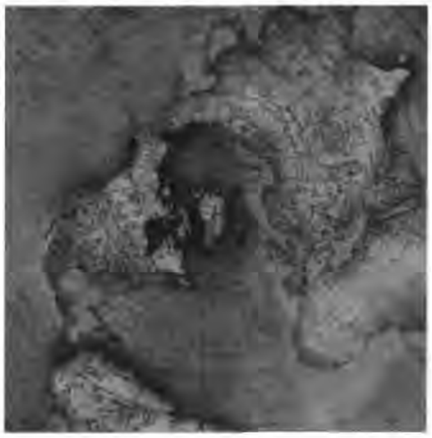

Dataquest

North American Semiconductor Price Outlook: First Quarter 1996

Pricing Trends

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North American Semiconductor Price Outlook: First Quarter 1996

Methodology and Sources

This 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 1995 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	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
74LS TTL												
74LS00	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.14	0-8
74LS74	0.16	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.15	0.16	0-8
74LS138	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0-8
74LS244	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25	0-8
74AC TTL												
74AC00	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.18	0-8
74AC74	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0-8
74AC138	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.31	0.30	0.31	0-8
74AC244	0.45	0.45	0.45	0.45	0.45	0.45	0.43	0.42	0.41	0.40	0.41	0-8
74F TTL												
74F00	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0-8
74F74	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.15	0.16	0-8
74F138	0.21	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0-8
74F244	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0-8
74HC CMOS												
74HC00	0.18	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0-8
74HC74	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0-8
74HC138	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0-8
74HC244	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0-8
74ALS TTL												
74ALS00	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.16	0.17	0-8
74ALS74	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.19	0.20	0-8
74ALS138	0.32	0.32	0.32	0.32	0.32	0.32	0.31	0.30	0.30	0.29	0.30	0-8
74ALS244	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.40	0.40	0.39	0.40	0-8

(Continued)

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

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
74AS TTL												
74AS00	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0-8
74AS74	0.22	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.20	0.19	0.20	0-8
74AS138	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.45	0.45	0.45	0.45	0-8
74AS244	0.71	0.71	0.71	0.71	0.71	0.71	0.70	0.69	0.69	0.69	0.69	0-8
74BC*												
74BC00	0.25	0.25	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0-8
74BC244	0.59	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0-8
74BC373	0.61	0.61	0.61	0.61	0.61	0.61	0.60	0.59	0.59	0.58	0.59	0-8
74ACT244	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.45	0.45	0.44	0.45	6-8
74ACT245	0.51	0.51	0.51	0.51	0.51	0.51	0.50	0.48	0.48	0.47	0.48	6-8

*Pricing for 74BC excludes 74ABT and 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 1995)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
74LS TTL					
74LS00	0.15	0.14	0.13	0.13	0.13
74LS74	0.17	0.16	0.15	0.15	0.15
74LS138	0.18	0.17	0.17	0.17	0.17
74LS244	0.26	0.25	0.26	0.26	0.26
74AC TTL					
74AC00	0.19	0.18	0.19	0.19	0.19
74AC74	0.23	0.22	0.21	0.21	0.21
74AC138	0.33	0.31	0.30	0.30	0.30
74AC244	0.45	0.41	0.40	0.40	0.40
74F TTL					
74F00	0.14	0.14	0.14	0.13	0.13
74F74	0.17	0.16	0.15	0.15	0.15
74F138	0.19	0.19	0.19	0.19	0.19
74F244	0.26	0.25	0.25	0.25	0.25
74HC CMOS					
74HC00	0.16	0.16	0.14	0.14	0.14
74HC74	0.18	0.18	0.18	0.18	0.18
74HC138	0.21	0.20	0.20	0.20	0.20
74HC244	0.29	0.28	0.27	0.27	0.27
74ALS TTL					
74ALS00	0.18	0.17	0.16	0.16	0.16
74ALS74	0.21	0.20	0.20	0.20	0.20
74ALS138	0.32	0.30	0.30	0.30	0.30
74ALS244	0.41	0.40	0.38	0.38	0.38
74AS TTL					
74AS00	0.21	0.20	0.20	0.20	0.20
74AS74	0.22	0.20	0.20	0.20	0.20
74AS138	0.47	0.45	0.45	0.45	0.45
74AS244	0.71	0.69	0.69	0.65	0.65
74BC*					
74BC00	0.25	0.24	0.24	0.22	0.22
74BC244	0.59	0.58	0.57	0.55	0.55
74BC373	0.61	0.59	0.59	0.57	0.57
74ACT244	0.47	0.45	0.45	0.44	0.44
74ACT245	0.51	0.48	0.48	0.45	0.45

*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 1995)

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

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
68EC000-16 PLCC	5.35	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4-8
68020-16 PQFP	18.50	17.50	17.50	17.50	17.50	17.50	15.00	15.00	15.00	15.00	15.00	4-8
68EC020-16 PQFP	9.45	8.75	8.75	8.75	8.75	8.75	8.00	8.00	8.00	8.00	8.00	4-8
68EC020-25 PQFP	9.98	9.10	9.10	9.10	9.10	9.10	8.00	8.00	8.00	8.00	8.00	4-8
68EC030-25 PQFP	23.00	21.00	21.00	21.00	21.00	21.00	19.00	19.00	19.00	19.00	19.00	3-5
68040-25	150.00	125.00	100.00	90.00	80.00	93.75	60.00	60.00	60.00	60.00	60.00	4-8
68LC040-25 CQFP 184	65.00	55.00	48.00	42.00	39.00	46.00	29.00	29.00	29.00	29.00	29.00	4-8
386SL-25 PQFP	40.00	36.00	36.00	36.00	36.00	36.00	31.00	31.00	31.00	31.00	31.00	4-10
AM386-40 PQFP[1]	22.00	21.00	20.00	19.00	18.00	19.50	18.00	18.00	18.00	18.00	18.00	6-12
80486SX-25 PQFP	35.00	30.00	25.00	25.00	25.00	26.25	20.00	20.00	20.00	20.00	20.00	4-10
80486DX-33 PQFP	68.00	55.00	45.00	38.00	32.00	42.50	25.00	25.00	25.00	25.00	25.00	4-10
80486DX-50	98.00	80.00	64.00	52.00	42.00	59.50	35.00	35.00	30.00	30.00	32.50	4-10
80486DX2-50 PQFP	49.00	41.00	33.00	27.00	24.00	31.25	20.00	20.00	20.00	20.00	20.00	4-10
80486DX2-66	68.00	56.00	46.00	45.00	45.00	48.00	40.00	40.00	40.00	40.00	40.00	12-16
80486DX4-75	106.50	94.00	90.00	75.00	65.00	81.00	62.00	62.00	62.00	62.00	62.00	12-16
Pentium-66	134.00	100.00	90.00	90.00	90.00	92.50	70.00	70.00	70.00	70.00	70.00	12-16
Pentium-75	151.33	100.00	95.00	90.00	85.00	92.50	80.00	80.00	80.00	80.00	80.00	12-16
Pentium-90	228.30	181.54	138.13	131.00	125.00	143.92	120.00	116.00	114.00	110.00	115.00	12-16
Pentium-100	281.92	199.32	152.36	135.59	125.00	154.57	125.00	125.00	125.00	125.00	125.00	12-16
PowerPC-601-66	110.60	105.07	99.82	94.83	90.09	97.45	85.00	80.00	75.00	70.00	77.00	12-16
PowerPC-601-80	159.42	146.66	134.93	121.44	109.29	128.08	97.00	97.00	97.00	97.00	97.00	12-16
PowerPC-601-100	273.38	246.04	221.43	199.29	179.36	211.53	174.00	174.00	174.00	174.00	174.00	12-16
Power PC 603-80	108.06	100.65	94.28	88.79	79.55	90.82	65.00	60.00	52.00	45.00	55.00	12-16
29000-25[2]	49.00	45.00	42.00	39.00	35.00	40.25	35.00	35.00	35.00	35.00	35.00	4-10

(Continued)

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

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
88100-25[2]	41.00	39.00	39.00	39.00	39.00	39.00	35.00	35.00	35.00	35.00	35.00	6-12
R4000SC-50	375.00	370.00	355.00	340.00	320.00	346.25	300.00	225.00	170.00	125.00	210.00	6-12
R4400SC-75	515.00	495.00	475.00	450.00	425.00	461.25	395.00	370.00	350.00	320.00	358.75	6-12
SPARC-25[2]	45.00	42.00	42.00	40.00	41.50	41.38	35.00	35.00	35.00	35.00	35.00	4-10
80960CA-25	57.50	57.50	45.00	42.00	42.00	46.625	40.00	40.00	40.00	40.00	40.00	4-10

[1]Estimated but not by survey
[2]Pricing excludes accessory parts like 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 price guidelines.
Source: Dataquest (December 1995)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
68EC000-16 PLCC	5.00	5.00	4.50	NA	NA
68020-16 PQFP	17.50	15.00	15.00	NA	NA
68EC020-16 PQFP	8.75	8.00	7.00	NA	NA
68EC020-25 PQFP	9.10	8.00	7.00	NA	NA
68EC030-25 PQFP	21.00	19.00	17.00	NA	NA
68040-25	93.75	60.00	50.00	NA	NA
68LC040-25 CQFP 184	46.00	29.00	NA	NA	NA
386SL-25 PQFP	36.00	31.00	NA	NA	NA
AM386-40 PQFP[1]	19.50	18.00	NA	NA	NA
80486SX-25 PQFP	26.25	20.00	NA	NA	NA
80486DX-33 PQFP	42.50	25.00	NA	NA	NA
80486DX-50	59.50	32.50	NA	NA	NA
80486DX2-50 PQFP	31.25	20.00	NA	NA	NA
80486DX2-66	48.00	40.00	NA	NA	NA
80486DX4-75	81.00	62.00	50.00	NA	NA
Pentium-66	92.50	70.00	60.00	NA	NA
Pentium-75	92.50	80.00	80.00	NA	NA
Pentium-90	143.92	115.00	100.00	NA	NA
Pentium-100	154.57	125.00	115.00	100.00	70.00
PowerPC-601-66	97.45	77.00	50.00	NA	NA
PowerPC-601-80	128.08	97.00	85.00	75.00	NA
PowerPC-601-100	211.53	174.00	123.00	99.00	75.00
Power PC 603-80	90.82	55.00	50.00	NA	NA
29000-25[2]	40.25	35.00	NA	NA	NA
88100-25[2]	39.00	35.00	NA	NA	NA
R4000SC-50	346.25	210.00	155.00	120.00	99.00
R4400SC-75	461.25	358.75	295.00	236.00	192.00
SPARC-25[2]	41.38	35.00	NA	NA	NA
80960CA-25	46.63	40.00	NA	NA	NA

NA = Not available
[1]Estimated but not by survey
[2]Pricing excludes accessory parts like 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 price guidelines.
Source: Dataquest (December 1995)

Table 5
Estimated DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ)	3.94	3.84	3.83	3.85	3.88	3.85	4.16	4.19	4.21	4.23	4.20	8-Allocation
256Kx4 DRAM 60ns SOJ	4.02	4.00	3.96	3.98	3.98	3.98	4.28	4.30	4.35	4.39	4.33	Allocation
4Mbx1 DRAM 70ns SOJ	13.09	12.91	12.50	12.31	11.75	12.37	11.20	10.81	10.36	9.75	10.53	8-Allocation
1Mbx4 DRAM 60ns SOJ	13.43	13.00	12.60	12.05	11.40	12.26	11.10	10.55	9.90	9.60	10.29	8-Allocation
512Kx8 DRAM 70ns	15.21	14.55	14.38	13.47	12.60	13.75	12.91	12.19	11.30	10.40	11.70	8-Allocation
256Kx16 DRAM 70ns SOJ	15.88	15.80	15.42	14.94	14.34	15.13	14.23	13.78	13.31	12.72	13.51	10-Allocation
4Mbx4 DRAM 70ns SOJ 300 mil	49.67	47.70	46.10	43.70	41.83	44.83	39.06	37.06	34.66	32.06	35.71	8-Allocation
1Mbx16 DRAM 60ns TSOP 300 mil	55.39	52.29	51.09	49.13	45.63	49.54	43.19	41.34	39.17	37.06	40.19	10-Allocation
2Mbx8 DRAM 60ns TSOP 300mil	52.57	50.95	48.73	45.90	43.62	47.30	40.50	38.85	37.06	34.69	37.77	12-Allocation
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	38.49	35.81	34.84	33.54	32.02	34.05	31.64	30.35	28.82	29.28	30.02	12-Allocation
4Mbx9 SIMM 2 (4Mbx4)+ 1 (4Mbx1)	123.67	119.14	115.18	109.68	104.94	112.24	98.25	93.43	87.65	81.26	90.15	12-Allocation
1Mbx36 SIMM 9 (1Mbx4)	132.91	125.19	121.34	116.04	109.78	118.09	106.89	101.60	95.34	92.45	99.07	10-Allocation
1Mbx32 SIMM 8 (1Mbx4)	118.14	112.32	108.86	104.11	98.50	105.95	95.90	91.15	85.54	84.48	89.27	8-Allocation
1Mbx32 SIMM 2 (1Mbx16)	119.64	112.96	110.35	106.12	99.47	107.23	98.33	91.60	86.08	82.60	89.65	10-Allocation
2Mbx32 SIMM 16 (1Mbx4)	231.98	224.64	217.73	208.22	196.99	211.90	197.83	184.94	173.79	162.48	179.76	10-Allocation
2Mbx32 SIMM 4 (1Mbx16)	239.28	227.06	218.70	210.64	201.77	214.54	193.23	180.05	168.79	154.42	174.12	10-Allocation
2Mbx36 SIMM 18 (1Mbx4)	252.33	249.77	244.78	237.89	228.36	240.20	218.39	205.49	192.98	177.37	198.55	10-Allocation
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	261.47	252.61	244.01	235.60	225.20	239.36	214.74	201.31	190.08	173.11	194.81	10-Allocation
256Kx4 VRAM 70ns SOJ	6.16	6.10	6.10	6.10	6.10	6.10	6.00	6.00	6.00	6.00	6.00	12-Allocation
128Kx8 VRAM 70ns SOJ	6.75	6.80	6.75	6.70	6.70	6.74	6.60	6.60	6.60	6.60	6.60	12-Allocation
256Kx16 VRAM 70ns SOP	24.25	23.00	22.25	21.50	20.75	21.88	18.40	17.80	17.20	16.60	17.50	10-Allocation

*Contract volume = at least 100,000 per order except VRAMs

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 1995)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
1Mbx1 DRAM 70-80ns (DIP/SOJ)	3.85	4.20	4.35	4.35	4.50
256Kx4 DRAM 60ns SOJ	3.98	4.33	4.55	4.60	4.60
4Mbx1 DRAM 70ns SOJ	12.37	10.53	8.00	7.25	6.50
1Mbx4 DRAM 60ns SOJ	12.26	10.29	8.02	7.25	6.50
512Kx8 DRAM 70ns	13.75	11.70	9.56	9.05	8.45
256Kx16 DRAM 70ns SOJ	15.13	13.51	12.06	11.50	10.30
4Mbx4 DRAM 70ns SOJ 300 mil	44.83	35.71	24.95	19.61	18.12
1Mbx16 DRAM 60ns TSOP 300 mil	49.54	40.19	28.30	23.40	18.25
2Mbx8 DRAM 60ns TSOP 300mil	47.30	37.77	26.10	21.60	18.20
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	34.05	30.02	25.49	23.56	21.88
4Mbx9 SIMM 2 (4Mbx4)+ 1 (4Mbx1)	112.24	90.15	63.69	51.12	47.01
1Mbx36 SIMM 9 (1Mbx4)	118.09	99.07	77.23	69.82	62.60
1Mbx32 SIMM 8 (1Mbx4)	105.95	89.27	70.58	63.80	57.20
1Mbx32 SIMM 2 (1Mbx16)	107.23	89.65	61.13	50.54	39.42
2Mbx32 SIMM 16 (1Mbx4)	211.896	179.76	138.59	125.28	112.32
2Mbx32 SIMM 4 (1Mbx16)	214.54	174.12	118.86	98.28	76.65
2Mbx36 SIMM 18 (1Mbx4)	240.20	198.55	155.91	140.94	126.36
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	239.36	194.81	130.84	109.55	87.30
256Kx4 VRAM 70ns SOJ	6.10	6.00	6.50	6.50	7.00
128Kx8 VRAM 70ns SOJ	6.74	6.60	6.30	6.30	6.50
256Kx16 VRAM 70ns SOP	21.88	17.50	16.00	16.00	15.00

*Contract volume = at least 100,000 per order except VRAMs
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 1995)

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	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
16Kx4 35ns	3.00	2.87	2.73	2.66	2.60	2.71	2.58	2.52	2.48	2.42	2.53	Allocation
8Kx8 25ns	2.90	2.84	2.63	2.55	2.50	2.63	2.50	2.50	2.50	2.50	2.50	Allocation
8Kx8 100-120ns	2.26	2.29	2.29	2.29	2.38	2.29	2.40	2.40	2.40	2.40	2.40	Allocation
64Kx4 10ns	10.00	10.00	10.00	9.00	9.00	9.50	8.24	8.24	7.42	7.42	7.83	Allocation
64Kx4 25ns	4.70	4.50	4.50	4.40	4.40	4.45	4.00	3.60	3.30	3.00	3.47	10-Allocation
32Kx8 12ns	6.25	6.15	5.65	5.25	5.25	5.57	4.25	4.25	3.95	3.95	4.10	Allocation
32Kx9 12ns Burst	14.00	13.00	13.00	13.00	13.00	13.00	12.00	10.00	10.00	8.00	10.00	Allocation
32Kx8 15ns, 5V	3.95	4.00	3.45	3.23	3.23	3.48	3.20	3.20	3.20	3.20	3.20	Allocation
32Kx8 15ns, 3.3V	4.58	4.50	4.50	4.48	4.45	4.48	4.26	4.16	4.05	4.03	4.16	Allocation
32Kx8 25ns	3.55	3.45	3.33	3.18	3.18	3.28	3.00	2.98	2.96	2.96	2.98	Allocation
32Kx8 70-100ns SOJ	3.48	3.45	3.45	3.35	3.30	3.37	3.03	2.94	2.84	2.84	2.94	Allocation
64Kx18 12ns Burst	36.00	34.33	32.67	30.33	28.33	31.41	28.00	27.33	26.67	24.67	26.67	Allocation
256Kx4 20ns	16.32	15.75	15.75	15.00	15.00	15.37	13.75	13.30	13.00	12.95	13.25	Allocation
128Kx8 15ns	22.47	21.92	21.83	20.40	20.03	21.04	19.45	18.87	18.37	17.65	18.59	Allocation
128Kx8 20ns	18.50	17.25	17.25	16.50	16.50	16.87	16.00	15.75	15.13	14.65	15.38	8-Allocation
128Kx8 25ns	16.50	16.00	16.00	15.00	15.00	15.50	14.08	14.08	13.20	13.20	13.64	Allocation
128Kx8 70-100ns SOJ	8.60	8.40	8.37	8.23	8.20	8.30	7.90	7.70	7.30	7.10	7.50	Allocation
32Kx32 15ns, 3.3V PQFP	27.00	25.00	24.00	23.00	22.00	23.50	19.93	19.07	18.10	17.34	18.61	Allocation

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 1995)

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	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
16Kx4 35ns	2.71	2.53	2.50	2.60	2.70
8Kx8 25ns	2.63	2.50	2.65	2.70	2.70
8Kx8 100-120ns	2.29	2.40	2.50	2.60	2.70
64Kx4 10ns	9.50	7.83	5.50	4.75	4.75
64Kx4 25ns	4.45	3.47	3.00	3.00	3.00
32Kx8 12ns	5.57	4.10	3.30	3.00	3.00
32Kx9 12ns Burst	13.00	10.50	9.00	8.00	7.00
32Kx8 15ns, 5V	3.48	3.20	3.20	3.20	3.20
32Kx8 15ns, 3.3V	4.48	4.16	3.50	3.30	3.00
32Kx8 25ns	3.28	2.98	2.95	2.95	2.95
32Kx8 70-100ns SOJ	3.37	2.94	2.75	2.75	2.75
64Kx18 12ns Burst	31.41	26.67	25.00	23.00	21.00
256Kx4 20ns	15.37	13.25	11.25	8.33	6.55
128Kx8 15ns	21.04	18.59	16.75	13.57	10.61
128Kx8 20ns	16.87	15.38	13.86	11.24	8.42
128Kx8 25ns	15.50	13.64	10.55	8.29	6.20
128Kx8 70-100ns SOJ	8.30	7.50	5.12	5.00	5.00
32Kx32 15ns, 3.3V PQFP	23.50	18.61	16.16	14.22	12.88

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 1995)

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	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
128Kx8 ROM	1.95	2.00	1.90	1.90	1.80	1.90	1.80	1.70	1.70	1.60	1.70	8-12
64Kx16 ROM	2.1	2.08	2.05	2.05	2.05	2.0575	2.05	2.05	2.05	2.05	2.05	8-12
256Kx8 ROM	2.6	2.55	2.50	2.45	2.40	2.48	2.40	2.40	2.40	2.40	2.40	8-12
512Kx8 ROM	3.5	3.5	3.40	3.30	3.30	3.38	3.10	2.90	2.70	2.50	2.80	8-12
256Kx16 ROM[1]	3.5	3.50	3.40	3.30	3.30	3.38	3.30	3.20	3.20	3.10	3.20	8-12
1Mbx8 ROM[2]	5.00	4.75	4.62	4.48	4.35	4.55	4.20	4.10	4.00	3.70	4.00	8-12
1Mbx16 ROM	7.80	7.59	7.44	7.25	7.16	7.36	6.50	5.80	5.20	4.10	5.40	8-12
2Mbx8 ROM	7.80	7.59	7.44	7.25	7.16	7.36	6.50	5.80	5.20	4.10	5.40	8-12

[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 1995)

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	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
128Kx8 ROM	1.90	1.70	1.60	1.60	1.60
64Kx16 ROM	2.06	2.05	2.05	2.15	2.25
256Kx8 ROM	2.48	2.40	2.40	2.45	2.50
512Kx8 ROM	3.38	2.80	2.50	2.50	2.50
256Kx16 ROM[1]	3.38	3.20	2.55	2.45	2.45
1Mbx8 ROM[2]	4.55	4.00	4.00	3.50	3.50
1Mbx16 ROM	7.36	5.40	4.98	4.52	4.50
2Mbx8 ROM	7.36	5.40	4.98	4.52	4.50

[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 1995)

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

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
32Kx8 EPROM	1.88	1.93	1.93	2.04	2.04	1.99	2.14	2.17	2.20	2.25	2.19	4-8
64Kx8 EPROM	2.05	2.15	2.15	2.20	2.20	2.18	2.30	2.30	2.30	2.30	2.30	4-8
128Kx8 EPROM	2.90	2.90	2.80	2.80	2.75	2.81	2.65	2.65	2.55	2.55	2.60	4-10
256Kx8 EPROM	4.85	4.85	4.80	4.80	4.80	4.81	4.80	4.80	4.70	4.70	4.75	4-10
128Kx16 EPROM	6.80	6.80	6.80	6.80	6.80	6.80	6.70	6.70	6.70	6.70	6.70	4-10
512Kx8 EPROM	8.30	8.30	8.30	8.10	8.10	8.20	7.90	7.75	7.60	7.45	7.68	4-10
256Kx16 EPROM	11.45	11.20	11.20	10.85	10.85	11.03	10.28	10.03	9.90	9.75	9.99	4-8

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 price guidelines.
Source: Dataquest (December 1995)

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	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
32Kx8 EPROM	1.99	2.19	1.90	2.00	2.00
64Kx8 EPROM	2.18	2.30	2.40	2.50	2.50
128Kx8 EPROM	2.81	2.60	2.75	2.95	2.95
256Kx8 EPROM	4.81	4.75	4.30	4.25	4.20
128Kx16 EPROM	6.80	6.70	4.55	4.46	4.40
512Kx8 EPROM	8.20	7.68	6.35	6.35	6.35
256Kx16 EPROM	11.03	9.99	8.25	8.15	8.10

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 1995)

Table 13
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
64Kx8, PDIP/PLCC	3.95	3.95	3.90	3.80	3.70	3.83	3.67	3.57	3.37	3.27	3.47	Allocation
64Kx8, TSOP	4.10	4.20	4.20	4.10	3.95	4.11	3.80	3.60	3.40	3.30	3.53	Allocation
128Kx8, PDIP/PLCC	4.66	4.68	4.59	4.55	4.48	4.56	4.27	4.12	3.98	3.92	4.07	Allocation
128Kx8, TSOP 12V	4.93	4.86	4.84	4.78	4.74	4.80	4.55	4.37	4.25	4.14	4.33	Allocation
128Kx8, TSOP 5V	6.53	6.38	6.23	5.50	5.50	5.90	5.40	5.40	5.10	5.10	5.25	Allocation
256Kx8, TSOP, 12V	10.10	9.91	9.73	9.53	9.30	9.61	8.53	7.75	7.40	6.90	7.64	Allocation
256Kx8, TSOP, 5V	10.70	10.53	10.33	10.18	9.93	10.24	9.13	8.60	8.25	7.90	8.47	Allocation
512Kx8, PDIP/PLCC	13.10	12.50	12.25	11.90	11.50	12.04	11.00	10.25	9.60	8.54	9.84	Allocation
512Kx8, TSOP, 12V	13.60	13.30	13.05	12.65	12.00	12.75	11.50	10.75	10.15	9.65	10.51	Allocation
512Kx8, TSOP, 5V	16.23	15.97	15.62	15.35	15.00	15.36	14.35	13.65	12.75	12.10	13.21	Allocation
1Mbx8, TSOP	18.00	17.55	17.45	17.10	16.90	17.25	16.50	15.50	14.25	13.00	14.80	12
2Mbx8, TSOP	40.00	39.50	38.25	36.10	32.00	36.47	29.65	26.80	25.42	24.20	24.00	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 price guidelines.
Source: Dataquest (December 1995)

Table 14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
64Kx8, PDIP/PLCC	3.83	3.47	3.00	2.50	2.50
64Kx8, TSOP	4.11	3.53	3.00	2.50	2.50
128Kx8, PDIP/PLCC	4.56	4.07	3.50	2.75	2.75
128Kx8, TSOP 12V	4.80	4.33	3.60	2.90	2.75
128Kx8, TSOP 5V	5.90	5.25	4.75	4.00	3.65
256Kx8, TSOP, 12V	9.61	7.64	5.25	4.00	3.50
256Kx8, TSOP, 5V	10.24	8.47	6.50	4.25	3.80
512Kx8, PDIP/PLCC	12.04	9.84	6.50	5.00	3.75
512Kx8, TSOP, 12V	12.75	10.51	7.20	5.00	3.75
512Kx8, TSOP, 5V	15.36	13.21	8.50	6.25	5.25
1Mbx8, TSOP	17.25	14.80	12.00	9.00	6.50
2Mbx8, TSOP	36.47	24.00	17.00	12.00	9.00

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 price guidelines.
Source: Dataquest (December 1995)

Table 15
Estimated Gate Array Pricing (5 to 19.99K Gates)—North American Production Bookings (Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K Gates, 160-Pin PQFP for 10K-29.9K Gates, 208-Pin PQFP for ≥30K Gates) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.9K Gates			
Gate Count Technology	1996	1997	1998	1996	1997	1998	Lead Time (Weeks)
CMOS							Production:
1.0 Micron	54	52	50	46	42	38	7-17
0.8 Micron	43	40	37	43	39	35	7-17
0.6/0.5 Micron	49	46	43	43	39	35	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	25	25	25	43	43	43	2-7
0.8 Micron	29	29	29	48	43	38	2-3
0.6/0.5 Micron	31	30	29	49	44	39	3-5
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines. Volume prices: For 100K units or greater, discount the above prices by 30 percent to 40 percent.
Source: Dataquest (December 1995)

Table 16
Estimated Gate Array Pricing (20 to 100K Gates)—North American Production Bookings (Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K Gates, 160-Pin PQFP for 10K-29.9K Gates, 208-Pin PQFP for ≥30K Gates) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	20-29.99K Gates			30-59.9K Gates			60-100K Gates			
Gate Count Technology	1996	1997	1998	1996	1997	1998	1996	1997	1998	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	47	45	43	49	49	49	48	48	48	7-17
0.8 Micron	39	35	31	37	34	33	39	35	31	7-17
0.6/0.5 Micron	38	34	30	34	31	28	32	30	28	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	33	28	25	12-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	60	60	60	83	83	83	119	119	119	2-7
0.8 Micron	64	64	64	86	86	86	99	99	99	2-3
0.6/0.5 Micron	59	53	47	88	80	80	107	100	93	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	114	101	99	5-8

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 price guidelines. Volume prices: For 100K units or greater, discount the above prices by 30 percent to 40 percent.
Source: Dataquest (December 1995)

Table 17
Estimated CBIC Pricing (5K to 19.99K Gates)—North American Production Bookings (Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K Gates, 160-Pin PQFP for 10K-29.9K Gates, 208-Pin PQFP for ≥30K Gates) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.9K Gates			
Gate Count Technology	1996	1997	1998	1996	1997	1998	Lead Time (Weeks)
CMOS							Production:
1.0 Micron	54	52	50	46	42	38	12-18
0.8 Micron	43	40	37	42	38	34	9-18
0.6/0.5 Micron	48	46	44	42	38	34	14-21
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	46	46	46	67	67	67	6-9
0.8 Micron	51	51	51	67	67	67	5-7
0.6 /0.5 Micron	57	57	57	73	73	73	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Source: Dataquest (December 1995)

Table 18
Estimated CBIC Pricing (20K to 100K Gates)—North American Production Bookings (Millicents per Gate) (Package: CMOS—84-Pin PLCC for <10K Gates, 160-Pin PQFP for 10K-29.9K Gates, 208-Pin PQFP for ≥30K Gates) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	20-29.99K Gates			30-59.9K Gates			60-100K Gates			
Gate Count Technology	1996	1997	1998	1996	1997	1998	1996	1997	1998	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	55	53	51	56	54	52	58	56	54	9-18
0.8 Micron	39	35	34	37	34	33	43	39	35	9-18
0.6/0.5 Micron	37	34	33	33	31	29	31	30	29	14-20
0.3 Micron	NA	NA	NA	NA	NA	NA	32	28	26	14-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	81	79	77	95	93	91	115	115	115	6-10
0.8 Micron	81	79	77	90	89	88	112	110	105	4-7
0.6 /0.5 Micron	85	83	81	91	84	77	116	109	102	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	110	105	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 price guidelines.
Source: Dataquest (December 1995)

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

		1995	1996				1996	1997				1997	Lead Time
Pin Count	Speed* (ns)	Q4	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	(Weeks)
≤20													
	6.1-7.5	2.40	2.20	2.20	2.20	2.20	2.20	2.10	2.10	2.10	2.10	2.10	2-10
	7.6-10.0	1.25	1.22	1.22	1.20	1.20	1.21	1.18	1.16	1.14	1.12	1.15	2-8
	10.1-14.99	1.55	1.40	1.40	1.33	1.30	1.36	1.28	1.26	1.24	1.22	1.25	4-10
	15 - <25	0.68	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	1-4
	> or = 25	0.64	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0-2
24													
	6.1-7.5	3.00	2.90	2.90	2.80	2.80	2.85	2.75	2.69	2.65	2.59	2.67	0-2
	7.6-10.0	1.65	1.60	1.56	1.54	1.52	1.56	1.52	1.50	1.50	1.48	1.50	2-6
	10.1-14.99	2.50	2.35	2.25	1.90	1.90	2.10	1.90	1.85	1.85	1.80	1.85	4-10
	15 - <25	0.91	0.90	0.90	0.90	0.90	0.90	0.91	0.91	0.91	0.91	0.91	1-4
	> or = 25	0.77	0.77	0.77	0.77	0.77	0.77	0.78	0.79	0.79	0.79	0.79	1-4
24 (22V10)													
	6.1-7.5	6.38	6.35	6.30	6.25	6.20	6.28	6.15	6.10	6.10	6.05	6.10	0-2
	7.6-10.0	3.60	3.52	3.47	3.42	3.38	3.45	3.40	3.40	3.40	3.40	3.40	0-2
	15 - <25	2.35	2.40	2.50	2.70	2.80	2.60	2.80	2.70	2.70	2.60	2.70	1-4
	> or = 25	1.40	1.35	1.35	1.30	1.30	1.33	1.30	1.30	1.30	1.30	1.30	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 discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1995)

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)	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
≤20						
	6.1-7.5	2.20	2.10	2.10	2.00	2.00
	7.6-10.0	1.21	1.15	1.15	1.10	1.10
	10.1-14.99	1.36	1.25	1.25	1.35	1.35
	15 - <25	0.70	0.70	0.70	0.75	0.75
	> or = 25	0.66	0.66	0.70	0.75	0.75
24						
	6.1-7.5	2.85	2.67	2.62	2.60	2.60
	7.6-10.0	1.56	1.50	1.45	1.40	1.40
	10.1-14.99	2.10	1.85	1.85	1.85	1.85
	15 - <25	0.90	0.91	0.91	0.91	0.91
	> or = 25	0.77	0.79	0.79	0.79	0.79
24 (22V10)						
	6.1-7.5	6.28	6.10	6.00	5.90	5.90
	7.6-10.0	3.45	3.40	3.40	3.20	3.20
	15 - <25	2.60	2.70	2.70	2.80	2.80
	> or = 25	1.33	1.30	1.40	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 price guidelines.
Source Dataquest (December 1995)

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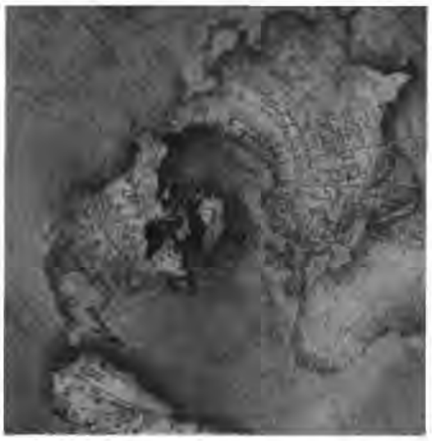

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North American Semiconductor Price Outlook: Fourth Quarter 1995

Pricing Trends

Program: Semiconductor Procurement Worldwide
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Publication Date: September 18, 1995
Filing: Competitive Dynamics

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North American Semiconductor Price Outlook: Fourth Quarter 1995

Methodology and Sources

This 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 1995 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 Year; Package PLCC; Dollars)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74LS TTL											
74LS00	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.15	0-8
74LS74	0.17	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0-8
74LS138	0.19	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0-8
74LS244	0.27	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0-8
74AC TTL											
74AC00	0.21	0.21	0.20	0.20	0.21	0.20	0.20	0.20	0.20	0.20	0-8
74AC74	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0-8
74AC138	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0-8
74AC244	0.46	0.46	0.45	0.45	0.46	0.45	0.45	0.45	0.45	0.45	0-8
74F TTL											
74F00	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0-8
74F74	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0-8
74F138	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0-8
74F244	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0-8
74HC CMOS											
74HC00	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0-8
74HC74	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0-8
74HC138	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0-8
74HC244	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0-8
74ALS TTL											
74ALS00	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0-8
74ALS74	0.22	0.22	0.21	0.21	0.22	0.21	0.21	0.21	0.21	0.21	0-8
74ALS138	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0-8
74ALS244	0.42	0.42	0.41	0.41	0.42	0.41	0.41	0.41	0.41	0.41	0-8

(Continued)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74AS TTL											
74AS00	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0-8
74AS74	0.23	0.23	0.22	0.22	0.23	0.22	0.22	0.22	0.22	0.22	0-8
74AS138	0.48	0.48	0.47	0.47	0.48	0.47	0.47	0.47	0.47	0.47	0-8
74AS244	0.72	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0-8
74BC*											
74BC00	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0-8
74BC244	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0-8
74BC373	0.62	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0-8
74ACT244	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	6-8
74ACT245	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	6-8

*Pricing for 74BC excludes 74ABT and 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 (September 1995)

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

Product	Year 1995	Year 1996	Year 1997	Year 1998	Year 1999
74LS TTL					
74LS00	0.15	0.15	0.13	0.13	0.13
74LS74	0.16	0.17	0.15	0.15	0.15
74LS138	0.18	0.18	0.17	0.17	0.17
74LS244	0.26	0.27	0.26	0.26	0.26
74AC TTL					
74AC00	0.21	0.20	0.19	0.19	0.19
74AC74	0.23	0.23	0.21	0.21	0.21
74AC138	0.33	0.34	0.30	0.30	0.30
74AC244	0.45	0.45	0.40	0.40	0.40
74F TTL					
74F00	0.15	0.15	0.14	0.14	0.13
74F74	0.17	0.17	0.15	0.15	0.15
74F138	0.21	0.21	0.19	0.19	0.19
74F244	0.27	0.27	0.25	0.25	0.25
74HC CMOS					
74HC00	0.18	0.18	0.15	0.14	0.14
74HC74	0.20	0.20	0.18	0.18	0.18
74HC138	0.22	0.22	0.20	0.20	0.20
74HC244	0.30	0.30	0.28	0.27	0.27
74ALS TTL					
74ALS00	0.18	0.18	0.17	0.16	0.16
74ALS74	0.21	0.21	0.20	0.20	0.20
74ALS138	0.32	0.32	0.30	0.30	0.30
74ALS244	0.41	0.41	0.40	0.38	0.38
74AS TTL					
74AS00	0.21	0.21	0.20	0.20	0.20
74AS74	0.22	0.22	0.20	0.20	0.20
74AS138	0.47	0.47	0.45	0.45	0.45
74AS244	0.71	0.71	0.69	0.69	0.65
74BC*					
74BC00	0.25	0.25	0.24	0.24	0.22
74BC244	0.59	0.59	0.58	0.57	0.55
74BC373	0.61	0.61	0.59	0.59	0.57
74ACT244	0.47	0.47	0.45	0.45	0.44
74ACT245	0.51	0.51	0.48	0.48	0.45

