Dataquest
A Gartner Group Company

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July 18, 1996

Dear Client:

Enclosed please find a copy of "North American Semiconductor Price Outlook: Third Quarter," product code SPSG-WW-MS-9603, which replaces a copy that was previously mailed to you. Because of a production error, we may have sent you a copy before it was three-hole drilled for you binder. There are no changes to the content of the document. We apologize for any inconvenience this may have caused.

Gordon Riley
Production Manager

SEMICONDUCTOR SUPPLY AND PRICING WORLDWIDE 1996
TABLE OF CONTENTS

PERSPECTIVES

9601	1/22/96	First Quarter Procurement Pulse: Orders Pick Up, Lead Times slip, and Inventories Rise Again
9602	1/29/96	Dataquest's First Quarter 1996 Memory Price Forecast
9603	2/5/96	Dataquest's Preliminary 1995 memory market Shares: Which Suppliers Have Momentum--and Why?
9604	2/12/96	1996 Semiconductor Cost Model Update
9605	1/29/96	April Procurement Pulse: Order Rates and Lead Times Fall Further while Inventories Rise
9606	1/10/96	ASIC Market: 1995 Is a Record-Breaking Year
9607	1/17/96	Third Quarter 1996 Price Survey Highlights: Gradually Lower Prices Still on the Horizon
9708	1/15/96	DRAM Product/Market Update 1996: Is Allocation a Thing of the Past?
9709	8/5/96	The SRAM Supply Bucket Finally Fills and Overflows: SRAM Market Update
9610	8/26/96	The Nonvolatile Memory Picture Becomes Clearer as Users Choose Long-Term Solutions
9611	9/30/96	Compute Microprocessor Supplier and Product Update: Intel Continues to Dominate a Compressed Market
9612	12/30/96	First Quarter 1997 Quarterly Price Survey highlights: Controlled Price Decreases Are Order of the Day

MARKET TRENDS

9601	5/13/96	Semiconductor Five-Year Forecast Trends--Spring 1996

MARKET STATISTICS

9601	3/18/96	North American Semiconductor Price Outlook: Second Quarter 1996
9602	4/29/96	Final 1995 Worldwide Semiconductor Market Share
9603	6/17/96	North American Semiconductor Price Outlook--Third Quarter
9604	9/23/96	North American Semiconductor Price Outlook--Fourth Quarter 1996
9605	1/6/97	North American Semiconductor Price Outlook--First Quarter 1997

REPORTS

9601	3/4/96	Focus Study: 1996b Semiconductor Industry Capital Spending Overview (Focus Report)
9602	4/22/96	Contract Manufacturing 1996 Update (Focus Report)
9603	12/30/96	IC Assembly Update 1996, Report 1: Commercial Aspects (Focused Report)

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February 1996

Dear Dataquest Client,

By now, you should have received the 1996 Dataquest research program binders for filing the newsletters and reports that will be sent to you throughout the year.

To let you know what documents you can expect to receive as part of your subscription, enclosed please find the 1996 datasheet for the research program to which you subscribe. The back side of the datasheet lists the Dataquest Perspectives, Market Trends reports, Market Statistics books, reports, and electronic newsletters that are included in this year's research portfolio.

If you have any questions about the research schedule, please contact your Dataquest research analyst or client services representative.

Sincerely,

Jeffrey A. Byrne
Vice President
Worldwide Marketing

SEMICONDUCTOR SUPPLY AND PRICING WORLDWIDE

Dataquest's Semiconductor Supply and Pricing Worldwide program responds to the quick information needs of semiconductor users. Clients of this program receive indispensable information needed to make solid, intelligent, and timely procurement and design-in decisions.

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

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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
- 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 order rates
- Average semiconductor lead times
- Semiconductor inventories of major users

Monthly Price/Lead-Time Updates

Dataquest publishes monthly price and lead-time updates on 25 products, three volume levels, and six 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

Annual Product/Market Updates

Product life cycles, market rankings, and supplier alliance analysis are provided for:

- DRAMs
- SRAMs
- Nonvolatile memory
- MPUs
- ASICs
- Semiconductor cost models

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WHAT YOU WILL RECEIVE AS A CLIENT

SEMICONDUCTOR SUPPLY AND PRICING WORLDWIDE

Perspective

Dataquest Perspectives present analysis and commentary on key technologies, companies, market opportunities, trends, and issues in the semiconductor market. A minimum of six Perspectives will be published on an event-driven basis throughout the year, as well as two Dataquest Predicts. Scheduled Perspectives for 1996 include:

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.

Available in July and December 1996

Product/Market Analysis: Comprehensive newsletters presenting analysis on products/markets and procurement issues such as product life cycles, market dynamics, alliances, and cost models/package costs.

Six Issues per Year

Market Analysis - 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.

Available Quarterly

Market Statistics

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.

Available Quarterly

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

Available in the Second and Fourth Quarters 1996

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 April 1996

Reports

Focus Studies: These reports examine 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 focused reports published throughout the year:

- **Capital Spending** — ***February 1996***
- **Contract Manufacturing Update** — ***April 1996***
- **IC Assembly** — ***December 1996***

Electronic News

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

Event-Driven

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 six regions (United States, Japan, Europe, Taiwan, Korea, and Singapore).

Weekly via Electronic Mail

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December 1995

Dear Dataquest Client:

In 1996, Dataquest will celebrate its 25th year as the leading global supplier of market intelligence to the IT vendor and financial communities. I would like to thank you, on behalf of all Dataquest associates worldwide, for your support. We are proud to be your information partner by providing the IT market insight and analysis you need to make crucial business and planning decisions.

The enclosed binder is for filing and storing the printed market research newsletters and reports that you will receive on an ongoing basis throughout 1996 as part of your subscription to Dataquest. You may notice that we've streamlined the binder tab and document filing structure this year. We hope that this 5-tab scheme increases your efficiency in filing and locating documents.

You probably know that in addition to paper-based delivery, Dataquest is also committed to delivering our market statistics and analysis electronically. We expect that our electronic products, known collectively as *Dataquest on the Desktop*, will play an increasing role in our ability to deliver information to you in a timely, efficient way. For your information, our electronic tools include:

- ***Dataquest on Demand***—Our monthly CD-ROM containing a rolling 13 months of Dataquest's printed documents
- ***MarketView***—A data analysis tool containing many of Dataquest's market statistics databases
- ***Electronic NewsTakes and Dataquest Alerts***—Weekly/event-driven summary and analysis of top IT news, published via e-mail or fax by most Dataquest research groups
- ***Dataquest Interactive***—Our Internet-based electronic delivery system that you are invited to preview at this URL: http://www.dataquest.com

One last note: an optional binder called *Electronic News* is available on request for clients who wish to file their electronic newsletters and Dataquest Alerts. To order your copy, please fill out the FaxBack form found in the binder pocket and fax it back to us.

We look forward to working with you in our continuing process to improve the content, quality, and timeliness of our products and services. I encourage you to share with us your comments about our publications and electronic delivery tools.

Sincerely,

Jeffrey A. Byrne
Vice President, Worldwide Marketing

1996 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 among 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*
- Computer and Client/Server Systems *Europe*
- Servers *Europe*
- UNIX and Open Systems *Europe*

Workstations
- Advanced Desktop and Workstation Computing *Worldwide*
- Workstations *Europe*

Computer Storage
- Removable Storage *Worldwide*
- Optical Disk Drives *Worldwide*
- Optical Disk Drives *Europe*
- Rigid Disk Drives *Worldwide*
  - RAID Storage Systems *Worldwide*
- Rigid Disk Drives *Europe*
- Tape Drives *Worldwide*
- Tape Drives *Europe*

Graphics
- Graphics and Displays *Worldwide*

Personal Computing
- Personal Computers *Worldwide*
- Personal Computers Strategic Service *Europe*
- Personal Computers *Asia/Pacific*
- Mobile Computing *Worldwide*
- PC Distribution Channels *Worldwide*
- PC Distribution Channels *Europe*
- Desktop PC Technology Directions *Worldwide*
- Mobile PC Technology Directions *Worldwide*
- Personal Computers *Central and Eastern Europe*

Quarterly Statistics
- Advanced Desktop and Workstation Quarterly Statistics *Worldwide*
- Workstation Quarterly Statistics *Europe*
- Server Quarterly Statistics *North America*
- Server Quarterly Statistics *Europe*
- PC Quarterly Statistics *United States*
- PC Quarterly Statistics *Europe*
- PC Quarterly Statistics *Japan*
- PC Quarterly Statistics *Asia/Pacific*
- PC Quarterly Statistics *Worldwide by Region*

Online, Multimedia, and Software

Emerging Technologies
- Multimedia *Worldwide*
- Multimedia *Europe* (Module)
- Online Strategies *Worldwide*
- Online Strategies *Europe* (Module)

Productivity/Development Tools
- Client/Server Software *Worldwide*
- Workgroup Computing *Worldwide*
- Workgroup Computing *Europe* (Module)
- Personal Computing Software *Worldwide*
- Personal Computing Software *Europe* (Module)

Technical Applications
- AEC and GIS Applications *Worldwide*
- Electronic Design Automation (EDA) *Worldwide*
- Mechanical CAD/CAM/CAE *Worldwide*
- CAD/CAM/CAE/GIS *Europe* (Module)
- CAD/CAM/CAE *Asia/Pacific* (Module)

Services

Customer Services
- Customer ServiceTrends *North America*
- Customer Services and Management Trends *Europe*

Professional Services
- Professional Service Trends *North America*
  - Systems Integration and Applications Development
  - Consulting and Education
  - Systems Management
- Vertical Market Opportunities *North America*
- Professional Services *Europe*
  - Systems Integration
  - Consulting and Education
  - Systems Management
- Professional Services Vertical Market Opportunities *Europe*
- Professional Service Trends *Asia/Pacific*

Sector Programs
- System Services *North America*
  - Desktop Services
  - Notebook Services
  - Server Services
- User Computing Services *Europe*
- Network Integration and Support Services *North America*
- Network Integration and Support Services *Europe*
- Software Services *North America*
- Strategic Service Partnering *North America*

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1996 RESEARCH PROGRAMS

Document Management	**Copiers** Copiers *North America* Copiers *Europe* **Facsimile** Facsimile *North America* **Printers** Printers *North America*	Printers *Europe* Colour Products *Europe* (Module) Printer Quarterly Statistics *Europe* Printer Distribution Channels *Europe* Printers *Asia/Pacific* Printer Quarterly Statistics *Asia/Pacific*
Semiconductors	**Regional Markets** Semiconductors *Worldwide* Semiconductors *Europe* Semiconductors *Japan* Semiconductors *Asia/Pacific* • China/Hong Kong • Taiwan • Korea • Singapore **Devices** ASICs *Worldwide* ASIC Applications *Europe* Memories *Worldwide* Memory Applications *Europe* Memory IC Quarterly Statistics *Worldwide* Embedded Microcomponents *Worldwide* Microcomponent Applications *Europe* DRAM Quarterly Supply/Demand Report **User Issues** Semiconductor Supply and Pricing Worldwide	**Application Markets** Semiconductor Application Markets *Worldwide* Semiconductor Application Markets *Europe* Semiconductor Application Markets *Asia/Pacific* Communications Semiconductors & Applications *WW* Consumer Multimedia Semiconductors & Applications *Worldwide* Semiconductor Directions in PCs & PC Multimedia *WW* PC Teardown Analysis PC Watch *Europe* Electronic Equipment Production Monitor *Europe* Electronic Application Markets *Europe* —Automotive Electronic Application Markets *Europe* —Communications Electronic Application Markets *Europe* —Consumer Electronic Application Markets *Europe* —EDP **Manufacturing** Semiconductor Equipment, Manufacturing, & Materials *Worldwide* LCD Industry *Worldwide* Semiconductor Contract Manufacturing *Worldwide*
Telecommunications	**Networking** Networking *North America* • Local Area Networks *North America* • Wide Area Networks *North America* • Modems *North America* Networking *Europe* • Asynchronous Transfer Mode *Europe* • ISDN *Europe* • Modems *Europe* • Local Area Networks *Europe* • WANs *Europe* Quarterly Market Watch *North America* • Intelligent Hubs & Switches • Network Interface Cards Network Distribution Channels *Europe* **Voice** Voice Communications *North America* • Voice Processing *North America* • Computer-Integrated Telephony & Automatic Call Distributors *North America*	• Premise Switching Systems *North America* Voice Communications *Europe* • Voice Processing *Europe* • Call Centres *Europe* • Telephones *Europe* • PBX/KTS Systems *Europe* **Public** Public Network Equipment & Services *North America* • Public Network Equipment *North America* • Public Network Services *North America* Public Network Equipment & Services *Europe* • Public Network Equipment *Europe* • Public Network Services *Europe* **Personal** Cellular Telephony *Worldwide* Personal Communications *North America* Personal Communications *Europe* • Infrastructure and Services *Europe* • Terminals *Europe* Personal Communications Distribution Europe
Cross-Technology Programs	**Technology Insights for:** Financial Services Government Agencies Publishing, Media, and Consulting Firms	IT Business Development for Financial Organizations IS and Purchasing Organizations IT Supporting Industries
Emerging IT Markets	**Central and Eastern Europe** Personal Computers Telecommunications **Latin America** Personal Computers Printers	**Asia/Pacific** IT Market Insight *Asia/Pacific* Personal Computers *Asia/Pacific* & Quarterly Statistics Printers *Asia/Pacific* & Quarterly Statistics Professional Service Trends *Asia/Pacific* • Country-level reports on Asia/Pacific IT markets

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Program Code: NONE-WW MKTG 1/96 (PSB)

DATAQUEST 1996 CONFERENCES

Dataquest sponsors an on-going series of conferences and invitational events focusing on trends and issues in information technology and IT services. These conferences are the preeminent source of insight and analysis of global IT market dynamics.