*Pricing for 74BC excludes 74ABT and 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 (September 1995)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
68EC000-16 PLCC[1]	5.35	5.35	5.35	5.35	5.35	5.00	5.00	5.00	5.00	5.00	4-8
68020-16 PQFP[1]	18.50	18.50	18.50	18.50	18.50	17.50	17.50	17.50	17.50	17.50	4-8
68EC020-16 PQFP[1]	9.45	9.45	9.45	9.45	9.45	8.75	8.75	8.75	8.75	8.75	4-8
68EC020-25 PQFP	9.98	9.98	9.98	9.98	9.98	9.10	9.10	9.10	9.10	9.10	4-8
68EC030-25 PQFP[1]	23.00	23.00	23.00	23.00	23.00	21.00	21.00	21.00	21.00	21.00	3-5
68040-25	150.00	150.00	150.00	150.00	150.00	125.00	100.00	80.00	70.00	93.75	4-8
68LC040-25 CQFP 184[1]	85.00	78.00	70.00	65.00	74.50	55.00	48.00	42.00	39.00	46.00	4-8
386SL-25 PQFP[1]	40.00	40.00	40.00	40.00	40.00	36.00	36.00	36.00	36.00	36.00	4-10
AM386-40 PQFP[1]	26.00	24.00	23.00	22.00	23.75	21.00	20.00	19.00	18.00	19.50	6-12
80486SX-25 PQFP	49.50	45.00	40.00	35.00	42.38	30.00	25.00	25.00	25.00	26.25	4-10
80486DX-33 PQFP	90.00	82.00	72.00	68.00	78.00	55.00	45.00	38.00	32.00	42.50	4-10
80486DX-50	180.00	150.00	120.00	98.00	137.00	80.00	64.00	52.00	42.00	59.50	4-10
80486DX2-50 PQFP	90.00	72.00	58.00	49.00	67.25	41.00	33.00	27.00	24.00	31.25	4-10
80486DX2-66	128.00	105.00	83.00	68.00	96.00	56.00	46.00	45.00	45.00	48.00	12-16
80486DX4-75	185.00	170.00	145.00	122.00	155.50	97.00	80.00	68.00	56.00	75.25	12-16
Pentium-66	265.00	235.00	149.00	134.00	195.75	100.00	90.00	90.00	90.00	92.50	12-16
Pentium-75	285.00	260.00	169.00	143.65	214.41	129.29	125.00	125.00	125.00	126.07	12-16
Pentium-90	525.00	340.00	272.00	217.60	338.65	174.08	139.26	125.00	125.00	140.84	12-16
Pentium-100	665.00	431.00	344.80	275.84	429.16	209.64	167.71	134.17	125.00	159.13	12-16
PowerPC 601-66	129.00	129.00	116.42	110.60	121.26	105.07	99.82	94.83	90.09	97.45	12-16
PowerPC 601-80	192.00	187.00	173.28	159.42	177.93	146.66	134.93	121.44	109.29	128.08	12-16

(Continued)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
PowerPC 601-100	375.00	337.50	303.75	273.38	322.41	246.04	221.43	199.29	179.36	211.53	12-16
Power PC 603-80	140.00	129.00	108.38	92.12	117.38	78.30	66.56	56.57	48.09	62.38	12-16
29000-25[2]	58.00	55.00	52.00	49.00	53.50	45.00	42.00	39.00	35.00	40.25	4-10
88100-25[2]	41.00	41.00	41.00	41.00	41.00	39.00	39.00	39.00	39.00	39.00	6-12
R4000SC-50	425.00	405.00	385.00	375.00	397.50	370.00	355.00	340.00	320.00	346.25	6-12
R4400SC-75	660.00	610.00	575.00	515.00	590.00	495.00	475.00	450.00	425.00	461.25	6-12
SPARC-25[2]	47.00	46.00	45.00	45.00	45.75	42.00	42.00	40.00	41.50	41.38	4-10
80960CA-25[1]	55.00	50.00	48.00	45.00	49.50	45.00	45.00	42.00	42.00	43.50	4-10

[1]Estimated but not by survey
[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 (September 1995)

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

Product	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
68EC000-16 PLCC[1]	5.35	5.00	4.75	4.5	NA
68020-16 PQFP[1]	18.50	17.50	17.17	16.75	NA
68EC020-16 PQFP[1]	9.45	8.75	8.50	7.80	7.30
68EC020-25 PQFP[1]	9.98	9.10	8.45	8.00	7.50
68EC030-25 PQFP[1]	23.00	21.00	19.00	17.00	NA
68040-25	150.00	93.75	60.00	50.00	NA
68LC040-25 CQFP 184[1]	74.50	46.00	29.00	NA	NA
386SL-25 PQFP[1]	40.00	36.00	31.00	28.00	NA
AM386-40 PQFP[1]	23.75	19.50	18.00	NA	NA
80486SX-25 PQFP	42.38	26.25	20.00	NA	NA
80486DX-33 PQFP	78.00	42.50	25.00	NA	NA
80486DX-50	137.00	59.50	35.00	NA	NA
80486DX2-50 PQFP	67.25	31.25	20.00	NA	NA
80486DX2-66	96.00	48.00	40.00	NA	NA
80486DX4-75	155.50	75.25	62.00	50.00	NA
Pentium-66	195.75	92.50	70.00	70.00	NA
Pentium-75	214.41	126.07	100.00	80.00	NA
Pentium-90	338.65	140.84	115.00	100.00	NA
Pentium-100	429.16	159.13	137.00	117.00	100.00
PowerPC 601-66	121.26	97.45	79.00	50.00	NA
PowerPC 601-80	177.93	128.08	97.00	85.00	85.00
PowerPC 601-100	322.41	211.53	174.00	123.00	100.00
Power PC 603-80	117.38	62.38	50.00	50.00	NA
29000-25[2]	53.50	40.25	40.00	NA	NA
88100-25[2]	41.00	39.00	35.00	NA	NA
R4000SC-50	397.50	346.25	205.00	155.00	120.00
R4400SC-75	590.00	461.25	369.00	295.00	236.00
SPARC-25[2]	45.75	41.38	37.00	NA	NA
80960CA-25	49.50	43.50	40.00	NA	NA

NA = Not available
[1]Estimated but not by survey
[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 (September 1995)

Table 5
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; U.S. Dollars)*

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Times (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.10	4.10	4.15	4.20	4.14	4.25	4.25	4.25	4.25	4.25	8-Allocation
256Kx4 DRAM 60ns SOJ	4.20	4.35	4.40	4.50	4.36	4.55	4.55	4.55	4.55	4.55	Allocation
4Mbx1 DRAM 70ns SOJ	12.40	12.60	13.25	13.25	12.88	13.15	13.10	12.62	12.25	12.78	8-Allocation
1Mbx4 DRAM 60ns SOJ	12.66	13.10	13.45	13.50	13.18	13.35	13.27	12.75	12.25	12.91	8-Allocation
512Kx8 DRAM 70ns	14.14	14.46	15.25	15.50	14.84	15.30	15.25	14.70	14.30	14.89	8-Allocation
256Kx16 DRAM 70ns SOJ	14.75	14.80	15.65	15.75	15.24	15.75	15.60	15.20	14.60	15.29	10-Allocation
4Mbx4 DRAM 70ns SOJ 300 mil	47.63	47.75	49.00	50.00	48.60	50.00	48.00	45.00	42.00	46.25	8-Allocation
1Mbx16 DRAM 60ns TSOP 300 mil	53.62	53.90	55.60	56.00	54.78	55.00	53.30	50.80	47.75	51.71	10-Allocation
2Mbx8 DRAM 60ns TSOP 300mil	51.38	51.82	52.50	53.00	52.18	52.80	51.00	48.00	46.00	49.45	12-Allocation
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	35.25	37.55	38.05	38.20	37.26	36.95	36.28	35.53	34.85	35.90	12-Allocation
4Mbx9 SIMM 2 (4Mbx4) +1 (4Mbx1)	116.50	119.36	121.25	122.08	119.80	118.15	114.10	109.62	104.25	111.53	12-Allocation
1Mbx36 SIMM 9 (1Mbx4)	121.00	124.42	131.05	131.50	126.99	125.54	124.43	121.03	118.88	122.47	10-Allocation
1Mbx32 SIMM 8 (1Mbx4)	111.28	114.80	117.60	117.80	115.37	114.80	112.14	106.86	103.19	109.25	8-Allocation
1Mbx32 SIMM 2 (1Mbx16)	112.91	117.81	121.20	121.80	118.43	116.83	112.53	108.60	104.80	110.69	10-Allocation
2Mbx32 SIMM 16 (1Mbx4)	NA	NA	230.20	231.00	230.60	228.60	225.32	216.00	208.00	219.48	10-Allocation
2Mbx32 SIMM 4 (1Mbx16)	NA	NA	242.40	244.00	243.20	233.00	226.20	215.80	206.00	220.25	10-Allocation
2Mbx36 SIMM 18 (1Mbx4)	NA	NA	257.10	258.00	257.55	255.30	251.86	242.50	233.50	245.79	10-Allocation
2Mbx36 SIMM 4 (1Mbx16) +2 (1Mbx4)	NA	NA	264.30	266.00	265.15	259.70	252.74	241.70	228.50	245.66	10-Allocation
256Kx4 VRAM 70ns SOJ	5.57	6.10	6.32	6.32	6.08	6.40	6.35	6.35	6.30	6.35	12-Allocation
128Kx8 VRAM 70ns SOJ	6.21	6.30	6.75	6.75	6.50	6.80	6.75	6.70	6.70	6.74	12-Allocation
256Kx16 VRAM 70ns SOP	25.00	25.00	24.75	24.25	24.75	23.00	22.25	21.50	20.75	21.88	10-Allocation

*Contract volume = at least 100,000 per order except VRAMs
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 1995)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.14	4.25	4.35	4.35	4.35
256Kx4 DRAM 60ns SOJ	4.36	4.55	4.60	4.60	4.60
4Mbx1 DRAM 70ns SOJ	12.88	12.78	9.45	7.25	6.50
1Mbx4 DRAM 60ns SOJ	13.18	12.91	9.95	7.25	6.50
512Kx8 DRAM 70ns	14.84	14.89	12.00	11.60	11.50
256Kx16 DRAM 70ns SOJ	15.24	15.29	14.14	13.10	12.30
4Mbx4 DRAM 70ns SOJ 300 mil	48.60	46.25	35.00	24.95	18.65
1Mbx16 DRAM 60ns TSOP 300 mil	54.78	51.71	39.00	27.25	19.25
2Mbx8 DRAM 60ns TSOP 300mil	52.18	49.45	37.00	26.20	18.75
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	37.26	35.90	33.35	NA	NA
4Mbx9 SIMM 2 (4Mbx4) +1 (4Mbx1)	119.80	111.53	87.45	63.15	48.80
1Mbx36 SIMM 9 (1Mbx4)	126.99	122.47	99.55	73.25	66.50
1Mbx32 SIMM 8 (1Mbx4)	115.37	109.25	83.60	62.40	57.00
1Mbx32 SIMM 2 (1Mbx16)	118.43	110.69	84.00	59.60	43.50
2Mbx32 SIMM 16 (1Mbx4)	230.6	219.48	169.20	126.00	114.00
2Mbx32 SIMM 4 (1Mbx16)	243.20	220.25	166.00	119.00	87.00
2Mbx36 SIMM 18 (1Mbx4)	257.55	245.79	189.10	140.50	128.00
2Mbx36 SIMM 4 (1Mbx16) +2 (1Mbx4)	265.15	245.66	185.90	133.50	100.00
256Kx4 VRAM 70ns SOJ	6.08	6.35	6.10	6.00	6.00
128Kx8 VRAM 70ns SOJ	6.50	6.74	6.45	6.30	6.30
256Kx16 VRAM 70ns SOP	24.75	21.88	17.50	16.00	16.00

NA = Not available
*Contract volume = at least 100,000 per order except VRAMs
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 1995)

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	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
16Kx4 35ns	3.90	3.60	3.30	3.00	3.45	2.87	2.73	2.66	2.60	2.72	Allocation
8Kx8 25ns	2.96	2.90	2.90	2.90	2.92	2.77	2.63	2.55	2.50	2.61	Allocation
8Kx8 100-120ns	1.78	1.80	1.80	1.85	1.81	1.80	1.80	1.80	1.80	1.80	Allocation
64Kx4 10ns	8.38	6.28	7.00	10.00	7.92	10.00	10.00	9.00	9.00	9.50	Allocation
64Kx4 25ns	5.20	5.10	5.10	5.00	5.10	4.60	4.50	4.40	4.40	4.48	10-Allocation
32Kx8 12ns	6.67	5.89	6.00	6.25	6.20	5.65	5.65	5.25	5.25	5.45	Allocation
32Kx9 12ns Burst	14.00	14.00	14.00	14.00	14.00	13.00	13.00	13.00	13.00	13.00	Allocation
32K x 8, 15ns, 5V	4.00	4.00	4.15	4.15	4.08	4.00	3.65	3.45	3.45	3.64	Allocation
32K x 8, 15ns, 3.3V	6.00	6.00	6.15	6.15	6.08	6.00	5.75	5.45	5.40	5.65	Allocation
32Kx8 25ns	3.72	3.72	3.75	3.80	3.75	3.70	3.65	3.60	3.60	3.64	Allocation
32Kx8 70-100ns SOJ	3.14	3.50	3.50	3.55	3.42	3.50	3.40	3.30	3.30	3.38	Allocation
64Kx18 12ns Burst	35.00	35.00	37.00	37.00	36.00	35.00	33.00	30.00	27.00	31.25	Allocation
256Kx4 20ns	14.90	14.83	15.15	16.13	15.25	15.00	15.00	14.00	14.00	14.50	Allocation
128K x 8, 15ns	19.25	18.31	19.28	21.42	19.57	20.25	20.25	19.10	19.10	19.68	Allocation
128Kx8 20ns	16.50	16.33	17.00	19.00	17.21	17.00	17.00	16.00	16.00	16.50	8-Allocation
128Kx8 25ns	13.34	13.30	15.00	17.00	14.66	16.00	16.00	15.00	15.00	15.50	Allocation
128Kx8 70-100ns SOJ	8.47	8.38	8.40	8.50	8.44	8.40	8.30	8.20	8.00	8.23	Allocation
32Kx32 15ns, 3.3V PQFP	NA	NA	28.00	29.00	28.50	27.00	26.00	25.00	24.00	25.50	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 price guidelines.
Source: Dataquest (September 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
16Kx4 35ns	3.45	2.72	2.50	2.50	2.60
8Kx8 25ns	2.92	2.61	2.65	2.65	2.70
8Kx8 100-120ns	1.81	1.80	1.90	1.93	1.93
64Kx4 10ns	7.92	9.50	7.83	5.50	4.75
64Kx4 25ns	5.10	4.48	3.48	3.00	3.00
32Kx8 12ns	6.20	5.45	4.10	3.30	3.00
32Kx9 12ns Burst	14.00	13.00	10.00	9.00	7.00
32K x 8, 15ns, 5V	4.08	3.64	4.50	3.50	3.30
32K x 8, 15ns, 3.3V	6.08	5.65	4.50	3.50	3.30
32Kx8 25ns	3.75	3.64	3.20	3.00	3.00
32Kx8 70-100ns SOJ	3.42	3.38	2.85	2.50	2.50
64Kx18 12ns Burst	36.00	31.25	25.00	25.00	25.00
256Kx4 20ns	15.25	14.50	11.25	8.33	6.55
128K x 8, 15ns	19.57	19.68	16.75	10.61	7.33
128Kx8 20ns	17.21	16.50	14.51	8.42	6.30
128Kx8 25ns	14.66	15.50	13.64	8.00	6.20
128Kx8 70-100ns SOJ	8.44	8.23	6.12	5.90	5.90
32Kx32 15ns, 3.3V PQFP	28.50	25.50	20.2	16.16	14.22

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 1995)

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	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
128Kx8 ROM	1.66	1.85	1.90	1.95	1.84	2.00	1.90	1.90	1.80	1.90	8-12
64Kx16 ROM	2.08	2.08	2.10	2.10	2.09	2.08	2.05	2.05	2.05	2.06	8-12
256Kx8 ROM	2.53	2.60	2.60	2.60	2.58	2.55	2.50	2.45	2.40	2.48	8-12
512Kx8 ROM	3.33	3.35	3.40	3.50	3.40	3.50	3.40	3.30	3.30	3.38	8-12
256Kx16 ROM[1]	3.25	3.30	3.40	3.50	3.36	3.50	3.40	3.30	3.30	3.38	8-12
1Mbx8 ROM[2]	4.80	5.21	5.21	5.00	5.06	4.75	4.62	4.48	4.35	4.55	8-12
1Mbx16 ROM	8.20	8.20	8.15	7.80	8.09	7.59	7.44	7.25	7.16	7.36	8-12
2Mbx8 ROM	8.20	8.20	8.15	7.80	8.09	7.59	7.44	7.25	7.16	7.36	8-12

[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 (September 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
128Kx8 ROM	1.84	1.90	1.70	1.60	1.60
64Kx16 ROM	2.09	2.06	2.05	2.05	2.15
256Kx8 ROM	2.58	2.48	2.40	2.40	2.45
512Kx8 ROM	3.40	3.38	2.80	2.50	2.50
256Kx16 ROM[1]	3.36	3.38	3.20	2.55	2.45
1Mbx8 ROM[2]	5.06	4.55	4.00	4.00	3.50
1Mbx16 ROM	8.09	7.36	5.40	4.98	4.52
2Mbx8 ROM	8.09	7.36	5.40	4.98	4.52

[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 (September 1995)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
32Kx8 EPROM	1.55	1.65	1.75	1.75	1.68	1.60	1.60	1.63	1.63	1.62	4-8
64Kx8 EPROM	1.90	1.92	1.95	1.93	1.93	1.90	1.90	1.90	1.90	1.90	4-8
128Kx8 EPROM	2.58	2.60	2.63	2.63	2.61	2.60	2.55	2.50	2.50	2.54	4-10
256Kx8 EPROM	4.62	4.70	4.75	4.80	4.72	4.80	4.75	4.60	4.50	4.66	4-10
128Kx16 EPROM	4.85	5.55	6.21	6.50	5.78	6.50	6.31	5.19	4.60	5.65	4-10
512Kx8 EPROM	7.00	7.62	8.01	8.20	7.71	8.20	7.96	7.36	6.82	7.59	4-10
256Kx16 EPROM	9.15	10.23	11.16	11.43	10.49	11.20	11.20	11.00	10.85	11.06	4-8

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 price guidelines.
Source: Dataquest (September 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
32Kx8 EPROM	1.68	1.62	1.80	1.90	2.00
64Kx8 EPROM	1.93	1.90	2.10	2.40	2.50
128Kx8 EPROM	2.61	2.54	2.65	2.75	2.95
256Kx8 EPROM	4.72	4.66	4.30	4.30	4.25
128Kx16 EPROM	5.78	5.65	4.55	4.55	4.46
512Kx8 EPROM	7.71	7.59	6.55	6.35	6.35
256Kx16 EPROM	10.49	11.06	9.35	8.25	8.15

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 1995)

Table 13
Estimated Flash Memory Price Trends – North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
64Kx8, PDIP/PLCC	3.90	3.90	3.90	3.95	3.91	3.95	3.90	3.80	3.70	3.84	Allocation
64Kx8, TSOP	3.95	3.95	4.00	4.10	4.00	4.20	4.15	4.05	3.95	4.09	Allocation
128Kx8, PDIP/PLCC	4.53	4.50	4.65	4.70	4.60	4.65	4.60	4.50	4.40	4.54	Allocation
128Kx8, TSOP	4.82	4.98	5.00	5.00	4.95	4.90	4.90	4.80	4.80	4.85	Allocation
256Kx8, TSOP, 12V	9.40	9.85	10.00	10.10	9.84	10.00	9.85	9.70	9.50	9.76	Allocation
256Kx8, TSOP, 5V	10.20	10.65	10.65	10.70	10.55	10.60	10.45	10.30	10.00	10.34	Allocation
512Kx8, PDIP/PLCC	10.30	10.80	13.00	13.10	11.80	13.00	13.00	12.00	11.50	12.38	Allocation
512Kx8, TSOP, 12V	10.80	11.30	13.50	13.60	12.30	13.50	13.50	12.50	12.00	12.88	Allocation
512Kx8, TSOP, 5V	16.61	16.13	16.50	17.50	16.69	17.50	17.00	16.50	15.00	16.50	Allocation
1Mbx8 TSOP	19.22	19.20	18.80	18.00	18.81	17.00	16.52	15.47	14.08	15.77	12
2Mbx8 TSOP	51.67	50.00	45.00	40.00	46.67	35.00	33.00	31.00	29.00	32.00	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 price guidelines.
Source: Dataquest (September 1995)

Table 14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
64Kx8, PDIP/PLCC	3.91	3.84	3.00	2.50	2.50
64Kx8, TSOP	4.00	4.09	3.20	2.60	2.50
128Kx8, PDIP/PLCC	4.60	4.54	3.50	2.75	2.75
128Kx8, TSOP	4.95	4.85	3.60	2.85	2.75
256Kx8, TSOP, 12V	9.84	9.76	6.50	4.50	3.50
256Kx8, TSOP, 5V	10.55	10.34	6.80	4.70	3.70
512Kx8, PDIP/PLCC	11.80	12.38	8.50	6.50	5.00
512Kx8, TSOP, 12V	12.30	12.88	9.00	7.00	5.00
512Kx8, TSOP, 5V	16.69	16.50	11.00	8.00	6.00
1Mbx8 TSOP	18.81	15.77	12.00	9.00	6.50
2Mbx8 TSOP	46.67	32.00	20.00	15.00	10.00

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 price guidelines.
Source: Dataquest (September 1995)

Table 15
Estimated Gate Array Pricing (5K to 19.99K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.9K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS							Production:
1.0 Micron	63	54	52	54	46	42	7-17
0.8 Micron	51	43	40	50	43	39	7-17
0.6/0.5 Micron	58	49	46	50	43	39	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	26	25	25	45	43	43	2-7
0.8 Micron	30	29	29	50	48	43	2-3
0.6/0.5 Micron	33	31	30	52	49	44	3-5
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Volume prices: For 100,000 units or greater, discount the prices by 30 to 40 percent.
Source: Dataquest (September 1995)

Table 16
Estimated Gate Array Pricing (20K to 100K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	20-29.99K Gates			0-59.9K Gates			60-100K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	55	47	45	58	49	49	56	48	48	7-17
0.8 Micron	46	39	35	44	37	34	46	39	35	7-17
0.6/0.5 Micron	45	38	34	40	34	31	38	32	30	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	39	33	28	12-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	63	60	60	87	83	83	125	119	119	2-7
0.8 Micron	67	64	64	90	86	86	104	99	99	2-3
0.6/0.5 Micron	62	59	53	93	88	80	113	107	100	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	120	114	101	5-8

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 price guidelines.
Volume prices: For 100,000 units or greater, discount the prices by 30 to 40 percent.
Source: Dataquest (September 1995)

Table 17
Estimated CBIC Pricing (5K to 19.99K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.99 Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS							Production:
1.0 Micron	63	54	52	54	46	42	12-18
0.8 Micron	50	43	40	49	42	38	9-18
0.6/0.5 Micron	57	48	46	49	42	38	14-21
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	48	46	46	70	67	67	6-9
0.8 Micron	54	51	51	70	67	67	5-7
0.6 /0.5 Micron	60	57	57	77	73	73	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Source: Dataquest (September 1995)

Table 18
Estimated CBIC Pricing (20K to 100K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	20-29.99K Gates			30-599K Gates			60-100K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	65	55	53	66	56	54	68	58	56	9-18
0.8 Micron	46	39	35	44	37	34	50	43	39	9-18
0.6/0.5 Micron	44	37	34	39	33	31	37	31	30	14-20
0.3 Micron	NA	NA	NA	NA	NA	NA	38	32	28	14-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	85	81	79	100	95	93	121	115	115	6-10
0.8 Micron	85	81	79	95	90	89	118	112	110	4-7
0.6/0.5 Micron	89	85	83	96	91	84	122	116	109	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	110	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 price guidelines.
Source: Dataquest (September 1995)

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

		1995				1995	1996				1996	
Pin Count	Speed* (ns)	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Lead Time (Weeks)
≤20												
	6.1-7.5	2.40	2.40	2.40	2.40	2.40	2.20	2.20	2.20	2.20	2.20	2-10
	7.6-10.0	1.32	1.32	1.25	1.25	1.29	1.22	1.22	1.20	1.20	1.21	2-8
	10.1-14.99	1.40	1.40	1.55	1.55	1.48	1.40	1.40	1.33	1.30	1.36	4-10
	15 - <25	0.68	0.68	0.68	0.68	0.68	0.70	0.70	0.70	0.70	0.70	1-4
	> or = 25	0.64	0.64	0.64	0.64	0.64	0.66	0.66	0.66	0.66	0.66	0-2
24												
	6.1-7.5	3.00	3.00	3.00	3.00	3.00	2.90	2.90	2.80	2.80	2.85	0-2
	7.6-10.0	1.95	1.90	1.70	1.65	1.80	1.60	1.56	1.54	1.52	1.56	2-6
	10.1-14.99	2.50	2.50	2.50	2.50	2.50	2.35	2.25	1.90	1.90	2.10	4-10
	15 - <25	0.93	0.92	0.91	0.91	0.92	0.90	0.90	0.90	0.90	0.90	1-4
	> or = 25	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	1-4
24 (22V10)												
	6.1-7.5	6.50	6.45	6.40	6.38	6.43	6.35	6.30	6.25	6.20	6.28	0-2
	7.6-10.0	4.00	3.82	3.70	3.60	3.78	3.52	3.47	3.42	3.38	3.45	0-2
	15 - <25	2.60	2.50	2.40	2.35	2.46	2.40	2.50	2.70	2.80	2.60	1-4
	> or = 25	1.53	1.50	1.45	1.40	1.47	1.35	1.35	1.30	1.30	1.33	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 (September 1995)

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)	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
≤ 20						
	6.1-7.5	2.40	2.20	2.10	2.10	2.00
	7.6-10.0	1.29	1.21	1.15	1.15	1.10
	10.1-14.99	1.48	1.36	1.25	1.25	1.35
	15 - <25	0.68	0.70	0.70	0.70	0.75
	> or = 25	0.64	0.66	0.66	0.70	0.75
24						
	6.1-7.5	3.00	2.85	2.67	2.62	2.60
	7.6-10.0	1.80	1.56	1.50	1.45	1.40
	10.1-14.99	2.50	2.10	1.85	1.85	1.85
	15 - <25	0.92	0.90	0.91	0.91	0.91
	> or = 25	0.77	0.77	0.79	0.79	0.79
24 (22V10)						
	6.1-7.5	6.43	6.28	6.10	6.00	5.90
	7.6-10.0	3.78	3.45	3.40	3.40	3.20
	15 - <25	2.46	2.60	2.70	2.70	2.80
	> or = 25	1.47	1.33	1.30	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 price. These prices are intended as guidelines.
Source: Dataquest (September 1995)

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North American Semiconductor Price Outlook: Third Quarter 1995

Pricing Trends

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North American Semiconductor Price Outlook: Third Quarter 1995

Methodology and Sources

This 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 1995 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 Year; Package PLCC; Dollars)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74LS TTL											
74LS00	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.15	0-8
74LS74	0.17	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0-8
74LS138	0.19	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0-8
74LS244	0.27	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0-8
74AC TTL											
74AC00	0.21	0.21	0.20	0.20	0.21	0.20	0.20	0.20	0.20	0.20	0-8
74AC74	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0-8
74AC138	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0-8
74AC244	0.46	0.46	0.45	0.45	0.46	0.45	0.45	0.45	0.45	0.45	0-8
74F TTL											
74F00	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0-8
74F74	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0-8
74F138	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0-8
74F244	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0-8
74HC CMOS											
74HC00	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0-8
74HC74	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0-8
74HC138	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0-8
74HC244	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0-8
74ALS TTL											
74ALS00	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0-8
74ALS74	0.22	0.22	0.21	0.21	0.22	0.21	0.21	0.21	0.21	0.21	0-8
74ALS138	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0-8
74ALS244	0.42	0.42	0.41	0.41	0.42	0.41	0.41	0.41	0.41	0.41	0-8

(Continued)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74AS TTL											
74AS00	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0-8
74AS74	0.23	0.23	0.22	0.22	0.23	0.22	0.22	0.22	0.22	0.22	0-8
74AS138	0.48	0.48	0.47	0.47	0.48	0.47	0.47	0.47	0.47	0.47	0-8
74AS244	0.72	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0-8
74BC*											
74BC00	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0-8
74BC244	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0-8
74BC373	0.62	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0-8
74ACT244	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	6-8
74ACT245	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	6-8

*Pricing for 74BC excludes 74ABT and 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 (June 1995)

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

Product	Year 1995	Year 1996	Year 1997	Year 1998	Year 1999
74LS TTL					
74LS00	0.15	0.15	0.13	0.13	0.13
74LS74	0.16	0.17	0.15	0.15	0.15
74LS138	0.18	0.18	0.17	0.17	0.17
74LS244	0.26	0.27	0.26	0.26	0.26
74AC TTL					
74AC00	0.21	0.20	0.19	0.19	0.19
74AC74	0.23	0.23	0.21	0.21	0.21
74AC138	0.33	0.34	0.30	0.30	0.30
74AC244	0.45	0.45	0.40	0.40	0.40
74F TTL					
74F00	0.15	0.15	0.14	0.14	0.13
74F74	0.17	0.17	0.15	0.15	0.15
74F138	0.21	0.21	0.19	0.19	0.19
74F244	0.27	0.27	0.25	0.25	0.25
74HC CMOS					
74HC00	0.18	0.18	0.15	0.14	0.14
74HC74	0.20	0.20	0.18	0.18	0.18
74HC138	0.22	0.22	0.20	0.20	0.20
74HC244	0.30	0.30	0.28	0.27	0.27
74ALS TTL					
74ALS00	0.18	0.18	0.17	0.16	0.16
74ALS74	0.21	0.21	0.20	0.20	0.20
74ALS138	0.32	0.32	0.30	0.30	0.30
74ALS244	0.41	0.41	0.40	0.38	0.38
74AS TTL					
74AS00	0.21	0.21	0.20	0.20	0.20
74AS74	0.22	0.22	0.20	0.20	0.20
74AS138	0.47	0.47	0.45	0.45	0.45
74AS244	0.71	0.71	0.69	0.69	0.65
74BC*					
74BC00	0.25	0.25	0.24	0.24	0.22
74BC244	0.59	0.59	0.58	0.57	0.55
74BC373	0.61	0.61	0.59	0.59	0.57
74ACT244	0.47	0.47	0.45	0.45	0.44
74ACT245	0.51	0.51	0.48	0.48	0.45

*Pricing for 74BC excludes 74ABT and 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 (June 1995)

Table 3
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-, 16-, and 32-Bit25,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
68EC000-16 PLCC	5.35	5.35	5.35	5.35	5.35	5.00	5.00	5.00	5.00	5.00	4-8
68020-16 PQFP	18.50	18.50	18.50	18.50	18.50	17.50	17.50	17.50	17.50	17.50	4-8
68EC020-16 PQFP	9.45	9.45	9.45	9.45	9.45	8.75	8.75	8.75	8.75	8.75	4-8
68EC020-25 PQFP	9.98	9.98	9.98	9.98	9.98	9.10	9.10	9.10	9.10	9.10	4-8
68EC030-25 PQFP	23.00	23.00	23.00	23.00	23.00	21.00	21.00	21.00	21.00	21.00	3-5
68040-25	150.00	150.00	150.00	150.00	150.00	125.00	125.00	125.00	125.00	125.00	4-8
68LC040-25 CQFP 184	85.00	78.00	70.00	65.00	74.50	55.00	48.00	42.00	39.00	46.00	4-8
386SL-25 PQFP	40.00	40.00	40.00	40.00	40.00	36.00	36.00	36.00	36.00	36.00	4-10
AM386-40 PQFP*	26.00	24.00	23.00	22.00	23.75	21.00	20.00	19.00	18.00	19.50	6-12
80486SX-25 PQFP	49.50	45.00	40.00	35.00	42.38	30.00	25.00	25.00	20.00	25.00	4-10
80486DX-33 PQFP	90.00	82.00	72.00	68.00	78.00	55.00	45.00	38.00	32.00	42.50	4-10
80486DX-50	180.00	150.00	120.00	98.00	137.00	80.00	64.00	52.00	42.00	59.50	4-10
80486DX2-50 PQFP	90.00	72.00	58.00	49.00	67.25	41.00	33.00	27.00	24.00	31.25	4-10
80486DX2-66	128.00	105.00	83.00	68.00	96.00	56.00	46.00	45.00	45.00	48.00	4-10
80486DX4-75	185.00	170.00	145.00	122.00	155.50	97.00	80.00	68.00	56.00	75.25	4-10
Pentium-66	265.00	235.00	191.00	171.00	215.50	138.00	111.00	100.00	100.00	112.25	4-10
Pentium-75	285.00	260.00	216.00	174.00	233.75	140.00	112.00	100.00	100.00	113.00	8-12
Pentium-90	525.00	340.00	275.00	221.00	340.25	177.00	145.00	119.00	100.00	135.25	8-12
Pentium-100	665.00	431.00	345.00	276.00	429.25	221.00	176.00	141.00	113.00	162.75	10-14
PowerPC-601-66	129.00	129.00	121.00	113.00	123.00	109.00	101.00	90.00	85.00	96.25	4-8
PowerPC-601-80	192.00	187.00	177.00	161.00	179.25	148.00	135.00	122.00	110.00	128.75	4-8
PowerPC-601-100	375.00	352.00	314.00	285.00	323.75	248.00	224.00	205.00	190.00	213.50	8-12
Power PC 603-80	140.00	129.00	120.00	103.00	123.00	86.00	69.00	58.00	53.00	63.00	8-12
29000-252	58.00	55.00	52.00	49.00	53.50	45.00	42.00	39.00	35.00	40.25	4-8
88100-252	41.00	41.00	41.00	41.00	41.00	39.00	39.00	39.00	39.00	39.00	4-8

(Continued)

Table 3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-, 16-, and 32-Bit25,000 per Year; Dollars)
(Package: 8/16-Bit Devices—PDIP; 32-Bit Devices—Ceramic PGA; Exceptions Noted)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
R4000SC-50	425.00	405.00	385.00	375.00	397.50	370.00	355.00	340.00	320.00	346.25	4-8
R4400SC-75	660.00	610.00	575.00	515.00	590.00	495.00	475.00	450.00	425.00	461.25	4-8
SPARC-252	47.00	46.00	45.00	45.00	45.75	42.00	42.00	42.00	40.00	41.50	4-8
80960CA-25	55.00	50.00	48.00	45.00	49.50	45.00	45.00	42.00	42.00	43.50	4-10

*Estimated but not by survey
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 1995)

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

Product	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
68EC000-16 PLCC	5.35	5.00	4.75	4.50	NA
68020-16 PQFP	18.50	17.50	17.17	16.75	NA
68EC020-16 PQFP	9.45	8.75	8.50	7.80	7.30
68EC020-25 PQFP	9.98	9.10	8.45	8.00	7.50
68EC030-25 PQFP	23.00	21.00	19.00	17.00	NA
68040-25	150.00	125.00	110.00	100.00	NA
68LC040-25 CQFP 184	65.00	39.50	29.00	NA	NA
386SL-25 PQFP	40.00	36.00	31.00	28.00	NA
AM386-40 PQFP*	23.75	19.50	18.00	NA	NA
80486SX-25 PQFP	42.38	25.00	25.00	NA	NA
80486DX-33 PQFP	78.00	42.50	25.00	NA	NA
80486DX-50	137.00	59.50	35.00	NA	NA
80486DX2-50 PQFP	67.25	31.25	20.00	NA	NA
80486DX2-66	96.00	48.00	40.00	NA	NA
80486DX4-75	155.50	75.25	62.00	50.00	NA
Pentium-66	215.50	112.25	100.00	100.00	NA
Pentium-75	233.75	113.00	100.00	100.00	NA
Pentium-90	340.25	135.25	115.00	100.00	NA
Pentium-100	429.25	162.75	137.00	117.00	100.00
PowerPC-601-66	123.00	96.25	79.00	50.00	NA
PowerPC-601-80	179.25	128.75	97.00	77.00	50.00
PowerPC-601-100	344.75	213.50	174.00	123.00	94.00
Power PC 603-80	123.00	63.00	50.00	45.00	NA
29000-252	53.50	40.25	40.00	NA	NA
88100-252	41.00	39.00	35.00	NA	NA
R4000SC-50	397.50	346.25	205.00	155.00	120.00
R4400SC-75	590.00	461.25	369.00	295.00	236.00
SPARC-252	45.75	41.50	37.00	NA	NA
80960CA-25	49.50	43.50	40.00	NA	NA

NA = Not available
*Estimated but not by survey
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 1995)

Table 5
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; U.S. Dollars)*

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Times (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.10	4.10	4.15	4.20	4.14	4.20	4.20	4.10	4.10	4.15	8-Allocation
256Kx4 DRAM 60ns SOJ	4.20	4.35	4.40	4.50	4.36	4.50	4.50	4.55	4.55	4.53	Allocation
4Mbx1 DRAM 70ns SOJ	12.40	12.60	12.70	12.75	12.61	12.60	11.73	11.00	10.50	11.46	8-Allocation
1Mbx4 DRAM 60ns SOJ	12.66	13.10	13.25	13.35	13.09	13.15	12.60	12.25	11.80	12.45	8-Allocation
512Kx8 DRAM 70ns	14.14	14.46	15.10	15.22	14.73	15.06	14.48	13.21	13.00	13.94	8-Allocation
256Kx16 DRAM 70ns SOJ	14.75	14.80	15.55	15.57	15.17	15.20	15.00	14.50	14.00	14.68	10-Allocation
4Mbx4 DRAM 70ns SOJ 300 mil	47.63	47.75	48.25	48.51	48.04	46.75	44.30	40.10	36.85	42.00	8-Allocation
1Mbx16 DRAM 60ns TSOP 300 mil	53.62	53.90	54.30	54.50	54.08	52.50	49.90	46.35	43.90	48.16	10-Allocation
2Mbx8 DRAM 60ns TSOP 300mil	51.38	51.82	52.25	52.26	51.93	50.59	47.23	40.91	38.15	44.22	12-Allocation
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	35.25	37.55	37.75	38.58	37.28	36.43	35.51	34.44	32.60	34.75	12-Allocation
4Mbx9 SIMM 2 (4Mbx4) +1 (4Mbx1)	116.50	119.36	119.67	120.08	118.90	113.25	106.13	104.45	89.03	103.22	12-Allocation
1Mbx36 SIMM 9 (1Mbx4)	121.00	124.42	127.25	128.06	125.18	124.36	120.69	118.25	115.73	119.76	10-Allocation
1Mbx32 SIMM 8 (1Mbx4)	118.00	114.80	115.22	116.80	116.21	113.20	107.80	104.73	100.40	106.53	8-Allocation
1Mbx32 SIMM 2 (1Mbx16)	112.91	117.81	117.94	118.01	116.67	112.44	106.79	101.36	93.80	103.60	10-Allocation

(Continued)

Table 5 (Continued)
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; U.S. Dollars)*

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Times (Weeks)
256Kx4 VRAM 70ns SOJ	5.57	6.10	6.20	6.20	6.02	6.30	6.20	6.10	6.00	6.15	12-Allocation
128Kx8 VRAM 70ns SOJ	6.21	6.30	6.50	6.60	6.40	6.55	6.50	6.40	6.35	6.45	12-Allocation
256Kx16 VRAM 70ns SOP	25.00	25.00	27.00	28.00	26.25	27.00	26.00	25.00	24.00	25.50	10-Allocation

*Contract Volume = at least 100,000 per order except VRAMs
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 1995)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1995	1996	1997	1998	1999
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.14	4.15	4.15	4.15	4.20
256Kx4 DRAM 60ns SOJ	4.36	4.53	4.55	4.65	NA
4Mbx1 DRAM 70ns SOJ	12.61	11.46	7.47	7.25	7.05
1Mbx4 DRAM 60ns SOJ	13.09	12.45	8.45	8.22	8.01
512Kx8 DRAM 70ns	14.73	13.94	12.00	11.60	11.50
256Kx16 DRAM 70ns SOJ	15.17	14.68	13.00	12.20	12.00
4Mbx4 DRAM 70ns SOJ 300 mil	48.04	42.00	30.32	22.76	18.65
1Mbx16 DRAM 60ns TSOP 300 mil	54.08	48.16	35.43	25.20	19.86
2Mbx8 DRAM 60ns TSOP 300mil	51.93	44.22	31.11	22.41	18.75
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	37.28	34.75	27.39	25.34	25.60
4Mbx9 SIMM 2 (4Mbx4) A182+1 (4Mbx1)	118.90	103.22	63.92	52.82	51.24
1Mbx36 SIMM 9 (1Mbx4)	125.18	119.75	83.05	80.98	79.09
1Mbx32 SIMM 8 (1Mbx4)	116.21	106.53	73.60	71.76	71.08
1Mbx32 SIMM 2 (1Mbx16)	116.67	103.60	78.54	57.40	46.53
256Kx4 VRAM 70ns SOJ	6.02	6.15	6.00	6.10	6.10
128Kx8 VRAM 70ns SOJ	6.40	6.45	6.20	6.30	6.30
256Kx16 VRAM 70ns SOP	26.25	25.50	20.00	18.00	15.00

NA = Not available
*Contract volume = at least 100,000 per order except VRAMs
Note: Actual negotiated merket 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 1995)

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	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
16Kx4 35ns	3.90	3.60	3.30	3.00	3.45	2.87	2.73	2.66	2.60	2.72	16
8Kx8 25ns	2.96	2.90	2.90	2.90	2.92	2.77	2.63	2.55	2.50	2.61	8-10
8Kx8 100-120ns	1.78	1.80	1.80	1.85	1.81	1.80	1.80	1.80	1.80	1.80	Allocation
64Kx4 10ns	8.38	6.28	5.00	4.90	6.14	4.00	3.80	3.72	3.65	3.79	4-10
64Kx4 25ns	5.20	5.10	4.81	4.73	4.96	3.82	3.65	3.57	3.51	3.64	10-Allocation
32Kx8 12ns	6.67	5.89	5.32	4.43	5.58	4.31	4.27	4.15	3.86	4.15	4-16
32Kx9 12ns Burst	14.00	14.00	14.00	14.00	14.00	13.00	13.00	13.00	13.00	13.00	Allocation
32K x 8, 15ns, 5V	4.00	4.00	4.00	4.00	4.00	3.53	3.35	3.32	3.29	3.37	10-14
32K x 8,15ns, 3.3V	6.05	6.00	6.00	6.00	6.01	5.41	4.59	4.14	4.04	4.55	2-8
32Kx8 25ns	3.72	3.72	3.70	3.70	3.71	3.55	3.53	3.50	3.50	3.52	6-12
32Kx8 70-100ns SOJ	3.14	3.50	3.50	3.50	3.41	3.00	3.00	3.00	3.00	3.00	12
64Kx18 12ns Burst	35.00	35.00	35.00	35.00	35.00	33.00	33.00	30.67	28.33	31.25	4-8
256Kx4 20ns	14.90	14.83	14.30	14.25	14.57	14.09	13.93	13.77	13.77	13.89	Allocation
128K x 8, 15ns	19.25	18.31	17.30	17.25	18.03	16.72	16.42	15.08	14.75	15.74	Allocation
128Kx8 20ns	16.50	16.33	16.27	16.18	16.32	15.58	15.33	14.00	13.50	14.60	8-Allocation
128Kx8 25ns	13.34	13.30	13.28	13.25	13.29	13.16	12.87	12.53	12.33	12.72	Allocation
128Kx8 70-100ns SOJ	8.47	8.38	8.32	8.30	8.37	7.64	7.25	6.89	6.55	7.08	Allocation

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 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
16Kx4 35ns	3.45	2.72	2.50	2.50	2.60
8Kx8 25ns	2.92	2.61	2.65	2.65	2.70
8Kx8 100-120ns	1.81	1.80	1.90	1.93	1.93
64Kx4 10ns	6.14	3.79	3.50	3.50	3.25
64Kx4 25ns	4.96	3.64	3.00	3.00	3.00
32Kx8 12ns	5.58	4.15	3.41	3.10	3.10
32Kx9 12ns Burst	14.00	13.00	10.00	9.00	7.00
32K x 8, 15ns, 5V	4.00	3.37	3.12	3.05	3.05
32K x 8,15ns, 3.3V	5.41	4.55	3.58	3.35	3.05
32Kx8 25ns	3.71	3.52	3.16	3.00	3.00
32Kx8 70-100ns SOJ	3.41	3.00	2.45	2.45	2.55
64Kx18 12ns Burst	35.00	31.25	25.00	25.00	25.00
256Kx4 20ns	14.57	13.89	9.29	6.80	5.55
128K x 8, 15ns	18.03	15.74	8.71	6.88	5.76
128Kx8 20ns	16.32	14.60	8.50	6.70	5.50
128Kx8 25ns	13.29	12.72	8.25	6.50	5.40
128Kx8 70-100ns SOJ	8.37	7.08	6.00	6.00	6.00

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 price guidelines.
Source: Dataquest (June 1995)

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	Q1 1995	Q2	Q3	Q4	Year 1995	Q1 1996	Q2	Q3	Q4	Year 1996	Lead Time (Weeks)
128Kx8 ROM	1.66	1.85	1.85	1.85	1.80	1.80	1.80	1.75	1.70	1.76	5-8
64Kx16 ROM	2.08	2.08	2.10	2.10	2.09	2.08	2.05	2.05	2.05	2.06	5-8
256Kx8 ROM	2.53	2.60	2.60	2.60	2.58	2.55	2.50	2.45	2.40	2.48	5-8
512Kx8 ROM	3.33	3.35	3.35	3.35	3.35	3.30	3.18	3.08	3.00	3.14	5-8
256Kx16 ROM1	3.25	3.30	3.30	3.30	3.29	3.25	3.10	3.00	2.90	3.06	5-8
1Mbx8 ROM2	4.80	5.21	5.45	5.45	5.23	5.25	5.20	4.93	4.48	4.97	6-10
1Mbx16 ROM	8.20	8.20	8.15	8.10	8.16	7.99	7.53	7.25	6.65	7.36	6-10
2Mbx8 ROM	8.20	8.20	8.15	8.10	8.16	7.99	7.53	7.25	6.65	7.36	6-10
21Mbx8 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 (June 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
128Kx8 ROM	1.80	1.76	1.62	1.62	1.60
64Kx16 ROM	2.09	2.06	2.05	2.05	2.08
256Kx8 ROM	2.58	2.48	2.40	2.40	2.45
512Kx8 ROM	3.35	3.14	2.60	2.50	2.50
256Kx16 ROM1	3.29	3.06	2.55	2.45	2.45
1Mbx8 ROM2	5.23	4.97	4.25	4.00	4.00
1Mbx16 ROM	8.16	7.36	5.40	4.98	4.52
2Mbx8 ROM	8.16	7.36	5.40	4.98	4.52
1256Kx16 ROM: 150ns and above; 40-pin PDIP					
21Mbx8 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 (June 1995)

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

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
32Kx8 EPROM	1.55	1.65	1.75	1.75	1.68	1.60	1.60	1.63	1.63	1.62	4-8
64Kx8 EPROM	1.90	1.92	1.95	1.93	1.93	1.90	1.90	1.90	1.90	1.90	4-8
128Kx8 EPROM	2.58	2.60	2.63	2.63	2.61	2.60	2.55	2.50	2.50	2.54	4-10
256Kx8 EPROM	4.62	4.70	4.75	4.80	4.72	4.80	4.75	4.60	4.50	4.66	4-10
128Kx16 EPROM	4.85	5.55	6.21	6.50	5.78	6.50	6.31	5.19	4.60	5.65	4-10
512Kx8 EPROM	7.00	7.62	8.01	8.20	7.71	8.20	7.96	7.36	6.82	7.59	4-10
256Kx16 EPROM	9.15	10.23	11.16	11.43	10.49	11.20	11.20	11.00	10.85	11.06	4-8

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 price guidelines.
Source: Dataquest (June 1995)

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	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
32Kx8 EPROM	1.68	1.62	1.80	1.90	2.00
64Kx8 EPROM	1.93	1.90	2.10	2.40	2.50
128Kx8 EPROM	2.61	2.54	2.65	2.75	2.95
256Kx8 EPROM	4.72	4.66	4.30	4.30	4.25
128Kx16 EPROM	5.78	5.65	4.55	4.55	4.46
512Kx8 EPROM	7.71	7.59	6.55	6.35	6.35
256Kx16 EPROM	10.49	11.06	9.35	8.25	8.15

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 1995)

Table 13
Estimated Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Times (Weeks)
64Kx8, PDIP/PLCC	3.90	3.90	3.88	3.83	3.88	3.51	3.43	3.35	3.28	3.23	6-20
64Kx8, TSOP	3.95	3.95	3.93	3.88	3.94	3.86	3.51	3.35	3.28	3.23	6-20
128Kx8, PDIP/PLCC	4.53	4.50	4.50	4.42	4.49	4.22	3.97	3.75	3.63	3.89	6-20
128Kx8, TSOP	4.82	4.98	4.76	4.56	4.78	4.23	4.07	3.98	3.78	4.02	4-17
256Kx8, TSOP, 12volt	7.78	9.85	9.90	9.90	9.32	9.75	9.55	9.13	8.18	9.15	6-16
256Kx8, TSOP, 5V	10.20	10.65	10.79	10.79	10.61	10.57	10.57	9.93	9.68	10.19	6-20
512Kx8, PDIP/PLCC	10.30	10.80	11.20	11.60	10.98	11.60	10.55	9.63	8.38	10.04	6-16
512Kx8, TSOP, 12V	10.80	11.30	11.70	12.30	11.53	12.20	11.13	10.22	8.64	10.55	4-16
512Kx8, TSOP, 5V	16.61	16.13	16.04	15.88	16.17	15.07	14.74	13.53	12.42	13.94	6-20
1Mbx8 TSOP	19.22	19.20	19.00	18.56	19.00	17.61	16.52	15.47	14.08	15.92	6-12
2Mbx8 TSOP	51.67	50.00	47.92	45.00	48.65	41.34	36.84	25.38	24.44	32.00	6-20

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 (June 1995)

Table 14
Estimated Long-Range Flash Memory Price Trends—North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
64Kx8, PDIP/PLCC	3.88	3.38	2.50	2.50	2.60
64Kx8, TSOP	3.94	3.42	2.50	2.50	2.60
128Kx8, PDIP/PLCC	4.49	3.89	2.95	2.75	2.55
128Kx8, TSOP	4.78	4.02	3.05	2.75	2.55
256Kx8, TSOP, 12volt	9.32	9.15	5.46	4.25	3.50
256Kx8, TSOP, 5V	10.61	10.19	6.46	4.75	4.05
512Kx8, PDIP/PLCC	10.98	10.04	6.45	5.45	4.54
512Kx8, TSOP, 12V	11.53	10.55	6.55	5.45	4.54
512Kx8, TSOP, 5V	16.17	13.94	9.33	7.25	5.48
1Mbx8 TSOP	19.00	15.92	9.75	6.25	5.50
2Mbx8 TSOP	48.65	32.00	16.81	12.25	10.86

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 (June 1995)

Table 15
Estimated Gate Array Pricing (5K to 19.99K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.9K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS							
1.0 Micron	63	54	52	54	46	42	7-17
0.8 Micron	51	43	40	50	43	39	7-17
0.6 /0.5 Micron	58	49	46	50	43	39	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							
1.0 Micron	26	25	25	45	43	43	2-7
0.8 Micron	30	29	29	50	48	43	2-3
0.6 /0.5 Micron	33	31	30	52	49	44	3-5
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Volume prices: For 100,000 units or greater, discount the prices by 30 to 40 percent.
Source: Dataquest (June 1995)

Table 16
Estimated Gate Array Pricing (20K to 100K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test aud Excludes Special Test)

	20-29.99K Gates			0-59.9K Gates			60-100K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	55	47	45	58	49	49	56	48	48	7-17
0.8 Micron	46	39	35	44	37	34	46	39	35	7-17
0.6 /0.5 Micron	45	38	34	40	34	31	38	32	30	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	39	33	28	12-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	63	60	60	87	83	83	125	119	119	2-7
0.8 Micron	67	64	64	90	86	86	104	99	99	2-3
0.6 /0.5 Micron	62	59	53	93	88	80	113	107	100	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	120	114	101	5-8

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 price guidelines
Volume prices: For 100,000 units or greater, discount the prices by 30 to 40 percent.
Source: Dataquest (June 1995)

Table 17
Estimated CBIC Pricing (5K to 19.99K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) Includes Standard Commercial Test and Excludes Special Test)

	5-9.99K Gates			10-19.99 Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS							Production:
1.0 Micron	63	54	52	54	46	42	12-18
0.8 Micron	50	43	40	49	42	38	9-18
0.6 /0.5 Micron	57	48	46	49	42	38	14-21
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	48	46	46	70	67	67	6-9
0.8 Micron	54	51	51	70	67	67	5-7
0.6 /0.5 Micron	60	57	57	77	73	73	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines. Source: Dataquest (June 1995)

Table 18
Estimated CBIC Pricing (20K to 100K Gates)—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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

	20-29.99K Gates			30-599K Gates			60-100K Gates			
Gate Count Technology	1995	1996	1997	1995	1996	1997	1995	1996	1997	Lead Time (Weeks)
CMOS										Production:
1.0 Micron	65	55	53	66	56	54	68	58	56	9-18
0.8 Micron	46	39	35	44	37	34	50	43	39	9-18
0.6 /0.5 Micron	44	37	34	39	33	31	37	31	30	14-20
0.3 Micron	NA	NA	NA	NA	NA	NA	38	32	28	14-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	85	81	79	100	95	93	121	115	115	6-10
0.8 Micron	85	81	79	95	90	89	118	112	110	4-7
0.6 /0.5 Micron	89	85	83	96	91	84	122	116	109	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	110	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 price guidelines.
Source: Dataquest (June 1995)

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

		1995				1995	1996				1996	
Pin Count	Speed* (ns)	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	Lead Time (Weeks)
≤20												
	6.1-7.5	2.40	2.40	2.40	2.40	2.40	2.20	2.20	2.20	2.20	2.20	2-10
	7.6-10.0	1.32	1.32	1.25	1.25	1.29	1.22	1.22	1.20	1.20	1.21	2-8
	10.1-14.99	1.40	1.40	1.55	1.55	1.48	1.40	1.40	1.33	1.30	1.36	4-10
	15 - <25	0.68	0.68	0.68	0.68	0.68	0.70	0.70	0.70	0.70	0.70	1-4
	> or = 25	0.64	0.64	0.64	0.64	0.64	0.66	0.66	0.66	0.66	0.66	0-2
24												
	6.1-7.5	3.00	3.00	3.00	3.00	3.00	2.90	2.90	2.80	2.80	2.85	0-2
	7.6-10.0	1.95	1.90	1.70	1.65	1.80	1.60	1.56	1.54	1.52	1.56	2-6
	10.1-14.99	2.50	2.50	2.50	2.50	2.50	2.35	2.25	1.90	1.90	2.10	4-10
	15 - <25	0.93	0.92	0.91	0.91	0.92	0.90	0.90	0.90	0.90	0.90	1-4
	> or = 25	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	1-4
24 (22V10)												
	6.1-7.5	6.50	6.45	6.40	6.38	6.43	6.35	6.30	6.25	6.20	6.28	0-2
	7.6-10.0	4.00	3.82	3.70	3.60	3.78	3.52	3.47	3.42	3.38	3.45	0-2
	15 - <25	2.60	2.50	2.40	2.35	2.46	2.40	2.50	2.70	2.80	2.60	1-4
	> or = 25	1.53	1.50	1.45	1.40	1.47	1.35	1.35	1.30	1.30	1.33	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 1995)

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)	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
≤ 20						
	6.1-7.5	2.40	2.20	2.10	2.10	2.00
	7.6-10.0	1.29	1.21	1.15	1.15	1.10
	10.1-14.99	1.48	1.36	1.25	1.25	1.35
	15 - <25	0.68	0.70	0.70	0.70	0.75
	> or = 25	0.64	0.66	0.66	0.70	0.75
24						
	6.1-7.5	3.00	2.85	2.67	2.62	2.60
	7.6-10.0	1.80	1.56	1.50	1.45	1.40
	10.1-14.99	2.50	2.10	1.85	1.85	1.85
	15 - <25	0.92	0.90	0.91	0.91	0.91
	> or = 25	0.77	0.77	0.79	0.79	0.79
24 (22V10)						
	6.1-7.5	6.43	6.28	6.10	6.00	5.90
	7.6-10.0	3.78	3.45	3.40	3.40	3.20
	15 - <25	2.46	2.60	2.70	2.70	2.80
	> or = 25	1.47	1.33	1.30	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 price. These prices are intended as guidelines.
Source: Dataquest (June 1995)

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Competitive Dynamics

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Product Analysis

ASIC Products and Market Update: Profitability Correlates with Strong Demand Levels

Abstract: *This article highlights the current status of the ASIC industry and notes important developments in this critical semiconductor market from a user's perspective. We provide analysis using the latest market data, product life cycle, supplier base, and market outlook information. Strategic recommendations are then made to users.*
By Mark Giudici

ASIC Suppliers a Happy Group as Users Demand Ever-Higher Levels of Customized Quick-Turn ICs

Application-specific integrated circuits (ASICs) at various times have been thought to be the end-all solution for glue logic, proprietary functionality, and system interconnect problems. ASICs have evolved into a mature and realistic IC consolidation/competitive cost solution to system design. The past four years witnessed a market shakeout and subsequent profitable period for the survivors. ASIC suppliers still in the market now are consolidating market presence by keeping in step with costly state-of-the-art process technology. This market is not for the faint of heart—suppliers' price cut wounds are now healing. Suppliers experienced increased volumes and profits in 1994 for the second year running because users better understand the advantages and limitations of ASIC solutions.

This article provides ASIC users with practical and strategic information for choosing devices, technologies, and suppliers. This analysis comprises three sections. The first serves as a guide to cost-effective, long-term procurement by analyzing the ASIC technology migration path. The second section reviews the product strategies and the merchant/captive market situation of the leading ASIC suppliers. The third section combines the

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analysis of the ASIC life cycles and the supplier base. This arrangement provides a concise way of assessing the market dynamics of the ASIC industry and how to best obtain these devices for the remainder of this decade. The goal of this article is to enable ASIC users to best meet their needs for these critical devices with a sound strategy that will provide a cost-effective, stable, and long-term supply despite shifts in the market.

Definitions

An ASIC is a logic product customized for a single user. Dataquest defines an ASIC to include: gate arrays, cell-based integrated circuits (CBICs), programmable logic devices (PLDs), and full-custom ICs. Dataquest defines gate arrays 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 customized digital or mixed-linear/digital ICs that use a full set of masks; the device consists of precharacterized cells or macros including standard cells, megacells, and compilable cells customized by using automatic place and route. PLDs are ASIC devices programmed after assembly. This market segment does not include memory devices such as PROMs and ROMs. There are three subgroups within the PLD definition. Mature PLD products are low-density, usually bipolar devices, while newer-technology CMOS PLDs include field-programmable gate arrays (FPGAs) and complex PLDs with densities up to 40,000-plus gates. Full-custom devices are ASICs customized using a full set of masks and using manual place and route.

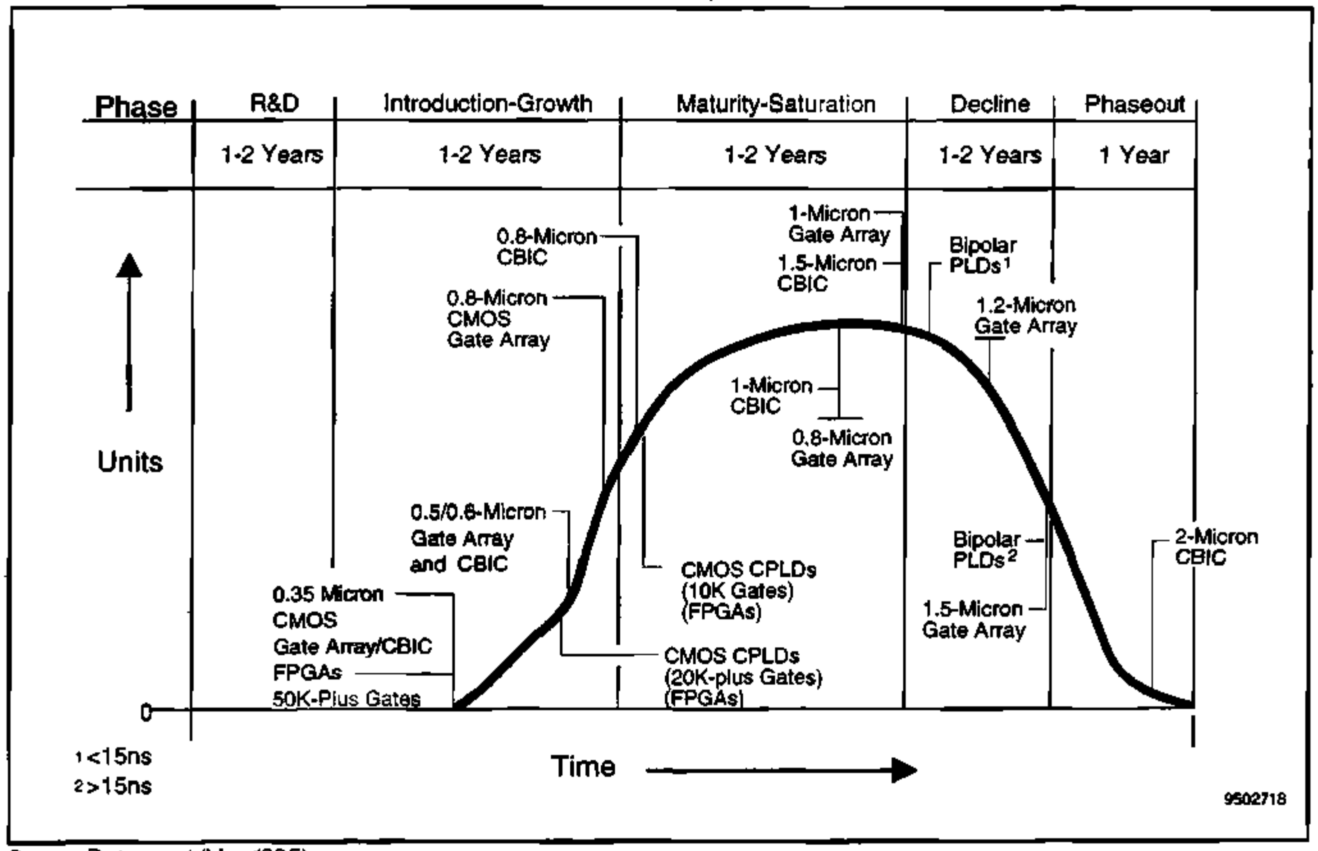
ASIC Technology Life Cycles

This section uses information on ASIC product life cycles as a guide to assist users in adjusting to forces affecting the marketplace during the short and long term. Because an ASIC is as much a technology as a specific product, this market does not lend itself well to traditional product life-cycle analysis. Nevertheless, a look at ASIC product/technology life-cycle curves can assist users in positioning ASIC products with other IC life cycles such as standard logic or microprocessors. For example, although any given gate array product offering is not 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 illustrates the product/technology life-cycle curve for the ASIC market (gate arrays, CBICs, complex PLDs, and simple PLDs) as of May 1995. The ASIC product/technology life cycle is generally shorter than most IC life cycles, running from four to seven years, excluding R&D.

The life cycle of ASICs now in the growth stage should extend into the year 2001 (a space odyssey). As seen in Figure 1, this arena consists primarily of submicron silicon technology and niche BiCMOS and gallium-arsenide (GaAs) families. Dataquest expects CMOS to remain the predominant ASIC technology of the future because of many factors (mainly cost). The CMOS versus BiCMOS and GaAs battle continues to favor CMOS because of speed and lower power enhancements that continue to push out the more costly (real or perceived) BiCMOS and GaAs solutions. Although extremely competitive, the ASIC market greatly benefited from the continued strength of the data processing market in 1994. Every segment, save bipolar, grew aggressively as consolidations of subsystems increased very strongly last year, continuing the trend set in 1993.

Figure 1
ASIC Product/Technology Life Cycles as of May 1995 (Production Unit Volume)



Source: Dataquest (May 1995)

Only the 0.8-micron CBIC family migrated into the maturity-saturation segment of the 1994 life-cycle curve as the user community attempted to digest the attractively priced offerings brought to market over the past two years. Many of the older technologies migrated from maturity into the decline phase since our last report. The decline portion of the curve increased with the addition of fast (less than 15ns) PLDs, 1.0-micron gate arrays, and 1.5-micron CBICs, while the slower PLD products and 1.5-micron gate arrays barely remain in the decline segment. The phaseout group now includes only the 2.0-micron CBIC family because both 2- and 3-micron gate arrays and CBICs have now slipped off the life-cycle curve. Any company using products in (or beyond) this phaseout segment should seriously plan on end-of-life buying strategies or rapidly design in newer technologies as the supply base for these products continues to shrink. Depending on the product or supplier, support beyond the end of this year for these parts is questionable.

Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of ASIC products. This analysis covers product positioning, market rankings, geographic focus, and related issues. Table 1 highlights Dataquest's final 1994 worldwide ASIC market share ranking of the top 10 suppliers in terms of revenue. This table serves as the background for the analysis of the top 10 suppliers and also for the product life cycle/supplier base discussion.

Table 1
ASIC Supplier Ranking (Factory Revenue in U.S. Dollars)

			Product Ranking			
1994 Overall Ranking	Market Share (%)	Company	Gate Arrays MOS/BiCMOS	Bipolar	CBIC MOS/ BiCMOS	PLDs MOS/ BiCMOS
1	10.0	NEC	1	3	8	-
2	8.8	Fujitsu	3	1	11	-
3	7.6	LSI Logic	2	-	6	-
4	6.5	Toshiba	4	-	9	-
5	5.7	IBM	6	-	3	-
6	5.5	Texas Instruments	8	16	2	8
7	5.2	AT&T	-	5	1	7
8	5.2	Hitachi	5	2	15	-
9	3.4	VLSI	10	-	4	-
10	3.0	Xilinx	-	-	-	1
Segment Subtotals (Billions of Dollars)			4.52	0.82	4.11	1.13
Total Market (Billions of Dollars)*	10.84					

*Includes some segments not shown
Source: Dataquest (May 1995)

Last year saw another stellar growth year in the ASIC market (18.9 percent), following the very strong market (17.4 percent growth, excluding IBM) in 1994. The North American market pulled the market for the most part, with 14 percent regional growth, followed by Japan with 28 percent growth. Japan's dollar growth was inflated partially because of the yen's 8 percent rise in value in 1994, however. The Asia/Pacific companies moderated their growth to a very healthy 28.1 percent, compared with 1993, while European companies grew a by a lackluster 8.8 percent in 1994.

NEC

Bolstered by strong MOS/BiCMOS gate array sales, NEC extended its lead as the No. 1 ASIC supplier in 1994. Although hindered somewhat by the lingering domestic recession and a slower-responding vertically integrated corporate structure, NEC last year surpassed gate array market leader LSI Logic even though increased sales came primarily from internal divisions and yen appreciation. NEC slipped to the No. 3 bipolar gate array supplier, primarily supporting its internal mainframe computer division with these high-speed, power-hungry devices. Reinforcing its commitment to the CBIC market, NEC rose to the No. 8 position after slipping to the No. 10 position in 1992 primarily because of increased Japanese and European demand. NEC remains very dedicated to the merchant market by providing top technology at competitive prices while still providing almost half of its ASIC production to internal divisions.

Fujitsu

Combine a lingering Japanese recession with a strong dependence on internal mainframe computer sales growth and the main reason Fujitsu maintained its No. 2 worldwide position ASIC supplier position in 1994 is provided. Although Fujitsu grew 15 percent in overall sales, compared with 1993, this was the second lowest level of growth of the top five ASIC suppliers. It remains the top supplier of bipolar gate arrays. However, the bipolar gate array market declined 6 percent last year. Fujitsu maintained its No. 3 ranking as a MOS/BiCMOS gate supplier while slipping from No. 6-ranked CBIC supplier to No. 11, despite putting increased attention toward the CBIC market into the Japanese market. Fujitsu's heavy dependence on internal mainframe computer sales allowed for strong growth in past years and resulted in a fluke rise in 1994 revenue unlikely to recur.

LSI Logic

Although NEC is the largest total ASIC supplier, LSI Logic remains the largest merchant market ASIC supplier. Last year was an excellent one for LSI as it posted its strongest financial report on record. LSI maintained its ranking as the overall No. 3 ASIC supplier, yet slipped to No. 2 as worldwide MOS/BiCMOS gate array suppler and dramatically rose to the No. 6 (from No. 11) position as a MOS/BiCMOS CBIC supplier. LSI's commitment to supplying the market with the highest level of technology in both the gate array and CBIC markets continues to remain the cornerstone of its long-term strategy. Unlike many of its competitors, LSI is not hindered with mainframe computer product encumbrances, which allows it to focus on customer partnering, megacells, library cells, and intellectual property.

Toshiba

Toshiba rose to the No. 4-ranked ASIC supplier position largely because of its focus on customer (not internal) MOS gate array needs. Its past emphasis on the North American market that demands very high-gate-count CMOS gate arrays allowed this Japanese supplier to have the highest growth rate of the top five suppliers (29 percent). Toshiba's widely publicized three-day turnaround for prototype gate arrays (at a very low premium) increased market awareness for the company as being both a volume and quick-turn supplier. While maintaining its No. 4 position in the MOS/BiCMOS gate array segment, Toshiba also maintained its No. 9 CBIC ranking. Toshiba continues to focus on cutting-edge, high-gate-count CMOS and BiCMOS gate arrays primarily for the merchant market and will remain a stable supplier of these parts. It also will continue to focus on domestic CBIC sales as Japanese applications increasingly turn to this ASIC solution.

IBM

Climbing from No. 6 to No. 5 in overall 1994 ASIC sales, IBM continues to focus on very-high-end ASIC solutions. IBM remains on plan at being a strategic supplier of high-density, cost-effective CMOS gate arrays and CBICs. Shifting from a captive supplier into the merchant market is not an easy task, and IBM is not immune to some of the problems other large companies faced in this transition. IBM's aggressive goal is to have its ASIC business equally split between internal and external customers by year-end 1996. The company has the tools to reach this ambitious goal via its design, process technology, and fab capacity, and is rapidly working to market its strengths to an increasingly sophisticated audience.

Texas Instruments

Texas Instruments (TI) slipped to the No. 6 position as an overall ASIC supplier, despite its shift in emphasis on the gate array market. TI's strong No. 2 presence in the CBIC market was unchanged as it continues to capitalize on its large cell library and advanced design tool support. Reflecting a focus on the MOS/BiCMOS gate array market, the company rose to the No. 8 worldwide supplier position last year. While TI focused on the growing MOS/BiCMOS gate array market, and to a lesser extent CBICs, it gained market position despite de-emphasizing the bipolar gate array market. TI rose to No. 16 in that shrinking market. TI sold its PLD business to Actel and will continue to focus on its core competencies, MOS CBICs and gate arrays. We expect TI to continue focusing on its strengths, MOS/BiCMOS gate array design technology, while continuing to support its aging CBIC and bipolar gate array offerings.

AT&T

Ranked No. 7 overall, AT&T continued to hold its own in the CBIC market and remained the top-ranked worldwide CBIC supplier. The company also remains the No. 5-ranked bipolar gate array supplier. AT&T continues to focus on the burgeoning FPGA market, where it rose from No. 8 to become the No. 7 worldwide MOS/BiCMOS PLD supplier. Although the CBIC market remains a steady, growing market for AT&T, its 31 percent growth in the FPGA arena highlights the commitment the company has for this rapidly expanding ASIC segment. AT&T's focus will remain on its CMOS/BiCMOS CBICs, with emphasis placed on its current and future FPGA product lines.

Hitachi

Ranked No. 8 overall, Hitachi rose to be the No. 5 largest MOS/BiCMOS gate array supplier and also rose to be the No. 15 CBIC supplier in 1994. It continues to focus on the domestic Japanese market, where high-volume use of CBICs is becoming more popular. More than two-thirds of its gate array production still goes toward internal consumption, leaving a small merchant market offering of relatively expensive products. Hitachi has now shifted emphasis from BiCMOS to straight CMOS gate array offerings, responding to market demand for a more cost-effective, high-performance gate array solution.

VLSI Technology

Ranked No. 9 overall, ASIC supplier VLSI maintained its position in 1994 by having offsetting gains and losses in the respective CBIC (up 32 percent) and gate array (down 25 percent) markets. The company's overall ASIC market share of 3.4 percent slipped because it grew only 8 percent (less than half of the worldwide ASIC growth of 19 percent) in 1994. VLSI continues to support both CBIC and advanced gate array offerings and remains committed to these markets.

Xilinx

The dramatic rise of Xilinx into the top 10 worldwide ASIC suppliers is a result of its focus on the high-density programmable logic market. Xilinx provides the ASIC market a viable alternative to low-gate-count gate arrays for prototype, initial production, and short-model-life products. Traditionally seen as low-gate-count devices, FPGAs are now reaching and exceeding the 40,000-gate barrier, and Xilinx is the No. 1 ranked supplier in this exploding market category. The MOS/BiCMOS PLD (dominated by FPGAs) market grew by 23 percent, while Xilinx grew at a blistering 39 percent by supplying high-gate-count and production volume low- to midgate-count product.

Supply Base Analysis

This section uses information on ASIC product/technology life cycles and suppliers in presenting a product family evaluation of the supply base over the long term for MOS/BiCMOS gate arrays, CBICs, and PLDs. The goal of this section is to provide users with a practical means of gauging the long-term supply and direction for these ASICs, and to help in selecting suppliers for these devices.

Each segment contains a table showing the size of the market in terms of factory revenue during 1994, 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 expected availability of MOS/BiCMOS gate arrays, MOS/BiCMOS CBICs, and MOS/BiCMOS PLDs. The summary includes a statement on whether the user faces a favorable or critical supply base for each product technology. Building on the prior sections, we now discuss factors affecting the supply base, such as supplier strategies.

Supply Base for MOS/BiCMOS Gate Arrays

Table 2 highlights the major players and the size of the MOS/BiCMOS gate array market. Worldwide factory revenue grew a healthy 19 percent in 1994 after 1993's strong rebound of 22 percent growth. The top five suppliers account for nearly 60 percent (58.7 percent) of the overall market.

Table 2
Supply Base for MOS/BiCMOS Gate Arrays (Percentage Share of Factory Revenue)

Company	Market Share (%)
NEC	15.6
LSI Logic	12.7
Fujitsu	12.0
Toshiba	11.6
Hitachi	6.8
IBM	6.2
Motorola	4.1
Texas Instruments	3.6
Mitsubishi	3.1
VLSI Technology	2.3
Others	21.9
Total	100.0
Total Market (Billions of Dollars)	4.52

Source: Dataquest (May 1995)

Workhorse Gate Array Technology Remains at 0.8 to 1.0 Microns

Figure 1 illustrated how the mainstream technology remains at the 0.8- to 1.0-micron range, and we expect it to remain there for next few years. For gate arrays with densities of more than 20,000 gates, the 0.8-micron technology will remain the production leader through 1996, after which the 0.6-micron technology families will begin production ramp-ups.

Users of submicron gate arrays can expect ample supplies of these devices from the top suppliers for the foreseeable future. As the shift to higher-speed and lower-power systems continues, many users of the 0.6- and 0.5-micron technology will benefit from the inherent lower-voltage advantages of these parts.

Users of 1.2- and 1.5-micron devices still have selected supplier support, but should soon plan to compare estimated system production/spares requirements with the shrinking supply base. For users of 2.0- and 3.0-micron technology, comparisons should have been made by now and plans put in place for alternative sourcing if expected system life cycles go beyond the next year or more.

Supply Base for MOS/BiCMOS CBICs

Table 3 provides information on the market size and leading suppliers of MOS/BiCMOS CBICs. Worldwide CBIC factory revenue growth rivaled the gate array growth rate by jumping 21 percent in 1993. This market remains less stratified than the gate array supply base and also has no Japanese suppliers in the top seven rankings. Many Japanese CBIC suppliers are now focusing on their domestic high-volume game and consumer market, which may change these rankings in upcoming years.