North America	January 24	Capitalizing on the Wireless Phenomenon	San Jose, California
	January 30	Dataquest Predicts	Boston, Massachusetts
	February 20	Dataquest Predicts	San Jose, California
	March 7	Channel Trends Conference	San Jose, California
	April 1-2	ServiceTrends Conference	Orlando, Florida
	April 1 *	Mining the Internet	Boston, Massachusetts
	May 6-7	Personal Computer Conference	San Jose, California
	May 13-14	Copier Conference	Boston, Massachusetts
	June 26-27	Storage Track Conference	Monterey, California
	July 1 *	SEMICON/West	San Francisco, California
	September 25-26 *	Multimedia	San Jose, California
	October 24-25	Semiconductors '96	Palm Desert, California
	December 1 *	Mining the Internet	San Jose, California
Europe	January 24	Computer Storage	Munich, Germany
	May 22-23	Semiconductors '96	Frankfurt, Germany
	September 10	Computer Storage	London, England
Japan	May 13-14	Semiconductors '96	Tokyo, Japan
	September 10-12	Computers and Peripherals	Tokyo, Japan
	December 6	Telecommunications	Tokyo, Japan
Dataquest Invitational Computer Conferences	December 1 *	Asia/Pacific Series	Tokyo, Japan
	December 1 *	Asia/Pacific Series	Seoul, Korea
	December 1 *	Asia/Pacific Series	Beijing, PRC
	December 1 *	Asia/Pacific Series	Shanghai, PRC
	December 1 *	Asia/Pacific Series	Xi'an, PRC
	December 1 *	Asia/Pacific Series	Guangzhou, PRC
	March 5	Dataquest Storage Solutions Series - USA	San Jose, California
	April 10	Dataquest Storage Solutions Series - USA	Irvine, California
	April 24	Dataquest Storage Solutions Series - USA	Nashua, New Hampshire
	September 24	Dataquest Storage Solutions Series - USA	Newton, Massachusetts
	April 1	Mediterranean Series	Dubai, UAE
	May 21	Mediterranean Series	Athens, Greece
	October 30	Mediterranean Series	Tel Aviv, Israel
	November 6	Mediterranean Series	Istanbul, Turkey

**** Date tentative/may change***

Dataquest Invitational Computer Conferences *(continued)*

January 17	Dataquest Storage Solutions Series-Europe	Paris, France
January 23	Dataquest Storage Solutions Series-Europe	Munich, Germany
January 30	Dataquest Storage Solutions Series-Europe	Milan, Italy
February 1	Dataquest Storage Solutions Series-Europe	Rome, Italy
June 10	Dataquest Storage Solutions Series-Europe	Budapest, Hungary
June 12	Dataquest Storage Solutions Series-Europe	Prague, Czech Republic
June 21	Dataquest Storage Solutions Series-Europe	St. Petersburg, Russia
June 25	Dataquest Storage Solutions Series-Europe	Moscow, Russia
July 1	Dataquest Storage Solutions Series-Europe	Warsaw, Poland
September 1	Dataquest Storage Solutions Series-Europe	Amsterdam, Holland
September 5	Dataquest Storage Solutions Series-Europe	Stockholm, Sweden
September 11	Dataquest Storage Solutions Series-Europe	London, England
September 19	Dataquest Storage Solutions Series-Europe	Frankfurt, Germany
October 1 *	Latin America Series	Caracas, Venezuela
October 1 *	Latin America Series	Mexico City, Mexico
October 1 *	Latin America Series	São Paulo, Brazil
October 1 *	Latin America Series	Buenos Aires, Argentina
October 1 *	Latin America Series	Santiago, Chile
October 1 *	Latin America Series	Bogotà, Columbia
October 1 *	Latin America Series	Lima, Peru
February 19	South Africa Series	Capetown, South Africa
February 22	South Africa Series	Johannesburg, South Africa
April 11	LINK Series - North America	Orlando, Florida
April 30	LINK Series - North America	Austin, Texas
May 1	LINK Series - North America	Philadelphia, Pennsylvania
May 9	LINK Series - North America	Charlotte, North Carolina
May 14	LINK Series - North America	Denver, Colorado
May 21	LINK Series - North America	Portland, Oregon
November 1 *	LINK Series - North America	Montréal, Québec
November 1 *	LINK Series - North America	Ottawa, Ontario
November 1 *	LINK Series - North America	Calgary, Alberta
November 1 *	LINK Series - North America	Vancouver, BC
November 1 *	LINK Series - North America	Toronto, Ontario

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Here's How to Order Your *Electronic News* Binder

Dataquest provides a separate binder called *Electronic News* to help you organize your printouts of the electronic newsletters and Dataquest Alerts that will be sent to you by your Dataquest North America research programs throughout the year.

Although not all clients will print out electronic news bulletins or file faxes, the *Electronic News* binder is available by request for those who do.

To order your *Electronic News* binder, just fill out the form below and fax it back to us. We will mail your binder to you immediately.

Note: If you subscribe to more than one Dataquest North America research program, then indicate how many binders you need in the space provided below (plan on one binder per research program), and we'll send them to you in one shipment.

Thank you for helping us serve you better.

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Dataquest ALERT

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Fourth Quarter 1996 Procurement Pulse: Order Rates Rising, Lead Times Low and Stable, and Inventories Well Managed

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

Figure 1
Averaged Monthly Semiconductor Orders

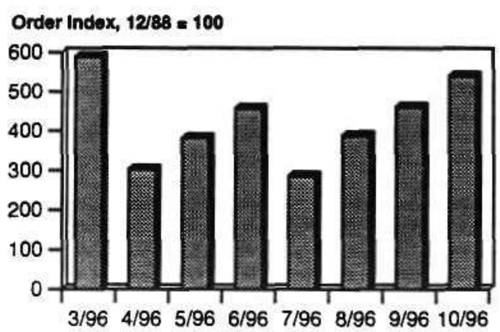


Figure 2
Averaged Semiconductor Lead Times

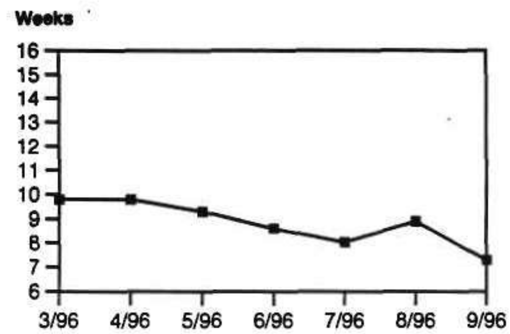


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

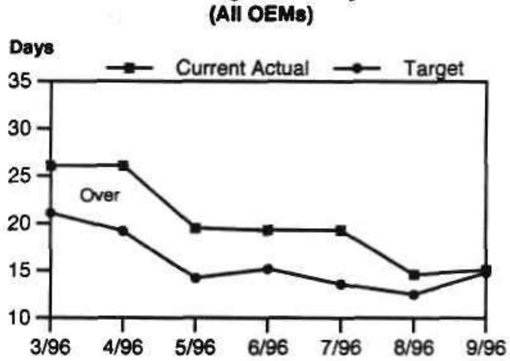
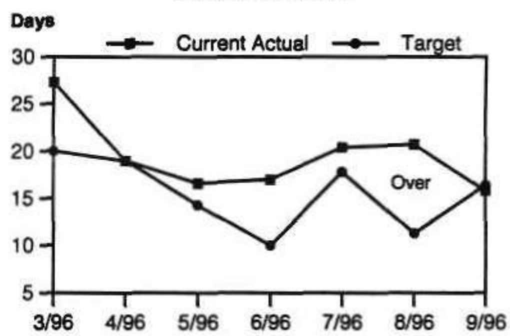


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



966957

Source: Dataquest (October 1996)

Semiconductor Order Rate Expected to Rise for the Third Straight Month

As shown in Figure 1, the outlook for semiconductor order activity will rise gradually after two previous incrementally higher forecasts. Although 17 percent higher than September's forecast index, the October outlook is historically upbeat as it wraps up the year-end holiday push. With prices at historical lows for many ICs, this rising booking outlook is another encouraging sign that the overall market is relatively healthy. The continued buoyancy of the electronics market continues to benefit from overall price declines, with steady unit volumes being ordered at lower dollar outlays. The overall sample has seen price cuts in all areas tracked in this survey—DRAM, MPUs, logic, flash memory, and SRAM (although at more moderate rates of under 2 percent per month). In contrast to the declining contract DRAM prices, spot market pricing for most discrete DRAM parts and SIMMs has risen over the past few weeks as demand for high-density SIMMs and their corresponding parts has risen, and spot suppliers scramble to catch up. The computer subset of the respondents saw a similar DRAM price cut of 2 percent in September after a 5 percent average drop noted in August. Although overall prices continue to decline, pricing for different semiconductor packaging (except for three respondents using TSOP) has reached parity. Improvement in availability is providing cost relief in all areas, and the outlook through the next six to nine months is for more of the same.

Lead Times for Semiconductors Now Slip Below Eight Weeks

Figure 2 highlights the drop in the average lead time for respondents in September to 7.3 weeks, the lowest on record (since 1989)! The continual decline of average lead times correlates directly to increased availability of components relative to demand. Now beginning a fourth quarter of a buyer's market, many procurement managers continue to balance price cuts with supply base relations. Improved service levels combined with ever-lower prices are fraying some long-term supplier relations. Out of the entire sample, only two respondents noted problems with products, those being ASICs and memory parts. For the majority of the respondents and the overall market, problem products are a thing of the past, with sights now set on predictable pricing. Like last quarter, over half of this month's respondents noted price fluctuations as the key issue facing them. The spot market will continue to vacillate around the declining contract price curve, causing uncertainty for some buyers. The overall trend, however, is for continued good availability, consistently declining contract prices and low (8- to 10-week) lead times for the next six months.

Semiconductor Inventories under Control

Figures 3 and 4 highlight how the inventory bubble has now passed through the industry as target and actual levels are back to or below the levels of third quarter 1995. Even with semiconductor order rates forecast to pick up again, the increase in fourth quarter business has not increased reported levels of semiconductor inventory. The overall targeted and actual semiconductor inventory levels for September were 14.8 days and 15.1 days, respectively, compared with August's 12.6-day and 14.6-day inventory levels. The computer subset has fluctuated recently, now being more in line with the overall sample. The current target and actual inventory levels of 16.4 days and 15.8 days compare to August levels of 11.3 and 20.7 days on hand for the computer subset. Although it took a bit longer for the inventory correction to occur, inventory levels now are in line with historical levels once again. We expect to see stabilized inventory levels in the future, more in line with system sales levels.

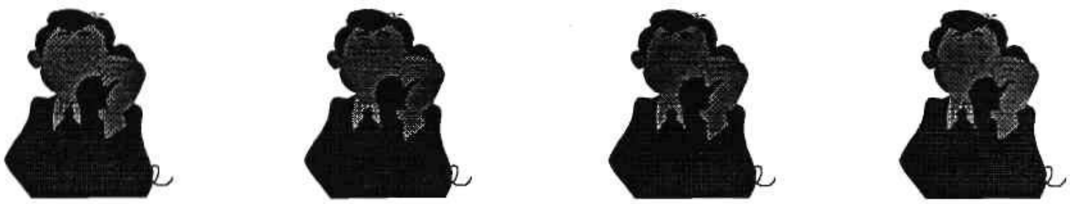
Dataquest Perspective

Availability of semiconductors remains very good to excellent as it is continues to be the buyer's turn to take advantage of the supply-demand situation. Prices and lead times remain on a downward slope despite the efforts of some memory suppliers to curtail output. Rumors of increased inventories of semiconductors held by suppliers, if true, could have the effect of extending the price decline trend well into 1997 unless demand dramatically increases. Although Dataquest forecast lower growth rates for PCs and other electronics relative to 1995, the overall trend follows an upward growth slope. With user semiconductor inventory levels now in line with user demand, we expect to see more balance in these indexes in the next few months—especially as end-of-year financials gain attention. Allocations are, for the time being, last year's problem (despite spot market rumormongering) as suppliers resign themselves to beat competitive bids via price to maintain solid order levels. Dataquest expects to see continued improvement in semiconductor availability through the end of the year. Any DRAM and MPU price elasticity has not (as yet) propped up prices. The spot market remains as volatile as ever, with many price points now above contract levels—at least for this week. We'll see how long this situation lasts relative to contract pricing as long-term supply relative to steady demand equates to long-term lower prices overall.
By *Mark A. Giudici*

F.Y.I.

Dataquest Teleconference

251 River Oaks Parkway, San Jose, CA 95134-1913 Phone 408-468-8000 Fax 408-954-1780



TOPIC: **Dataquest's latest quarterly Semiconductor price forecast. What will Micron's anti-dumping rumblings mean to the market? Cost based pricing is again in vogue.**

SCOPE: The session opens with comments by analysts from the Semiconductor Supply and Pricing Service (SPSG) and the Memory IC Service (MMRY). Questions will be taken following these statements.

WHO: Discussion leaders are Mark Giudici and Jim Handy. Invitees will consist of SSPS, MEMORY, and Cross-Industry clients.

WHEN: Wednesday June 12, 1996 at 9:00 a.m. PDT.

HOW: To confirm your attendance, fax Jenny Williams at (408) 468-8044 or call Jenny Williams at (408) 468-8263 ***no later than June 10, 1996.***

Clients who respond by June 10 will receive tables (via fax) before the teleconference.