Table 3
Supply Base for MOS/BiCMOS CBICs
(Percentage Share of Factory Revenue)

Company	Market Share (%)
AT&T	11.5
Texas Instruments	8.2
IBM	8.1
VLSI Technology	6.4
Hewlett-Packard	6.2
LSI Logic	6.0
NCR	5.8
NEC	5.3
Toshiba	4.2
Mietec	4.0
Others	34.3
Total	100.0
Total Market (Billions of Dollars)	4.11

Source: Dataquest (May 1995)

Figure 1 showed that the CBIC technology closely parallels the gate array technology curve. In some ways the CBIC life cycle is slightly longer in the maturity phase because of the higher complexity and longer life cycles of the application markets they go into. The current mainstream CBIC technology is 1.0-micron, closely followed by 0.8-micron products. Yet there are some 1.2- to 1.5-micron CBICs still in high-volume production (saturation phase) designed over three years ago.

Supply Base for MOS/BiCMOS PLDs

Table 4 provides an encompassing view of the size and players of the total MOS/BiCMOS PLD market in 1994. Following very strong growth of 37 percent in 1993, this segment of the market slowed somewhat to catch its breath, growing a healthy 23 percent in 1994. With more than 80 percent (80.9 percent) of the market consolidated in the top five suppliers, this market remains increasingly top-heavy. Countering this market dominance is the fact that three of the top five suppliers are fabless.

Table 4
Supply Base for MOS/BiCMOS PLDs
(Percentage Share of Factory Revenue)

Company	Market Share (%)
Xilinx	28.3
Altera	17.5
AMD	16.6
Lattice	11.8
Actel	6.7
Cypress	4.9
AT&T	3.7
Texas Instruments	2.6
Intel	2.3
Atmel	1.3
Others	4.3
Total	100.0
Total Market (Billions of Dollars)	1.14

Source: Dataquest (May 1995)

Maturation has now taken over some segments of this market. The 2,000- to 10,000-gate-equivalent segment remains in the early maturity phase as volumes ramp up for these devices as the 20,000-gate-plus density families now begin prototype runs for future production. As life cycles of end systems continue to shrink, these high-density, quick-to-market products continue to gain ground on the lower-density gate array product families. Dataquest expects the product life cycle of these products to mirror the submicron gate array market because these devices are often used as prototype and/or market entry designs for larger-volume, higher-density gate arrays.

Dataquest Perspective

The ongoing strong growth in the 1994 ASIC market parallels the overall semiconductor industry in general, thanks largely to the extraordinary growth cycle of the PC market. As of this writing the PC market, ergo the semiconductor/ASIC market, looks to repeat 1994 growth levels. Large top-tier system companies are those that typically use ASICs, and the latest customization wave is using higher-density parts (gate arrays, CBIC, or CPLDs). The difference from the past is that many large users have either reached the integration wall or cannot wait for standard gate array or CBIC prototype delays and are either opting for FPGA or good old (but flexible) standard logic solutions. The suppliers listed in this newsletter have all weathered past market turbulence and remain very competitive, both from support and price perspectives. The continued appreciation of the yen against the dollar is causing some Japanese suppliers to flatten price declines or actually raise ASIC prices, which may be followed by others in the market. As this market continues to mature and the levels of integration increase (that is, 100,000-plus usable gates), consolidation will occur because of the paradox of integration where the number of devices declines per system faster than the rate of system sales increases. The resulting fewer devices sold will not require the current number of ASIC suppliers. To reduce supply base risk, ASIC users should regularly review the R&D plans, capital spending budgets, and general financial health of their suppliers. The increased sophistication of ASIC users (knowing when and where to use ASICs in the current market) continues to bode well for the future health of this market segment.

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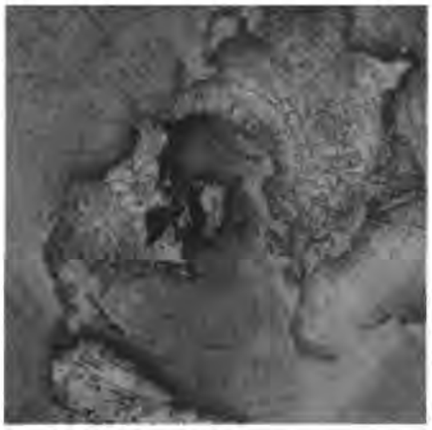

Dataquest

North American Semiconductor Price Outlook: Second Quarter 1995

Pricing Trends

Program: Semiconductor Procurement Worldwide
Product Code: SPSG-WW-PT-9501
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North American Semiconductor Price Outlook: Second Quarter 1995

Methodology and Sources

This 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 1995 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 Year; Package PLCC; Dollars)

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74LS TTL												
74LS00	0.15	0.15	0.15	0.14	0.14	0.15	0.14	0.13	0.13	0.13	0.13	0-8
74LS74	0.17	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.15	0.15	0.15	0-8
74LS138	0.19	0.19	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0-8
74LS244	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0-8
74AC TTL												
74AC00	0.21	0.21	0.21	0.20	0.20	0.21	0.20	0.20	0.20	0.20	0.20	0-8
74AC74	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0-8
74AC138	0.34	0.33	0.33	0.32	0.32	0.33	0.31	0.31	0.30	0.30	0.31	0-8
74AC244	0.47	0.46	0.46	0.45	0.45	0.46	0.45	0.45	0.44	0.44	0.45	0-8
74F TTL												
74F00	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0-8
74F74	0.17	0.17	0.17	0.17	0.16	0.17	0.16	0.16	0.16	0.16	0.16	0-8
74F138	0.23	0.22	0.21	0.21	0.20	0.21	0.20	0.20	0.20	0.20	0.20	0-8
74F244	0.28	0.27	0.27	0.27	0.26	0.27	0.26	0.26	0.26	0.26	0.26	0-8
74HC CMOS												
74HC00	0.19	0.18	0.18	0.17	0.17	0.18	0.16	0.16	0.16	0.16	0.16	0-8
74HC74	0.21	0.21	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.18	0.19	0-8
74HC138	0.24	0.23	0.22	0.22	0.21	0.22	0.21	0.21	0.20	0.20	0.21	0-8
74HC244	0.31	0.30	0.30	0.29	0.29	0.30	0.29	0.28	0.28	0.27	0.28	0-8
74ALS TTL												
74ALS00	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0-8
74ALS74	0.22	0.22	0.22	0.21	0.21	0.22	0.21	0.20	0.20	0.20	0.20	0-8
74ALS138	0.33	0.33	0.33	0.32	0.32	0.33	0.32	0.31	0.31	0.31	0.31	0-8
74ALS244	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0-8

(Continued)

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

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
74AS TTL												
74AS00	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0-8
74AS74	0.23	0.23	0.23	0.22	0.22	0.23	0.22	0.21	0.21	0.21	0.21	0-8
74AS138	0.48	0.48	0.48	0.47	0.47	0.48	0.46	0.46	0.46	0.45	0.46	0-8
74AS244	0.72	0.72	0.70	0.70	0.70	0.71	0.70	0.69	0.69	0.69	0.69	0-8
74BC*												
74BC00	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.24	0-8
74BC244	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0-8
74BC373	0.62	0.62	0.61	0.61	0.61	0.61	0.60	0.60	0.60	0.60	0.60	0-8

*Pricing for 74BC excludes 74ABT and 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 (March 1995)

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

Product	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
74LS TTL						
74LS00	0.16	0.15	0.13	0.13	0.13	0.13
74LS74	0.18	0.16	0.15	0.15	0.15	0.15
74LS138	0.20	0.18	0.17	0.17	0.17	0.17
74LS244	0.29	0.26	0.26	0.26	0.26	0.26
74AC TTL						
74AC00	0.20	0.21	0.20	0.20	0.20	0.20
74AC74	0.24	0.23	0.23	0.23	0.23	0.23
74AC138	0.34	0.33	0.31	0.30	0.30	0.30
74AC244	0.47	0.46	0.45	0.44	0.44	0.44
74F TTL						
74F00	0.18	0.15	0.14	0.14	0.14	0.13
74F74	0.19	0.17	0.16	0.16	0.15	0.15
74F138	0.24	0.21	0.20	0.20	0.20	0.20
74F244	0.29	0.27	0.26	0.26	0.26	0.26
74HC CMOS						
74HC00	0.21	0.18	0.16	0.16	0.16	0.16
74HC74	0.22	0.20	0.19	0.18	0.18	0.18
74HC138	0.25	0.22	0.21	0.20	0.20	0.20
74HC244	0.36	0.30	0.28	0.27	0.26	0.26
74ALS TTL						
74ALS00	0.19	0.18	0.17	0.17	0.17	0.17
74ALS74	0.23	0.22	0.20	0.20	0.20	0.20
74ALS138	0.34	0.33	0.31	0.31	0.31	0.31
74ALS244	0.43	0.41	0.40	0.40	0.40	0.40
74AS TTL						
74AS00	0.22	0.21	0.20	0.20	0.20	0.20
74AS74	0.23	0.23	0.21	0.21	0.21	0.21
74AS138	0.49	0.48	0.46	0.45	0.45	0.44
74AS244	0.72	0.71	0.69	0.69	0.69	0.69
74BC*						
74BC00	0.26	0.25	0.24	0.24	0.24	0.23
74BC244	0.60	0.59	0.58	0.58	0.57	0.57
74BC373	0.62	0.61	0.60	0.60	0.59	0.58

*Pricing for 74BC excludes 74ABT and 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 (March 1995)

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

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
68EC000-16 PLCC	5.65	5.35	5.35	5.35	5.35	5.35	5.00	5.00	5.00	5.00	5.00	4-8
68020-16 PQFP	19.10	18.95	18.95	18.95	18.95	18.95	17.60	17.60	17.60	17.60	17.60	4-8
68EC020-16 PQFP	12.30	9.45	9.45	9.45	9.45	9.45	8.80	8.80	8.80	8.80	8.80	4-8
68EC020-25 PQFP	10.60	9.98	9.98	9.98	9.98	9.98	9.10	9.10	9.10	9.10	9.10	4-8
68EC030-25 PQFP	25.00	23.00	23.00	23.00	23.00	23.00	21.00	21.00	21.00	21.00	21.00	3-5
68040-25	175.00	150.00	150.00	150.00	150.00	150.00	125.00	125.00	125.00	125.00	125.00	4-8
68LC040-25 CQFP 184	79.00	79.00	79.00	79.00	79.00	79.00	45.00	45.00	45.00	45.00	45.00	4-8
386SL-25 PQFP	43.00	40.00	40.00	40.00	40.00	40.00	36.00	36.00	36.00	36.00	36.00	4-10
AM386-40 PQFP[1]	28.00	26.00	24.00	23.00	22.00	23.75	21.00	20.00	19.00	18.00	19.50	6-12
80486SX-25 PQFP	55.00	49.50	49.50	49.50	49.50	49.50	36.00	36.00	36.00	36.00	36.00	4-10
80486DX-33 PQFP	119.00	90.00	85.00	80.00	75.00	82.50	70.00	65.00	60.00	65.00	65.00	4-10
80486DX-50	250.00	180.00	155.00	140.00	120.00	148.75	100.00	90.00	80.00	70.00	85.00	4-10
80486DX2-50 PQFP	119.00	90.00	85.00	80.00	75.00	82.50	70.00	65.00	60.00	65.00	65.00	4-10
80486DX2-66	154.00	128.00	116.00	105.00	95.00	111.00	85.00	77.00	70.00	63.00	73.75	4-10
80486DX4-75	295.00	185.00	176.00	167.00	159.00	171.00	151.00	143.00	136.00	129.00	139.00	4-10
Pentium-60	295.00	265.00	252.00	240.00	227.00	246.00	218.00	205.00	194.00	185.00	200.50	4-10
Pentium-66	373.00	275.00	261.00	245.00	229.00	252.50	218.00	205.00	194.00	185.00	200.50	4-10
Pentium-100	855.00	665.00	631.00	600.00	570.00	616.50	541.00	514.00	488.00	464.00	501.75	10-14
PowerPC-601-66	144.00	129.00	129.00	121.00	113.00	123.00	109.00	101.00	95.00	90.00	98.75	4-8
PowerPC-601-80	205.00	192.00	187.00	177.00	166.00	180.50	160.00	150.00	142.00	134.00	146.50	4-8
PowerPC-601-100	480.00	375.00	355.00	335.00	320.00	346.25	310.00	300.00	290.00	280.00	295.00	8-12
29000-25[2]	61.50	58.00	55.00	52.00	49.00	53.50	48.00	46.00	44.00	42.00	45.00	4-8
88100-25[2]	45.00	41.00	41.00	41.00	41.00	41.00	39.00	39.00	39.00	39.00	39.00	4-8
R4000SC-50	445.00	425.00	405.00	385.00	375.00	397.50	370.00	355.00	340.00	320.00	346.25	4-8

(Continued)

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

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
R4400SC-75	728.00	660.00	610.00	575.00	515.00	566.67	495.00	475.00	450.00	425.00	461.25	4-8
SPARC-25[2]	47.00	47.00	46.00	45.00	45.00	45.75	42.00	42.00	42.00	40.00	41.50	4-8
80960CA-25	63.00	55.00	50.00	48.00	45.00	49.50	45.00	45.00	42.00	42.00	43.50	4-10

[1]Estimated but not by survey
[2]Pricing excludes accessory parts like 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 1995)

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

Product	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
68EC000-16 PLCC	5.65	5.35	5.00	4.75	4.50	4.25
68020-16 PQFP	19.10	18.95	17.60	17.17	16.75	16.00
68EC020-16 PQFP	12.30	9.45	8.80	8.50	7.80	7.30
68EC020-25 PQFP	10.60	9.98	9.10	8.45	8.00	7.50
68EC030-25 PQFP	25.00	23.00	21.00	19.00	17.00	17.00
68040-25	180.00	150.00	125.00	110.00	100.00	90.00
68LC040-25 CQFP 184	81.00	79.00	45.00	42.00	42.00	35.00
386SL-25 PQFP	45.00	40.00	36.00	31.00	28.00	25.00
AM386-40 PQFP[1]	32.00	23.75	19.50	18.00	18.00	18.00
80486SX-25 PQFP	65.00	49.50	36.00	36.00	36.00	36.00
80486DX-33 PQFP	149.00	82.50	65.00	55.00	50.00	50.00
80486DX-50	342.50	148.75	85.00	75.00	75.00	75.00
80486DX2-50 PQFP	149.00	82.50	65.00	56.00	50.00	50.00
80486DX2-66	225.00	111.00	73.75	65.00	49.00	49.00
80486DX4-75	345.00	171.00	139.00	112.00	89.00	71.00
Pentium-60	345.00	246.00	200.50	160.40	128.32	102.66
Pentium-66	425.12	252.50	200.50	160.40	128.32	102.66
Pentium-100	974.47	616.50	501.75	401.40	321.12	256.90
PowerPC-601-66	186.00	123.00	98.75	75.00	65.00	65.00
PowerPC-601-80	235.00	180.50	146.50	123.00	98.00	85.00
PowerPC-601-100	525.00	346.25	295.00	215.00	145.00	99.00
29000-25[2]	64.75	53.50	45.00	40.00	40.00	40.00
88100-25[2]	49.80	41.00	39.00	35.00	35.00	35.00
R4000SC-50	495.00	397.50	346.25	205.00	155.00	120.00
R4400SC-75	802.00	566.67	461.25	369.00	295.00	236.00
SPARC-25[2]	52.00	45.75	41.50	37.00	35.00	35.00
80960CA-25	69.00	49.50	43.50	40.00	40.00	40.00

[1]Estimated but not by survey
[2]Pricing excludes accessory parts like 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 1995)

Table 5
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; U.S. Dollars)*

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.10	4.10	4.10	4.05	4.05	4.08	3.96	3.96	3.94	3.94	3.95	8-Allocation
256Kx4 DRAM 60ns ZIP	4.30	4.20	4.20	4.15	4.15	4.18	4.23	4.32	4.40	4.55	4.38	Allocation
256Kx4 VRAM 100ns ZIP	5.87	5.57	5.30	5.19	5.09	5.29	4.99	4.89	4.79	4.69	4.84	12-Allocation
128Kx8 VRAM 100ns SOJ	6.27	6.21	6.15	6.08	6.02	6.12	5.96	5.90	5.84	5.78	5.87	12-Allocation
4Mbx1 DRAM 70-80ns SOJ	12.60	12.40	12.13	11.93	11.67	12.03	11.23	10.86	10.28	9.83	10.55	8-Allocation
1Mbx4 DRAM 60ns SOJ	12.63	12.66	12.45	12.25	11.99	12.34	11.28	10.90	10.31	9.85	10.59	8-Allocation
512Kx8 DRAM 70-80ns	14.25	14.14	13.83	13.22	12.91	13.53	12.15	11.62	10.93	10.44	11.29	8-Allocation
256Kx16 DRAM 70-80ns SOJ	14.80	14.75	14.42	14.00	13.75	14.23	13.10	12.35	11.62	10.93	12.00	10-Allocation
256Kx16 VRAM 70ns SOP	25.00	25.00	24.20	22.75	20.13	23.02	19.12	18.54	17.96	17.42	18.26	10-Allocation
1Mbx9 SIMM 80ns (3 pc)	34.36	33.86	33.20	31.12	29.82	32.00	29.78	29.32	28.88	28.48	29.12	12-Allocation
4Mbx9 SIMM 70ns	121.50	116.50	113.64	108.65	102.33	110.28	82.12	82.00	78.90	77.84	80.22	12-Allocation
1Mbx36 SIMM 70-80ns	119.35	121.00	116.50	111.75	109.00	114.56	103.04	101.51	96.73	94.11	98.85	10-Allocation
4Mbx4 DRAM 70ns SOJ 400 mil	48.76	46.52	41.50	37.80	34.20	40.01	33.45	31.28	29.51	28.34	30.65	8-Allocation
4Mbx4 DRAM 70ns SOJ 300 mil	49.72	47.63	42.33	38.57	34.88	40.85	34.12	31.91	30.10	28.91	31.26	8-Allocation

(Continued)

Table 5 (Continued)
Estimated DRAM Price Trends—North American Bookings
(Contract Volume; U.S. Dollars)*

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
1Mbx16 DRAM 60ns TSOP 300 mil	57.99	53.62	50.13	47.37	44.42	48.89	42.38	40.81	38.77	36.52	39.62	10-Allocation
2Mbx8 DRAM 60ns TSOP 300mil	53.34	51.38	46.52	43.57	40.32	45.45	38.75	36.19	36.73	34.44	36.53	12-Allocation
1Mbx32 DRAM 8(1Mbx4)	NA	111.18	107.27	103.51	98.64	105.15	95.73	93.15	87.32	83.54	89.94	8-Allocation
1Mbx32 DRAM 2(1Mbx16)	NA	112.91	109.42	103.27	95.84	105.36	89.76	86.62	85.54	78.04	84.99	10-Allocation

NA = Not available
*Contract Volume = at least 100,000 per order except VRAMs
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 1995)

Table 6
Estimated Long-Range DRAM Price Trends—North American Bookings (Contract Volume; U.S. Dollars)*

Product	1994	1995	1996	1997	1998	1999
1Mbx1 DRAM 70-80ns (DIP/SOJ)	4.00	4.08	3.95	3.95	4.00	4.00
256Kx4 DRAM 60ns ZIP	4.23	4.18	4.38	4.55	4.65	NA
256Kx4 VRAM 100ns ZIP	5.95	5.29	4.84	4.60	4.65	4.65
128Kx8 VRAM 100ns SOJ	6.18	6.12	5.87	5.63	5.70	5.70
4Mbx1 DRAM 70-80ns SOJ	12.64	12.03	10.55	8.94	7.67	7.80
1Mbx4 DRAM 60ns SOJ	12.69	12.34	10.59	8.94	7.67	7.80
512Kx8 DRAM 70-80ns	14.63	13.53	11.29	9.44	8.35	8.40
256Kx16 DRAM 70-80ns SOJ	15.08	14.23	12.00	10.30	9.74	9.83
256Kx16 VRAM 70ns SOP	28.38	23.02	18.26	16.43	14.79	13.31
1Mbx9 SIMM 80ns (3 pc)	34.34	32.00	29.12	27.39	25.34	25.60
4Mbx9 SIMM 70ns	122.26	110.28	80.22	55.44	54.68	54.68
1Mbx36 SIMM 70-80ns	122.07	114.56	98.85	75.07	66.07	55.28
4Mbx4 DRAM 70ns SOJ 400 mil	55.00	40.01	30.65	26.67	20.32	18.50
4Mbx4 DRAM 70ns SOJ 300 mil	NA	40.85	31.26	27.46	20.41	18.50
1Mbx16 DRAM 60ns TSOP 300 mil	67.20	48.89	39.62	29.72	24.20	18.74
2Mbx8 DRAM 60ns TSOP 300mil	56.09	45.45	36.53	28.17	22.76	18.65
1Mbx32 DRAM 8(1Mbx4)	NA	105.15	89.94	76.52	66.36	66.90
1Mbx32 DRAM 2(1Mbx16)	NA	105.36	84.99	63.34	53.40	42.48

NA = Not available
*Contract Volume = at least 100,000 per order except VRAMs
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 1995)

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	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
16Kx4 25ns	2.85	2.85	2.85	2.85	2.85	2.85	2.82	2.80	2.80	2.78	2.80	Allocation
8Kx8 25ns	2.63	2.96	2.96	2.96	2.96	2.96	2.92	2.84	2.80	2.77	2.83	Allocation
16Kx4 35ns	3.90	3.90	3.90	3.90	3.90	3.90	3.88	3.85	3.85	3.82	3.85	Allocation
8Kx8 100-120ns	1.74	1.78	1.80	1.85	1.90	1.83	1.90	1.90	1.90	1.90	1.90	4-10
64Kx4 10ns	8.63	8.38	7.88	7.63	7.25	7.79	6.74	6.27	5.83	5.42	6.07	10-Allocation
64Kx4 25ns	5.25	5.20	5.10	4.81	4.73	4.96	3.82	3.65	3.57	3.51	3.64	4-16
32Kx8 12ns	7.00	6.67	6.17	6.13	5.88	6.21	5.29	4.76	4.29	3.86	4.55	Allocation
32Kx9 12ns Burst	15.00	12.00	11.50	10.50	10.00	11.00	NA	NA	NA	NA	NA	10-14
32Kx8 25ns	4.00	3.72	3.63	3.55	3.38	3.57	3.49	3.35	3.30	3.28	3.36	2-8
32Kx8 70-100ns SOJ	3.14	3.14	3.07	3.02	3.00	3.06	3.00	3.00	2.80	2.80	2.90	6-12
64Kx18 12ns Burst	37.15	35.00	33.00	30.67	28.33	31.75	NA	NA	NA	NA	NA	12
256Kx4 20ns	16.00	14.90	14.83	13.77	13.70	14.30	11.86	10.03	7.87	7.41	9.29	4-8
128Kx8 15ns	NA	19.25	18.87	18.29	17.35	18.44	15.61	14.83	14.08	13.38	14.48	Allocation
128Kx8 25ns	13.39	13.34	13.29	13.14	12.54	13.08	11.45	10.30	9.78	9.30	10.21	Allocation
128Kx8 70-100ns SOJ	8.50	8.47	8.38	8.32	8.30	8.37	7.64	7.25	6.89	6.55	7.08	8-Allocation
32Kx8 15ns 5V	NA	3.76	3.68	3.61	3.53	3.65	3.44	3.35	3.32	3.29	3.35	Allocation
32Kx8 15ns 3.3V	NA	5.64	5.41	5.02	4.88	5.24	4.59	4.36	4.14	4.04	4.28	Allocation

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 1995)

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	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
16Kx4 25ns	2.85	2.85	2.80	2.85	2.85	2.90
8Kx8 25ns	2.63	2.96	2.83	2.85	2.85	2.90
16Kx4 35ns	3.90	3.90	3.85	3.90	3.90	4.00
8Kx8 100-120ns	1.73	1.83	1.90	1.90	1.93	1.93
64Kx4 10ns	10.82	7.79	6.07	4.86	3.88	3.50
64Kx4 25ns	5.31	4.96	3.64	3.00	3.00	3.00
32Kx8 12ns	7.64	6.21	4.55	3.41	3.10	3.10
32Kx9 12ns Burst	17.04	11.00	NA	NA	NA	NA
32Kx8 25ns	4.06	3.57	3.36	3.16	3.00	3.00
32Kx8 70-100ns SOJ	3.19	3.06	2.90	3.00	3.00	3.00
64Kx18 12ns Burst	48.99	31.75	NA	NA	NA	NA
256Kx4 20ns	16.75	14.30	9.29	6.80	5.55	5.00
128Kx8 15ns	NA	18.44	14.48	8.71	6.88	5.76
128Kx8 25ns	14.20	13.08	10.21	6.70	5.50	5.00
128Kx8 70-100ns SOJ	8.80	8.37	7.08	5.15	5.15	5.05
32Kx8 15ns 5V	NA	3.65	3.35	3.12	3.05	3.05
32Kx8 15ns 3.3V	NA	5.24	4.28	4.03	3.58	3.35

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 1995)

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	1994 Year	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
128Kx8 ROM	1.77	1.66	1.63	1.60	1.60	1.62	1.60	1.60	1.60	1.60	1.60	5-8
64Kx16 ROM	2.10	2.08	2.08	2.05	2.05	2.07	2.05	2.05	2.05	2.05	2.05	5-8
256Kx8 ROM	2.55	2.53	2.48	2.45	2.43	2.47	2.40	2.40	2.40	2.40	2.40	5-8
512Kx8 ROM	3.40	3.33	3.31	3.31	3.30	3.31	3.18	3.08	3.00	2.86	3.03	5-8
256Kx16 ROM[1]	3.28	3.25	3.20	3.20	3.18	3.21	3.08	3.00	2.90	2.76	2.94	5-8
1Mbx8 ROM[2]	4.85	4.80	4.63	4.51	4.48	4.61	4.35	4.23	4.20	4.18	4.24	6-10
1Mbx16 ROM	8.33	8.20	8.10	8.02	7.99	8.08	7.83	7.67	7.52	7.36	7.60	6-10
2Mbx8 ROM	8.33	8.20	8.10	8.02	7.99	8.08	6.95	6.33	6.10	6.10	6.37	6-10

[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 (March 1995)

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	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
128Kx8 ROM	2.02	1.62	1.60	1.62	1.62	1.66
64Kx16 ROM	2.10	2.07	2.05	2.05	2.05	2.08
256Kx8 ROM	2.62	2.47	2.40	2.40	2.40	2.45
512Kx8 ROM	3.42	3.31	3.03	2.60	2.50	2.50
256Kx16 ROM[1]	3.42	3.21	2.94	2.55	2.45	2.45
1Mbx8 ROM[2]	4.89	4.61	4.24	4.00	4.00	4.00
1Mbx16 ROM	9.02	8.08	7.60	6.08	4.98	4.52
2Mbx8 ROM	9.02	8.08	6.37	6.08	4.98	4.52

[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 (March 1995)

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

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
32Kx8 EPROM	1.60	1.55	1.55	1.55	1.55	1.55	1.60	1.60	1.63	1.63	1.62	4-8
64Kx8 EPROM	2.00	1.90	1.83	1.80	1.80	1.83	1.90	1.90	1.90	1.90	1.90	4-8
128Kx8 EPROM	2.64	2.58	2.55	2.53	2.53	2.55	2.50	2.50	2.50	2.50	2.50	4-10
256Kx8 EPROM	4.75	4.62	4.56	4.50	4.50	4.55	4.46	4.38	4.32	4.28	4.36	4-10
128Kx16 EPROM	5.10	4.85	4.85	4.85	4.85	4.85	4.80	4.68	4.50	4.42	4.60	4-10
512Kx8 EPROM	7.25	7.00	7.00	6.75	6.75	6.88	6.70	6.83	6.50	6.40	6.61	4-10
256Kx16 EPROM	9.25	9.15	8.75	8.65	8.65	8.80	8.61	8.52	8.48	8.42	8.51	4-8

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 price guidelines.
Source: Dataquest (March 1995)

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	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
32Kx8 EPROM	1.80	1.55	1.62	1.80	1.90	2.00
64Kx8 EPROM	2.44	1.83	1.90	2.10	2.40	2.50
128Kx8 EPROM	2.99	2.55	2.50	2.65	2.75	2.95
256Kx8 EPROM	5.06	4.55	4.36	4.30	4.30	4.25
128Kx16 EPROM	5.38	4.85	4.60	4.55	4.55	4.46
512Kx8 EPROM	9.10	6.88	6.61	6.35	6.35	6.35
256Kx16 EPROM	10.01	8.80	8.51	8.35	8.25	8.15

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 1995)

Table 13
Estimated Flash Memory Price Trends – North American Bookings
(12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
64Kx8, PDIP/PLCC	4.10	3.90	3.75	3.65	3.60	3.73	3.41	3.35	3.21	3.04	3.25	6-12
64Kx8, TSOP	4.15	3.95	3.80	3.70	3.65	3.78	3.46	3.40	3.26	3.09	3.30	6-17
128Kx8, PDIP/PLCC	4.75	4.53	4.17	3.87	3.68	4.06	3.30	3.24	3.18	3.09	3.20	6-17
128Kx8, TSOP	5.00	4.82	4.45	4.15	3.97	4.35	3.50	3.38	3.24	3.15	3.32	4-17
256Kx8, TSOP	8.82	7.78	7.58	7.28	6.93	7.39	6.51	6.07	5.43	5.30	5.83	6-16
512Kx8, PDIP/PLCC	12.03	10.30	9.55	8.80	8.05	9.18	7.96	7.61	7.12	6.98	7.42	6-16
512Kx8, TSOP	13.00	10.80	10.15	9.75	8.75	9.86	8.25	7.75	7.31	7.20	7.63	4-16
1Mbx8 TSOP	21.07	19.22	17.83	17.17	16.03	17.56	12.03	11.28	10.66	10.21	11.05	6-10
2Mbx8 TSOP	NA	51.67	48.33	40.67	32.18	43.21	29.56	26.83	23.14	19.52	24.76	

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 1995)

Table 14
Estimated Long-Range Flash Memory Price Trends—North American Bookings (12 Volts; Volume: 10,000 per Year; Speed: 150ns; Dollars)

Product	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
64Kx8, PDIP/PLCC	4.30	3.73	3.25	2.75	2.75	2.80
64Kx8, TSOP	4.40	3.78	3.30	2.80	2.80	2.85
128Kx8, PDIP/PLCC	5.00	4.06	3.20	2.95	2.95	2.90
128Kx8, TSOP	5.42	4.35	3.32	3.00	3.00	2.95
256Kx8, TSOP	10.27	7.39	5.83	5.46	4.95	4.85
512Kx8, PDIP/PLCC	17.80	9.18	7.97	6.95	6.50	6.35
512Kx8, TSOP	20.01	9.86	7.70	7.01	6.60	6.45
1Mbx8 TSOP	24.29	17.56	11.05	9.75	8.75	8.00
2Mbx8 TSOP	NA	43.21	24.76	18.81	14.95	12.25

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 1995)

Table 15
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)
(Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	5-9.99K Gates			10-19.99K Gates			Current Lead Time
Technology	1993	1994	1995	1993	1994	1995	(Weeks)
CMOS							Production:
1.0 Micron	71	65	63	62	58	54	7-17
0.8 Micron	61	55	51	60	53	50	7-17
0.6 /0.5 Micron	63	57	58	61	53	50	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	27	26	26	45	45	45	2-7
0.8 Micron	30	30	30	50	50	50	2-3
0.6 /0.5 Micron	33	33	33	58	53	52	3-5
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Source: Dataquest (March 1995)

Table 16
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) (Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype) (Includes Standard Commercial Test and Excludes Special Test)

Gate Count	20-29.99K Gates			30-59.9K Gates			60-100K Gates			Current Lead Time
Technology	1993	1994	1995	1993	1994	1995	1993	1994	1995	(Weeks)
CMOS										Production:
1.0 Micron	60	57	55	61	58	58	61	58	56	7-17
0.8 Micron	56	49	46	55	47	44	55	50	46	7-17
0.6 /0.5 Micron	57	49	45	56	43	40	56	42	38	12-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	39	12-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	63	63	63	89	87	87	130	125	125	2-7
0.8 Micron	68	67	67	95	90	90	115	108	104	2-3
0.6 /0.5 Micron	78	64	62	109	95	93	132	115	113	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	120	5-8

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 price guidelines.
Source: Dataquest (March 1995)

Table 17
Estimated CBIC 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)
(Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	5-9.99K Gates			10-19.99K Gates			Lead Time
Technology	1993	1994	1995	1993	1994	1995	(Weeks)
CMOS							Production:
1.0 Micron	71	70	63	72	65	54	12-18
0.8 Micron	61	55	50	65	51	49	9-18
0.6 /0.5 Micron	63	56	57	68	50	49	14-21
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	48	48	48	72	70	70	6-9
0.8 Micron	57	54	54	74	72	70	5-7
0.6 /0.5 Micron	67	63	60	85	81	77	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	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 price guidelines.
Source: Dataquest (March 1995)

Table 18
Estimated CBIC 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)
(Volume: 10,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype)
(Includes Standard Commercial Test and Excludes Special Test)

Gate Count	20-29.99K Gates			30-59.9K Gates			60-100K Gates			Lead Time
Technology	1993	1994	1995	1993	1994	1995	1993	1994	1995	(Weeks)
CMOS										Production:
1.0 Micron	73	71	65	75	72	66	80	74	68	9-18
0.8 Micron	58	50	46	65	47	44	70	52	50	9-18
0.6 /0.5 Micron	59	50	44	64	43	39	66	42	37	14-20
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	38	14-20
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	89	85	85	107	102	100	130	121	121	6-10
0.8 Micron	89	85	85	108	100	95	130	121	118	4-7
0.6 /0.5 Micron	102	91	89	124	105	96	150	130	122	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	NA	NA	125	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 price guidelines.
Source: Dataquest (March 1995)

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

Pin Count	Speed* (ns)	1994 Q4	1995 Q1	Q2	Q3	Q4	1995 Year	1996 Q1	Q2	Q3	Q4	1996 Year	Lead Time (Weeks)
≤ 20													
	6.1-7.5	2.50	2.40	2.40	2.40	2.40	2.40	2.20	2.20	2.20	2.20	2.20	2-10
	7.6-10.0	1.40	1.32	1.32	1.25	1.25	1.29	1.22	1.22	1.20	1.20	1.21	2-8
	10.1-14.99	1.55	1.40	1.40	1.55	1.55	1.48	1.40	1.40	1.33	1.30	1.36	4-10
	15 - <25	0.68	0.68	0.68	0.68	0.68	0.68	0.70	0.70	0.70	0.70	0.70	1-4
	> or = 25	0.64	0.64	0.64	0.64	0.64	0.64	0.66	0.66	0.66	0.66	0.66	0-2
24													
	6.1-7.5	3.10	3.00	3.00	3.00	3.00	3.00	2.90	2.90	2.80	2.80	2.85	0-2
	7.6-10.0	2.15	1.95	1.90	1.70	1.65	1.80	1.60	1.56	1.54	1.52	1.56	2-6
	10.1-14.99	2.50	2.50	2.50	2.50	2.50	2.50	2.35	2.25	1.90	1.90	2.10	4-10
	15 - <25	0.98	0.93	0.92	0.91	0.91	0.92	0.90	0.90	0.90	0.90	0.90	1-4
	> or = 25	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	1-4
24 (22V10)													
	6.1-7.5	6.95	6.50	6.45	6.40	6.38	6.43	6.35	6.30	6.25	6.20	6.28	0-2
	7.6-10.0	4.50	4.00	3.82	3.70	3.60	3.78	3.52	3.47	3.42	3.38	3.45	0-2
	15 - <25	2.70	2.60	2.50	2.40	2.35	2.46	2.40	2.50	2.70	2.80	2.60	1-4
	>or=25	1.55	1.53	1.50	1.45	1.40	1.47	1.35	1.35	1.30	1.30	1.33	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 (March 1995)

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)	1994 Year	1995 Year	1996 Year	1997 Year	1998 Year	1999 Year
≤ 20							
	6.1-7.5	2.73	2.40	2.20	2.10	2.10	2.00
	7.6-10.0	1.51	1.29	1.21	1.15	1.15	1.10
	10.1-14.99	1.48	1.48	1.36	1.25	1.25	1.35
	15 - <25	0.68	0.68	0.70	0.70	0.70	0.75
	> or = 25	0.64	0.64	0.66	0.66	0.70	0.75
24							
	6.1-7.5	3.28	3.00	2.85	2.67	2.62	2.60
	7.6-10.0	2.29	1.80	1.56	1.50	1.45	1.40
	10.1-14.99	2.40	2.50	2.10	1.85	1.85	1.85
	15 - <25	1.05	0.92	0.90	0.91	0.91	0.91
	> or = 25	0.78	0.77	0.77	0.79	0.79	0.79
24 (22V10)							
	6.1-7.5	8.48	6.43	6.28	6.10	6.00	5.90
	7.6-10.0	4.96	3.78	3.45	3.40	3.40	3.20
	15 - <25	2.98	2.46	2.60	2.70	2.70	2.80
	>or=25	1.59	1.47	1.33	1.30	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 price. These prices are intended as guidelines.
Source: Dataquest (March 1995)

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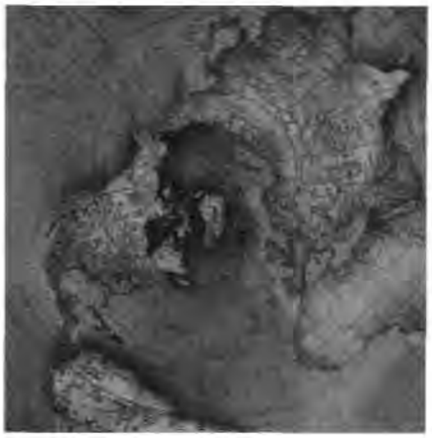

Dataquest

The OEM-Supplier Relationship: So What's the Problem?

Focus Report

Program: Semiconductor Procurement Worldwide
Product Code: SPSG-WW-FR-9502
Publication Date: December 11, 1995
Filing: Focus Studies

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Chapter 1
Introduction

Executive Summary

Electronic original equipment manufacturers, or electronic OEMs, are a large and growing part of the world economy. All industrialized countries and many developing regions are counting on electronics production to provide sustainable growth in the 21st century. One of the keys to success for all electronic OEMs is the proper management of their IC supply base.

In order to take the temperature of this critical electronic OEM-supplier relationship, Dataquest recently surveyed over 60 OEMs. The results of the survey not only indicate how OEMs feel about their suppliers, but also show the current trends and directions in supply base management.

Some of the findings of this survey are as follows:

- Almost 90 percent of all OEMs have created a strategic materials organization as the primary interface with the supply base. Suppliers need to understand that the design-in route is no longer through the back door of engineering. Also, medium-size-to-large OEMs not using a strategic organization should take a critical look at their current procurement group.
- Over half of OEMs feel they have a "true partnership" with at least 80 percent of their key suppliers. Dataquest was surprised by this level of OEM-supplier closeness because of the ongoing tight IC market and firm pricing. Clearly, the heated, confrontational environment between IC makers and users is fading. However, OEMs do not hand out partner status; it must be earned.
- Over half of the OEMs expect suppliers to meet their lead times "all the time," but experience on-time delivery "most of the time." This common disconnect can be corrected if the OEM provides better forecasts and the supplier gives realistic lead times.
- Slightly more than half of IC users believe they are paying "average pricing," but fully 25 percent feel that their supply base is charging excessively.
- Over 15 percent of respondents report that the initial quote price rarely matches billing price. In this case, suppliers can go a long way in building OEM partnerships by making quote and billing pricing more consistent.
- Over two-thirds of respondents still use fax or mail to send purchase orders (POs). Although much touted, electronic data interchange (EDI) is used exclusively by less than 15 percent of the OEMs. It is interesting that companies selling the latest in technology can be very resistant to operational change.

These and other findings of the survey are explored further in the rest of this document.

Statement of Research Methodology

The 1995 OEM Study contains the results of a telephone survey conducted by Dataquest's Research Operations group. The survey questionnaire was developed by analysts from Dataquest's Semiconductor service and comprised a total of 22 questions (see Appendix A). Trained interviewers conducted the survey, and Research Operations analysts tabulated the survey results using SPSS statistics software.

Dataquest conducted the study during October 1995. We contacted respondents based on a list of original equipment manufacturers published by the Printed Circuit Directories, augmented by current Dataquest clients.

Dataquest placed a total of 708 calls to about 400 names from the two lists. The sample disposition is as follows:

- Completed interviews: 63
- Unable to contact respondents, left message: 570
- Refused interview/wrong telephone number/no incidence (did not qualify to participate in study): 75

Analysis of Survey Respondents

The respondent companies were put into one of seven categories, telecommunications/broadcasting, PC/workstation, other computers and peripherals, industrial, scientific/testing/measurement, military/aerospace, and miscellaneous. As shown in Figure 1-1, each category had at least 10 percent of the total respondents, with telecom/broadcasting having the most, at 20 percent.

Another way to analyze these OEMs is by annual purchases of ICs. Overall, the respondents represent primarily medium-size companies, with some small and several very large firms (see Figure 1-2). It should be noted that 48 of 63 firms, or 76 percent of all respondents, provided annual IC purchasing data.

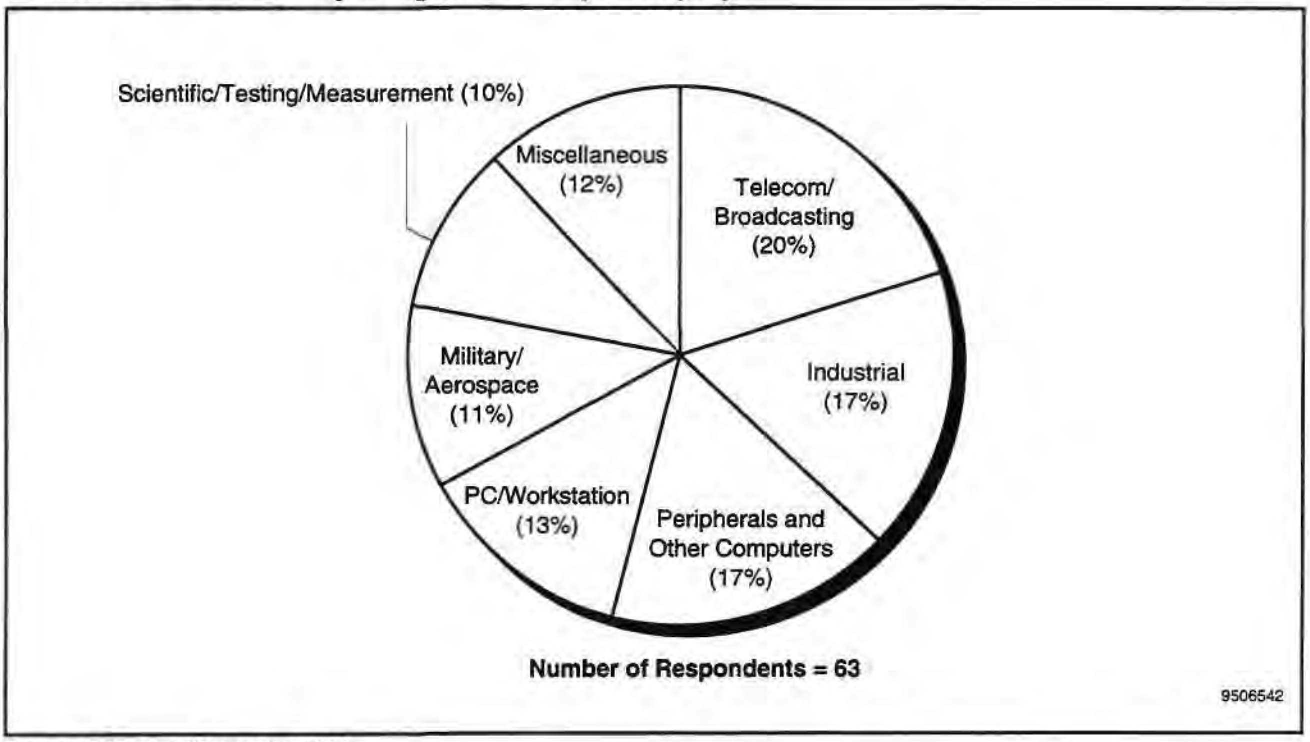
Electronic OEM Market Overview

As mentioned earlier, the worldwide electronic market is huge and is forecast to be almost $800 billion in 1995 (see Figure 1-3). By the end of the century this market will be nearly $1.2 trillion.

In recent years, the PC market has shown phenomenal growth and currently drives much of the supply base. Whether it is cables, connectors, passive devices, batteries, or memory ICs, most OEM suppliers strive to service the PC industry. A quick look at the numbers and it is easy to see why suppliers are keen to win sockets in the PC. In 1994, PCs accounted for over 11 percent of total electronic equipment revenue, with $80 billion in revenue. By 1999, the PC market is forecast to be $165 billion, which is over 15 percent of the total electronic equipment market.

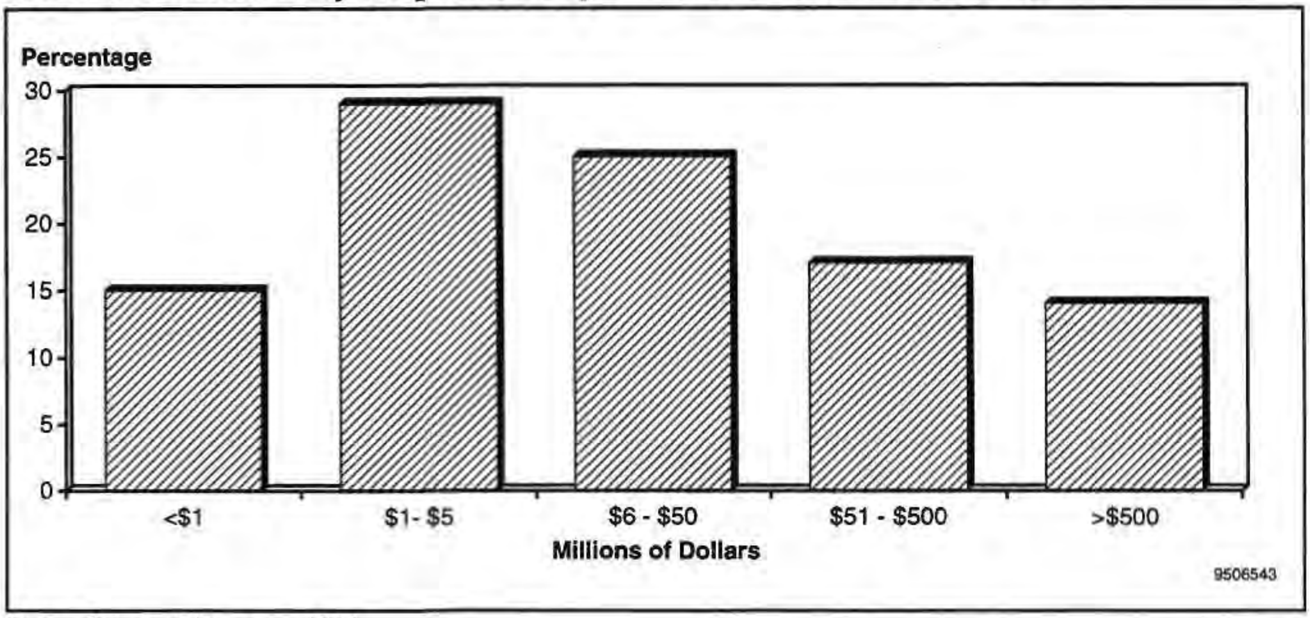
The Dataquest OEM-Supplier Survey includes companies from all sectors: data processing, communications, consumer, industrial, military/aerospace, and transportation.

Figure 1-1
Electronic OEM Survey Respondents by Category



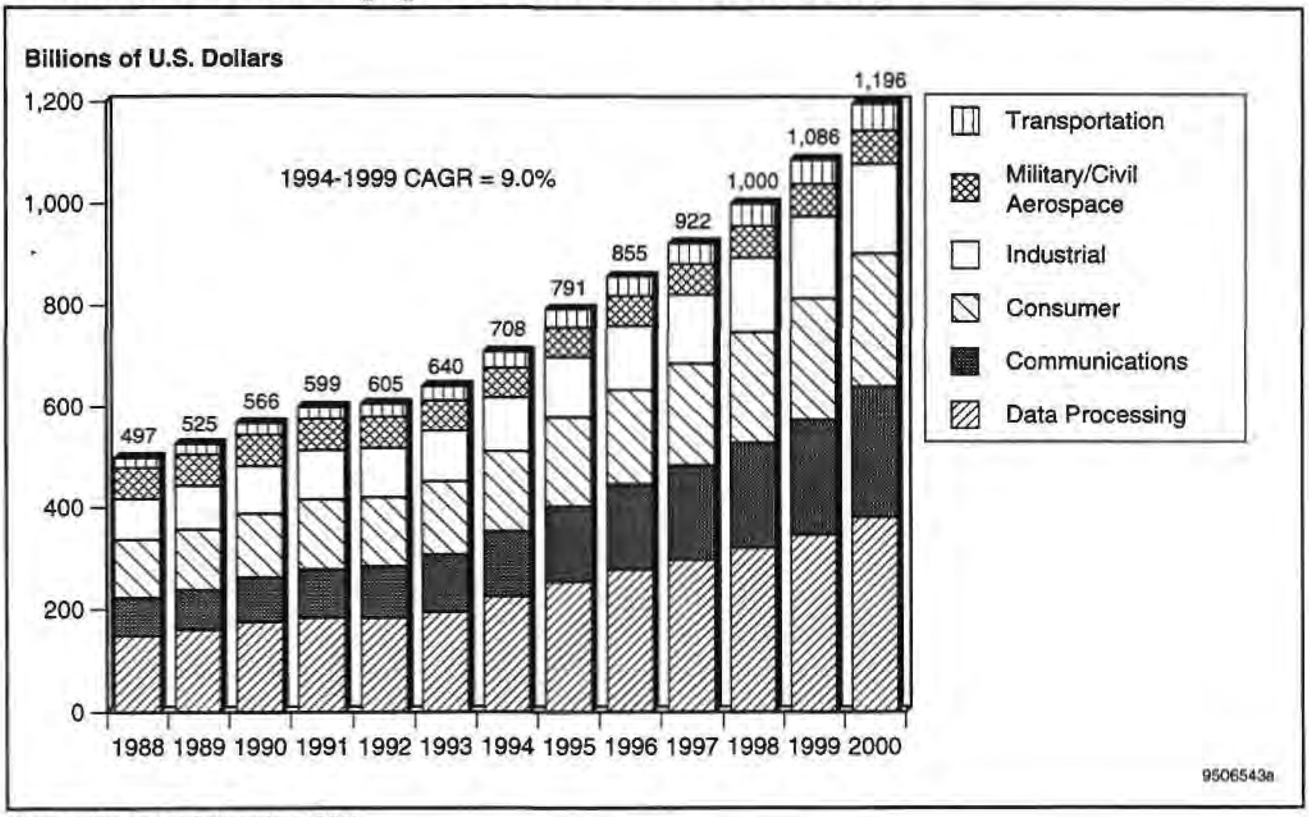
Source: Dataquest (December 1995)

Figure 1-2
Electronic OEM Survey Respondents by Annual IC Purchases (N = 48)



Source: Dataquest (December 1995)

Figure 1-3
Worldwide Electronic Equipment Production Revenue Forecast



Source: Dataquest (December 1995)

Chapter 2
The IC Supplier and the Customer

Strategic Procurement Trends

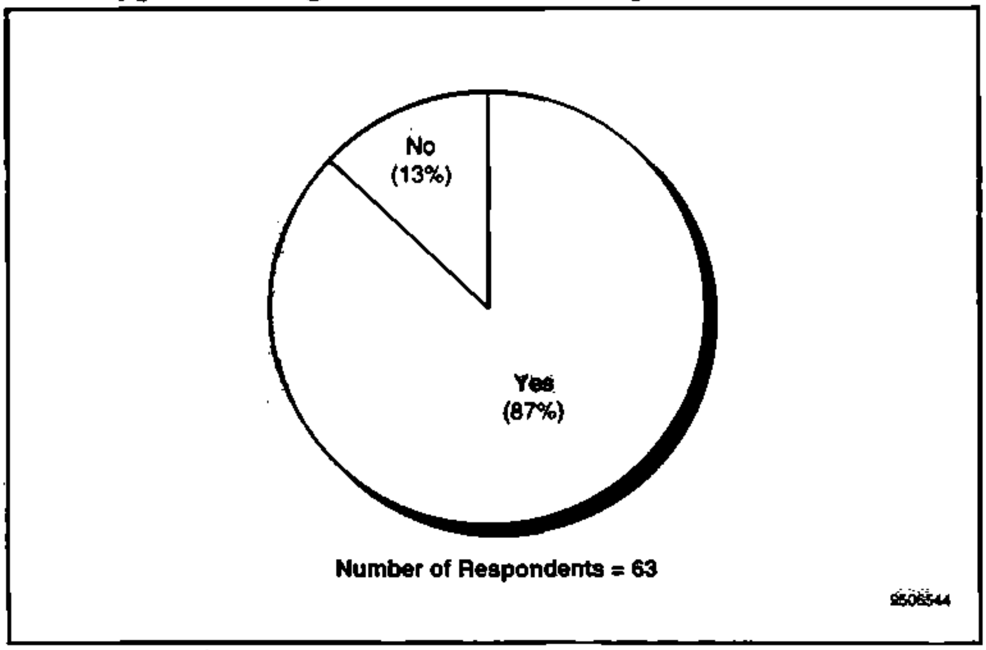
At one time, electronic OEMs dealt directly with their suppliers, primarily through the purchasing organization and project engineering. Although generally effective, the buyers tended to be too tactical and the engineers often looked only at the technical aspects of the devices.

As the OEM business grew and supplier management became more time-consuming and complicated, OEMs set up strategic procurement groups to manage the overall business relationship with their supplier base. According to the survey, this trend toward supply base management is now firmly rooted across the OEM spectrum.

As shown in Figure 2-1, 87 percent of all respondents have a strategic procurement organization. Companies that do not have supply base management tend to be small, engineering-driven scientific and industrial equipment firms.

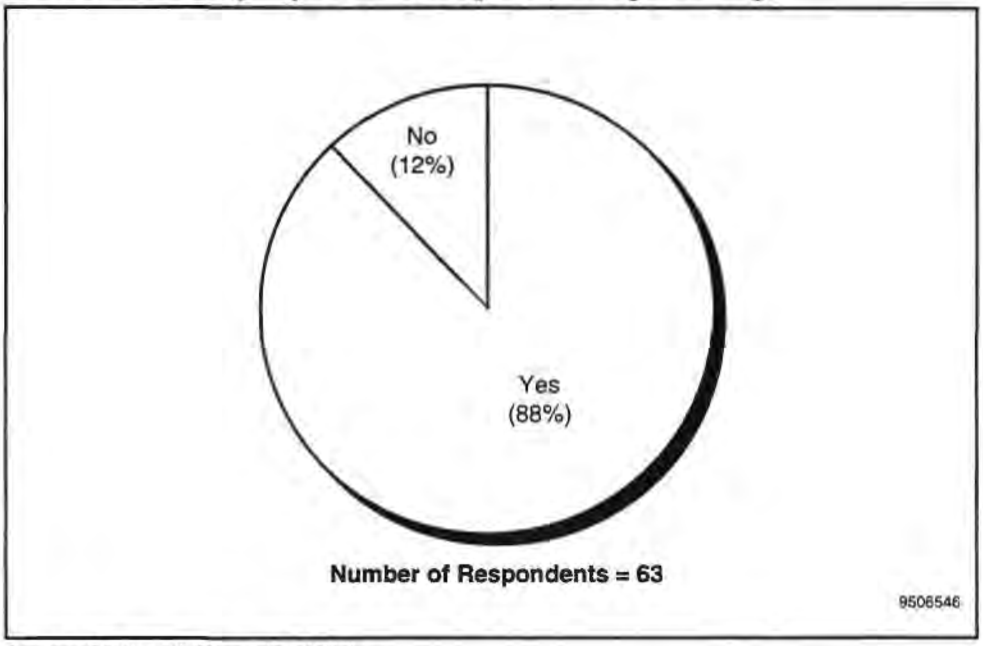
Along with supply base management, another key ingredient of a strategic materials organization is component engineering. Component engineers are responsible for qualifying new parts and, in the best companies, work very closely with supply base management. Thus, it is not surprising that a very high percentage of respondents (88 percent) have component engineering (Figure 2-2) and written procedures for qualifying ICs (Figure 2-3).

Figure 2-1
Does Your Company Have a Supply Base Management or Some Other Type of Strategic Procurement Group?



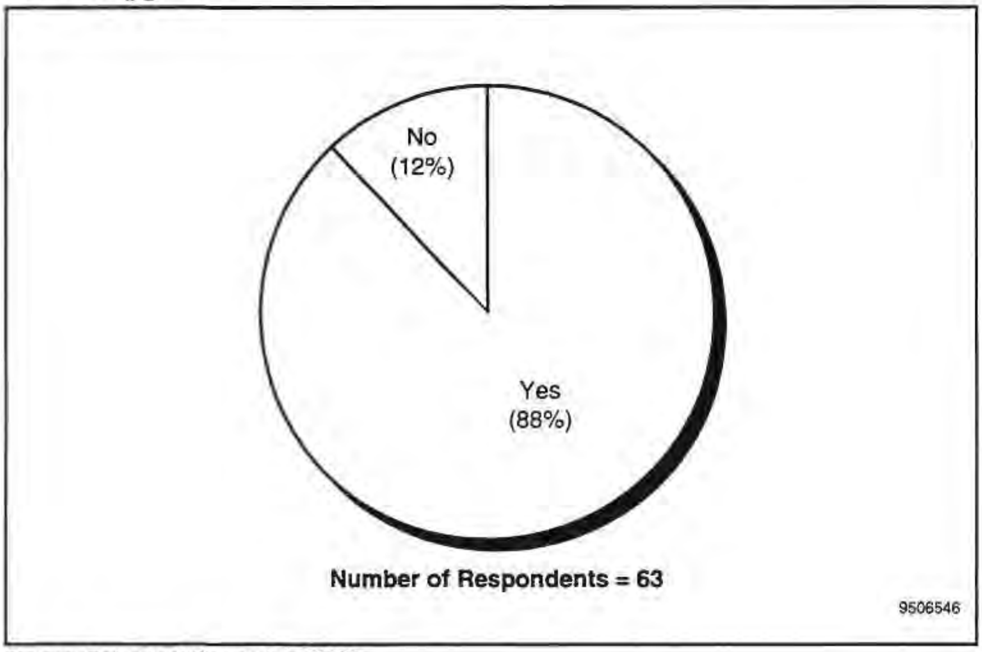
Source: Dataquest (December 1995)

Figure 2-2
Does Your Company Have Component Engineering?



Source: Dataquest (December 1995)

Figure 2-3
Does Your Company Have a Written Procedure for Qualifying New Suppliers?



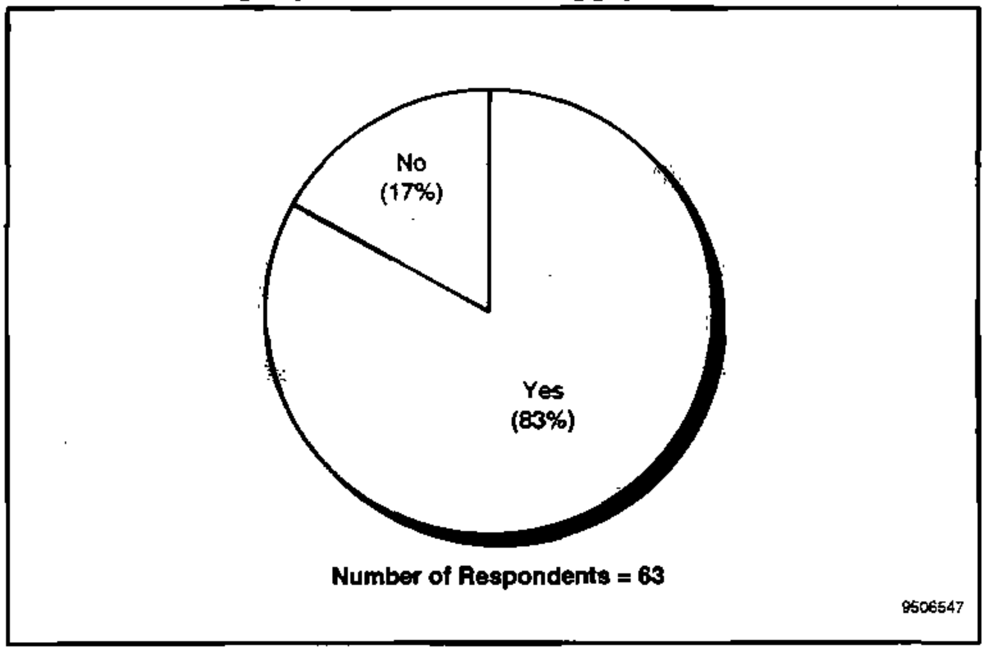
Source: Dataquest (December 1995)

How Close Are OEMs to Their Supply Base?

OEMs with multiple suppliers usually group their supply base in tiers. One popular method is to set up an approved vendor list (AVL) and a preferred vendor list (PVL). The AVL is a listing of the total supply base, while the PVL includes only those suppliers receiving the lion's share (about 80 percent) of the business.

For suppliers, it is critical to understand this tiered system and, more specifically, how to move from the AVL to the PVL. Clearly, most OEMs have embraced the tiered supply base approach, as over 80 percent of respondent companies group their suppliers by preference and usage (see Figure 2-4).

Figure 2-4
Does Your Company Have a Tiered Supply Base?



Source: Dataquest (December 1995)

When asked for their number of key semiconductor suppliers, 90 percent of the respondents indicated that fewer than 50 semiconductor suppliers were key, with the median value being 10 (see Table 2-1). From this point, the survey focused on each OEM's top 10 suppliers only.

Table 2-1
Number of Key Semiconductor Suppliers

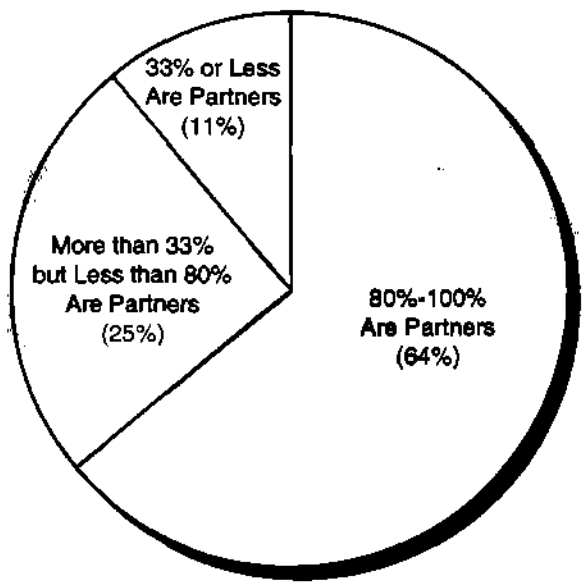
Suppliers	<10	10-49	50-99	100 or More	Total
Respondents	20	37	2	4	63
Percentage	31.8	58.7	3.1	6.4	100.0

Source: Dataquest (December 1995)

The next survey question asked OEMs to describe their relationship with their 10 key suppliers. To this all-important question, a surprisingly high number (64 percent) reported that they feel they have a "true partnership" with at least 80 percent of their key suppliers. The next-largest group of OEMs, 25 percent, said that they were partners with less than 80 percent but more than 33 percent of their suppliers. The smallest number of OEMs, 11 percent, have partner relationships with less than 33 percent of their suppliers. Figure 2-5 shows this data.

The last question concerning overall relationships with key suppliers asked OEMs if they would like to change anything. Nearly 100 percent of respondents were happy with their level of closeness. It can be deduced that supply base management at each OEM has made a conscious decision about how close to be with suppliers and is satisfied with the results.

Figure 2-5
How Close Are OEMs to Their Key Suppliers?



Source: Dataquest (December 1995)

Chapter 3
Critical Supplier Parameters

Lead Times

The next set of questions examined the details of supplier management—lead times, flexibility, and pricing (the big issue). The first two questions compare lead time expectations to reality. As shown in Figure 3-1, 40 of 62 (63 percent) expect the supply base to meet or exceed lead times all the time. In other words, there is little room for supplier error, and performance expectations are quite high. Also, this suggests that OEMs prefer to carry relatively little safety stock, usually less than a 30-day supply.

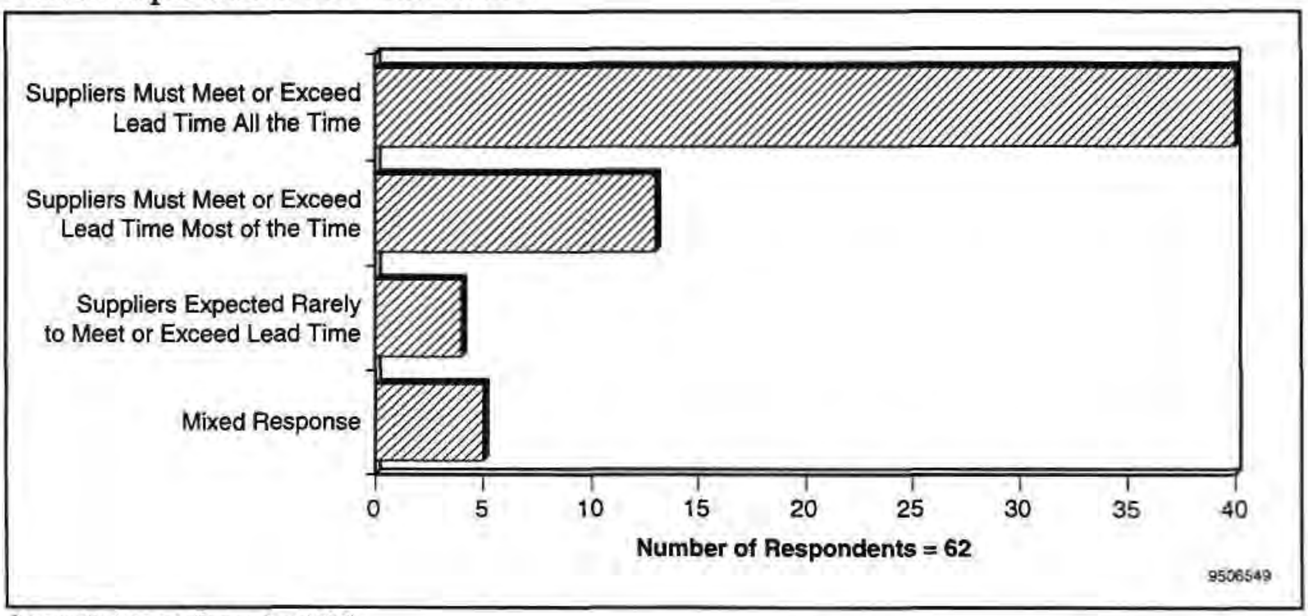
Reality is somewhat different from expectations, as only 15 out of 62 OEMs, or 24 percent, actually have suppliers meeting their lead times all the time. The good news is that 65 percent of the suppliers (nearly two-thirds) meet 100 percent of their deliveries most of the time (Figure 3-2).

The importance of lead time is shown by the fact that 75 percent of all respondents track lead time performance all the time (Figure 3-3). Surprisingly, slightly more than half, 55 percent, share this data with their key suppliers all the time (Figure 3-4).

Pricing

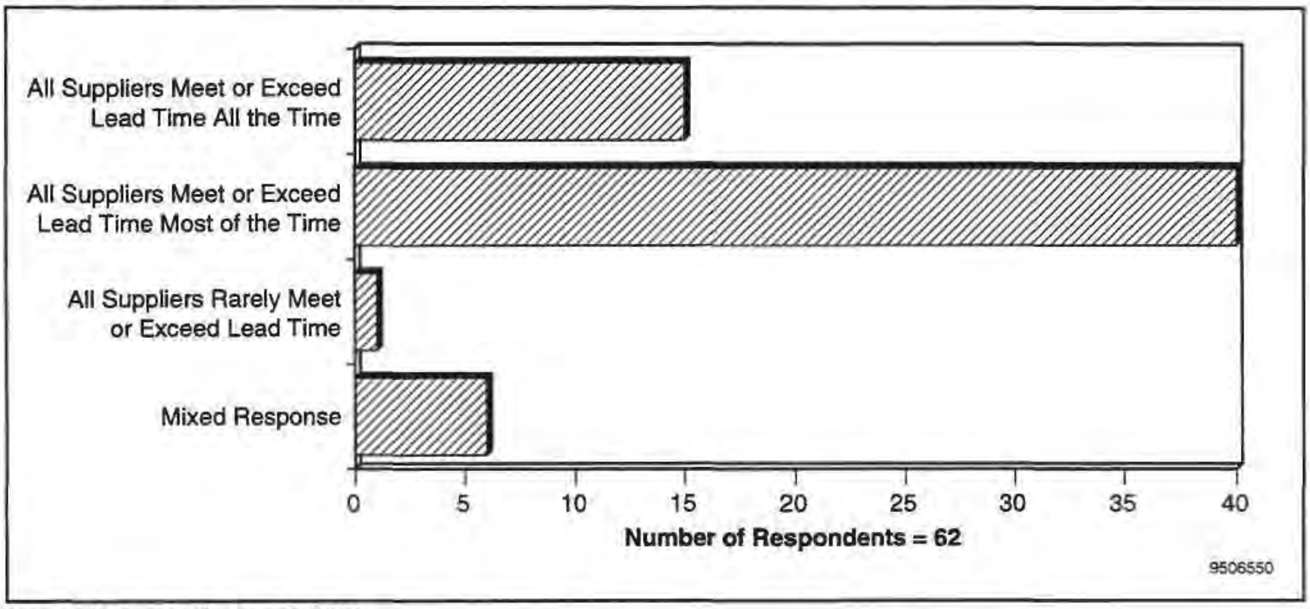
The next question covered the always compelling topic of pricing. As shown in Figure 3-5, more than half of all respondents felt that they receive average pricing from all their suppliers, while only 15 percent see lower-than-average pricing from all their suppliers. Nearly 25 percent report mixed pricing (some below average, some average, and some higher than average) from their supply base.

Figure 3-1
OEM's Expectations for Lead Times



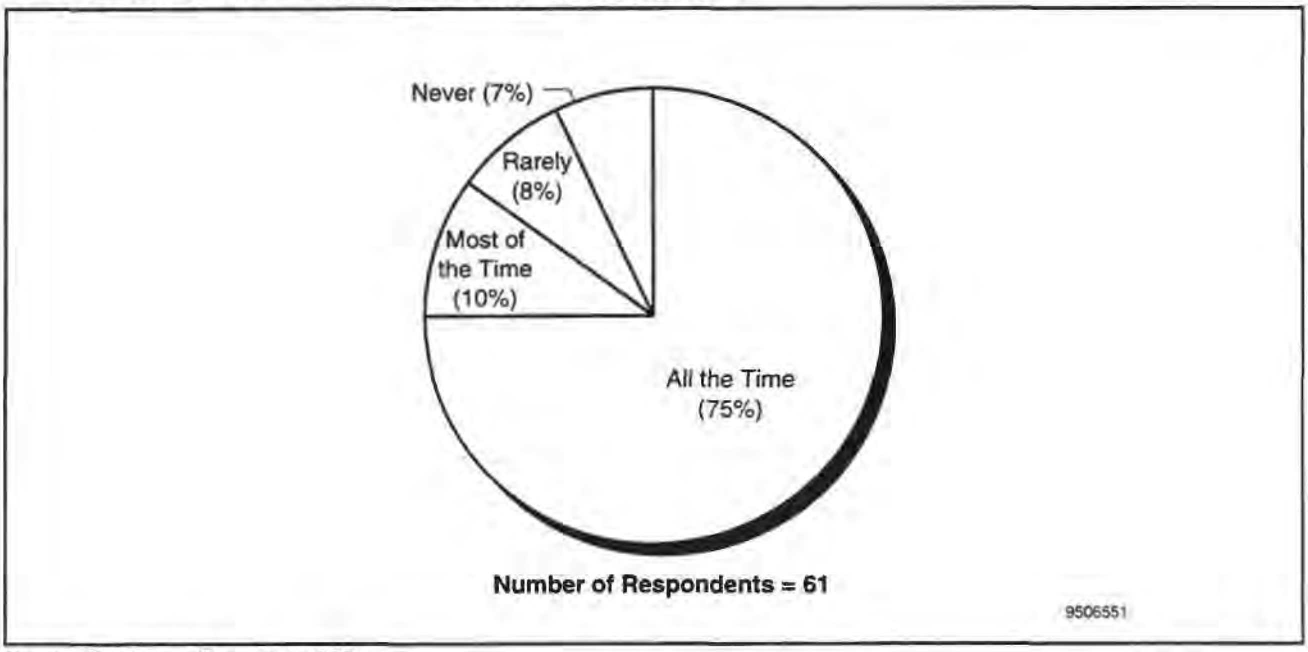
Source: Dataquest (December 1995)

Figure 3-2
OEM's Actual Lead Times



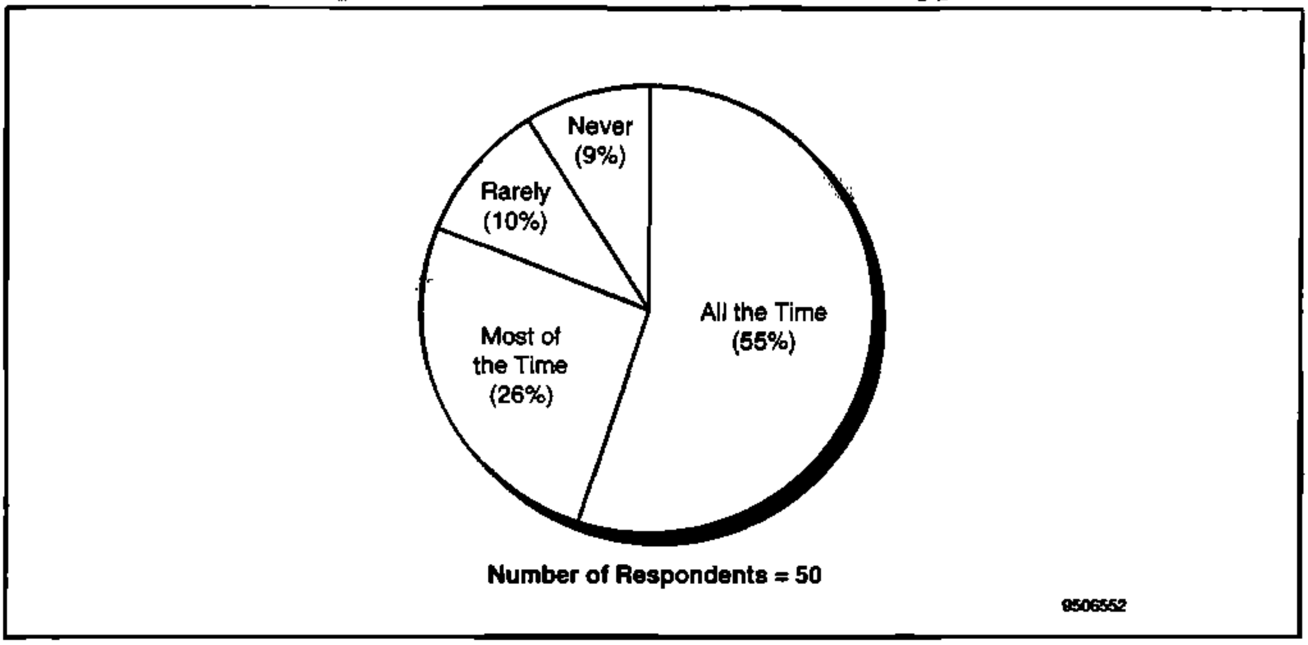
Source: Dataquest (December 1995)

Figure 3-3
How Often Do You Track Lead Time Performance?