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July Procurement Pulse: Order Rates Moderate, Lead Times Fall Further And Inventories Stabilize

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

Figure 1
Averaged Monthly Semiconductor Orders

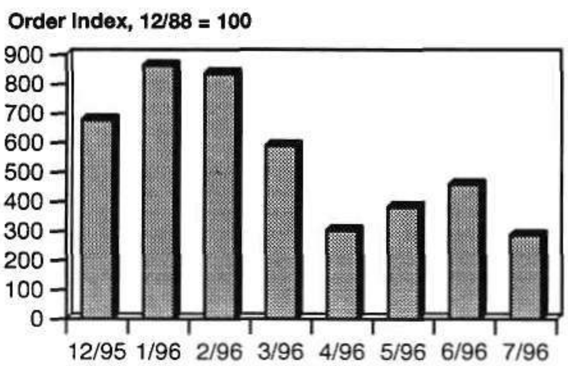


Figure 2
Averaged Semiconductor Lead Times

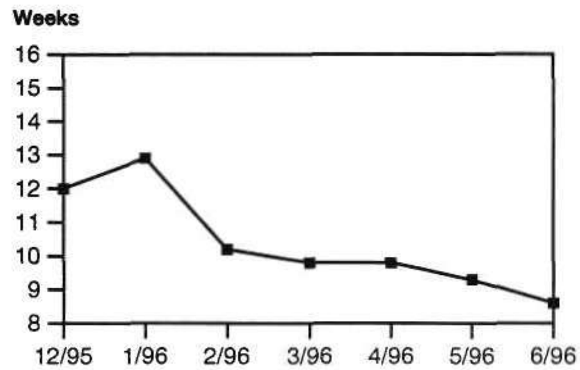


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

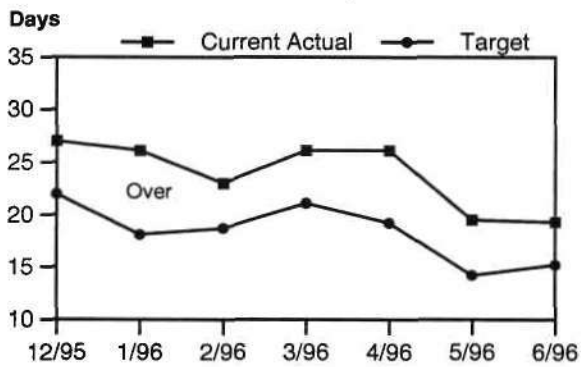
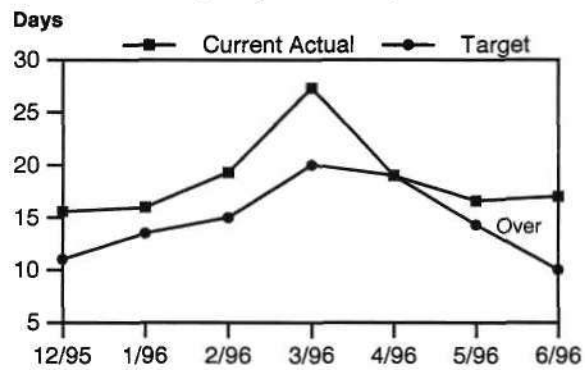


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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Source: Dataquest (July 1996)

Semiconductor Order Rate Expected to Slip in July after Two Months of Higher Forecasts

As shown in Figure 1, the outlook for semiconductor order activity is expected to drop slightly after the increase in forecast expectations over the past two months. Although it is 37 percent lower than June's forecast index, July's index has historically been lower because of seasonality. Another influence is the lower overall prices of semiconductors, which affects this dollarized index. The buoyancy of the electronics market continues to benefit from overall price declines where steady unit volumes are being ordered at lower dollar outlays. The overall sample has seen price cuts in all areas tracked in this survey--DRAM, MPUs, logic, flash memory, and SRAM (although at more moderate rates than in the first and second quarters). DRAM pricing for the overall sample fell on average 5 percent in June after a 6 percent average drop in May. The computer subset of the respondents saw a more aggressive DRAM price cut of 9 percent in June after a 8 percent average drop in May. Although overall prices continue to decline, pricing for different semiconductor packaging (except for two respondents using TSOP) has reached parity. Improvement in availability is providing cost relief now in all areas, and the outlook for the next six to nine months is for more of the same.

Lead Times for Semiconductors Now Slip Below Nine Weeks

Figure 2 shows that the average lead time for respondents in March fell to 8.6 weeks, the lowest noted since May 1991! The rapid fall of average lead times correlates directly to increased availability of components relative to demand. Now well into the third quarter of a buyer's market, many procurement managers are balancing price cuts with supply base relations. Improved service levels combined with ever-lower prices are fraying some long-term supplier relations. Of the entire sample, four respondents noted problems with products, those being ASICs, linear, and discrete parts. For the majority of the respondents and the overall market, problem products are a thing of the past, and sights are now set on predictable pricing. As they did last quarter, over half of this month's respondents noted price fluctuations as the key issue now facing them. The spot market will continue to vacillate around the declining contract price curve, causing uncertainty for some buyers. The overall trend, however, is for continued good availability, consistently declining prices, and low lead times (eight weeks to 10 weeks) for the next six months.

Semiconductor Inventories Back to Historical Levels

Figures 3 and 4 show that the inventory bubble has now passed through the industry, as target and actual levels are now back to the levels seen before the third quarter of 1995. Even though semiconductor order rates are forecast to slow as noted above, the moderated trend in overall and computer sales reflects the seasonally slow period of electronics sales before the fourth quarter holiday push. The overall targeted and actual semiconductor inventory levels for June were 15.2 days and 19.3 days, respectively, compared with May's 14.2-day and 19.5-day inventory levels. The computer subset again is more aggressive than the overall average. The current target and actual inventory levels of 10.0 days and 17.0 days compare well with the May levels of 14.3 and 16.7 days on hand for the computer subset. Although it took a bit longer for the inventory correction to occur, inventory levels now are in line with historic levels once again. We expect to see stabilized inventory levels in the future, more in line with system sales levels.

Dataquest Perspective

Availability of semiconductors remains very good to excellent as it is now the buyer's turn to take advantage of the supply/demand situation. Prices and lead times continue to decline despite efforts by some memory suppliers to curtail output. Rumors of increased inventories of semiconductors being held by suppliers, if true, could have the effect of extending the price decline trend well into 1997 unless demand dramatically increases. Although Dataquest forecast lower growth rates for PCs and other electronics relative to 1995, the overall trend follows an upward growth slope. With user semiconductor inventory levels now in line with user demand, we expect to see more balance in these indexes in the next few months—especially as end-of-year financials gain attention. Allocations are, for the time being, last year's problem as suppliers resign themselves to beating competitive bids via price to maintain solid order levels. Dataquest expects to see continued improvement in semiconductor availability through the end of the year. Any DRAM and MPU price elasticity has not (as yet) propped up prices. The spot market continues to lead pricing lower, and the summer slow period will most likely bring more of the same. Declining prices will be with us for the remainder of this year.

By Mark A. Giudici

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March Book-to-Bill Ratio Dives to 0.80: Is There Life After Price Erosion?

The March 1996 (seasonally adjusted, three-month moving average) semiconductor book-to-bill ratio fell to 0.80 after February's downward adjusted 0.89 ratio. March 1996 average bookings were 12.5 percent lower than February and 14.5 percent less than March 1995 average bookings. Average billings in March 96 were 3.1 percent down from February levels but were up 22.7 percent from March 1995.

Before Jumping Overboard, Ask "Is This Trip Necessary?"

The March book-to-bill ratio (using January, February, and March data) takes the full brunt of the dramatic price declines that began in earnest late in December 1995. A dollarized ratio is designed to identify revenue changes—or price shifts. The continued January through March price erosion of 5 to 15 percent per month for select DRAM and SRAM products at both the spot and contract levels obviously will affect the "three-month moving average" book-to-bill. Add to this a system inventory overhang from 1995 that needed burning off, plus large quantities of aftermarket semiconductors available, and the result is reduced orders for OEM chips. Billings and shipments of semiconductors through this period were a mix of bookings made earlier for higher-priced products, which, combined with lower volumes and price, equates to a low book-to-bill ratio.

Dataquest expects that overall pricing will continue to decline for the remainder of this year as supplies continue to come to market in the face of lower than 1995 growth rates. (It will be difficult to repeat a back- to-back 40 percent growth forecast for 1996.) In fact, our October 1995 forecast for 1996 of 22 percent for the worldwide semiconductor market has been lowered to the low teens primarily because of price erosion in many key memory areas. We will release the finalized forecast within 2 to 3 weeks. Does this mean a repeat of 1985 is in the offing? We think not.

Once price declines become smaller and more predictable (around May and June), Dataquest anticipates that the market and the book-to-bill ratio will settle down and again reflect a cost-based price/revenue growth pattern. This will equate to revenue growth tied to yield improvements and unit growth based on end-system growth, not primarily undersupplied semiconductor unit shipments. In other words, the book-to-bill ratio most likely will remain below 1.0 for the next 2 to 3 months as price declines at the booking level assimilate into billings. Unit shipment volumes should pick up within this period as the semiconductor aftermarket inventory bubble deflates and price elasticity spurs some increased unit demand. Some prudent suppliers have reallocated capacity to more lucrative devices, which will also shore up the price decline rate.

So What?!

Low book-to-bill ratios always get news ink, but the dynamic behind the ratio is the important thing to watch. Dramatic price swings (both up and down) have always skewed this index. In this instance, the downward slide of the book-to-bill ratio correlates with known lower first quarter 1996 prices and somewhat lower unit booking levels because of inventory issues, and therefore it should not be a surprise. Price declines are a double-edged sword. While fabs keep running at lower profit per unit, customers get a better deal, which may result in additional unit sales. Stay tuned for future changes.
By Mark A. Giudici

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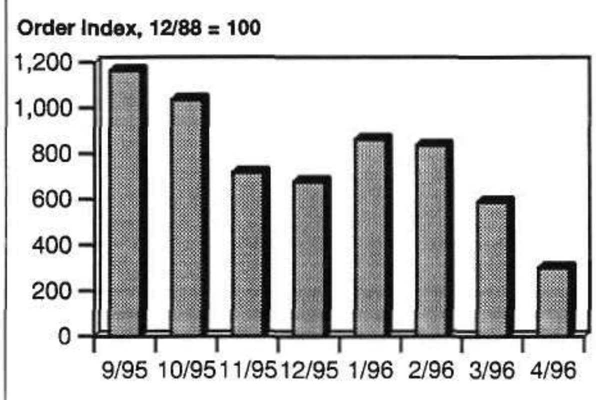
April Procurement Pulse: Order Rates and Lead Times Fall Further While Inventories Rise

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



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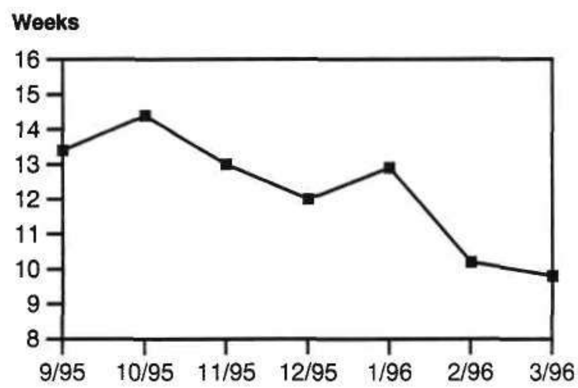


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

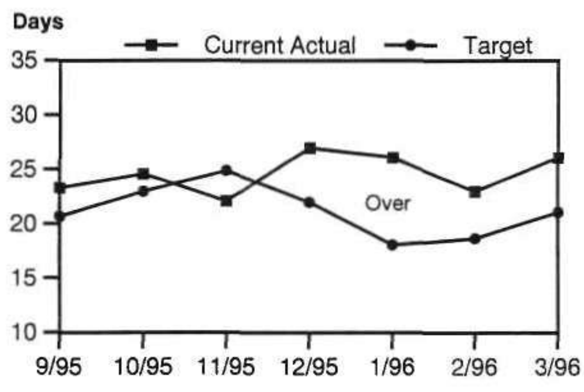
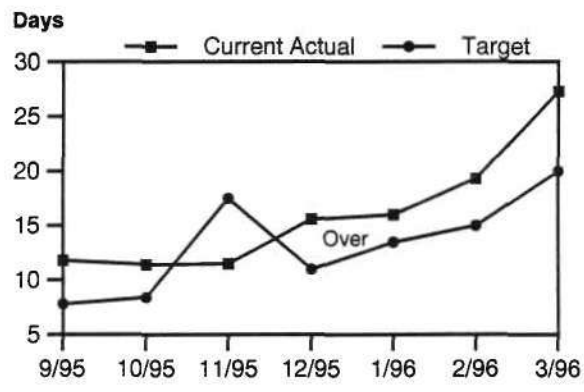


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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Source: Dataquest (April 1996)

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

Semiconductor Order Rate Forecast Is Lowest Recorded Since December 1992

As seen in Figure 1, the outlook for semiconductor order activity is expected to drop further relative to the past few months. This new low dollarized index is 49 percent lower than last month's index, reflecting lower than needed semiconductor purchases in dollars. It now appears that the buoyancy of the current electronics market is benefiting from overall price declines where steady unit volumes are being ordered at lower dollar outlays. The overall sample has seen price cuts in all areas tracked in this survey—DRAM, microprocessors, logic, flash memory, and SRAM. DRAM pricing for the overall sample fell 12 percent, on average, in March after a 19 percent average drop noted in February. The computer subset of the respondents also saw an 11 percent drop in DRAM pricing in March after a free fall averaging 33 percent in February. Although overall prices continue to decline, pricing for different semiconductor packaging (except for one respondent using TSOP) has reached parity. Improvement in availability is providing cost relief in many areas, and the outlook through the next six to nine months is for more of the same.

Lead Times for Semiconductors Also Slip Below 10 Weeks

Figure 2 shows that the average lead time for respondents in March fell to 9.8 weeks, the lowest seen since September 1992! The rapid fall of average lead times correlates directly to increased availability of components relative to demand. The transition from a seller's to a buyer's market is nearing completion as procurement managers work aggressively to lower costs and improve supplier support levels, rather than focusing on product availability. Of the entire sample, only two respondents noted problems with products, those being ASICs and microprocessors. For the majority of the respondents and the overall market, problem products are a thing of the past, and sights are now set on predictable pricing. Over half of this month's respondents cited price fluctuations as the key issue now facing them. The spot market will continue to be volatile, vacillating around the declining contract price curve and causing uncertainty for some buyers. The overall trend, however, is for continued good availability, consistently declining prices, and short lead times (under 10 weeks) for the next six months.

Semiconductor Inventories Jump Up

Figures 3 and 4 show that, despite steady system demand, semiconductor inventory levels continue to rise, especially for the computer subset of Dataquest's sample. Even though order rates are forecast to decline as noted above, the upward trend in overall and computer semiconductor stocks generally precedes a slow downturn in overall system sales. The overall targeted and actual semiconductor inventory levels for March were 21.1 days and 26.1 days, respectively, compared with February's 18.7-day and 23.0-day inventory levels. The computer subset now exceeds the overall average, with target and actual inventory levels of 20.0 days and 27.3 days, compared with February levels of 15.0 and 19.3 days on hand. By historic standards, these semiconductor inventory levels are reaching the outer bounds of acceptability by financial departments. We expect to see some lowering of inventory levels in the near future to keep overall costs more controlled.