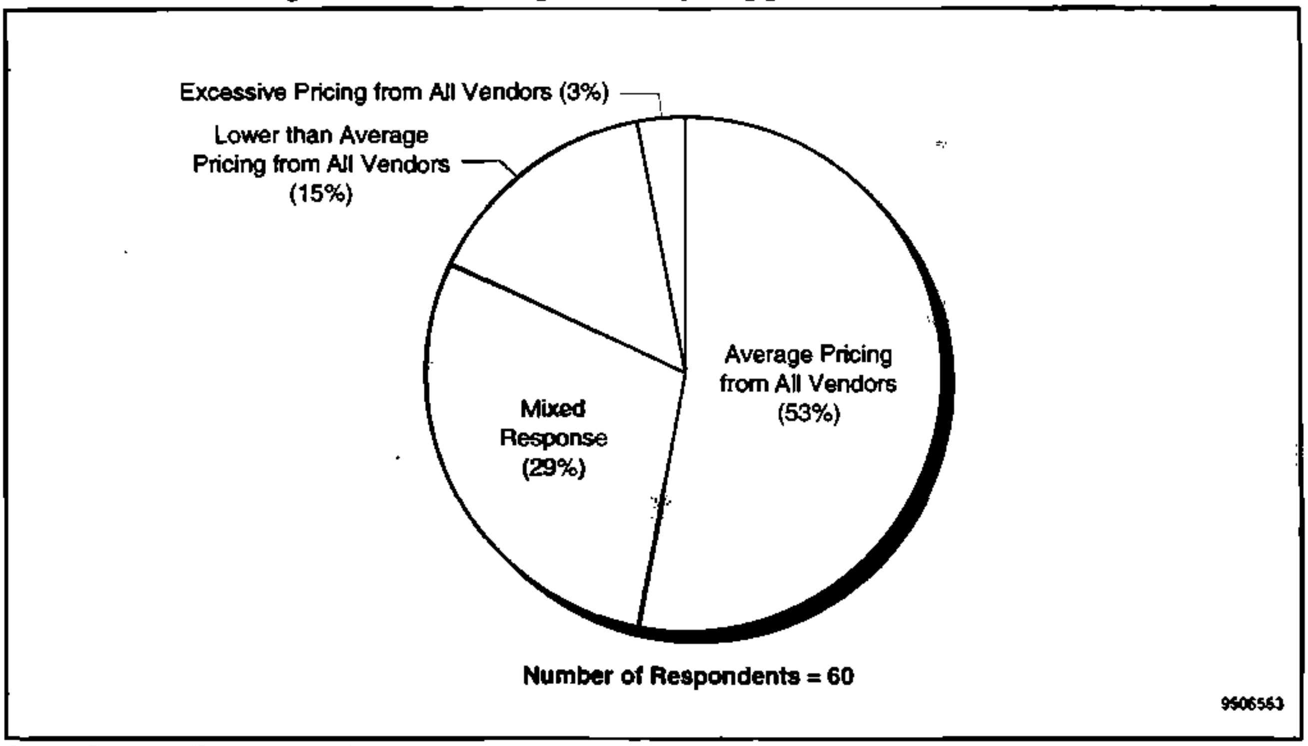
Source: Dataquest (December 1995)

Figure 3-4
How Often Do You Report Lead Time Performance Data to Suppliers?



Source: Dataquest (December 1995)

Figure 3-5
Describe the Pricing You Are Getting from Key Suppliers

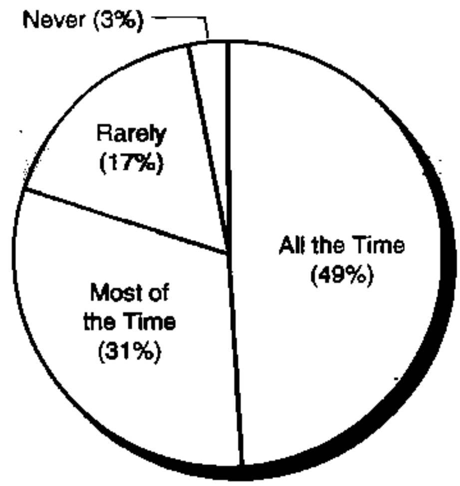


Source: Dataquest (December 1995)

Surprisingly, 25 percent of all respondents feel they are paying excessive prices to at least one of their key suppliers. This pervasive attitude of leaving money on the table stems partly from the general environment of suspicion in the buyer-seller marketplace. Another reason: Some chip manufacturers are using the current undersupply scenario to their advantage and offering less than optimal pricing.

Another hot pricing topic is the issue of quote price versus actual price. The survey shows that 80 percent of respondents receive consistent pricing from their suppliers at least most of the time (Figure 3-6). What is particularly disturbing, though, is the very high percentage, 17 percent, that rarely receives consistent pricing. This is definitely an area for supplier improvement.

Figure 3-6
How Often Are Initial Price Quotes Equal to Actual Billing Prices?



Source: Dataquest (December 1995)

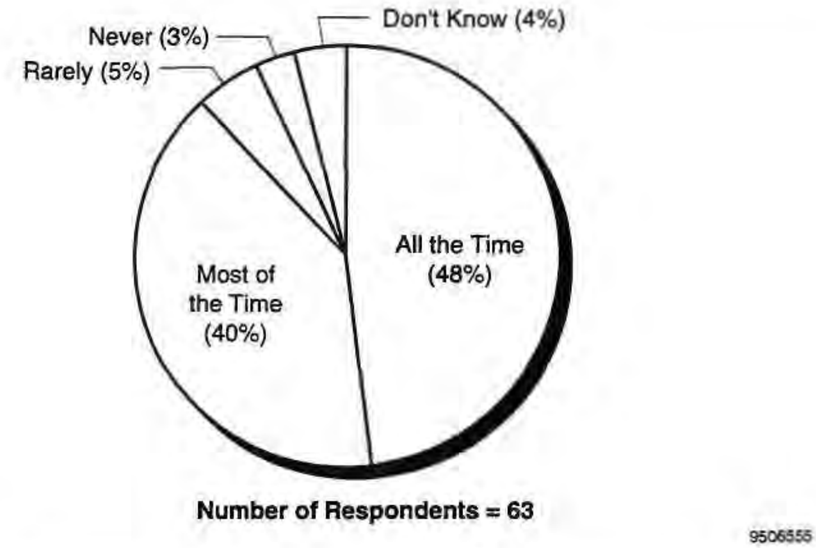
The final question on pricing dealt with component cost versus total cost. For example, it makes no sense to get a great part price if delivery is slow or quality is lacking. The vast majority of respondents, 88 percent, use total-cost analysis at least some of the time (Figure 3-7). Although nearly everyone recognizes the importance of total cost, most supply base managers are still graded primarily against component cost or price.

Flexibility

The volatile nature of most electronic system markets forces OEMs to expect incredible supplier flexibility. Upsides and downsides of more than 10 percent on short notice are not unusual. As shown in Figure 3-8, 69 percent of respondents report that all their key suppliers provide upsides and downsides of more than 10 percent.

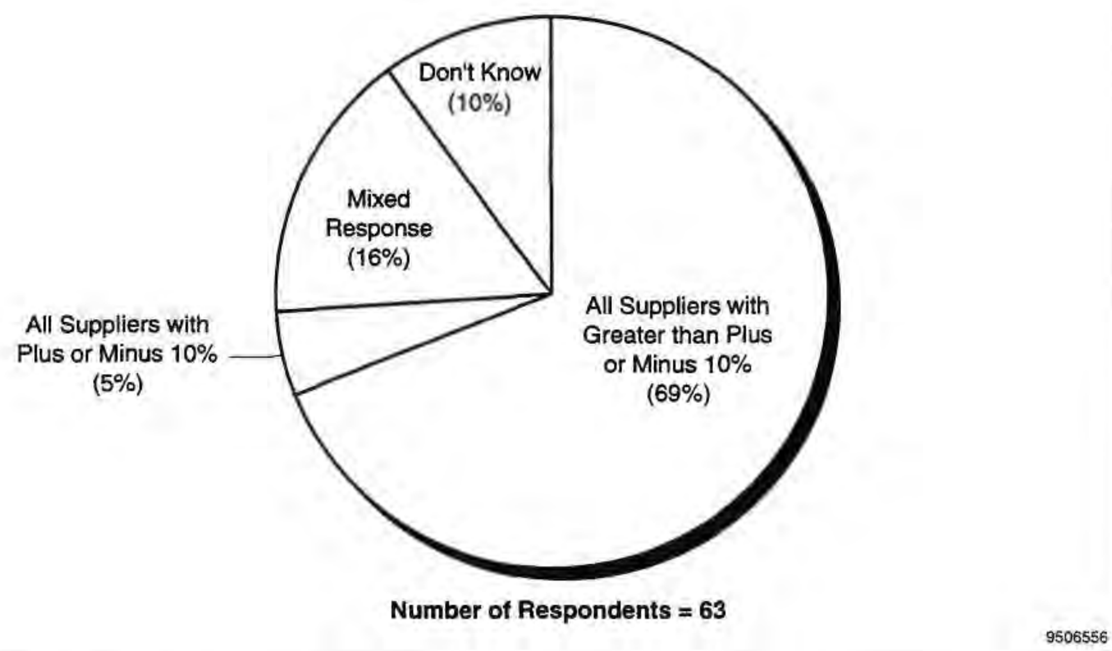
There is room for improvement, however, as 16 percent receive mixed levels of flexibility from their key suppliers. Further, most OEMs within this 16 percent report that 50 percent or less of their supply base provides outstanding flexibility.

Figure 3-7
Do You Use Total Cost Analysis?



Source: Dataquest (December 1995)

Figure 3-8
How Flexible Are Your Key Suppliers?



Source: Dataquest (December 1995)

Chapter 4

Challenges Facing OEMs

Managing ASIC Suppliers

In many respects, ASICs are the ultimate challenge for OEMs and the supply base. Unlike standard off-the-shelf products, ASICs are highly customized, frequently single-sourced, very complex, and carry high average selling prices. Of the total of 63 respondents, 36 (or 57 percent) purchase ASICs.

The number of ASIC suppliers per OEM varied from one to 10, with two being the most frequent (see Table 4-1).

Table 4-1
Number of ASIC Suppliers per OEM (N = 36)

ASIC Suppliers	1	2	3	4	5	6	7	8	9	10
Respondents	4	11	3	3	5	5	1	2	0	2
Percentage	11.1	30.5	8.3	8.3	13.9	13.9	2.8	5.6	0	5.6

Source: Dataquest (December 1995)

ASIC contracts can be structured on a time or volume basis. According to the survey, OEMs overwhelmingly prefer time-based contracts (see Figure 4-1). Only 14 percent of all respondents use strictly volume-based contracts. Even in the mixed category, only two of seven respondents use volume.

The most popular time contract is the annual contract. ASICs are typically single sourced, so OEMs are somewhat limited in their price negotiation strategies. One strategy is to source multiple ASIC devices at one supplier and negotiate one annual contract on the whole lot.

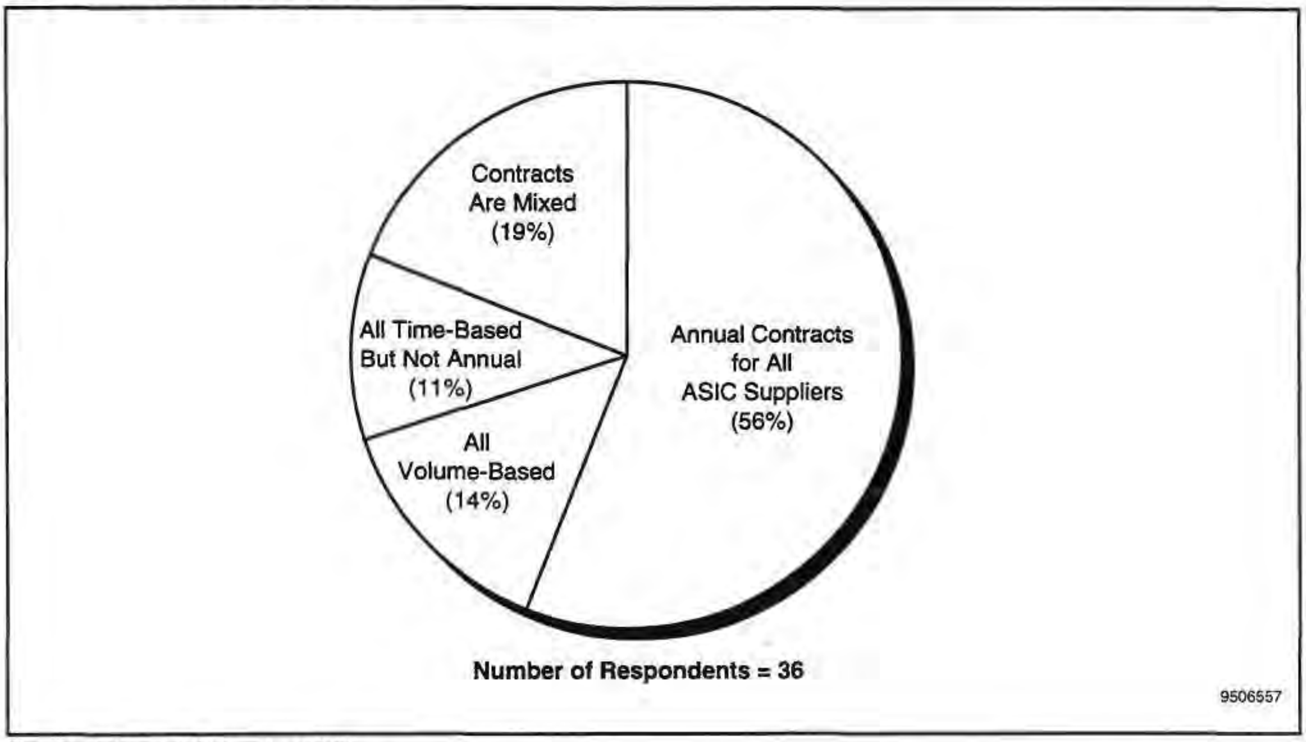
Whatever the structure of their ASIC contract, OEMs indicate that they are unanimously satisfied with the arrangement. In other words, OEMs do not feel there is any advantage in changing how they do business with their ASIC supply base.

ASIC nonrecurring engineering costs (NREs) vary greatly, usually depending on the number of times the device is turned, or redone. In concrete terms, the NRE averages around $50,000 for a middle-density (50,000-gate) digital device.

Such a nontrivial expense can be handled up front or amortized into the production price of the device. The survey indicates that 85 percent of the respondents prefer to pay the NRE separately and up front with all their ASIC suppliers (see Figure 4-2). As with the ASIC contract, nearly all OEMs are content with their current NRE payment method.

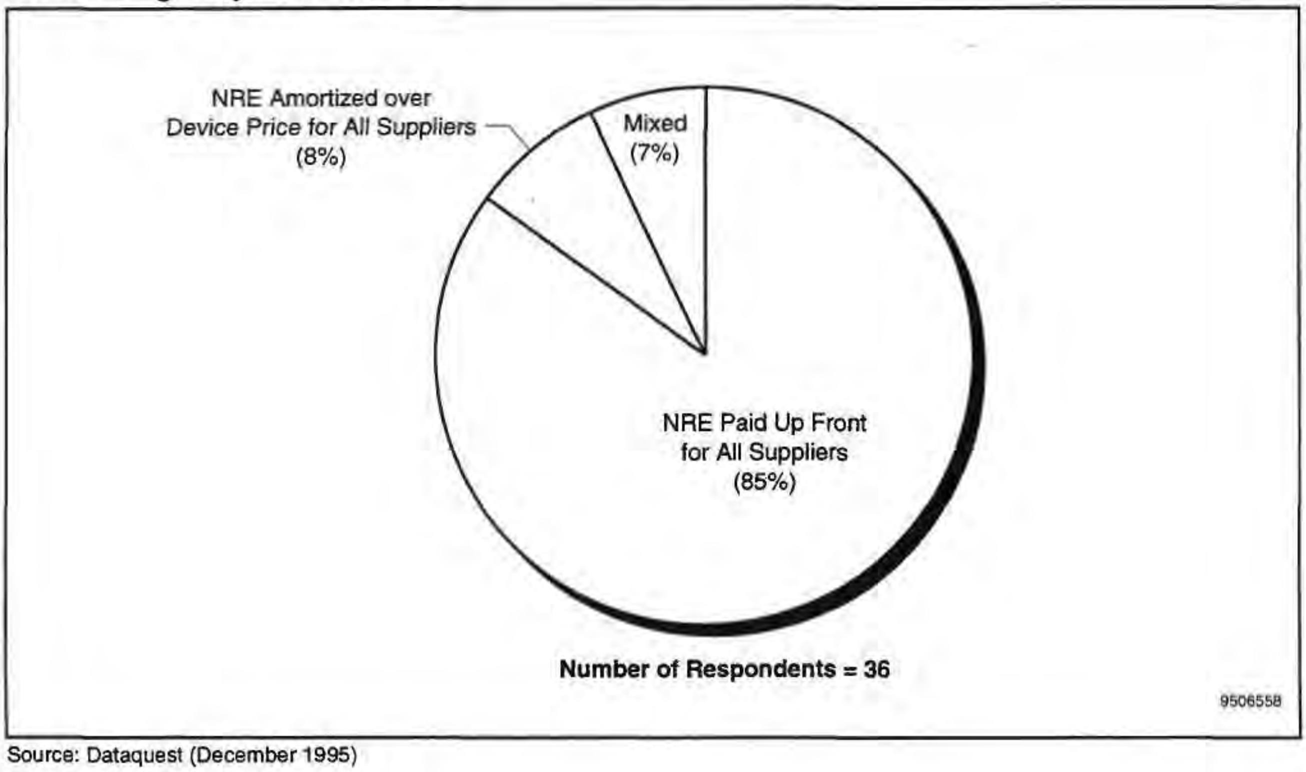
One respondent commented that the NRE should disappear when a long-term partnership is established and there is substantial commitment to new products. This is an innovative idea but will no doubt be a very tough sell to most ASIC suppliers.

Figure 4-1
Structure of ASIC Contracts



Source: Dataquest (December 1995)

Figure 4-2
NRE Charge Payment Method



Source: Dataquest (December 1995)

The Purchase Order Process

PO processing can be done in a variety of ways. The old standby is to telephone the order and then confirm via fax or mail. This method has served the industry well for years and is still very popular.

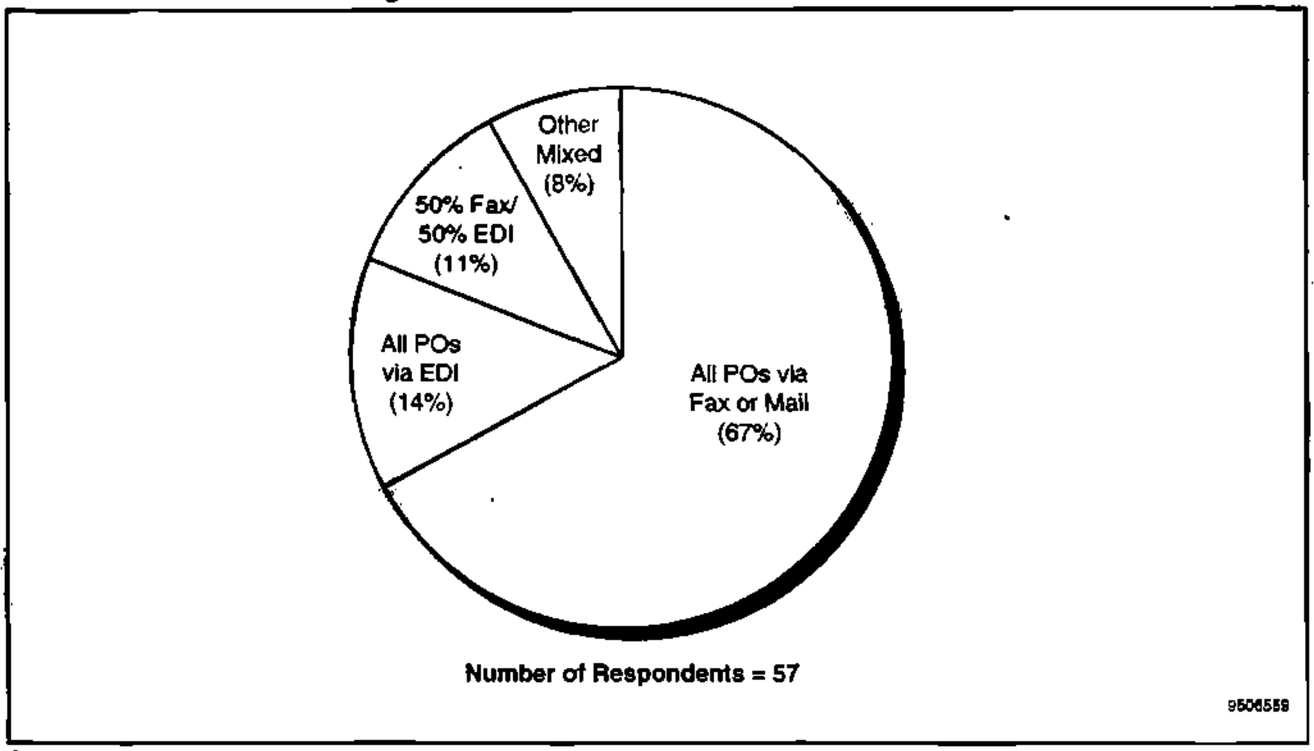
A new and potentially paperless method is electronic data interchange. Using EDI, a buyer sends requirements over the desktop PC to the supplier. Electronic communication generally makes it easier for the buyer to share more extensive data with the supplier, such as forecast build schedules, shortage reports, and quality statistics.

An even more radical idea is vendor-managed inventory (VMI), in which the OEM and the supplier work extremely closely. The supplier is not only given forecast build plans, but may also help to create them. In some companies, VMI works so well that suppliers send parts when needed without being prompted by a PO. This is referred to as a reverse PO system.

The inventory in a VMI process is generally kept very near the OEM plant, sometimes actually within the plant. Obviously, in practical terms, all of this coordinated management means that VMI could be employed only with the OEM's most important suppliers.

As shown in Figure 4-3, over two-thirds of all OEMs still place POs via fax or mail. EDI shows some promise, but it has not been widely embraced. Less than 15 percent of the respondents are using EDI with all suppliers, and 11 percent are using EDI with half their supply base. Vendor-managed inventory is in use at only one OEM and with only some of its supply base.

Figure 4-3
Purchase Order Processing Method



Source: Dataquest (December 1995)

When asked whether OEMs are satisfied with their purchase order process, the respondents overwhelmingly voted for the status quo. Only one OEM expressed a desire for significant change, in this case from EDI to VMI.

OEM-Supplier Conflicts

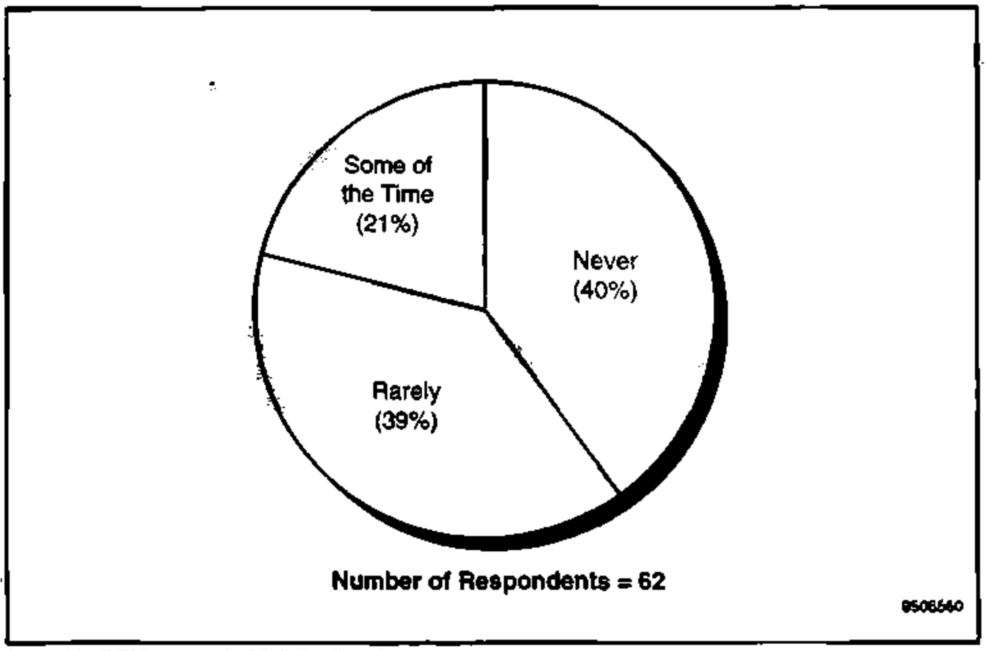
As with any business relationship, OEMs and their suppliers experience good times and not-so-good times. Nonperformance by the supplier in any area can severely test the OEM-supplier bond. The last two questions in the survey probed the OEM's attitude toward the supplier during those rough periods.

The first of the two questions asked: "How often would you be willing to accept a temporary setback in quality, cost, or delivery until a key supplier could get back on track?" The message that came back could not have been clearer. Almost 80 percent responded "never" or "rarely" (see Figure 4-4).

The next question asked: "If key suppliers could give you annual reductions in cost, how often would you be willing to allow them a reasonable, short-term increase in price?" Here the OEMs are much less strident, with 41 percent marking "never" or "rarely." Fully one-half would accept a conditional short-term increase some of the time (see Figure 4-5).

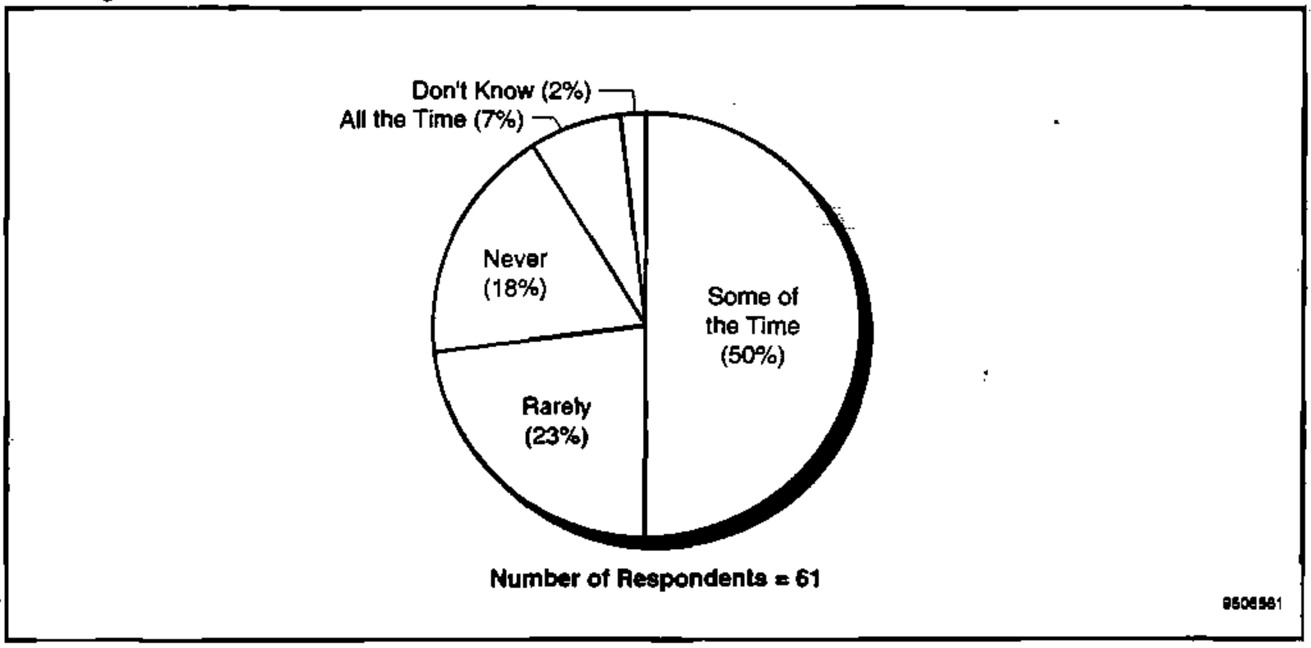
Read carefully, these two questions are very similar, with the exception that the second question provides an incentive for the OEM to be flexible. Many OEMs indicated that a long-term financial gain can keep the supplier relationship from being destroyed even through tough times.

Figure 4-4
How Often Would You Be Willing to Accept a Temporary Setback in Quality, Cost, or Delivery until a Key Supplier Could Get Back on Track?



Note: No OEM responded "all the time."
Source: Dataquest (December 1995)

Figure 4-5
If Key Suppliers Could Give You Annual Reductions in Cost, How Often Would You Be Willing to Allow Them a Reasonable, Short-Term Increase in Price?



Source: Dataquest (December 1995)

Chapter 5
Dataquest Perspective

Over the last four years, IC supplies have been tight, and prices have remained high. At the same time, OEMs have added extra features and functionality to their products but have not been able to pass all this cost to the final customer. The result has been that many OEMs have seen their profit margins drop more than 10 basis points. Given this background, it is somewhat surprising that Dataquest's OEM Survey showed only low levels of animosity toward suppliers.

In general, OEMs are striving to maintain a "partner" relationship with their key suppliers. Much of this attitude is driven by the dedicated strategic procurement organizations that work to foster a loyal and world-class supply base. For their part, suppliers are also thinking more strategically and want to keep key customers for a long time.

This is not to say that either the IC user or maker has gone soft. In a partnership arrangement, the OEM gives key suppliers more business but, in exchange, demands better service, pricing, and flexibility. The key suppliers now expect more timely and accurate forecasts, as well as an inside track on future business.

Despite this overall healthy picture, there are some significant disconnects. For example:

- There is a measurable amount of distrust, as 25 percent of OEMs believe that some prices are excessive.
- Many OEMs note that the quote price is different from the actual price. The supply base could do much to improve this situation.
- OEMs religiously track lead times, but only half share this data with their suppliers. Sharing this type of data provides an environment in which needs and expectations can be discussed in a serious, but non-confrontational, manner.
- OEMs appear reluctant to help a supplier unless there is a tangible payoff. This attitude does not square very well with a true partnership relationship. Perhaps part of this view stems from the IC undersupply and the one-sided pricing environment. It would be interesting to see if OEMs are more charitable when the supply/demand picture is more balanced.

Perhaps the best analogy to the OEM-supplier relationship is taken from family life. In the early days of the electronics industry, both suppliers and OEMs acted like spoiled children. The atmosphere could be confrontational, and all actions were driven by immediate and short-term needs.

Although not fuller adult in nature, the electronics industry has matured, with both IC makers and users trying to think long term and strategically. Dataquest expects this partnership trend to grow but only with the key suppliers. Life for those suppliers on the outside will become worse as the supply-demand picture eventually shifts in favor of IC users. Dataquest will continue to monitor closely the ongoing and intriguing relationships between OEMs and their suppliers.

Appendix A

The OEM Survey

October 23, 1995

Hello, this is ______ with Dataquest in San Jose (California). We're doing a quick study on semiconductor procurement practices. (IF DQ CLIENT: You might have heard about this from Scott Hudson or Mark Giudici.) All of your individual responses are confidential and will be used for research only. And because you are busy, in appreciation for your time, we'll send you a summary of the research findings.

1. To begin, does your company have supply base management or some type of strategic procurement organization?
   - ❑ Yes
   - ❑ No
   - ❑ Do not know/Refused

2. Does your company have component engineering?
   - ❑ Yes
   - ❑ No
   - ❑ Do not know/Refused

3. Does your company have a written procedure for qualifying new suppliers?
   - ❑ Yes
   - ❑ No
   - ❑ Do not know/Refused

4. Does your company have a tiered supply base (for example Approved Vendor List and Preferred Vendor List)
   - ❑ Yes
   - ❑ No
   - ❑ Do not know/Refused

A. How many KEY semiconductor suppliers in total does your company deal with?

   ___________*

A lot of my questions will involve dividing up this number into various categories.

* If have more than 20 suppliers, say, "Please focus on the top 10 key suppliers."

5. To start, please divide this total supplier number into the following three categories: how many suppliers do you have a...

   (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

   ______ Very close relationship or true partnership with *versus*
   ______ Good working relationship with *versus*
   ______ Suppliers you are not really close to, as if they are merely one of many vendors
   ______ Do not know/Refused

   < MUST TOTAL QUESTION A, PAGE 1 >

6. Now, would you prefer that these relationships be distributed *differently*? IF YES, how many would you like in each category?

   ______ Very close or true partnership
   ______ Good working or valued supplier relationship
   ______ Suppliers not really close to or one of many
   Do not know/Refused
   ______ DO NOT WANT CHANGES

   < MUST TOTAL QUESTION A, PAGE 1 >

7. How many of your key suppliers do you expect to meet or exceed your lead time requirements...?

   (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

   ______ All the time *versus*
   ______ Most of the time *versus*
   ______ Rarely
   ______ Never
   ______ Do not know/Refused

   < MUST TOTAL QUESTION A, PAGE 1 >

DEFINITION

Lead time: The time it takes from issuing a purchase order to when the items arrive at the receiving dock.

8. Now, how often do your key suppliers *actually* meet your lead time expectations...?

   (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

   ______ All the time *versus*
   ______ Most of the time *versus*
   ______ Rarely
   ______ Never
   ______ Do not know/Refused

   < MUST TOTAL QUESTION A, PAGE 1 >

9. How often do you actively track your key suppliers' lead time performance? (READ LIST, CHECK ONE ONLY)
   - ❑ All the time
   - ❑ Most of the time
   - ❑ Rarely—**SKIP TO QUESTION 11**
   - ❑ Never—**SKIP TO QUESTION 11**
   - ❑ Do not know/Refused—**SKIP TO QUESTION 11**

10. How often do you show this lead time performance data to them during performance reviews? (READ LIST, CHECK ONE ONLY)
    - ❑ All the time
    - ❑ Most of the time
    - ❑ Rarely
    - ❑ Never
    - ❑ Do not know/Refused

11. In general, how many of your key suppliers would you say charge excessive pricing? Charge average pricing? How many charge lower-than-standard pricing?

    (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

    ______ Excessive pricing
    ______ Average pricing
    ______ Lower-than-standard pricing
    ______ Do not know/Refused

    < MUST TOTAL QUESTION A, PAGE 1 >

12. How often are initial price quotes equal to the actual billing price? (CHECK ONE ONLY)
    - ❑ All the time
    - ❑ Most of the time
    - ❑ Rarely
    - ❑ Never
    - ❑ Do not know/Refused

13. How often do you use some type of "total cost analysis" in comparing prices from different suppliers? (CHECK ONE ONLY)
    - ❑ All the time
    - ❑ Most of the time
    - ❑ Rarely
    - ❑ Never
    - ❑ Do not know/Refused

DEFINITION

Total cost analysis: May include transportation cost/time, previous history, flexibility, quality, or reliability

14. Now, regarding the level of flexibility of your key suppliers, how many have....

(READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

_____ More than 10% upside/downside flexibility
_____ 5 to 10% flexibility
_____ Less than 5% flexibility
_____ No flexibility
_____ Do not know/Refused

< MUST TOTAL QUESTION A, PAGE 1 >

B. Of your key suppliers, how many are ASIC suppliers?

_____

15. How many of your ASIC contracts are structured as....

(READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

_____ Annual contracts *versus*
_____ Set time other than one year *versus*
_____ Contract based on volume not time
_____ Some other structure (please describe)
_____ Do not know/Refused

OTHER Please describe the contract structure:

____

____

16. Would you like these contracts to be structured differently? IF YES, how many would you like in each category?

(READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

_____ Annual contracts
_____ Set time other than one year
_____ Contract based on volume not time
_____ Some other structure (please describe)
_____ Do not know/Refused
_____ DO NOT WANT THEM TO BE DIFFERENT

OTHER Please describe the desired contract structure:

____

____

17. How are nonrecurring engineering charges handled? (NREs)

    (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

    ❑ Total NRE up front and production pricing for devices
    ❑ NRE amortized over set production period
    ❑ Other (please describe)
    ❑ Do not know/Refused

    < MUST TOTAL QUESTION A, PAGE 1 >

    OTHER Please describe other NRE situation:

    ____

    ____

18. Would you like these NREs to be handled differently?
    IF YES, how many would you like in each category?

    (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

    ❑ Total NRE up front and production pricing for devices
    ❑ NRE amortized over set production period
    ❑ Other (please describe)
    ❑ Do not know/Refused
    ❑ DO NOT WANT THEM TO BE DIFFERENT

    < MUST TOTAL QUESTION A, PAGE 1 >

    OTHER Please describe the desired NRE handling:

    ____

    ____

19. We're almost done. I have some final questions about purchase orders. How many key suppliers do you currently share order information with by...?

    (READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

    ______ PO via fax or mail
    ______ PO via electronic data interchange (EDI)
    ______ Vendor-managed inventory (vendor is responsible for inventory)
    ______ Other (please describe)
    ______ Do not know/Refused

    < MUST TOTAL QUESTION A, PAGE 1 >

    OTHER Please describe the PO situation:

    ______

    ______

20. Would you like to share PO information differently?
IF YES, how many would you like in each category?

(READ LIST, DIVIDE UP TOTAL INTO CATEGORIES BELOW)

_____ PO via fax or mail
_____ PO via EDI
_____ Vendor-managed inventory (vendor is responsible for inventory)
_____ Other (please describe)
_____ Do not know/Refused
_____ OK AS IS

OTHER Please describe the desired PO situation:

____

____

21. How often would you be willing to accept a temporary setback in quality, cost, or delivery until a key supplier can get back on track? (CHECK ONE ONLY)

- ❑ All the time
- ❑ Some of the time
- ❑ Rarely
- ❑ Never
- ❑ Other (please describe)
- ❑ Do not know/Refused

OTHER Please describe the temporary setback situation:

____

____

22. If key suppliers could give you annual reductions in cost, how often would you be willing to allow them a reasonable, <u>short-term</u> increase in price?

- ❑ All the time
- ❑ Some of the time
- ❑ Rarely
- ❑ Never
- ❑ Other (please describe)
- ❑ Do not know/Refused

OTHER Please describe the profit situation:

____

____

23. My final question: What is your annual semiconductor procurement volume in dollars?

$ ____________________

That concludes our survey! I appreciate your time and input.

NAME ______________________________

COMPANY ______________________________

DIVISION ______________________________

STREET ______________________________

CITY/STATE/ZIP ______________________________

PHONE ______________________________

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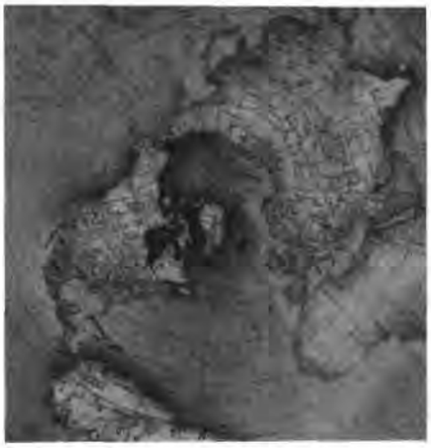

Dataquest

Low-Voltage IC Update: What's the Rush?

Focus Report

Program: Semiconductor Procurement Worldwide
Product Code: SPSG-WW-FR-9501
Publication Date: April 24, 1995
Filing: Focus Studies

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Executive Summary

3V Memory Today

Although a 3V industry standard has existed since 1984, 3V memory ICs did not emerge until the recent past. The original rationale of the 3V standard itself is somewhat alarming: 3V-level tolerance will become a limiting factor when feature sizes shrink below the 0.25-micron level. This should occur later this decade. That means the market must move to 3V and lower voltages.

For the near-term, the 3V memory market is just emerging from the nascent stage of its technology cycle. As a result of current mixed market review and lower production volumes for 3V memory, pricing is higher than for 5V-comparable devices. This results in yet another obstacle to quick market acceptance. This report shows that a lack of key 3V memory ICs could somewhat constrain the growth prospects for some newly emerging 3V systems. Some system designers already work at "designing around" the limited availability of 3V devices.

Chapter 2
3V Market Drivers

DRAM Needs 3V Technology

The current drive toward 3V technology appears to be driven by applications. Strangely, however, the anticipation of high-density DRAM production difficulties motivated the entire move to lower voltages.

DRAMs have been believed to follow what the industry knows as "Moore's Law," which states that the density of DRAMs quadruples on average every three years. This trend, when plotted using Dataquest's historical DRAM unit shipment figures from 1978 to 1993, shows a growth rate that averages just 233 percent, rather than 300 percent, over every three-year period (see Figure 2-1).

Highly Predictable DRAM Trends

Two other highly predictable trends drive the DRAM density increase: the size of a production DRAM die, and the minimum manufacturable feature size on this die. These highly predictable phenomena provide a basis for estimating semiconductor technology to meet certain physical barriers. The DRAM technology through its history, however, has bypassed a set of physical barriers that indicated a limit to future generations of DRAM. The forecasts of the DRAM technology's demise typically said that the physical barriers would apply to three generations of density after the current generation.

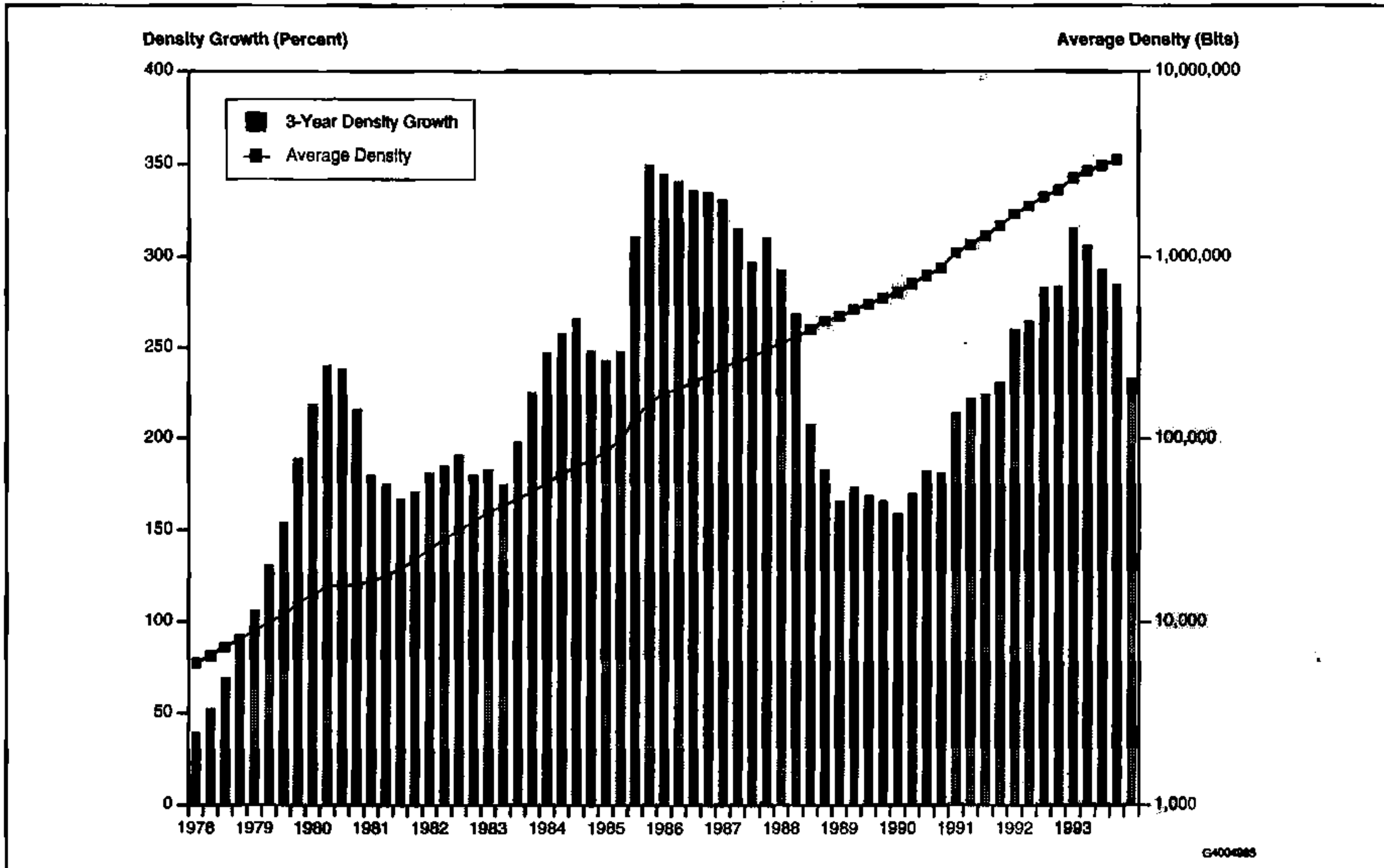
For example, regarding 3V technology, astute process researchers during the mid-1980s became concerned about the trends driving increasing DRAM densities. These trends ultimately required the use of submicron-process geometries that could not withstand a 5V potential. After a lot of consideration, the Electronic Industry Association's (EIA) Joint Electron Devices Engineering Committee (JEDEC) settled upon a 3.3V standard as the target for the next generation of all digital logic products.

Before adoption of the 3.3V standard, the 5V standard had been the major logic-level standard for some 25 years. An old gate topology—used in almost none of the transistor-transistor logic (TTL)-compatible logic manufactured today—set the 5V standard. Since that time the market door has remained open to the establishment of even lower voltage standards.

There is industry agreement that the 3.3V-level tolerance becomes a limiting factor when feature sizes shrink below the 0.25-micron level. Current target voltages lie from 1V to 2V.

Realizing that a voltage change was unavoidable, manufacturers expressed a desire to not run devices at the two different voltages. Few manufacturers were willing to embrace the extra pin needed to put both 3V and 5V supplies into the device. Despite this resistance, there were two good reasons to lower the voltage from an applications viewpoint.

Figure 2-1
Average DRAM Density Growth



Source: Dataquest (April 1995)

First, microprocessors were already becoming so fast that there was a lot of trouble using the standard TTL logic levels without experiencing a lot of noise problems on the circuit board. Although high-speed specialty logic companies were devising innovative ways of counteracting the problems, these approaches were cures to an existing problem rather than approaches to preventing the problem in the first place. Many designers were considering the use of emitter-coupled logic (ECL) I/O levels in future designs, simply because the use of TTL I/O levels was proving to be too unreliable. ECL logic runs on a 1V swing and is much less noisy than TTL. The 3V logic signal is a compromise between ECL levels and TTL levels. Second, there is a push to solve power consumption problems in PCs. Battery-operated systems stimulated the initial thrust on reducing PC power consumption, for example, laptop computers. The recent advent of the "green PC" campaign, however, most dramatically increased the importance of lower-power products.

3V Power Savings

We can readily compute the power saving afforded by shifting from 5V to 3.3V because power is directly proportional to the square of the voltage used. The difference in power consumption of the same system running at 5V and at 3.3V is $3.3^2/5^2 = 10.9/25 = 44$ percent. That shows that the lower-voltage system operates at 44 percent of the power of the higher-voltage system.

However, this savings of more than half the power comes at a cost. When run at voltages far lower than the voltages for which they were designed, standard memories slow down significantly. Most SRAMs will run at 3V but will exhibit an access time about three times as long as they would at their standard voltage.

Although not widely done because of the small size of the market, redesigning and optimizing the memory part for 3V operations solves the speed problem to a certain degree. Extreme optimization, however, renders the part unusable at 5V. Other devices, most notably flash memory, lose some of their functionality at 3V. There is not now a multiply sourced flash memory that offers 3V programmability. The only one Dataquest has even heard of is from Atmel, a company that specializes in lower-voltage technologies.

Application Drivers

Since the adoption of the 3V standard, demand has been slow to materialize. Why?

The argument in favor of saving power through 3V technology needs evaluation in terms of the applications using the technology. Who stands to merit? How much is the merit? Are 3V versions of all of the appropriate components available, and, if so, is there a cost-adder? What is the cost versus the value of making a 3V system?

3V Today

In the world of truly tiny battery-operated components—for example, telecommunications or portable instrumentation—3V has already made its transition. Pagers use 3V microcontrollers. Pagers that offer features that require memory tend to employ 3V SRAM. Digital cellular phones popularly surround 3V digital signal processing (DSP) chips with 3V SRAM and flash memory, while analog cellular phones use 3V EEPROM for identification codes. Bar code scanners, also built around 3V MPUs, store data in 3V SRAMs. Ironically, none of these applications uses DRAMs, the devices that originally drove the adoption of a 3V standard.

After the smallest battery-operated devices, which tend to be new twists on existing applications, come the new applications, which include battery-operated general-purpose portable computing equipment. Advanced Micro Devices introduced a 3V version of the 386 CPU back in 1991, but it failed to gain market acceptance. For applications that do not use a 3V CPU, there is little rationale for surrounding it with 3V memory and peripherals, even if the original power source offers a voltage lower than 5V. Linear IC companies such as Linear Technology and Maxim have put a lot of finesse into power-conversion ICs. These companies offer very high efficiency 3V to 5V up-converters in tiny form factors with the easiest possible design effort. Once a power-conversion device converts the power for one component, it becomes easy to rationalize using the same source to power any and all 5V components.

Why 5V Laptops?

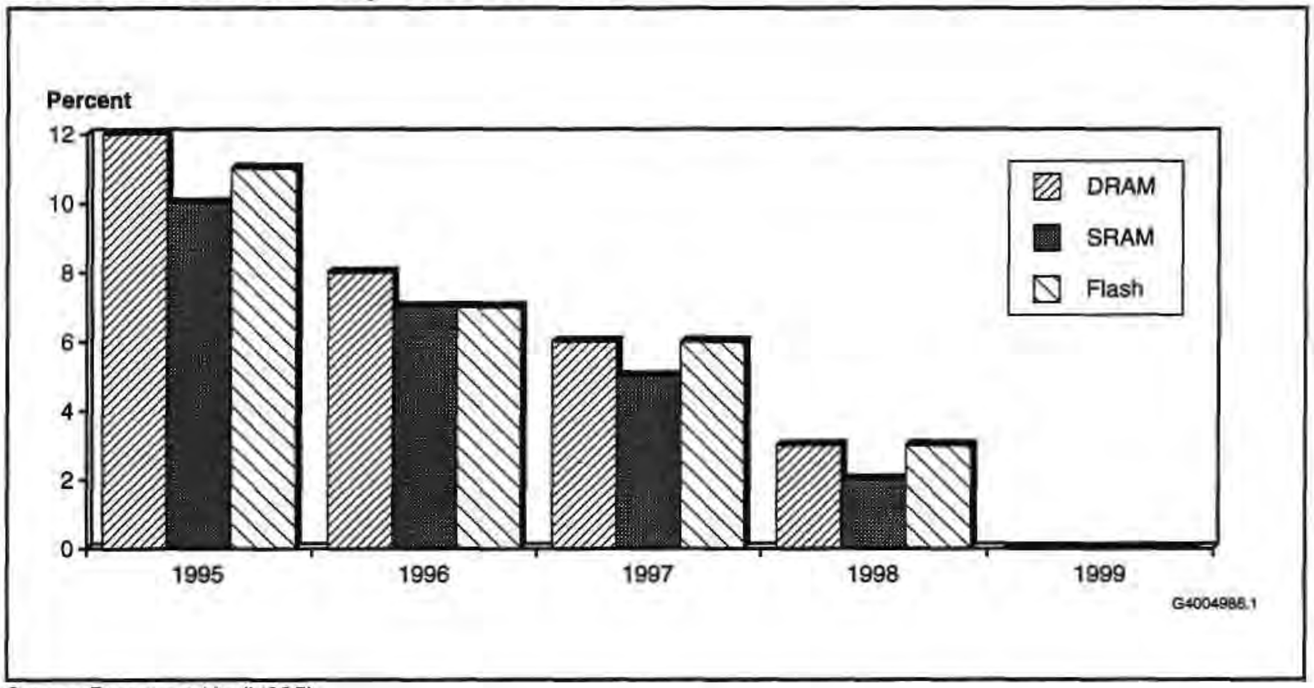
Still, with the power savings that 3V has to offer, why does anyone use 5V parts in a laptop computer? There is still a markup for 3V versions of any widely available part. The rotating media and the backlit LCD consume about 70 percent of the power used in a PC. If a designer will pay extra for power savings, the reasonable place to spend it is where it will do the most good, and this is not on the motherboard.

Ironically, the memory used in notebook computers is likely to be 3V DRAM in a 5V system. Notebook computers often use DRAM and sometimes pseudo SRAM, which is also a form of DRAM. DRAMs can benefit from 3V technology at the 16Mb density, but this density is not in widespread use in notebook computers.

Still, the computers of tomorrow that use 16Mb DRAMs will probably use versions of the component that have 3V cores surrounded by 5V periphery—with an inefficient 3V-to-5V converter on the chip. All of the CPU and surrounding logic will be 5V. In the near term, this type of chip likely will sell for a lower price than straight 3V DRAMs. Figures 2-2 highlights the 3V price premiums for the major memory families compared with like 5V memory devices. Dataquest expects process technology progress to gradually phase out price premiums.

On another front, there has been a push recently from Intel for new computer designs to use 3V logic around the CPU. A new version of the Pentium processor and the DX4 version of the 486 both were announced early in 1995. The versions both use a 3V interface that is intolerant of being connected to a 5V component. Here again there is an irony. The only

Figure 2-2
3.3V versus 5.0V Memory Price Premiums



Source: Dataquest (April 1995)

components tied directly to the CPU in most systems are the cache SRAM and the core logic chipset. The DRAMs, which were the driver for the 3V conversion in the first place, are almost always on the other side of a bunch of buffer chips. These buffers can just as easily perform logic-level conversion.

So we have two sides of the system. The 3V side has been compelled by the CPU to use more-costly 3V products. By contrast, the 5V side—the cheaper side—contains the DRAM chips.

The ultimate impact of Intel's change should not be underestimated. Intel's push will do a lot to force improved availability of 3V parts, if only core logic and SRAM. Intel's strategy subsequently will help cause pricing for 3V components to move closer to their 5V counterparts.

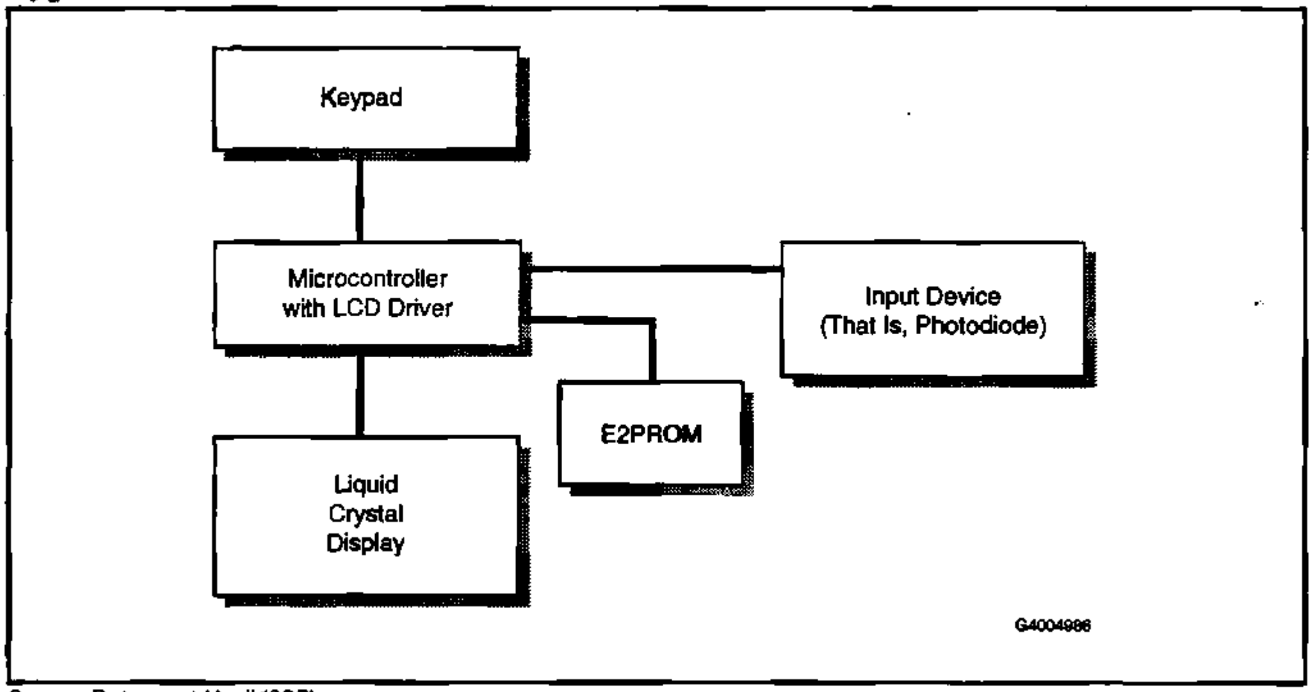
Although 3V technology will eventually find its way into desktop computers, the push is not there from the standpoint of power consumption. This leaves the system designer with a consideration only coming from the dictates of the CPU's I/O pins. This means that there is little reason for rapid market adoption of 3V devices into desktop computing environments, except where dictated by the CPU.

3V System Applications

Figure 2-3 illustrates a typical handheld device, possibly an inventory-management unit such as a bar code scanner or a measurement system in a delivery truck. There is little overall semiconductor content in such a system. Much of the value derives from the software or the fact that the manufacturer serves a limited market. There are a few instances where the volumes are high enough to allow such devices to be priced based upon cost.

Even so, the bulk of the market is not sensitive to absolute component costs. Because there are few devices in such systems, it is not surprising to find almost no DRAMs. This reminds us of the market's irony—no 3V DRAMs in these systems although DRAM initially drove the 3V trend.

Figure 2-3
Typical Low-End Handheld Device



Source: Dataquest (April 1995)

Chapter 3

3V IC Products

3V ASICs

This chapter starts with a brief look at 3V ASICs and then moves through 3V microcomponents and to 3V memory ICs. The 3V technology trend appears most pronounced in the MPU market, although low-voltage IC technology has started to pervade all segments. For example, a host of ASIC and logic IC suppliers have announced 3V products.

For the purpose of this report, the targeted application for 3V ASICs is more significant than the actual product because the ASIC announcements reveal the full spectrum of emerging 3V applications. Some highlights follow.

During 1993 NEC Electronics Inc. announced its true 3V, 0.5-micron cell-based ASIC family (CB-C8 family). NEC noted in the product's announcement an increased interest in 3V products from designers of everything from cellular telephones, PDAs, and pen-based notebook computers to high-end workstations and mainframes.

Toward the end of 1993 VLSI Technology announced the availability of its 0.5-micron (0.4-micron effective channel length) CMOS gate array, embedded gate array, and cell-based IC products. VLSI said that the 3.3V-optimized technology used for these product families is targeted for high-speed, high-complexity designs including workstations and computers, fiber channel and other evolving transmission systems, wireless communications products, and high-density storage applications.

Microcomponents

Small form-factor PCs require low-power technology, as do cellular, digital cordless, and personal communications systems. Microcomponent suppliers are responding with a host of 3V microprocessors—including 3V Pentiums (P54C)—and peripherals devices. During 1994 the market started to move more to the leading-edge 3V MPUs. We should note that Intel's 3V Pentiums are not 5V-tolerant, however, which puts pressure on other IC suppliers to respond with 3V parts.

MPUs Drive 3V System Trends

Historically, design issues and high pricing caused system designers to resist a move to the energy-efficient 3V technology. For example, 3V technology appears ideal for laptop PCs, but 5V laptops remain the norm. Fueled by increased demand for portable computers with longer battery life, however, MPU suppliers now lead the drive to wider market availability of 3V products.

The x86 Backdrop

During 1993 and before, Intel introduced the SL series of 386 and 486 microprocessors for use in energy-efficient green PCs. The first 486 3.3V selections included the 33-MHz 486 SL and a 3.3V 40-MHz version of the 486 DX2. Intel added the SL technology to its entire 486 line with no price premium. The SL line featured a fully static CPU core that can be reduced to a 0-MHz sleep mode. Intel's expanded 3.3V SL line now includes the high-performance 486DX4 series.

A 3V processor typically extends the battery life of a notebook by a factor of twice that of 5V technology. By the second half of 1993 energy-conscious manufacturers of notebook PCs started migrating from 5V technology to 3V. Zenith now offers a notebook computer family that implements a full range of 3.3V SL Intel processors, including the IntelDX4. Compaq and Texas Instruments also rank as leading suppliers of 3V notebook PCs. The first half of 1994 marked the appearance of 3V color notebooks such as NEC Technology's 80486DX4-based system.

Other 3V Microcomponents

The move to low-power MPUs fuels demand for support chips. During 1993 National Semiconductor introduced the Super I/O Model PC87332VLJ, calling it the first single-chip I/O device for use in green PCs. The device features 3.3V power operation, a small footprint size, and an open architecture with the speed and performance required in high-performance PC designs. In an alliance with Pico Power, National tailored the device into a chipset for palmtops. Also, National and NEC have agreed to develop a low-power, 3.3V Ethernet controller for notebook PCs.

Suppliers such as Cirrus Logic and Chips & Technologies Inc. (C&T) now serve 3V controller applications. Cirrus Logic expanded its family of LCD VGA controllers during 1994 with the introduction of the CL-GD6245. Cirrus describes the device that features a direct 32-bit local-bus interface as the smallest full-featured controller for the 486 subnotebook market. The host bus, memory, and LCD interface, as well as the core supply voltage, can be set to either 3.3V or 5V independently.

C&T announced the first members of the "Mustang" family of VGA graphics controllers aimed at bringing graphics and video-intensive capabilities to notebook computers. The 65540 and 65545 are the first members of this graphics controller family and are high-end, compatible additions to C&T's Vampire line of flat panel display controllers. Both products are available in 3.3V and 5V versions.

3V Pentium—The P54C

During 1994 Intel relentlessly pushed the Pentium technology including the 3V Pentiums (P54C) with an eye on Winter COMDEX, the holiday season, and 1995 corporate orders. Early in 1994 Elonex, the United Kingdom-based PC manufacturer, announced a 3V 90-MHz, Pentium system/motherboard. Intel's price list the first quarter of 1995 includes three 3V Pentium products. These are 75-, 90-, and 100-MHz devices, each housed in a ceramic pin grid array (PGA).

Also, chipset companies are working on 3V Pentium chipsets, for example, OPTi's PTM3V.

3V MPUs for Handheld Communication

Motorola introduced several 32-bit MPUs aimed at communications and multimedia applications during 1993. The products—the 68341, 68349, and 68040V—include 3V versions. Motorola targets the 68341 at Compact Disc-Interactive products. The 68040V is a 3.3V version of the 68040.

The 68349 reflects the role for 3V technology in wireless communications applications. Motorola designed the 68349, also known as the "Dragon," for the power and performance demands of personal intelligent communicators.

3V DSPs represent another emerging low-voltage application. During 1993 AT&T Microelectronics Japan announced a DSP for 3V cellular phone applications. Other leading DSP suppliers such as TI have entered or targeted the 3V cellular market.

More 3V ICs for Wireless Communication

As indicated, portable wireless communication means low power. For example, Philips Semiconductors during 1994 introduced a low-voltage RF IC (SA601) that integrates all of the front-end functions needed for a variety of 900-MHz wireless receiver applications. The single-IC solution offers simplified design, small size, low power consumption, and low cost to wireless system designers. Total current draw is only 7.4mA at 3V.

From Philips' perspective, the SA601 addresses a large and growing market for low-voltage RF receivers ranging from cellular phones to remote control. Philips targets this product as a complete RF receiver front-end solution for U.S. and European analog and digital cellular phone applications (AMPS, TACS, IS-54 and GSM), 900-MHz cordless phone applications (CT1 and CT2), as well as spread spectrum receivers in the 902- to 928-MHz industrial, scientific, and medical band.

Another example is OKI Semiconductor, which added 3V versions to its line of coder/decoders. OKI targets the 3V products for telecommunications applications including cellular, digital cordless, and personal communications systems.

Chapter 4
3V Memory ICs

3V Slow SRAM

Back in early 1993 Dataquest was able to list the offerings of 3V SRAM manufacturers on only a few lines of the *DQ Monday* newsletter. NEC, Mitsubishi, Hitachi, and OKI were the only companies public with their 3V offerings. This was before a burst of product announcements was made, which continues to this day. Still, there are many 3V SRAMs that have never been announced, yet they ship in production as custom parts. This is partly because SRAM manufacturers that have found that they can ship standard 5V SRAM screened for operation to a 3V specification, provided that they do not guarantee operation over a full commercial temperature range. Some parts consume inordinate amounts of current at low voltages when subjected to low temperatures. These products appear never to have been made available in through-hole packages but are offered instead in the TSOP and SOJ package, suiting them for volume applications and portable equipment.

Low-voltage SRAMs are also used in the PCMCIA card marketplace, although Dataquest expects these to soon be displaced by flash memory cards that offer lower cost and higher reliability at the expense of slow write cycles. At least one supplier offers three 3.3V SRAM cards: 1MB, 512KB, and 256KB. The PCMCIA-type cards have access times of 250ns and are priced at about $300.

Slow 3V SRAMs are a market with a true need, in portable systems, but this market has been incredibly slow to take off, and Dataquest estimates that it accounts for less than 5 percent of the North American slow SRAM market. Although we anticipate a big change over the long term, it is hard to tell when the switch will take place. We are inclined to expect a balance between 3V and 5V slow SRAMs, where each ships an equal number of units, to not occur for at least another three years.

3V Fast SRAM

The fast SRAM market has been a little slower to adopt 3V technology than has its slow counterpart. A few manufacturers distinguished themselves as being the first suppliers to commit to producing the highest speeds at 3.3V, but there is a certain element of work that was not deemed necessary by the bulk of the SRAM supplier base. This was tied to a difficulty in keeping the speed of 3V parts up to that needed in cache applications. When a 5V part for 3V is simply screened for operation, the access time can slow down by as much as three times that of the same device operating at 5V. Redesign is costly, especially when it is uncertain whether the market will develop, and many SRAM manufacturers were wary after AMD's 1991 announcement of a 3V 386 that did not attract significant design wins.

The year 1994 was one of change, with high-speed 3.3V SRAM announcements being limited to more exotic types, mainly those designed to work with Intel's new breed of 3.3V CPUs. This may have been in part because of Intel's becoming active in the definition of the ideal interface for its future processors, as well as a difficulty the new Intel CPUs have interfacing with anything but true 3.3V products. Intel changed its policy toward SRAM vendors from one of isolation to one of carefully controlled cooperation and advanced disclosure. From the end of 1993 to the present we have received three formal announcements of the part being sponsored by Intel, a 3V 32Kx32/36 with synchronous write cycles, pipelining, and burst read and write cycles. This closely matches the specifications for Intel's Pentium and 486 class of CPU.

It looks as though the fast SRAM market is developing more in response to the needs of select CPUs than it is in response to the needs of system designs. If effective means exist to isolate the memory from the CPU (which could arise through the use of the Pentium's pipelined accesses), then the 3V fast SRAM market could remain in limbo for quite a while longer.

Ironically enough, the SRAM, rather than the DRAM, is the device with the 3V interface, even though the DRAM is the chip that brought all of this movement into being in the first place.

3V DRAM

The 3V DRAM technology should start to permeate the market at the 16Mb density. However, suppliers continue to introduce 3V 4Mb devices. At the 16Mb density the DRAM market fragments toward specialty applications—which makes for a problematic 3V DRAM outlook.

3V DRAM Market Direction

Earlier in 1994 Toshiba introduced a series of low-voltage, 16Mb, 3V DRAMs in a 1Mx16-bit organization. The announcement signaled the direction of the DRAM market, including 3V.

Toshiba's announcement reflects two key DRAM trends:

- In the 16Mb DRAM market, wideword devices will be more popular than they have been in prior generations.
- Suppliers such as Toshiba will use the introduction of 1Mbx16-bit parts as a starting point for migrating customers to the JEDEC 3V standard.

Dataquest expects that over time this product's appeal will move from the original target market of battery-operated computing equipment into a more widespread penetration of the entire personal computing market, from portables through the desktop.

IBM has also shed some light on the future of 3V DRAMs. During early 1994 IBM Microelectronics announced a development effort on a line of JEDEC-standard, 16Mb synchronous DRAMs (SDRAMs). IBM targets the

3.3V device for 100-MHz system applications. The SDRAM includes two independent banks, TSOP package and pulsed control.

3V Nonvolatile Memory

There are four basic sorts of nonvolatile memory: flash, ROM, EPROM, and EEPROM. Each plays into a different market, and, as a result, each has different drivers motivating the production of 3V versions.

3V Flash

Flash memories are viewed as being the enabling technology for handheld devices of the future. As a result of this, there is a very big push toward the offering of 3V versions of flash memories. One difficulty with this is that the function of writing into a flash memory requires large voltage differences, on the order of 12V, and this must be generated somewhere within the system. There are two basic schools of thought on this problem. One is to generate the necessary voltages within the chip itself, and the other is to use an external supply. Although the art of generating 12V from 3.3V is well understood and can be done through a number of off-the-shelf solutions, there is incredible resistance to doing this, so it appears that the winner will be on-chip generation of the programming voltage.

3V ROM

Although mask ROM suits itself to a wide range of portable applications, it appears that 3V products are treated as an exception rather than as a rule. This well suits the nature of the market, where all production is custom, with the code programmed into the ROM at the factory, requiring custom tests, which would simply be augmented to add a 3V screen based upon the customer's need.

3V EPROM

EPROM is currently regarded as a product with a limited life span that fits into systems (mostly computers and laser printers) that have little or no 3V content. As a result, there is no noticeable activity toward the announcement of 3V EPROMs. Dataquest believes that 3V versions are available, but we suspect that they are all offered as custom screens to select customers willing to place very large orders. One such order we are aware of exists in the world of digital cellular telephones, but this application is slated to be moved to flash memory technology as soon as adequate volume is available.

EPROMs are slow devices, and users account for this by copying the contents into a DRAM or SRAM, whose speed is markedly faster. Because of this, the consequences of voltage-related speed degradation are not an issue in these applications.

3V EEPROM

EEPROM is used in numerous battery-operated devices, because it is a good low-cost match to a microcontroller. Serial EEPROMs are especially favored in these applications. As a result, Dataquest expects EEPROM to be at the forefront of low-voltage memory development for the long term.

EEPROM is an enabling technology for devices ranging from cellular telephones to television remote controls. The future of this technology seems bright, with the possible downside that vendors are now squeezing EEPROM into their microcontrollers, reducing the market's need for external devices.

Chapter 5
Dataquest Conclusions

This report shows that the 3V memory market is just now emerging from the nascent stage of its life cycle. Fueled by 3V microcomponents trends described in Chapter 3, Chapter 4 highlights the full range of 3V memories—slow SRAM, fast SRAM, DRAM, flash, ROM, EPROM, and EEPROM—introduced during the 1993 to 1994 period.

Today's 3V Memory Reality

The hard reality, however, is that—except for wireless communications—memory suppliers do not yet strongly support 3V applications. A host of factors would certainly justify the widespread availability today of competitively priced 3V memory ICs. For example, 3V devices use about half the power of 5V parts, making them ideally suited for green PCs. Also, JEDEC set a 3V standard during the 1980s recognizing that the 3V-level tolerance would become a limiting factor—especially for DRAM—when feature sizes ultimately shrink below the 0.25-micron level.

The ongoing PC application reality is that laptops continue to use 5V memories, although annoyingly short battery life remains users' No. 1 complaint. Laptop manufacturers pay a premium to lower energy consumption by the disk drive and display. By contrast, they have rejected a price premium for energy-saving 3V memories, although this attitude is changing.

A Systems Approach to 3V Memory

Finally, the report notes that for the near term a single system—Intel's P54C—is likely to drive 3V memory trends.

From Dataquest's perspective, however, the optimal route for development of the 3V memory market would be for suppliers to take a forward-looking, generic 3V systems perspective. We provide our top-level view of the role for 3V memories in several systems (see Chapter 2).

To summarize our outlook for 3V memory ICs:

- High-end Pentium-class systems will use 3V fast SRAMs and logic.
- 3V flash memory should ultimately displace SRAMs and EEPROMs in low-level handheld systems—with no role for DRAMs.
- During the post-1995 time frame, the PDA-type handheld market will emerge and create 3V opportunities for either SRAMs and ROMs, or DRAMs and flash, or some combination of these memory ICs.

Over the long term, the 3V and lower memory market likely will meet system requirements—but the route there might be tortuous.

Chapter 6
Contributors

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Focus Studies

Semiconductor Procurement Worldwide

Focus Analysis

1995 Semiconductor Industry Capital and R&D Spending Overview

Abstract: *This article is the Semiconductor Procurement Worldwide service's review of worldwide semiconductor capital spending and its impact on the semiconductor market. Much of the material has been provided by Dataquest's Semiconductor Equipment, Manufacturing, and Materials Worldwide service.*
By Mark Giudici

Overview

Capital spending, along with R&D patterns of semiconductor suppliers (or potential suppliers), is a good gauge on how a supplier is responding to market competition and what suppliers' plans are. Semiconductor users use this information to compare their strategic plans to those of their supply base in order to make adjustments on long-term arrangements if divergent spending levels occur.

This document highlights the major trends of semiconductor company capital and R&D spending and provides a capital spending forecast. Capital spending on semiconductor equipment directly relates to semiconductor unit supply, while R&D expenditure translates into long-term supplier viability. Knowledge of the industry's capital spending in comparison with aggregate end-market demand trends can help in semiconductor price negotiations. For example, if a large level of capital spending is not offset by a like increase in unit demand (possibly in the latter half of 1995), the potential for an oversupplied market exists. Early knowledge of the situation can benefit users during price or delivery negotiations. R&D spending level at an individual company highlights the relative health of a supplier and may hint at future alliances or product offerings.

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Semiconductor Capital Spending Forecast

This section presents data on worldwide semiconductor capital spending by region. Capital spending in a region includes spending by all semiconductor producers with plants in that region. Components of capital spending are property, plant, and equipment expenditure for front- and back-end semiconductor operations. Highlights of this section include the following:

- Dataquest has upgraded the 1994 forecast to 53.9 percent growth in global semiconductor capital spending, with momentum growth continuing into the following year and an upward revision of 17.2 percent growth in 1995.
- North America has shown consistent strength, with a 38.3 percent growth in 1994. Worldwide demand for desktop connectivity products and telecommunications equipment continues to fuel the investment strategies in U.S.-manufactured semiconductor products. North American capital spending is expected to moderate in 1995 and 1996 as the PC market exhibits more normal historic growth patterns, although PC unit sales will continue at a 15 percent compound annual growth rate (CAGR).
- Japanese companies have decided to invest in semiconductor capacity, despite their troubled domestic economy, to preserve their market share position in memories. Japan was the second-fastest-growing region for investment in 1994, as a result of this strategy of investing in next-generation memory capacity. Healthy but subdued growth of 14.9 percent is anticipated in 1995.
- Dataquest has been bullish on the prospects for Europe, and 1994 saw Europe experience 40.1 percent growth in capital spending as major new projects were begun by the multinational DRAM manufacturers. As these projects are equipped and new projects started, we expect a healthy 19.4 percent growth in 1995.
- The Asia/Pacific-ROW region grew an astronomical 90 percent in 1994, as Korean DRAM expansion accelerated and foundry expansion in Taiwan and Singapore took on a more "concrete" and very large flavor. Growth will continue at closer to overall market rates in 1995 through 1997, after increasing 163 percent in the two years 1993 to 1994. Projects being started in 1994 will continue to attract investment, but this year sees an investment spike that, we believe, will be difficult to repeat in growth rates but will be sustained as foundry projects are equipped. As the semiconductor investment picture picks up again in 1998, Asia/Pacific will again rise to above market growth rates.

Capital Spending Tables

Table 1 lists the projected top 20 semiconductor capital spending companies in 1994. Capital spending details are provided in two tables in this chapter. Table 2 shows historical semiconductor capital spending by region for the years 1987 through 1993. Table 3 shows the capital spending forecast by region for the years 1993 through 1998. Yearly exchange rate variations can have a significant effect on the interpretation of the 1987 through 1993 data. For more information about the exchange rates used and their effects, refer to Appendix B.