Dataquest Perspective

Availability of semiconductors has improved markedly since Dataquest's last report in January. Prices and lead times have declined, in part because of improved levels of supply, but also because of lower levels of expected demand. Although Dataquest forecast lower growth rates for PCs and other electronics products relative to 1995, the overall trend followed an upward growth slope. Some suppliers expected a steeper growth increase than is now shaping up, in aggregate balancing out the supply and demand equation that for over two years has favored suppliers. With inventory levels relatively high and semiconductor order rates relatively low, Dataquest expects to see more balance in these indexes in the next few months—especially as midyear financials gain attention. Allocations are, for the time being, yesterday's problem as suppliers now reluctantly follow prices down historic decline rates. Dataquest expects to see continued improvement in semiconductor availability through midsummer, when DRAM and microprocessor price elasticity may come into play by increasing overall unit demand. Declining prices will be with us, however, for the remainder of this year.
By *Mark A. Giudici*

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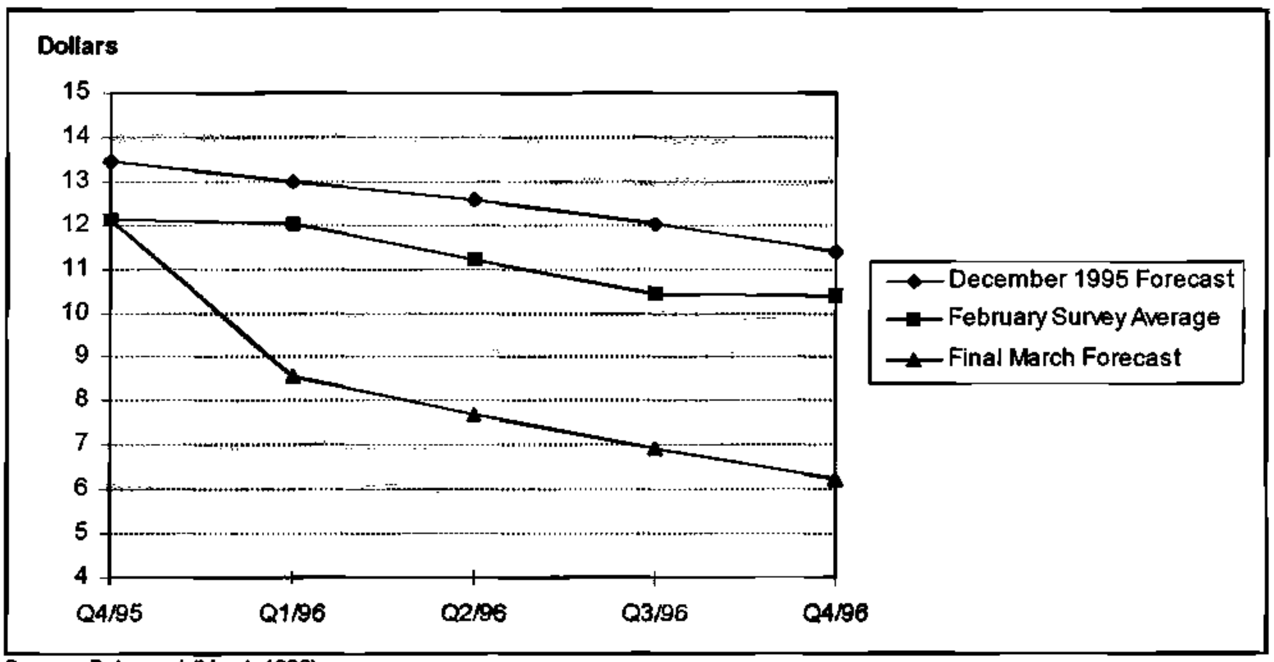
Lower Contract DRAM Prices Expected, Now and Later

Latest Quarterly Price Forecast Out: What Goes Around...

The latest Dataquest semiconductor price forecast is complete. Every quarter, Dataquest polls both users and suppliers for their views on semiconductor pricing and direction. The highlight of the forecast is that the DRAM market is being hammered hard on contract pricing for the first time in over two years. As shown in Figure 1, the prior quarterly price forecast, the initial survey input averages, and final forecast pricing highlight how fast price reductions have hit. Between the time we gathered the initial data in mid-February and the time we released the final forecast, there was an additional price drop of 10 percent to 15 percent. Also, some suppliers have recently disclosed contract pricing well below that shown in our final March forecast.

Figure 1
DRAM Price Shifts



Source : Dataquest (March 1996)

Spot Market Snowball Refuses to Melt, Finally Engulfs North American Market

The closely watched softening of the DRAM spot market began in October 1995 in Taiwan. It spread to Europe, then to Japan, and, last, to North America. In three months, the overabundance of DRAM has had an unanticipated, abrupt impact on the contract market. The reasons for the spot market softness are many and have been analyzed in earlier Dataquest Alerts—year-end inventory clearance by majority users, the quick shift from fast page mode (FPM) to extended data out (EDO) DRAM, and increased supplies because of improved DRAM yields, among other factors. After three months of continued lower spot market pricing, contract buyers, sensing a change in the market, began to use the spot softness as a negotiating tool to lower contract pricing. Some users shifted this emphasis to the point of having monthly rather than quarterly price reviews. (Dataquest has now heard of biweekly price reviews.) Now the gap between spot market and contract DRAM pricing has been reduced significantly.

EDO Follows FPM Down the Price Slide

Dataquest is now hearing of pricing under $7.00 at the spot level for EDO 1Mbx4 parts and prices below $30.00 for EDO 1Mbx16 devices (down from $53.50 for fourth quarter 1995 contracts). The EDO segment of the market is apparently following the FPM market down primarily because most manufacturers have long stated that they would be at price parity with EDO in 1996. Few people expected the abrupt price declines in the first quarter of this year and the parallel rise in EDO demand. As a result, we now have the market oddity of a part in shortage, the EDO 1Mbx16-60 DRAM, coming down in price! Also, a part that is easier to manufacture, the EDO 4Mbx4-60 DRAM, has remained relatively stable in price primarily because of the fact that the high-density DRAM modules using these chips (16MB and 32MB) have remained in short supply. We expect the spot market to soften further through the second quarter relative to contract pricing in part because of the close of the fiscal year for Japanese suppliers on March 31. Dataquest expects that many old contracts will be revised downward in price once the Japanese companies' books have closed for 1995.

Price Outlook: Continued Declines, but at a Slower Rate

Dataquest forecasts continued DRAM price declines throughout 1996 as a direct result of the large amount of DRAM fab capacity that continues to come to market (especially for the 16Mb density). Our forecast shows that contract pricing for DRAM dropped an average of 30 percent from the fourth quarter of 1995 to the first quarter of 1996. We do not expect to see again an abrupt 2-month to 3-month price fall of 20 percent to 30 percent because demand remains relatively healthy for PC s and electronics in general. The FPM inventory clearance continues to work its way through the market. It is possible that once this inventory bubble is absorbed, overall pricing could once again stabilize in the second half of this year. For now, however, pricing is based more on cost improvements than on demand levels. (Dataquest has gotten more inquiries on semiconductor costs in the past month than in the past two years!) We estimate that efficient manufacturers can now profitably sell a 1Mbx4 DRAM for $4.00 and a 1Mbx16 DRAM for $30.00. These cost-based prices imply that there is room for suppliers to sell these parts at still lower prices throughout the year without losing money. Users have to be judicious in using cost-based pricing because some suppliers are further along the cost curve than others.

Dataquest Perspective

It has been over two years since there has been any significant price movement in the DRAM market. Well, from December 1995 to March 1996, most DRAM prices declined between 15 percent and 30 percent or more! What normally takes four quarters (before 1994) took four months. Dataquest has boldly predicted for the past two years that 1996 would be a "transitional" year for the DRAM market. Transitional now takes on a different meaning for both suppliers and users of these critical parts. If memory prices drop low enough to spur enough additional DRAM demand, overall price cuts could theoretically slow. Another stabilizing effect on DRAM prices would be a strong increase in PC DRAM demand in the second half of this year. These two scenarios, while probable, are optimistic and are not in our price forecast at this time. On the other hand, the money freed up by lower memory costs could be used for additional hard drive storage, fast modems, MPEG sound cards, and so on, or simply pocketed by the PC maker. Although the contract-level price decline was not entirely expected, the overall price decline scenario was. Cool heads now need to prevail by booking and shipping real demand at reasonable prices.
Mark Giudici, Ron Bohn, Evelyn Cronin, and Jim Handy

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Dataquest Reports 33 Percent of U.S. Homes Will Have a PC by the End of 1996

New Study Finds Home Market Reaching Maturity Quickly

San Jose, Calif., March 18, 1996—A new Dataquest study reports 33 percent of the homes in the United States will have a PC by the end of 1996—up from 29 percent in 1995—but that the market is beginning to mature. In 1994, the U.S. home PC market grew 42 percent, and in 1995 the market grew 22 percent, but in 1996 the market is expected to grow 8 percent (see Table 1).

"With the maturing of the U.S. home market through the end of the decade, vendors must choose their battles carefully, and they must execute on existing opportunities with more targeted segmentation work," said Scott Miller, senior industry analyst of Dataquest's Personal Computing program. "The lucrative markets going forward are repeat customers and new high-income buyers, in that order."

The most penetrated group is households earning more than $100,000 per year, with 65 percent owning PCs. The least penetrated group is households earning less than $30,000 per year, with 12 percent owning PCs.

Table 1
United States Home PC Market Forecast Estimates
(Thousands of Units)

	1994	1995	1996	1997	1998	1999
New Unit Shipments	6,055	7,382	7,946	7,998	7,814	8,409
Total Installed Base	30,388	39,119	47,383	55,342	62,347	69,159
Growth Rate (%)	42.1	21.9	7.6	0.7	-2.3	7.6
Penetration Rate (%)	25.1	29.0	32.6	34.9	36.3	37.7

Note: New unit shipments does not include computers bought used, computers assembled from component parts purchased in electronics stores or other outlets, or employer-provided computers. Total installed base includes all personal computers now in use, regardless of origin.
Source: Dataquest (March 1996)

Dataquest's new report titled *The U.S. Home Market—Opportunity Lost?* reveals key insights on the home installed base. The report examines why people are buying computers for the home,

-MORE-

while other are staying away, and it explains what vendors will need to do to succeed in the market.

To inquire about Dataquest reports, please call 800-419-DATA. More information about Dataquest's programs, descriptions of recent research reports, and full text of press releases can be found on the Internet at http://www.dataquest.com.

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# # #

Dataquest

Perspective

Semiconductor Supply and Pricing Worldwide

Dataquest Predicts

First Quarter 1997 Quarterly Price Survey Highlights: Controlled Price Decreases Are Order of the Day

Abstract: *The year 1996 has been trying and testing time for all OEMs. Prices nose-dived, and most buyers were forced to reevaluate their procurement practices, especially regarding DRAM and SRAM price negotiations.*
By Evelyn Cronin

Overview

The spot market is still grabbing the headlines. However, trading remains feather light despite good pricing and availability. Inventory holding of all components, but especially DRAMs, is minimal at all OEMs, and at present, extreme caution is being used in order book management through the closing weeks of 1996.

Dataquest has just completed its first quarter 1997 price forecast. Looking forward to 1997 and beyond, most buyers feel confident of continued contract price reductions. However, for existing technologies, most buyers' expectations are for minimal price reductions quarter on quarter at the contract level, conducted in a controlled fashion. On newer technologies still in the growth phase of their life-cycle curve, buyers have far greater expectations. Price deltas quarter on quarter and year on year are far more significant.

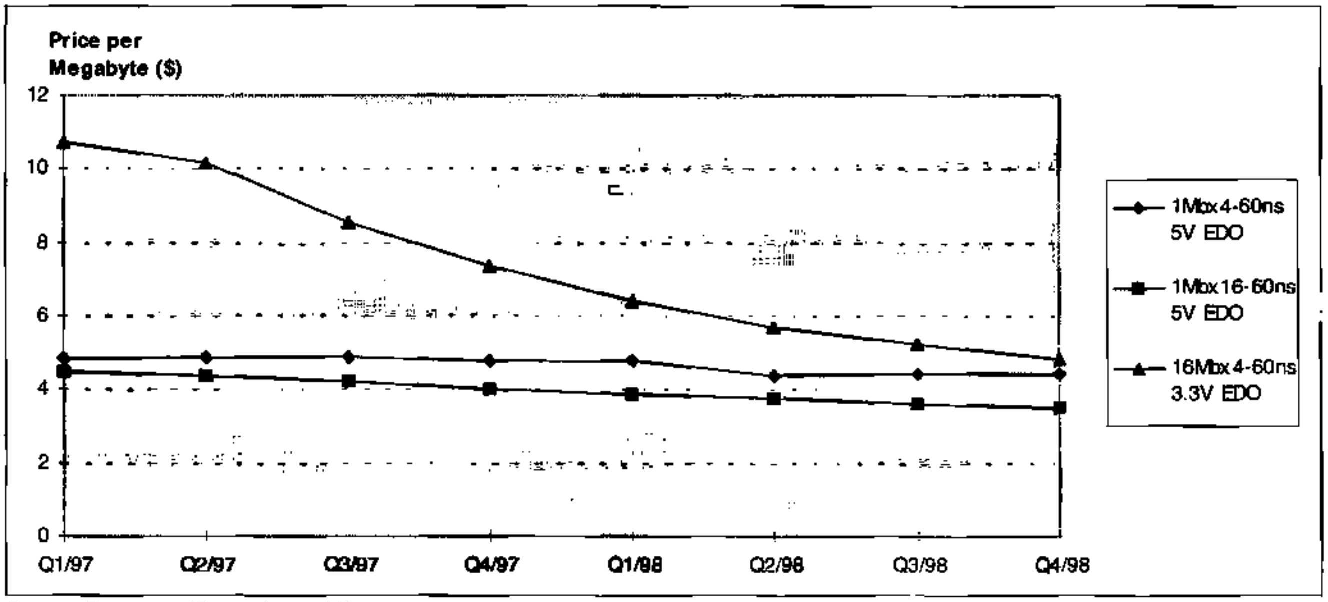
Price Forecast Highlights

Compared with our September 1996 forecast, overall prices have decreased further. This is largely driven by aggressive price reductions on technologies

Dataquest
Program: Semiconductor Supply and Pricing Worldwide
Product Code: SPSG-WW-DP-9612
Publication Date: December 23, 1996
Filing: Perspective
(For Cross-Technology, file in the Semiconductor Devices and User Issues binder)

in the growth phase. Existing technologies are exhibiting more stable price reductions. Overall demand for electronics remains strong, and Dataquest expects demand to remain that way for the rest of this year. However, excess capacity will remain a reality, especially on DRAM and PC cache SRAM throughout the foreseeable future. That said, buyers know that pricing on some of these devices is almost at rock bottom, and, thus, while they forecast continued price reduction, their expectations are low. Figure 1 plots the forecast price per megabyte for contract DRAM by quarter for 1997 and 1998. The 1Mbx4 and 1Mbx16 curves are largely flat. However, the 64Mb, based on 16Mbx4, shows very dramatic price reductions. Figure 2 shows the latest price forecast for the 150ns 128Kbx8 1Mb nonvolatile discrete devices by quarter for 1997 and 1998. The ROM device is showing almost flat pricing, while the flash and EPROM show price reductions, albeit by small amounts, quarter on quarter.

Figure 1
DRAM Price per Megabyte Forecast for 1997 and 1998



Source: Dataquest (December 1996)

DRAM

Highlights of the forecast for DRAM are:

- The next five years will be volatile and testing for buyers as new chip densities, module types, and technologies jostle for dominance and market share.
- Small, controlled price reductions are forecast for all 4Mb and 16Mb discrete asynchronous DRAM devices to the year 2001.
- Fast page mode (FPM) starts to become more expensive than extended data out (EDO) in 1997.
- 64Mb will increase in volume and decrease in price rapidly.

- However, synchronous 64Mb DRAM is demonstrating faster price deceleration than EDO 64Mb, starting in the fourth quarter of 1997.
- Initial EDO dual in-line memory module (DIMM) pricing shows a premium over EDO single in-line memory modules (SIMMs) remaining through 1997 and 1998.
- DIMM and SIMM pricing will track each other more closely in 1999 and beyond.
- 8Mb synchronous graphics RAM (SGRAM) will be coming out aggressively and will be cheaper than 4Mb video RAM (VRAM) in 1998.

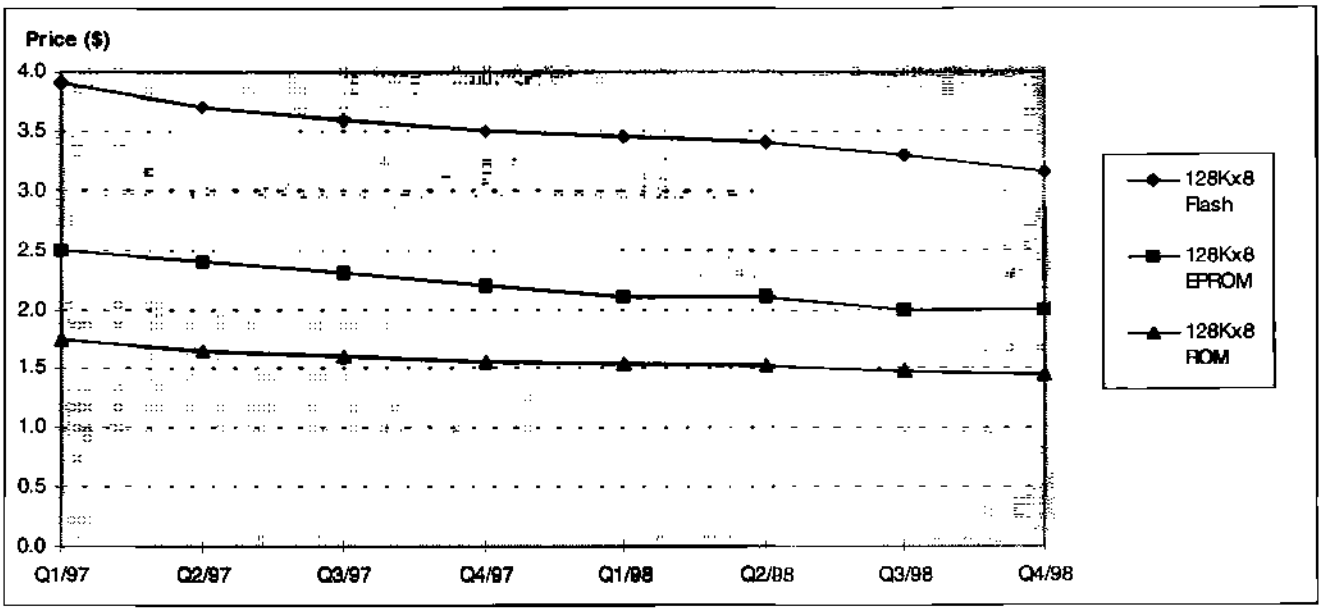
SRAM

Highlights of the forecast for SRAM are:

- Cutthroat market conditions remain throughout 1997, especially for PC cache applications.
- Contracted price reductions for PC cache applications will be more stable as most suppliers sell at rock bottom.
- Long term, the 32Kbx8 discrete family may increase in price as some suppliers cease manufacturing it.
- The 1Mb (128Kbx8) discrete family shows controlled price reductions quarter on quarter to the year 2001.

Figure 2

First Quarter 1997 Price Forecast for 1Mb 128Kbx8-150ns Nonvolatile Devices



Source: Dataquest (December 1996)

Flash

Highlights of the forecast for flash memory are:

- The trend to lower-voltage devices in all applications increases momentum.

- There will be price parity between 12V and 5V devices in the first half of 1998.
- Price reductions will be stable for 4Mb and below flash devices to the year 2001.
- There will be moderate price reductions at 8Mb to the year 2001.
- The greatest price reduction at 16Mb and above densities is forecast to the year 2001.

Other Nonvolatile

Highlights of the forecast for other nonvolatile memory are:

- These remain largely overshadowed by flash.
- Applications are more specialized, with a lot of new designs going over to flash.
- Steady price curves with small price reductions year on year will be seen.

Microprocessor

Highlights of the forecast for microprocessors are:

- Compute processors will remain largely in Intel's control to the year 2001.
- Initial pricing shows Pentiums remaining price competitive throughout 1997.
- A price adder for 3.3V and 2.9V remains for Pentiums at present, but this may change.
- Pentium Pro pricing is coming out very aggressively, particularly at 180 MHz and 200 MHz (with 256Kb cache).
- The Power PC 603-133 MHz is extremely price/performance assertive.

Dataquest Predicts

Dataquest continues to forecast strong overall demand for semiconductor applications throughout the next five years. Thus, demand for semiconductors will remain strong. However, the oversupply of certain components is set to continue for at least the next eighteen months. That said, however, there may continue to be some short-term supply imbalance as volume mixes change and manufacturers scramble to react by altering internal production plans accordingly.

The spot market is becoming less a factor in DRAM procurement—despite excellent pricing and availability, trading has been very light for the past three months. OEMs clearly prefer to maintain strategic alliances with DRAM manufacturers directly via contracted volumes.

On the whole, price reductions are forecast across the board. This is true of almost every device family tracked by Dataquest. On devices in the growth phase of the life-cycle curve, price reductions quarter on quarter will be largest, while on older technologies, price reductions will be smaller and more controlled.

For DRAM, there will be new challenges, with certain suppliers asserting their might and technology advantage by moving the market toward:

- Synchronous DRAM
- DIMM
- 64Mb

Pricing on these devices will depend considerably on the segment in which buyers participate and on the suppliers with which they deal. In general, however, these devices will have premiums initially, but price reductions will be very rapid. Dataquest believes that price parity will occur before volume parity on these new offerings from most suppliers.

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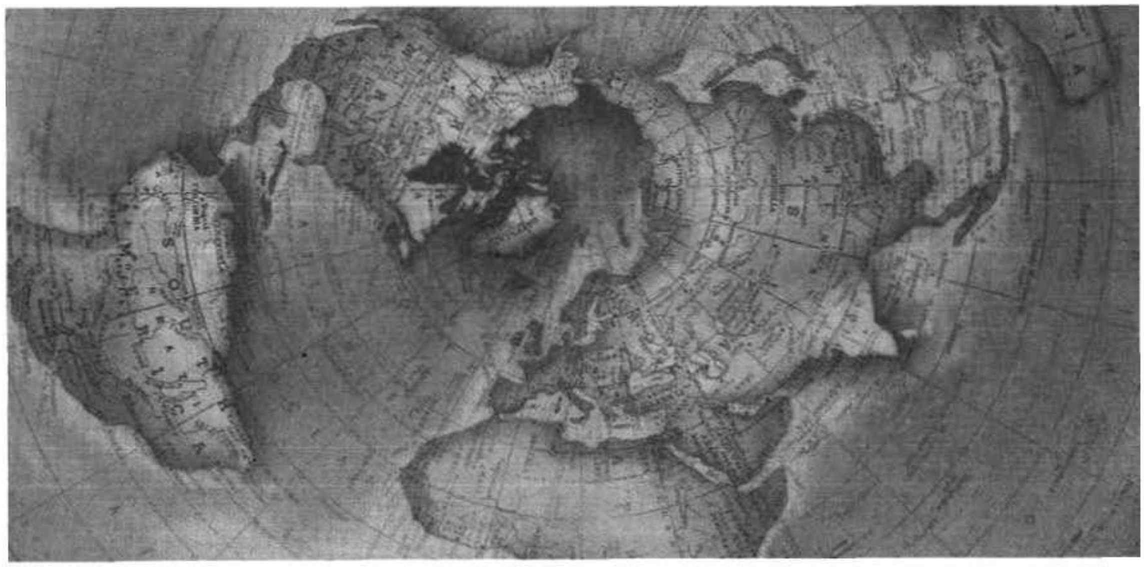
Perspective



Semiconductor Supply and Pricing Worldwide

Market Analysis

Compute Microprocessor Supplier and Product Update: Intel Continues to Dominate a Compressed Market

Abstract: *This article analyzes the events in the compute 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 1995 shipment data.*
By Mark Giudici

This document analyzes the developments of the compute microprocessor market from a product-base and supply-base perspective. Dataquest defines compute microprocessors as those using 16/32-bit, 32-bit, 32/64-bit, and 64-bit input/output (I/O) and using both CISC and RISC processors—this group is 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 and others accelerate the rate of change to higher-performance systems while reducing the system life cycles of many leading-edge products.

This document is divided into three sections. The first serves as a guide to the current state of microprocessor families relative to their position in the overall microprocessor product life-cycle curve, based on 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 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.

Dataquest

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MOS Microprocessor Product Life Cycles

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

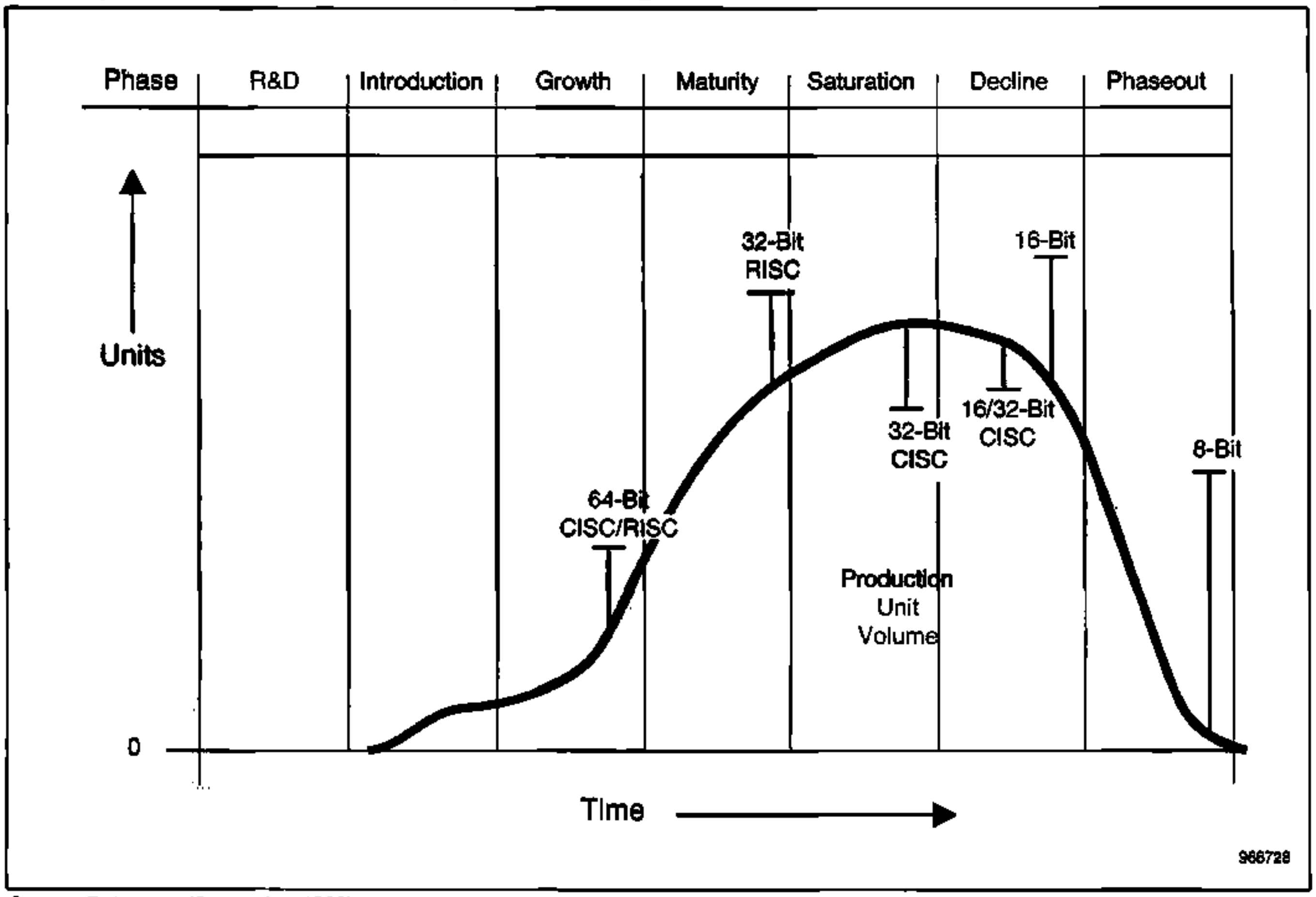
Life Cycles for MPU Products Again Stretch Because of Competition Slip

Figure 1 highlights the slight change in microprocessor family life cycles since last year. Intel Corporation's introductions of its Pentium and Pentium Pro products have slowed from the torrid pace of 1994 and 1995 to earlier product release intervals. This is because of an effective level of competition to Intel's earlier product introductions. This has resulted in an increase in life cycle from the pre-1995 range of between 10 and 20 years to the current range of 12 to 22 years from initial research and development through obsolescence (phaseout). The typical MPU life cycle that involves production volumes (growth through decline) now generally exceeds 8 years.