Table 1
Semiconductor Capital Spending—Top 20 Spenders, Comparison of 1993 and Projected 1994 Worldwide Capital Spending (Millions of U.S. Dollars)

1994 Rank	1993 Rank	Company	Projected 1994	1993	Percentage Change
1	1	Intel	2,500.0	1,700.0	47.1
2	2	Motorola	1,700.0	1,100.0	54.5
3	7	Samsung	1,300.0	630.0	106.3
4	5	Fujitsu	1,120.9	700.5	60.0
5	6	NEC	1,114.0	696.9	59.8
6	3	Hitachi	1,077.3	776.1	38.8
7	4	Toshiba	1,003.8	719.4	39.5
8	13	Hyundai	1,000.0	400.0	150.0
9	12	Goldstar	900.0	400.0	125.0
10	8	Texas Instruments	802.5	545.0	47.2
11	9	SGS-Thomson	750.0	480.0	56.3
12	10	Mitsubishi	673.3	449.6	49.7
13	15	Advanced Micro Devices	550.0	357.0	54.1
14	22	Matsushita	511.7	169.1	202.7
15	11	IBM Microelectronics	400.0	412.0	-2.9
16	14	Sony	391.7	359.7	8.9
17	16	Sanyo	381.9	339.9	12.4
18	21	Micron Technology	375.0	180.6	107.6
19	63	Chartered Semiconductor	350.0	15.0	2,233.3
20	19	Sharp	337.9	269.8	25.2
		Total Top 20 Companies	17,240.0	10,700.7	61.1
		Total Worldwide Capital Spending	21,699.2	14,095.1	53.9
		Percentage of Top 20 Companies	79.5	75.9	

Source: Dataquest (December 1994)

After a three-year rest, 1993 started an impressive growth cycle. After a 21.6 percent growth in semiconductor capital spending in 1993, a peak growth year of 53.9 percent followed in 1994. Dataquest has upgraded its forecast for 1995 to 17.2 percent growth worldwide, based primarily on the momentum in booking and backlog coming out of 1994.

The continued growth in PC unit sales, with increased growth in telecommunications and networking products, has created tremendous demand for a variety of semiconductor components. The wafer fab capacity crunch has continued into all regions and most semiconductor products, most notably DRAMs. The capacity shortage has given rise to sharp acceleration in capital spending in all areas, with the strongest growth occurring in DRAM expansion in Japan and Asia/Pacific.

The big-three Korean companies increased their spending by an unbelievable 124 percent to a combined $3.2 billion in 1994; the major Japanese suppliers of memory are not holding back either. Japanese companies

Table 2
Worldwide Capital Spending by Region—Historical
Includes Merchant and Captive Semiconductor Companies (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991	1992	1993	CAGR (%) 1988-1993
North America	2,594	3,434	3,875	4,088	3,851	4,132	4,985	7.7
Percentage Growth	24.6	32.4	12.8	5.5	-5.8	7.3	20.6	
Japan	2,432	4,610	5,473	5,425	5,636	3,955	4,311	-1.3
Percentage Growth	31.8	89.6	18.7	-0.9	3.9	-29.8	9.0	
Japan (Billions of Yen)	350	599	755	781	761	500	479	-4.4
Percentage Growth	13.7	71.1	26.0	3.4	-2.6	-34.3	-4.1	
Europe	875	984	1,211	1,512	1,234	1,187	1,598	10.2
Percentage Growth	14.4	12.5	23.1	24.9	-18.4	-3.8	34.6	
Asia/Pacific-ROW	534	1,060	1,905	1,495	2,274	2,316	3,202	24.7
Percentage Growth	22.2	98.5	79.7	-21.5	52.1	1.8	38.3	
Worldwide	6,435	10,088	12,464	12,520	12,995	11,590	14,095	6.9
Percentage Growth	25.5	56.8	23.6	0.4	3.8	-10.8	21.6	

Source: Dataquest (December 1994)

Table 3
Worldwide Capital Spending by Region—Forecast, 1993-1998
Includes Merchant and Captive Semiconductor Companies (Millions of U.S. Dollars)

	1993	1994	1995	1996	1997	1998	CAGR (%) 1993-1998
North America	4,985	6,893	8,134	8,456	8,926	10,318	15.7
Percentage Growth	20.6	38.3	18.0	4.0	5.6	15.6	
Japan	4,311	6,487	7,455	7,133	7,235	7,677	12.2
Percentage Growth	9.0	50.5	14.9	-4.3	1.4	6.1	
Japan (Billions of Yen)	479	660	758	725	736	781	10.2
Percentage Growth	-4.1	37.6	14.9	-4.3	1.4	6.1	
Europe	1,598	2,238	2,672	2,689	2,532	2,980	13.3
Percentage Growth	34.6	40.1	19.4	0.6	-5.8	17.7	
Asia/Pacific-ROW	3,202	6,081	7,175	7,157	7,665	9,661	24.7
Percentage Growth	38.3	89.9	18.0	-0.3	7.1	26.0	
Worldwide	14,095	21,699	25,436	25,435	26,358	30,636	16.8
Percentage Growth	21.6	53.9	17.2	0	3.6	16.2	

Source: Dataquest (December 1994)

collectively increased nearly 45 percent to $7.5 billion, a larger dollar increase than for the Korean companies. Intel and Motorola still head the list for 1994, as the microprocessor and microcontroller demand continues to be strong. Equipping new and acquired facilities for these two companies will continue to drive these companies in 1995. Samsung, with the aforementioned increase in DRAM capacity spending, jumps into the No. 3

spot, and fully eight companies are now part of the billion-dollar spending club. Fujitsu, NEC, Hitachi, Toshiba, Hyundai, Goldstar, and Texas Instruments all make the top 10 as the memory capacity keeps rolling in. SGS-Thomson falls out of the top 10—unable to keep pace with its 56 percent increase—shifting its investment to capacity expansion in North America but dropping a spot in the face of the DRAM madness. Smaller semiconductor companies in all regions have participated in the capital spending boom in 1994.

Chartered Semiconductor debuts on the top 20 list for 1994 as a major foundry project starts. In fact, foundry spending in Taiwan and Singapore more than tripled in 1994 to $1.2 billion as this industry has transformed into a dedicated niche business and is no longer a specialized way to use excess capacity. We suspect that TSMC will have also entered the top 20 by the time the dollars are finally counted for 1994.

When Will the Spending Boom End?

Our longer-term forecast projects that significant growth in capital spending will spill into 1995 from sheer momentum, with a moderated growth, although nudged upward, of 17.2 percent. Dataquest believes that a decelerating capital spending picture will begin to emerge as 1995 begins and as the capacity additions of 1993 and 1994 are ramped. From what we can see now, there is plenty of equipment that could be brought to bear on 16Mb DRAM capacity by midyear and online to answer demand through 1996. Any shortage will be driven by chip configuration mismatch rather than equipment capacity constraints.

Overall semiconductor product demand is expected to remain strong through 1998 with a CAGR of 14.8 percent, so we expect microcomponent capacity to start to ramp up again in 1997, with the next major investment cycle picking up in 1998. Our model does not currently include significantly more 16Mb DRAM capacity expansion (over what is already being put in place in 1994 and 1995) until 1998. We project a five-year worldwide capital spending CAGR of 16.8 percent through 1998, slightly ahead of the semiconductor consumption growth. We believe that capital spending may be positively influenced in 1997 and 1998 by the facility construction and purchase of equipment toward the world's first 300mm wafer fab. We have built this infrastructure investment into our model.

This year's outlook on capital spending has caused us to approach the cyclic nature of our forecast a bit differently. We had been contending that the cyclic nature of the equipment industry would moderate significantly from the previous boom-and-bust cycles. Although there is moderation on an overall percentage basis, clearly the magnitudes of the movement are not subsiding. Historically, annual fluctuations in capital spending have shown tremendous peak-to-trough variance, with previous cycles going from plus 43 percent to minus 30 percent (1984 to 1986) and plus 57 percent to minus 11 percent (1988 to 1992), and now a forecast plus 54 percent to flat (1994 to 1996). This cycle will now drive the wafer fab equipment industry into a decline again in 1996, triggered by the DRAM price-per-bit crossover of the 16Mb, making available some discretionary capacity as the 4Mb generation ramps down in the second half of 1995.

We now have a model that quantifies the over/underinvestment picture for wafer fab equipment and semiconductor capacity. Although the last several years of activity have created and sustained a net underinvestment, 1994 corrects this picture to create about a 17 percent overinvestment by the end of the year. Someday, factors such as the maturing of the semiconductor industry into worldwide economic cycles and companies gaining more experience in planning investment cycles will moderate this cycle further. Semiconductors are becoming more pervasive in everyday life. However, the memory cycle is still dominating the cyclical nature of investment in this industry, and it will probably take a couple more cycles before managers of wafer fab equipment companies can rest easier about the prospects for their business falling off a cliff.

The North American Market Continues to Exhibit Strategic Strength

Capital spending in North America grew 38.3 percent in 1994, with most of the investment growth coming from U.S. companies connected with ASIC and logic products. We expect capital spending to decelerate gradually through 1996 with a resumed acceleration in 1997, resulting in a CAGR of 15.7 percent for 1993 through 1998.

The relatively strong growth in capital spending has been driven by the ongoing growth in PCs, telecommunications, and networking. These products have seen increasing use as tools to increase the productivity of the workplace. These electronic products, with their increased semiconductor content, have created enormous demand for microprocessors, microcontrollers, SRAM, programmable logic and memory, standard logic, and peripherals controllers. The U.S. companies dominate many of these market segments. These segments combined are expected to maintain fairly stable growth rates over the next couple of years, with PC growth slowing, but networking and telecommunications expanding. New products and services—such as personal communicators, interactive television, and video-on-demand—provide the potential for enormous growth in semiconductor sales, especially for highly integrated complex logic and signal-processing chips that will be the core engines of future systems. The timing for growth in these new markets is uncertain, but they most likely will not kick in until the middle part of the decade and will not spur significant capital spending until late 1997 or 1998.

Although the strategic strength of the core logic products enables a healthy and flourishing semiconductor production environment, such an environment is also one that is less volatile in capital spending. The North American region grew at a rate significantly lower than the market at large in 1994. This trait will also enable the North American market to grow in capital spending faster than market rates in the slower years 1996 to 1997, despite the recent rise in interest rates. We believe that companies will strategically invest in capacity to preserve competitive advantage and that any cutbacks are likely to occur in the smaller companies rather than the first-tier manufacturers.

Capital investment in North America for 1994 is coming from equipping new fabs coming online by both the major and smaller companies. The major projects include Intel's Fab 11 in New Mexico; Advanced Micro Devices' Fab 25 in Austin, Texas; expected orders from Motorola's MOS-12 in Arizona; and ongoing purchases for Texas Instruments' DMOS-5 fab in Dallas. Smaller companies are also spurring the growth this year, with Cypress Semiconductor, Integrated Device Technology, VLSI Technology, Zilog, NCR, Atmel, and National all bringing on new capacity.

Japan: Memory Capacity Additions Drive This Second-Fastest-Growing Region in 1994

Japan's 50.5 percent increase in capital spending in 1994 (or 37.6 percent on a yen basis) is a signal that the Japanese companies have decided that enough is enough. Japan is still, and is determined to stay, the DRAM leader. Starting in October 1993, and with no sign of letting up, the green light was given on spending in the first-tier companies; smaller companies such as Matsushita joined in starting April 1994. Dataquest believes that this upturn will be sustained at least another six to nine months but will moderate over time because the Japanese economy will weigh down investment on a local basis. We are forecasting a subdued 14.9 percent growth in capital spending for 1995, factoring in a slight decline in 1996 because the mission will have been accomplished in DRAMs in the near term.

Some of the Japanese electronics giants are experiencing good profit growth driven by semiconductor operations. The demand for worldwide memory capacity presented an opportunity to grow profits from semiconductors. This, coupled with the aggressive investment by Korean companies, prompted an abrupt end to the investment freeze. Investments by Japanese companies will grow by nearly 45 percent in 1994, with only one company (NEC) spending more than 30 percent of its money outside Japan. Increased spending by LSI Logic, TI, and Motorola in their Japanese operations make up the majority of the difference.

Since the last investment cycle came to a sudden end, Japanese companies have had several finished buildings with only minimal equipment in them. As a result, spending growth now does not have to be as large to add equivalent capacity—all that had to be bought was equipment. This capacity came online quickly, thus providing the Japanese a strategic advantage in today's market. We believe that the Korean companies are not aware of this fact and are thus continuing to pour money into DRAM capacity. Beyond mid-1995, investment increases in Japan will need to come from growing the domestic economy. Dataquest believes that an economic recovery in Japan started this year, but with slow acceleration. The degree to which companies will invest will be affected by the strength of this recovery. We are therefore forecasting a below-average CAGR of 12.2 percent in Japan for the years 1993 through 1998.

Europe Moderates as the Players Shift

After a higher-than-expected growth bubble of 34.6 percent in 1993, European spending "moderated" to a slower-than-market growth in 1994 as multinationals (Intel) substantially completed the majority of their expansions in 1993. The growth of 40.1 percent in 1994 is nonetheless higher than in 1993, and was primarily fueled by the Europeans themselves, with the ever-present SGS-Thomson and Philips expanding in Nijmegen, Netherlands, and Ericsson equipping an expansion. Multinationals are still present, with Intel continuing to ramp Fab 10, Analog Devices announcing a subsidized expansion starting this year in Ireland, and the IBM/Siemens fab in France ramping 16Mb DRAMs. NEC's recent continued commitment to Europe has given the latest boost in investment momentum, creating the scenario of higher-than-the-market 19.4 percent growth in 1995.

We still look for one (not likely two since Hyundai bought the NCR operations) of the "big-three" Korean companies to announce a new fab for 16Mb DRAM pilot production lines in Europe during 1995. Europe could be viewed as a strategic location for production to take better advantage of European and 16Mb DRAM growth in the future, without the import tariffs.

Even with increased multinational presence starting again in 1995 as the economies pick up, we still expect Europe to be a below-average investment region in the long term, with a five-year CAGR of slightly more than 13 percent.

Asia/Pacific Madly Investing in Two Distinct Ways

The often erratic but sustained semiconductor capital spending growth in the Asia/Pacific region continued at the explosive rate of 89.9 percent in 1994. Our expectation is for more moderate growth of 18.0 percent in 1995 as several new fab projects continue to be built and equipped and the number of new projects grows. We expect Asia/Pacific to exhibit the most aggressive growth in capital spending of any region for the longer term. Dataquest forecasts a 1993 through 1998 CAGR of 24.7 percent, significantly up from our last update in July, as the foundry capacity expansion becomes evident through the decade.

Spending in 1994 came from two areas, DRAMs and foundry capacity. The Korean conglomerates are continuing their relentless DRAM capacity expansion plans in 1994. Hyundai has installed equipment for its new E-2 project, the second phase of a 200mm wafer, 16Mb DRAM fab started in 1992. Goldstar is expanding its equivalent C line, as the agreement with Hitachi for the 16Mb DRAM ramps. Samsung has accelerated its phase-two expansion of Line 5, also a 200mm, 16Mb DRAM facility. Taiwan players such as TI/Acer and MOSel-Vitelic have now entered into the picture, dramatically increasing their spending with new projects.

Taiwanese chip companies TSMC, Macronix, Winbond, and UMC, along with Chartered Semiconductor in Singapore, have added major projects in expansion of foundry capacity, and a new foundry player has emerged in Thailand—Submicron Technology (STI). STI has $1.6 billion in funding for two separate fab lines, the first to come online in 1996. Separate funding to establish a technology park similar to Hsin-chu in Taiwan exists, to be placed in or near Bangkok. The combined spending of these companies increased from about $400 million in 1993 to over $1.2 billion in 1994 and will probably grow to higher levels into 1995. The driving reason is the changing face of contract manufacturing in semiconductors. Gone are the days when excess fab capacity could support the foundry business of fabless companies (as well as companies with fabs).

Dataquest estimates that only about 40 percent of the contracted manufacturing of semiconductors originates from fabless companies. The remainder is from integrated manufacturers that wish to place manufacturing lower-value-added products away from their own facilities, to maximize resources and cost. The last few years have seen the flourishing of the dedicated foundry, which is most of this type of capacity in Asia/Pacific. It is still believed that the largest concentration of foundry capacity in the world, however, resides in Japan, with companies such as Rohm, Seiko-Epson, Sharp, and other large integrated companies.

However, the appetite for leading-edge foundries has caused another transformation to occur. With the cost of capital increasing and at a higher level for leading-edge equipment, foundry companies such as Chartered have established longer-term contracts with design companies, often with capital infusions toward production equipment. On the buyer's side, companies are now receiving guaranteed capacity for their products. It should be noted that TSMC, the largest foundry company, does not subscribe to the concept of capital infusion. This is a similar business model to Solectron's in the electronic equipment marketplace.

The foundry industry is now a *strategic* industry rather than simply a tactical one. With this transformation nearly complete, we are starting to see the dedicated investment to build new foundry capacity. As this new capacity comes online, primarily in 1996 and 1997, the mainstream integrated manufacturer could see restricted access and availability to the contract manufacturing business. This may affect capital spending adversely for those companies as the revenue-generating potential of excess capacity diminishes, possibly exacerbating the cyclical decline in 1997. We will be watching this closely.

Huge, long-term opportunities exist in developing countries such as China and the Unified States (formerly the Soviet Union) in addition to the established semiconductor-producing countries. Ultimate demand for semiconductor products in those countries could approach demand in superconsumer countries such as the United States and Japan. China, in particular, generates a gross domestic product (GDP) comparable to that of Japan if evaluated on a purchasing power parity basis. U.S., European, and Japanese telecommunications companies are working with the Chinese government to install telephone exchange equipment and digital lines.

Several hurdles must be overcome before either China or Russia becomes a viable market for front-end semiconductor manufacturing. Technology export restrictions must be eased to allow the construction of relatively advanced fabrication facilities. Foreign suppliers must establish local sales and service centers, and they need to define their market access. Financing capability must be established by the host countries. Solidification of international trade relationships through participation in the General Agreement on Tariffs and Trade (GATT) must also be established. China's internal political structure poses a potential barrier to achieving continued most-favored-nation status with the United States. It will likely take a few years to sort out these issues. Dataquest assumes that semiconductor investment in China will begin to expand in the 1996 time frame, accelerating into the latter half of the decade.

Who's Investing Where?

In our recent capital spending survey, Dataquest gathered a picture of how money is being spent. Table 4 summarizes how companies based in different regions are spending their money abroad. About 76 percent of money spent goes into the domestic economy worldwide. Asia/Pacific companies

Table 4
Regional Investment Patterns of Semiconductor Manufacturers in 1994
(Millions of U.S. Dollars)

	World	North America	Japan	Europe	Asia/Pacific-ROW	Percentage of World Spending
North American Companies	7,998.0	5,714.4	1,108.3	424.0	751.4	36.9
Japanese Companies	7,487.6	737.4	5,377.8	874.8	497.6	34.5
European Companies	1,513.5	261.9	0.6	899.7	351.4	7.0
Asia/Pacific-ROW Companies	4,700.0	180.0	0	39.0	4,481.0	21.7
All Companies	21,699.2	6,893.6	6,486.6	2,237.5	6,081.4	100.0
Percentage Growth	53.9	38.3	50.5	40.1	89.9	

Source: Dataquest (December 1994)

have historically placed all of their investments domestically, but 1994 saw the first year of diversification, and this should continue in 1995. Asia/Pacific companies spent about 95 percent of their money domestically, while Europeans placed slightly more than 40 percent of their investment outside of Europe. Japanese companies are very close to the worldwide average with about 72 percent domestic investment. North American companies are also high domestic spenders, with about 71 percent staying at home.

North America and Japan are net investors, while Europe and Asia/Pacific are net beneficiaries of that investment. This parallels these regions being net exporters and net importers of semiconductors, respectively.

Although all regions are spending in Asia/Pacific, and all multinational regions are investing in Europe, only North American companies have the strategic vision to invest in Japan. Japanese companies are also investing on a worldwide basis. We believe that this is one of the key elements necessary in a strategic plan for a semiconductor company to be competitive on a global basis.

Dataquest Perspective

Capital spending in 1994 has exploded. The major reasons for this are the surprisingly persistent growth in unit PC shipments and a correction of the underinvestment that had been a part of semiconductor manufacturing since 1991. Major DRAM expansion accelerated in the second half of 1993 and will continue through the first half of 1995. From what we can see now, there is plenty of equipment that could be brought to bear on 16Mb DRAM capacity by midyear 1995, and online to answer demand through 1996. Any shortage will be driven by chip configuration mismatch rather than equipment capacity constraints. A marked downturn in the DRAM investment cycle will be triggered by the DRAM price-per-bit crossover of the 16Mb, making available some discretionary capacity as the 4Mb generation ramps down in the second half of 1995.

Desktop connectivity products, telecommunications, and the PC market will lead to stable growth in microcomponents and logic devices, giving strategic strength to the North American region. Japan will be concentrating on ramping memories to preserve its market share against Korea. A struggling economy will keep capital investment muted once the DRAM ramp is satisfied. Globalization strategies will benefit both European and Asia/Pacific investment, the latter being the fastest-growing region of the next five years.

Dataquest believes that the relatively large capacity expansion phase of 1993 to 1994 (two-year growth of 87 percent) has fallen only a bit short of the 97 percent two-year growth recorded in the 1987 to 1988 expansion. It should be noted that the two-year growth rate of semiconductor production was 61 percent in 1986 to 1987, and 55 percent in 1992 to 1993. Momentum of investments will make 1995 a healthy growth year in capital spending, as it was in 1989.

However, we also believe that spending will decelerate in 1995, causing a flattish spending pattern through 1997. Although we continue to believe that the cyclical nature of investment in semiconductor capacity will diminish, it will take a couple more boom-and-bust cycles before the underlying semiconductor growth is large enough to dampen the memory component of the cycle. After a two-year flat period, investments should pick up again in late 1997 into 1998.

R&D Spending Trends: On the Rise?

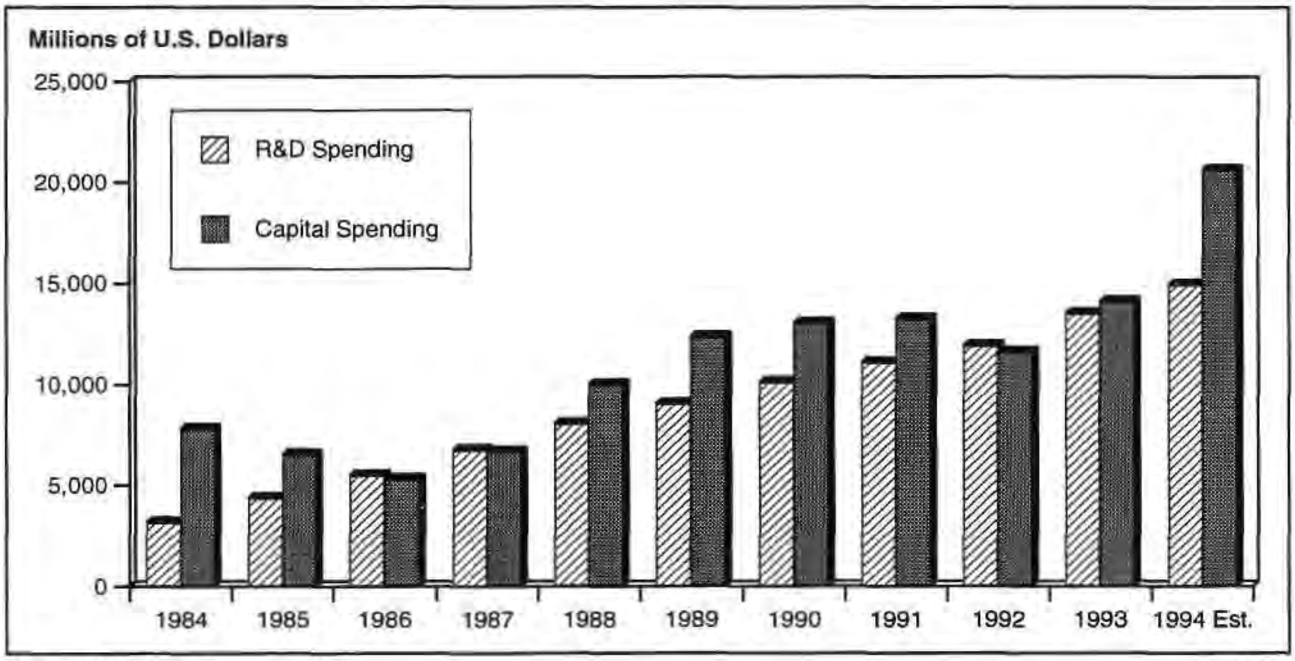
Worldwide semiconductor R&D spending has been on an ever-so-slight rise—increasing as a percentage of revenue at a rate of about 0.2 points annually. However, structural changes in semiconductor manufacturing strategies worldwide, with the emergence of the dedicated foundry and the fabless company, appear to have stabilized this trend for the industry as a whole. Large integrated manufacturers, however, may not see this trend on an individual basis, as the core reasons for the rise in R&D requirements remain intact.

While capital spending for production fluctuates with capacity use, semiconductor demand, and DRAM prices, R&D spending has increased every year since we have been tracking this statistic (1970). It has been imperative that semiconductor manufacturers invest in R&D to maintain competitive advantage by keeping pace with new market requirements and technologies. We do not see this trend changing anytime soon, but we do see a marked slowing in the rate of growth.

Regional Contrasts

Figure 1 shows the relative levels of worldwide semiconductor capital and R&D spending. We fully expect capital spending for production to break the $20 billion mark in 1994, while R&D spending nears $15 billion. In 1993, those levels were $14.0 billion and $13.5 billion, respectively. While the 10-year CAGR for R&D spending is about 14 percent, the last five years have seen that slow to slightly more than 10 percent. Several factors have played a part in this slowdown, the Japanese recession being a major one. Although the recession in Japan during 1991 and 1992 impacted the growth in R&D spending, the structural need of the worldwide semiconductor industry for investment was maintained. Still, we see several other issues playing a role today to actually lower the R&D requirements of the industry as a whole.

Figure 1
Worldwide Semiconductor Capital and R&D Spending, 1984-1994
(Millions of U.S. Dollars)



Source: Dataquest (November 1994)

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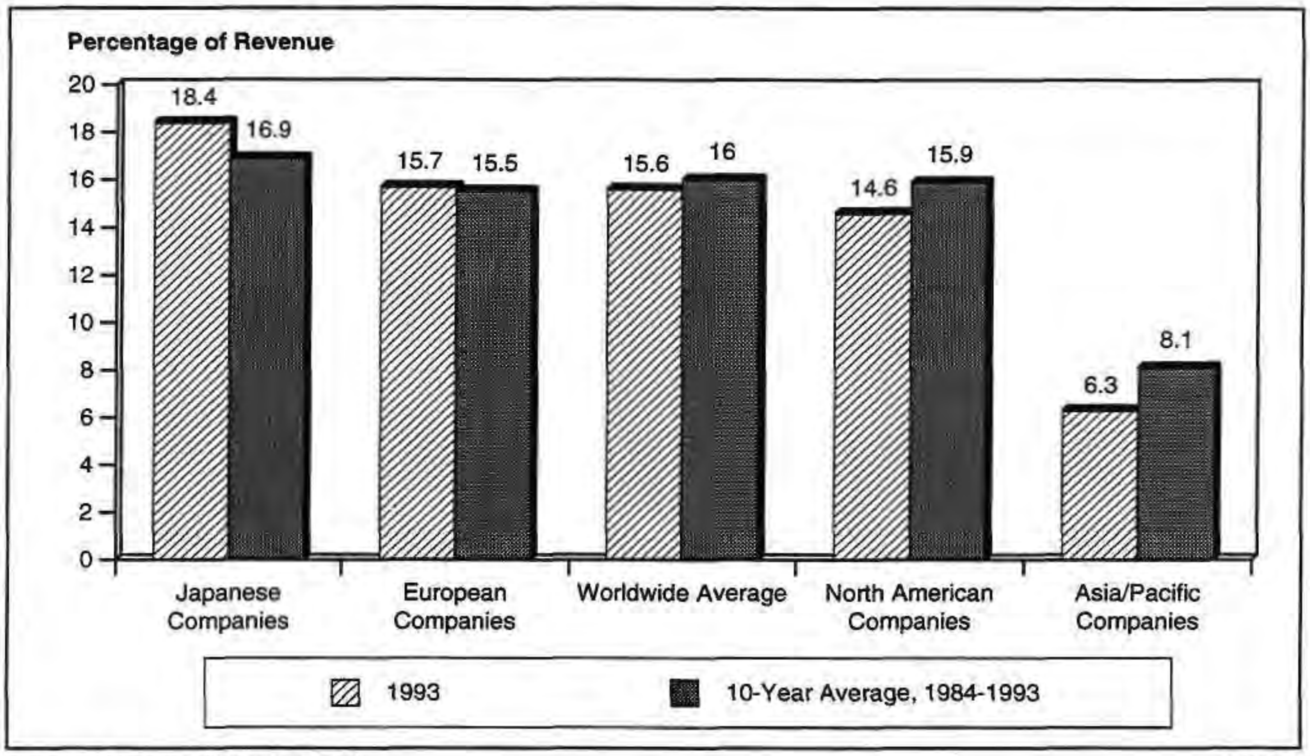
Some interesting contrasts emerge when 1993 R&D spending levels are compared against the 10-year average on a regional basis (see Figure 2). The year 1993 generally saw much higher growth in revenue than average, which tended to push percentage of sales below the 10-year average. This should not be interpreted as a trend, as we shall see later.

Asia/Pacific companies generally are investing less into R&D than others, primarily because of the relatively narrow semiconductor product offerings (concentrated in DRAMs) and the explosive growth in revenue these companies have experienced recently. In the past, these companies have generally not continued to invest in R&D as revenue growth fell off. However, we do not expect that to repeat in this particular cycle because Asia/Pacific companies have learned that investment in R&D is essential to their continued success.

Japanese companies have maintained relatively high levels of R&D investment through their recession; in fact, the Japanese have been the heaviest R&D spenders historically. With nearly 20 percent of R&D money spent in semiconductors coming from the government, we do not expect this to change. Japan faces a tough challenge ahead—a refocusing of its semiconductor manufacturing prowess away from the supercyclical DRAM into a more diversified product mix. To make this move, Japan must continue and perhaps increase relative spending in R&D.

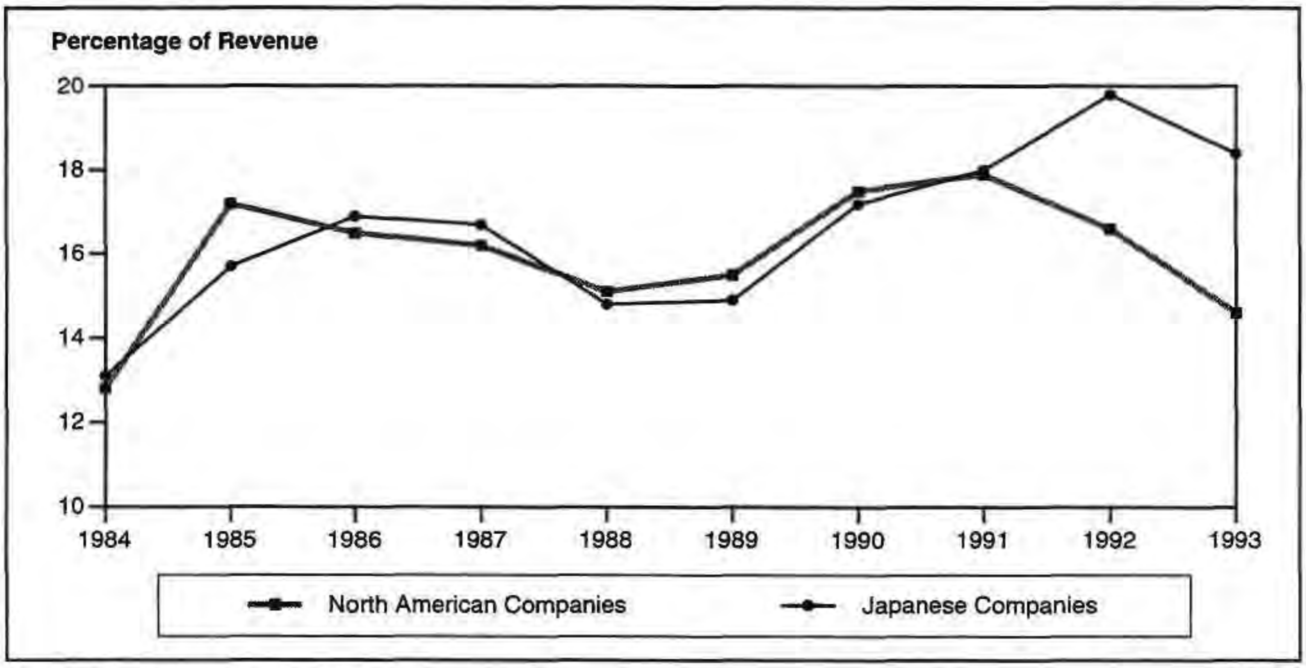
North American companies are now spending significantly fewer R&D dollars relative to revenue than historical or worldwide norms. Dataquest believes that this is a trend and that it is being influenced by a structural change in manufacturing strategy. Figure 3 compares the Japanese and

Figure 2
Regional R&D Spending as a Percentage of Revenue, 1993 Compared to 1984-1993 Average



Source: Dataquest (November 1994) G4006420

Figure 3
Japanese and North American Company R&D Spending as a Percentage of Revenue, 1984-1993



Source: Dataquest (November 1994) G4006421

North American companies' R&D spending trend over the last 10 years. These two countries have tracked one another quite well in the industry on this measure, with gradually rising relative R&D costs—except after 1992. North American companies, on average, have stabilized the rise in R&D costs for a couple of reasons. First, the restructuring of IBM Microelectronics is impacting the overall figures somewhat. Although IBM's R&D spending as a percentage of production revenue has not changed dramatically from the 35 to 40 percent range (although we might expect it to over the next few years), IBM has become a smaller part of the North American landscape. IBM's R&D spending is abnormally high for the industry because it has historically invested in equipment processing technology, sometimes to the point of funding supplier infrastructures. As this part of the landscape becomes smaller, it draws down the overall picture of R&D spending in North America.

Second, and more important, is the increasing fabless semiconductor contingent—a purely U.S. phenomenon to date. A major part of the fabless company model is the focusing of R&D resources on core competence. This is inherently more efficient and is a lower R&D cost structure than for a large integrated manufacturer. Initially, fabless company R&D was high relative to revenue, but the last two years have seen a dramatic increase in this part of the business (approaching 10 percent of the North American company revenue), and relative R&D cost benefits have started to emerge. This structural change in manufacturing should tend to increase the relative R&D spending done in Asia/Pacific, where the majority of dedicated foundries are located. However, the combined structure should have lower overall costs, stabilizing the rising R&D cost structure of the industry in the near term.

Company Information

Tables 4 and 5 list the top 25 merchant semiconductor manufacturers and their estimated capital and R&D spending levels in 1993. Although there is a slight skew of capital spending at the top (that is, the top manufacturers spend more relative capital on production), R&D spending is relatively balanced (the top manufacturers spend equivalent to the total market on a relative basis). However, one sees quite a variation as one scans through the list. It is clear that investment in capacity is a major weapon in attracting market share in the near to medium term, but also that investment in R&D is required for long-term holding power.

Dataquest Perspective

Worldwide semiconductor R&D spending has been on an ever-so-slight rise—increasing as a percentage of revenue at a rate of about 0.2 points annually. However, structural changes in semiconductor manufacturing strategies worldwide, with the emergence of the dedicated foundry and the fabless company, appear to have stabilized this trend for the industry as a whole.

Japanese companies face a restructuring challenge ahead, and the need for R&D investment may increase in the near term. North American companies, with an increasing fabless contingent, will likely trend below the worldwide average. Large integrated manufacturers, however, may not see this trend on an individual basis, because the core reasons for the rise on R&D requirements will remain intact.

Table 4
Top 25 Merchant Semiconductor Manufacturers' Capital and R&D Spending Relative to Revenue, Calendar Year 1993 (Millions of Dollars)

Rank	Company	Production Revenue	Capital Spending (Percentage of Revenue)	R&D Spending (Percentage of Revenue)
1	Intel	7,970	21.31	12.2
2	NEC	6,141	11.31	15.0
3	Motorola	5,957	18.5	9.7
4	Toshiba	5,727	12.6	15.9
5	Hitachi	5,015	15.5	18.7
6	Texas Instruments	4,083	13.3	8.8
7	IBM Microeletronics*	3,310	12.4	38.7
8	Samsung	3,044	20.7	5.6
9	Fujitsu	2,928	23.9	18.8
10	Mitsubishi	2,823	15.9	19.9
11	Matsushita	2,344	7.2	22.2
12	Philips	2,300	5.8	11.3
13	National Semiconductor	2,131	11.0	9.6
14	SGS-Thomson	2,088	23.0	14.4
15	Sanyo	1,843	18.4	15.6
16	Sharp	1,760	15.3	20.9
17	Advanced Micro Devices	1,660	21.5	15.8
18	Siemens	1,510	19.8	24.0
19	Sony	1,398	25.7	27.6
20	Oki	1,187	10.5	8.9
21	AT&T	1,110	10.0	13.8
22	Goldstar	946	42.3	7.4
23	Rohm	930	11.1	NA
24	Micron Technology	925	19.5	7.0
25	Hyundai	853	46.9	11.7
	Total Top 25	69,983	16.7	15.3
	Total Market*	87,662	15.9	15.4
	Top 25 Percentage of Total	79.8	83.8	79.2

*IBM Microelectronics revenue reflects valuation of both merchant and captive portions of IBM's business, which is different from Dataquest's merchant semiconductor market share reports. The total market number is a "production" figure that includes all captive production.
Source: Dataquest (November 1994)

Table 5
Top 25 R&D Spending

	Percent
Average	15.3
Maximum	38.7
Median	15.0
Minimum	5.6
Exchange Rate (Yen/U.S.$1)	111.2

Source: Dataquest (November 1994)

Dataquest Conclusions

Strategic semiconductor procurement organizations analyze the total makeup of their supply base starting with R&D expenditure and followed by capital spending plans, quality, delivery, and ultimately pricing issues. Long-term decisions regarding semiconductor sourcing require suppliers with a solid technology foundation combined with the financial wherewithal to follow through with production once the technology is ready. Regular reviews of a supplier's capital spending plans and ratio analysis of spending compared to sales as well as total expenses give a good picture of where a supplier plans to go. Doing a similar analysis of R&D spending versus sales and total expenses is also helpful as an early indicator of potential problems. The two areas reviewed in this report are important and often-overlooked parts of a total cost analysis. Regular reviews will prevent unpleasant surprises that may disrupt supply lines or cause supplier dislocations.

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