The lengthy R&D phase provides users a valuable opportunity to monitor a supplier's (or prospective supplier's) pace of technical achievement and legal standing, where applicable, as well as the supplier's timetable for bringing a new, state-of-the-art device to market. The somewhat competitive "586-class" market continues to cause some price and availability relief at the low end as Cyrix Corporation and Advanced Micro Devices Inc. compete legally with Intel in this area. The 486 market has declined rapidly to the status of a low-cost, entry-level processor with the main suppliers remaining AMD, Cyrix, IBM Corporation, and Texas Instruments Inc. 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 Inc. has now shifted its complete compute microprocessor focus to the PowerPC and has shifted its aging 68020/030/040 products to the embedded core market. The quickly accepted Pentium and other 32-bit and up RISC products are currently on the high end of the price/performance spectrum and are expected to come down the learning curve, faster than in the past, over the next one to three years.

Figure 2 highlights the product life cycle for select CISC 32-bit MPUs through 1995 using historical unit shipment data and shows that 1995 was the year that Pentium-class MPUs surpassed 486 processors. The mature Motorola 680xx products continued to decline in unit volume, while the shipment growth of the more advanced PowerPC 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 upcoming years, while the leading-edge MPU products win computer design-ins. The quick acceptance of Pentium-class computers and the gradual growth of Windows 95 is expected to bring a quick demise to 486 unit shipments, and this allowed Intel to remain the top semiconductor supplier in 1995. Because of the rapid acceptance of the Pentium-class devices, the life cycles of the 486 and 386 as primary PC engines have been truncated, but, as mentioned above, the 386 and 486 product families have good prospects of being the embedded processors of choice in the future because of the very large base of existing software expertise available.

Figure 1
Microprocessor Product Life Cycle as of August 1996



Source: Dataquest (September 1996)

Microprocessor Supplier Analysis

This section analyzes the product and market strategies of the leading suppliers of advanced microprocessors. Because of the level of interest of the Semiconductor Supply and Pricing program client base, this section focuses on suppliers that strongly serve the European and Americas markets: Intel, AMD, and Motorola Inc. Table 1 shows how Intel increased its lead as the top semiconductor company in 1995 by owning over three-fourths (77 percent) of the total microprocessor market. Only two suppliers exceeded the average market growth rate of 26 percent (a good year for microprocessors). They were Intel (29 percent), and IBM Corporation (144 percent). The lack of strong growth in the CISC arena (aside from Intel) highlights what the Pentium-class processors have done to demand for less-advanced processors. Highlighting the consolidation of this market, the top five suppliers account for close to 95 percent (93.6 percent) of the total.

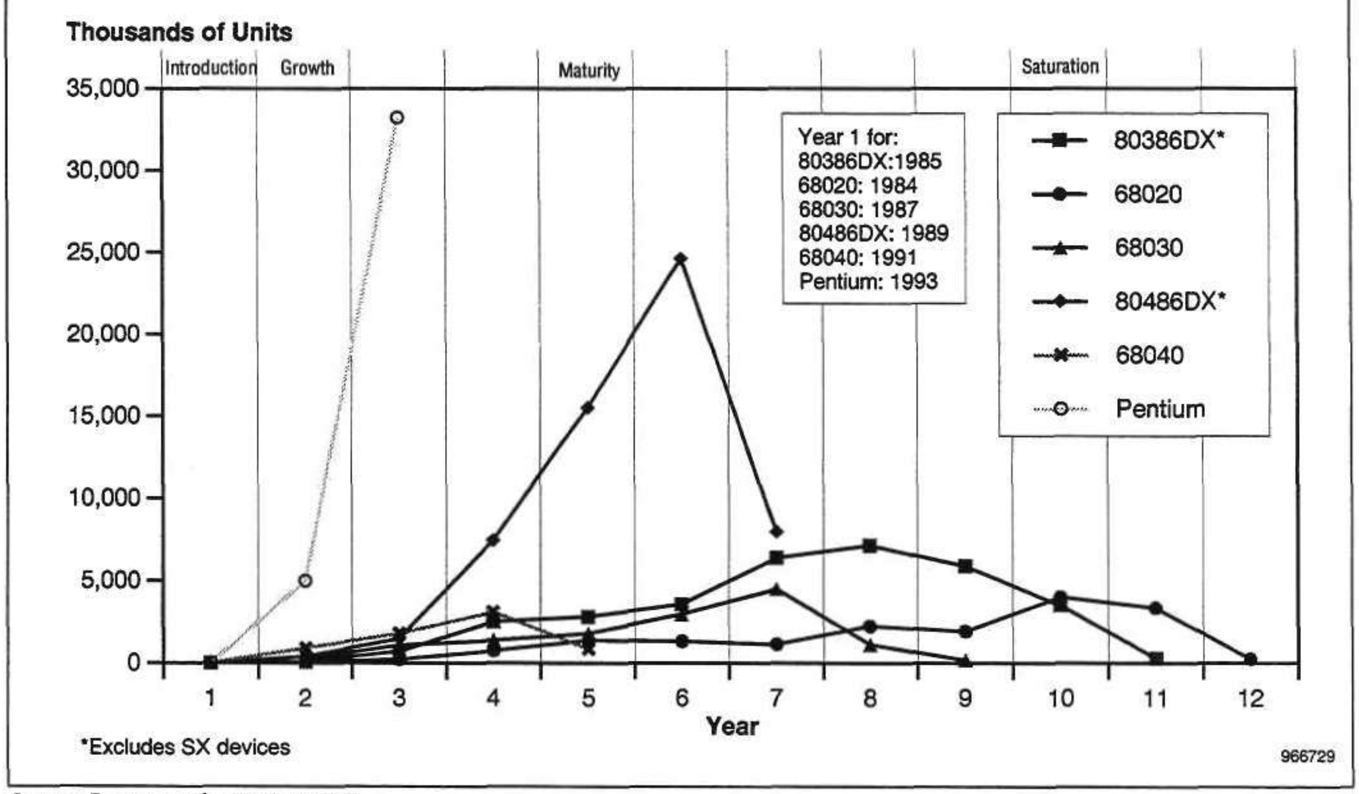
Intel

Intel again remained the No. 1 microprocessor (and semiconductor) supplier in the world in 1995 primarily because of the high growth of the Pentium product line. Intel's de-emphasis of the 486 product during 1995 follows the formula of jumping to the next generation as competition heats up in the existing market. Following this formula, Intel again is ceding the low-end, low-margin, more competitive under-75-MHz Pentium market to the competition and now is focusing on its mainstay high-end Pentium and Pentium Pro offerings.

Intel Strategy Redux: Take the High Road and Crank 'Em Out

Intel's strategy of leapfrogging the industry with advanced technology has gone into overdrive somewhat as competition has yet to catch up in any volume with high-speed production (over 100 MHz). The announcement of Pentium Pro availability in 1996 keeps competitors at bay, while high-end Pentium cost reductions allow for good margins and reduced customer pricing.

Figure 2
CISC MPU Life Cycle—1995



Source: Dataquest (September 1996)

Table 1
1995 Worldwide Compute Microprocessor Market Share Ranking (Millions of Dollars)

Company	Ranking	Segment Revenue ($)	Market Share (%)	1994-1995 Change (%)
Intel	1	10,617	77.1	29
AMD	2	824	5.9	-9
Motorola	3	656	4.8	11
IBM	4	600	4.3	144
Cyrix	5	212	1.5	-8
Top Five		12,909	93.6	26
All Others (17+ Companies)		854	6.2	27
Total		13,763	100.0	26

Source: Dataquest (September 1996)

Besides impacting the existing market, Intel's strategy has now put added pressure on competitive R&D efforts to keep up with the sped-up MPU technology treadmill. Keeping true to form, Intel flawlessly executed on its higher-technology/higher-price formula in 1995 and showed that keeping ahead of the technology curve is very profitable. The rapid ramp-up of the Pentium super scalar processor continues to keep Intel ahead of the rapidly growing processor market. By aligning itself with key system companies, Intel keeps its favored customers on the leading-edge and ensures itself a steady revenue stream to fund the next generation (or two) of product families. Not a company to leave money on the table, Intel will continue to focus on high-volume/low-cost embedded applications for the 386 and 486, ensuring a long life for this family. All this jockeying for supply dominance has forced many of the smaller PC clone companies to seek other sources of 486s. Cyrix's M1 and AMD's K5 products have been delayed until late 1996 because of respective die size and customer compatibility issues. Intel now has its Pentium Pro in production and has thus started another technology cycle.

Advanced Micro Devices

The year 1995 brought contraction for AMD in the processor market. Demand for AM486 kept AMD at the No. 2 position in the 32-bit and up microprocessor market last year. Relying on the aging but "clean" 486 products, AMD shrank by 8 percent in 1995. The prolonged delay of a clean K5 processor into late 1996 has given archrival Intel another window of revenue opportunity. AMD's absorption of NexGen to gain a leg up on Pentium compatibility has not borne fruit as yet. As a result, while the 486 market wanes, AMD can count on milking this "trailing-edge" business. AMD's stated strategy of catching up with Intel in technology with the K7 product, while ambitious, should keep this current lopsided battle going into the 21st century.

Motorola

Motorola barely remained the No. 3 microprocessor supplier because of the de-emphasis of the 68030/40 and its subsequent failure to deliver the

PowerPC shipments to Apple Computer Inc. that were to be replacements. In effect, Motorola gave the initial PowerPC 601 Apple business to alliance member IBM. During 1995, the 68040 was replaced by the PowerPC as the main engine for the current Apple Macintosh line. With the slower-than-planned growth of the Power PC for Apple computers and the companies' missed opportunity with the 601s, Motorola now has to compete with IBM for Apple's future PowerPC business. Besides being the leading volume microprocessor to date used in laser printers, the 68000 series is ensured continued growth in the near future as the processor of choice for the advanced Sega Genesis game. While the 68020/030 series focuses on laser printers and other embedded applications, there are no new developments for this series, as the integrated midrange 683xx family will take over future embedded applications in this area. Motorola will continue to grow in the processor arena; however, it will most likely be the embedded market in which the company has 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 more competitive, and also will allow the company to develop the early growth of the PowerPC in embedded applications.

IBM

We mention IBM here because of its high growth rate (144 percent) last year. IBM jumped up to become the fourth-ranked microprocessor supplier largely because of its shipments of 601 PowerPCs to Apple Computer in 1995. The other PowerPC supplier, Motorola, was unable to ship enough 601s last year to help its dwindling 68040 business, and IBM was the beneficiary. The future of the PowerPC and that of Apple are closely linked. With no merchant microprocessor products but the PowerPC, IBM's growth in this market is, ironically, tied to a system competitor.

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 in some ways became less competitive in 1995 because of the lack of critical (non-Intel Pentium-class) devices, while becoming even more monopolistic at the very high end of the technology spectrum. The result is an increased challenge for procurement managers, component engineers, and system designers at system companies concerning the choice of product, let alone supplier. The approach of this section combines product life cycle and key supplier analysis to summarize the anticipated MPU supply/supplier base from a user's perspective. The summary draws conclusions about whether the user faces a favorable or critical supply base for each family/device. Building on prior sections, we now discuss factors affecting the supply base, such as supplier strategies and strategic alliances.

Table 2 shows the estimated 1995 worldwide MPU process technology and fab capability by geographic location for the following major MPU suppliers: AMD, Fujitsu, Hewlett-Packard, IBM, Intel, Motorola, NEC, and TI. In most cases, the process technology of these fabs is between 0.35 micron and 1.0 micron.

Table 3 shows the size of the 32-bit and up MPU market in terms of units shipped in 1995, the relative market shares of the predominant devices, and a ranking of the suppliers of these product families.

Table 2
Estimated Worldwide MPU Process Technology and Production Fab Capacity (Facilities in Production or Slated to Begin Operation in 1995)

	Intel	Motorola	AMD	Fujitsu	TI	IBM	NEC	HP
Number of Fab Lines								
Americas	9	3	2		2	2		2
Europe	3*	1	1			1	1	
Japan				2	1	1	5	
Asia/Pacific								
Total	12	4	3	2	3	4	6	2
Cleanroom (Sq. Ft.)								
Americas	365,000	214,600	109,600		141,000	65,000		44,000
Europe	172,000*	28,000				20,000	50,000	
Japan				70,000	31,000		214,200	
Asia/Pacific								

*Includes Intel Israel
Source: Dataquest (September 1996)

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 1995. Unit shipments of 32-bit and up MPUs in 1995 grew a very healthy *58.4* percent following a strong 22.7 percent growth rate in 1994. As noted in Figures 2 and 3, MPUs such as the 486 and 68030 should have life cycles extending out to the year 2000, although sub-66-MHz versions will fade from mainstream production by the end of 1996.

X86 Market Kicks In with a Pentium Afterburner in 1995

As the market migrated to Pentium-class processors last year, Intel (and to a lesser extent, Cyrix) grew very strongly, while those without Pentium-like offerings were left with a declining 486 market. The growth in 1995 of the x86 market confirmed the obvious, that the future of this product family lies with the Pentium-class series of processors. The existence of some competition further strengthens this predominant product family, which should continue to provide competitively priced products for the future. AMD in 1994 became the big fish in the continually shrinking 80486 pond.

(The 80486 share of 32-bit shipments dropped from 53 percent in 1994 to 36 percent in 1995.) The group of competitors now focusing on the 486 market numbers three—AMD, Cyrix, and TI. This product family should see competitive pricing with good availability for the next two years as Intel leads the pack with its Pentium/Pentium Pro product line.

Table 3
Supply Base for 32-Bit Microprocessors 1995

Leading 32-Bit MPUs (Percentage of Market)	Company	1995 Units	1995 Family Market Share (%)
16-Bit x86 MPU (15.6 Percent)	NEC	12,050	41.9
	AMD	9,718	33.8
	Intel	6,405	22.3
	Harris Semiconductor	281	1.0
	Oki	160	0.6
	Sharp	140	0.5
	All Others	0	0
	Total 16-Bit x86 Market	28,754	100.0
32-Bit x86 MPU (38.2 Percent)	Intel	52,250	74.5
	AMD	10,877	15.5
	Cyrix	3,642	5.2
	IBM	2,133	3.0
	Texas Instruments	1,153	1.6
	NEC	110	0.2
	United Microelectronics	10	0
	All Others	0	0
	Total 32-Bit x86 Market	70,175	100.0
68000 MPU (29.7 Percent)	Motorola	50,315	92.4
	Hitachi	1,900	3.5
	Toshiba	1,600	2.9
	SGS-Thomson	600	1.1
	TCS	31	0.1
	All Others	0	0
	Total 68000 Market	54,446	100.0
RISC MPUs—SPARC (0.6 Percent)	Fujitsu	570	56.2
	Texas Instruments	445	43.8
	All Others	0	0
	Total SPARC Market	1,015	100.0
RISC MPUs—MIPS (2.5 Percent)	LSI Logic	3,100	66.3
	IDT	1,000	21.4
	NEC	448	9.6
	Toshiba	130	2.8
	All Others	0	0
	Total MIPS Market	4,678	100.0

(Continued)

Table 3 (Continued)
Supply Base for 32-Bit Microprocessors 1995

Leading 32-Bit MPUs (Percentage of Market)	Company	1995 Units	1995 Family Market Share (%)
Other RISC MPUs			
PowerPC (1.8 Percent)	IBM	2,121	62.9
	Motorola	1,250	37.1
	Total PowerPC Market	3,371	100.0
Alpha (0.1 Percent)	Digital Equipment Corp.	180	100.0
PA-RISC (0.1 Percent)	Hewlett-Packard	229	100.0
SHx (3.5 Percent)	Hitachi	6,500	100.0
i960 (3.0 Percent)	Intel	5,610	100.0
All Other RISC/CISC MPUs (4.9 Percent)		8,996	

Note: Total market size = 183.9 million units
Source: Dataquest (September 1996)

The Pentium processor ramped very quickly into production during 1995 and jumped into a rapid growth phase for the whole year, 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 this time frame but had cost or compatibility issues that have effectively delayed volume production until early 1996. The current price premiums enjoyed by the Pentium will decline over the next three years as competition increases from these two CISC products, which rival RISC processors, and as Intel Pentium Pros ramp up production. To date, Intel has proactively cut Pentium prices dramatically to "head 'em off at the pass," thus reducing the ability of competition to gain any early profits (which equals high profits) from early product shipments.

Motorola Shifts Production to PowerPC as the Main Customer Valiantly Fights the Pentium Tide

While de-emphasizing the 68040 compute MPU segment as this processor's main user (Apple Computer) shifted over to the PowerPC platform, Motorola kept production up supporting the more varied embedded markets for these core devices. 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 has an upward migration path for them in 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 at lower price and profit margins than that enjoyed by the compute MPUs.

Balancing the embedded market focus is the PowerPC MPU, released in 1994. This jointly developed processor did relatively well in 1995, considering that the main customer went through some tribulations and that half of the supply base (Motorola) had a slow start in providing large amounts of the 601 until very late in the year. Motorola realized (even without the slow start) that the shift to the PowerPC would result in a commensurate near-term revenue loss from the shift of existing 68040 Macintoshes not made up by increased PowerPC shipments. Thus, the company accelerated its focus on embedded designs.

Open System RISC Processors

Dataquest segments the RISC compute market to include the following processor families:

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

These RISC processors garner the most inquiries from Semiconductor Supply and Pricing Worldwide 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). Although the computing RISC segment of the market accounted for only 7.8 percent of all MPU shipments, this small segment of the market grew 44.3 percent compared with last year's shipments. These are the microprocessor products that continue to set performance standards for future 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 P/A RISC processor (2 percent), and the Alpha (1 percent).

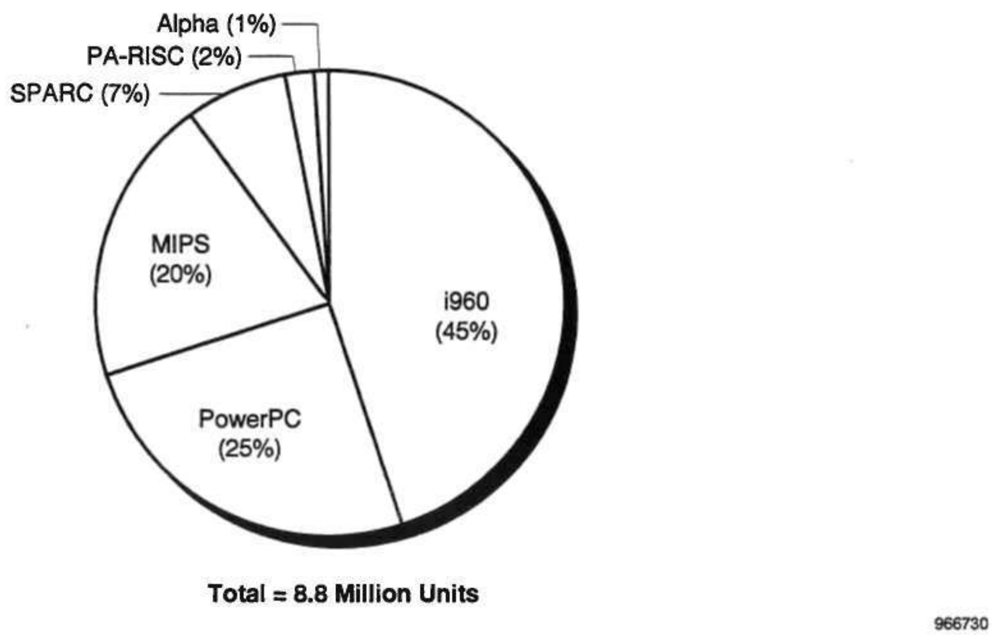
PowerPC

The PowerPC product family quickly took over the No. 1 RISC computing processor position, thanks largely to Apple Computer's switch to this new computing platform. IBM supplied most of this volume in 1994 and in 1995. Applications run the gamut from PCs to workstations to using the PowerPC as a high-performance future platform for embedded processors for the 68xxx families. Both Apple and Motorola have hitched their wagons to the PowerPC star, but the third member of the team, IBM, continues to straddle the Intel/PowerPC fence. Mixed signals continue to come from IBM and the PC Company regarding processor support that need better coordination. The quick adoption of the PowerPC as a standard processing platform could be at stake. Some of the significant PowerPC announcements in 1995 and 1996 were:

- Apple introduced its Power Macintosh 9500, using the high-performance PowerPC 604 processor, and the entry-level Quadra 630, using 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 Corporation 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.
- Apple announced the Macintosh Performa 6320CD, based on a 120-MHz 603e PowerPC.
- IBM announced the PowerPC 401GF embedded controller with speeds of 25, 50, 75, and 100 MHz.

Figure 3
RISC 32-Bit and Up Microprocessor Market by Architectural Family



Source: Dataquest (September 1996)

- Bandai Digital Entertainment Corporation announced the Pippin @World $599 video game, available in the third quarter of 1996, based on the PowerPC.
- Umax Computer Corporation, Taiwan, announced its PowerPC Platform Computer, able to run multiple PC operating systems.
- Motorola announced the 200-MHz PowerPC 603e priced at $360 for 1,000 units.
- IBM announced plans to make a PowerPC-based network computer by the end of 1996.

- IBM Microelectronics announced shipments of the PowerPC 604e with speeds of 166, 180, 200, and 225 MHz.
- IBM and Mitsubishi Corporation agreed for Mitsubishi to sell PowerPC embedded controllers under the Mitsubishi label.
- Power Computing Corporation released a new system line based on IBM's 604e PowerPC with speeds of 180, 200, and 225 MHz.
- Canon Inc. withdrew support from the PowerPC support group and sold its stake in Firepower Systems to Motorola.
- Apple announced the Multimedia Macintosh based on 225-MHz and 250-MHz 604e PowerPCs, to be available in 1997.
- Mitsubishi announced Diamondweb 40-inch Internet-access TV based on Motorola's MPC801 embedded PowerPC core.

Momentum for a price/performance competitor to Intel's Pentium continues to build, yet operating system and additional large computer company adoption still hinders the PowerPC. As Macintosh clones now begin to enter the market and Apple begins to license its Mac OS actively, the consumer will soon have yet 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.

SPARC Family

In 1995, the SPARC family of processors rose again to the No. 2 RISC compute ranking behind the PowerPC family. In 1994, the SPARC processor group, dominated by Sun Microsystems Inc., attempted to dissociate 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. In 1995 and 1996, most of the interest centered around the high end of the spectrum as the lower end got strong competition from high-end Pentium products. Some of the key events that impacted this market in 1995 and 1996 were:

- Ross Systems Inc. announced the SPARC Plug add-in workstation module, as well as a HyperSPARC processor.
- HAL Computer Systems Inc. announced its 3GB system based on the UltraSPARC processor.
- Sun Microsystems announced the UltraSPARC-based Ultra Workstation with Freedom Series accelerators.
- RDI Computer Corporation announced a large-screen (12.1-inch diagonal) Powerlite portable workstation based on the SPARC processor.
- Russia's Ministry of Fuel and Energy selected the SPARC-based Sun Microsystems network solution for its Federal Data Bank and Geophysical Expedition database.

- Sun announced ftSPARC, a fault-tolerant platform aimed at the telecommunications market. The ftSPARC is fully compatible with the Sun Solaris environment.
- Sun Microsystems and GNP Computer combined salesforces to aggressively target the telecommunications market.
- Tatung Science and Technology Inc. announced its COMPstation U170-ES, based on the UltraSPARC processor.

Although the SPARC family was the second-largest compute volume RISC family, it continues to mirror the market momentum of its largest computer user, Sun Microsystems. In spite of recent design-wins by Fujitsu, Ross Technology, and Tatung, the overall outlook for large embedded shipments in the near term is not high.

MIPS Family

The MIPS family of processors slipped back to the No. 3 RISC compute position in 1995. Besides shipments to Silicon Graphics (the lone computer user), 1995 saw large 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 1995 and 1996 were:

- LSI Logic Corporation announced three MIPS4000-based ASIC cores: CW4002, CW4003, and CW4011.
- IBM announced an $8,999 color laser printer based on the MIPS 100-MHz R4600 processor.
- Silicon Graphics Inc. announced its Indigo64 Impact 10000 workstation product line, based on the MIPS R10000 processor.
- NEC curtailed development and sales of MIPS-based workstations and servers in North America as it migrates to Intel-based platforms. This move was influenced by NEC's purchase of Packard Bell. NEC will continue to sell MIPS workstations and servers in Japan.
- The Nintendo 64 video game was released in Japan, based on the MIPS R4300 processor.
- Personal Computer Products Inc. and NEC joined to design, develop, and market a new printer controller based on NEC's 64-bit VR4300 MIPS processor.
- Canon announced a $12,500 color laser printer (CLBP 360PS) based on the 100-MHz MIPS R4600 processor.
- LSI Logic and Silicon Graphics extended and expanded the scope of their MIPS processor architecture license through 2004.

Strong growth in embedded applications will allow for continued growth of the product line, however, at the cost of fewer suppliers.

PA-RISC Family

The PA-RISC processor family (fourth-ranked) remains a proprietary high-performance workstation engine. Some of the major events in 1995 and 1996 were:

- Hewlett-Packard Company was selected as one of two companies to be prime contractors for the U.S. Army Workstation-1 (using PA-RISC-based workstations), a contract worth $495 million.
- Hewlett-Packard announced two new HP9000 workstations based on the PA-RISC 7100LC processor.
- Hewlett-Packard announced first quarter 1996 availability of the next-generation PA-8000 64-bit microprocessor (planned to exceed 360 SPECint92, being similar in architecture to Intel's P6 processor).
- Oracle Corporation chose HP 9000 enterprise servers for next-generation relational database development.
- Hewlett-Packard and Intel announced a joint-development agreement that will result in a jointly developed P7-generation (Merced) chip due out in 1998, in addition to Intel's independently planned successor to its P6 processor.
- Hewlett-Packard created the Enterprise Net Server Operation. The organization will promote partnerships with developers to port applications from UNIX to Windows NT. The organization is also expected to smooth the transition from the PA-RISC to Intel's Merced processor in late 1998.

HP's production model for the PA-RISC platform is systems profitability-based while alliance suppliers appear to use a device profitability model. In order for PA-RISC to remain a viable architecture, HP needs to be more visible as the architecture standard-bearer. Except for captive embedded designs, other embedded applications for this processor will grow slowly.

Alpha Family

Digital Equipment Corporation has put much effort into carefully crafting the Alpha microprocessor into a high-performance core of its own PC and other computer businesses, while simultaneously working on making the family a standard RISC architecture used by others. As an early (possibly too 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. This may change in 1997 as users now focus on this OS, which is attractive to business. In attempting to increase its supply base, Samsung was added as a second source for the Alpha, along with Mitsubishi. But neither of these companies has experience in the development or marketing of microprocessors. Some of the key 1995 and 1996 developments in the Alpha market were:

- Intlectronika (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.
- Samsung and Digital agreed to develop and manufacture Alpha RISC processors. Samsung planned on producing its first Alpha in 1997. Samsung also can distribute Alpha processors.
- Digital announced third quarter 1996 availability of the 21164 Alpha 433-MHz and 500-MHz processors. The 433-MHz product will sell for $1,500 in quantities of 1,000—half the price of the MIPS 10000.
- Digital announced midrange Alphaserver 4000 systems (300 and 400 MHz) and high-end Alphaserver 8000 systems at over 437 MHz.
- BTG Inc. released the superpowered AXP275 ULTRA "personal supercomputer" using an Alpha 21064A 275-MHz processor as its engine. Price: $17,000.
- Netscape Communications Corporation received its 2,000th 64-bit Alphaserver 8400 to handle its World Wide Web site traffic. The 8400 server is capable of handling 12 350-MHz Alpha processors and 14GB of memory.

Although Digital is going full tilt to promote the Alpha, the—until lately—slow ramp of Windows NT as a mainstream desktop operating system has hindered its efforts. The new interest in the NT platform for server use may accelerate this situation. By correctly focusing on computer applications and promoting its large (if somewhat inexperienced) alternate-sourced supplier, Digital now has a better way 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 through the microprocessor and PC markets for years to come. By cranking up the MPU treadmill, both competitors and customers alike may have some changes imposed on them. Although the RISC versus CISC distinctions once gave the RISC camp a performance advantage for the foreseeable future, the P6 architecture and performance specifications have narrowed the RISC/CISC gap dramatically. The Intel/Microsoft hardware/software duo will continue to rumble into the future, but the long-term future of the RISC processors continues to highlight glaringly that *both* hardware *and* software are key factors in user's decisions concerning a high-performance system choice. 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 all the while, with Intel firmly in control of this technology-driven moneymaking machine. By continuing to play technology leapfrog 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 the competition. Motorola's anticipated rocky transition from a 68xxx to a PowerPC customer base resulted in AMD's maintaining the No. 2 advanced microprocessor supplier position, with Cyrix and IBM taking the No. 3 and No. 4 positions. AMD's fall back to the Am486 with faster clocks, caused by its lack of K5 shipments, barely kept it in the No. 2 1995 position. Motorola's balanced mix of embedded products and, now, a multisourced RISC core will continue to provide users with a wide selection of price and performance options rivaled only by Intel. IBM's production of PowerPC 601 products kept this supplier in the market while it still announces plans of offering a strong Intel-based system line. Cyrix gained some ground in the 1995 MPU price war, more because of a lack of production from AMD and TI than because of increased customer loyalty. Both Cyrix and TI still plan advanced x86-like designs to complement their 386 and 486 products. TI plans on being one of the few remaining low-cost providers of 486 processors.

The RISC compute market continues, rightly, to focus on price/performance advances over CISC alternatives, and many suppliers have put in place the infrastructure needed by mainstream system users (common advanced operating systems, second sourcing, and so on) that will better facilitate market acceptance. The Pentium Pro and future P7 (Merced) architectures may somewhat blur this distinction, however. Software applications continue to be 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 (without performance degradation) between 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 comparative decisions. Marketing 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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Perspective

Semiconductor Supply and Pricing 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, but some family members are starting to dominate. This Perspective focuses on the life cycles and technology trends within the nonvolatile market and analyzes 1995 market share data by geographical region and device family.*
By Evelyn Cronin

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 products designed as flash EPROM/ EEPROM that incorporate either 3V, 5V, or 12V programming supplies and one-transistor (1T) or two-transistor (T2) memory cells with electrical programming and fast bulk/chip erase. Flash memory can erase data only by bulk/chip, not by byte.

Flash memory is now used on Pentium-based PC motherboards for BIOS and plug-and-play applications. Non-PC flash applications include wireless communications (digital cellular and Personal Handyphone) and consumer electronics (digital cameras and digital voice recorders).

Dataquest

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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 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: 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: Mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacture 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 ROMs to hold its BIOS software.

Life-Cycle Curves

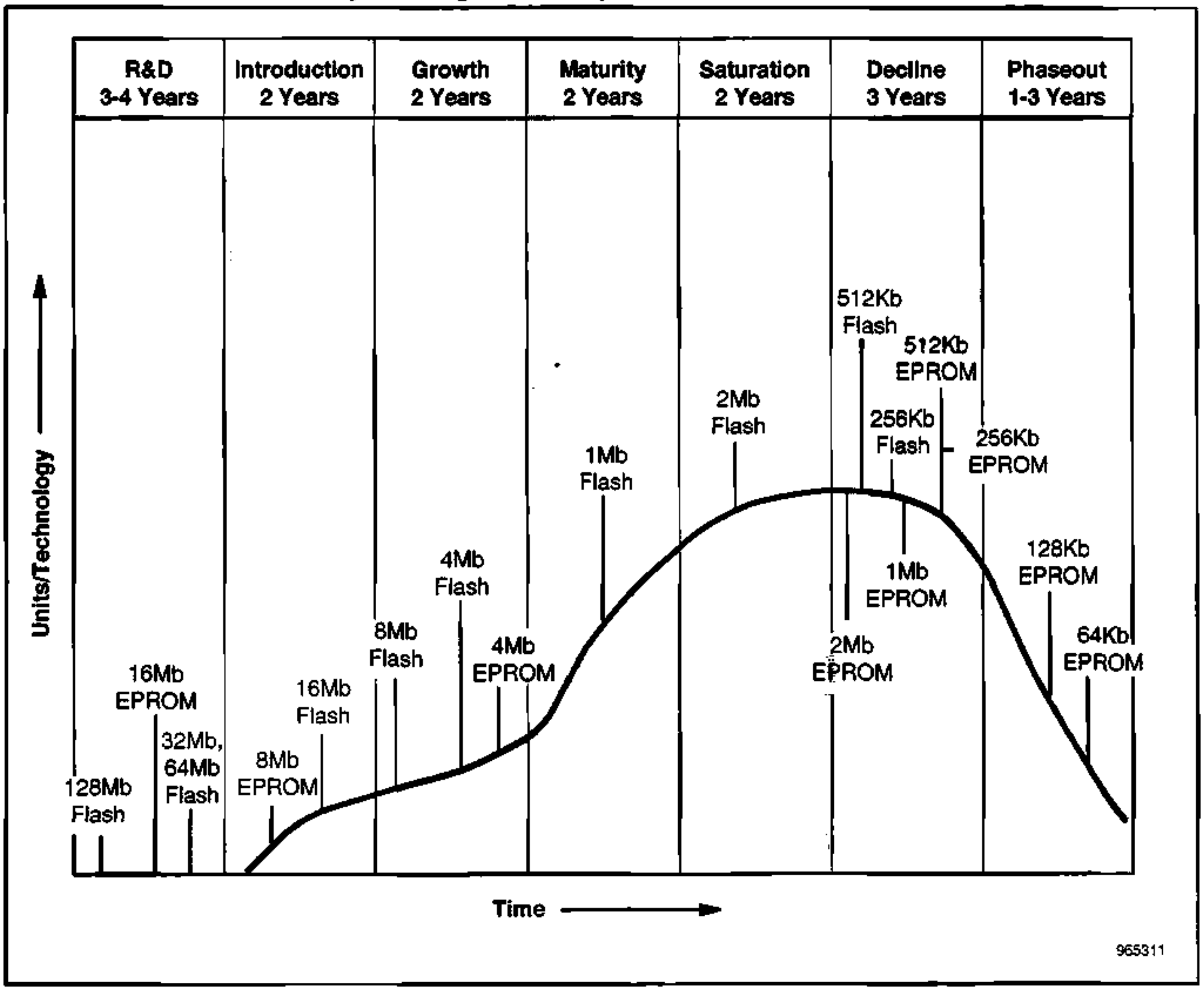
Examining the life-cycle curves for flash, EPROM, EEPROM, and mask ROM gives a useful perspective These life-cycle curves are based on unit shipments per technology density.

Figure 1 shows the life-cycle curves for flash and EPROM at various densities. What is immediately obvious is that EPROMs are 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, except at the 256Kb and 512Kb densities. Both flash and EPROM are in the decline stage at these densities, although EPROM is further along the stage than flash.

For flash, 1Mb is in solidly in the maturity stage, while the 2Mb has already reached the saturation stage. 4Mb and 8Mb flash are both still in the growth stage, with the 4Mb being further into this stage. The 16Mb flash sits in the introduction stage. Flash at higher densities (32Mb, 64Mb, and 128Mb) is in the research and development stage.

With EPROM, the story is rather different. The 64Kb and 128Kb are both in the phaseout stage of their life-cycle curve based on unit shipments. From 256Kb to 2Mb, they are sitting in the decline stage. Thus, the majority of EPROM is in the final stages of its life-cycle curve. The 4Mb EPROM is in its growth stage, with 8Mb in the introduction stage of its life cycle. EPROM at 16Mb is still at the research and development stage.

Figure 1
Flash and EPROM Life-Cycle Stages/Density



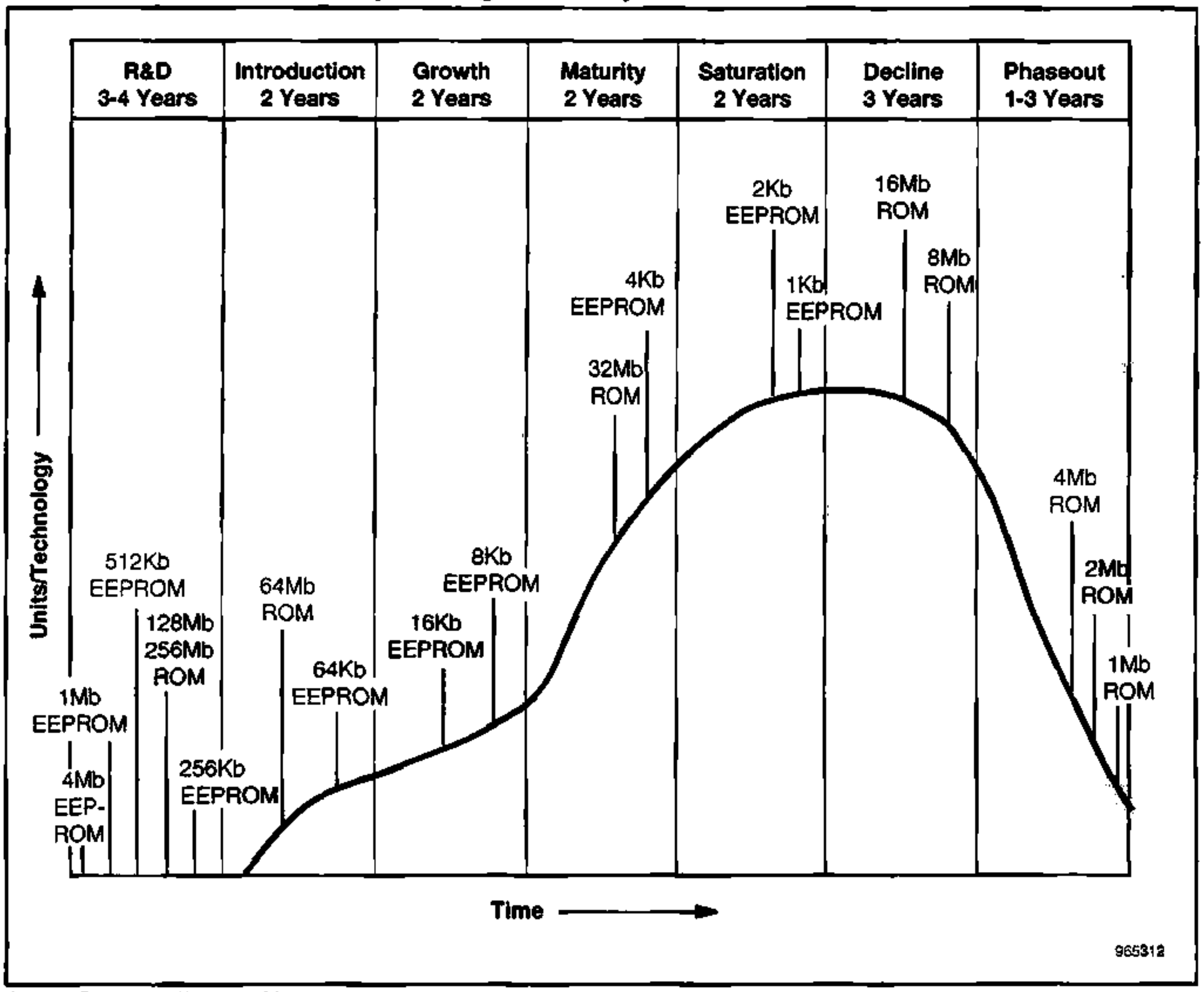
Source: Dataquest (August 1996)

Figure 2 shows the life cycles for mask ROM and EEPROM at various densities. These two subsets of the nonvolatile family make for interesting comparison. EEPROMs tend to be at very low densities, while ROMs include some of the largest densities in production. The 1Mb flash is in the phaseout stage, while 1Mb EEPROM is still in the R&D stage!

ROMs at 1Mb, 2Mb, and 4Mb are in the phaseout stage, with 8Mb and 16Mb mask ROMs in the decline phase. The 32Mb ROM still sits in the maturity stage of its life-cycle curve, while the 64Mb part is in the introduction phase. The 128Mb and 256Mb parts are still in the R&D stage.

EEPROMs are "newer" in terms of life-cycle positioning. The 1Kb and 2Kb both sit in the saturation stage of the life cycle curve, while the 4Kb is climbing up the maturity stage. The 8Kb and 16Kb parts are in the growth stage, with the 8Kb ahead. The 64Kb EEPROM remains in the introduction stage of its life-cycle curve, relative to volumes sold, along with the 256Kb.

Figure 2
ROM and EEPROM Life-Cycle Stages/Density



Source: Dataquest (August 1996)

EEPROMs from 512Kb to 4Mb, which remain in the research and development stage.

The Nonvolatile Market

The nonvolatile market was worth over $6.24 billion in 1995, based on revenue, a growth of some 15.5 percent from 1994. Table 1 shows the 1995 revenue for each nonvolatile device. This indicates the wide variation in the growth or decline rates of each device family.

The year 1995 was outstanding for flash memory as more and more applications came on line. As a result, flash grew by almost 120 percent in revenue from 1994 to 1995, a staggering rate by any memory standards. It is now the second-largest revenue earner of the nonvolatile group, up from the third spot in 1994.

Table 1
Worldwide Nonvolatile Revenue by Device Family
(Millions of Dollars)

Nonvolatile Device Families	1994	1995	1995 Growth (%)
Flash	884	1,942	119.68
EPROM	1,561	1,437	-7.94
EEPROM	744	793	6.59
Mask ROM	2,216	2,069	-6.63
Total	5,405	6,241	15.47

Source: Dataquest (August 1996)

The three other nonvolatile families, however, reacted differently to the market dynamics of 1995. While EEPROM continued to grow (albeit at a modest rate of just under 6.6 percent), EPROM and mask ROM were not so fortunate—both posted declines in 1995, coming in at about a negative 8 percent and negative 6.6 percent, respectively. Mask ROM continued to have the highest revenue for 1995, in excess of $2 billion. EPROM had the third-highest revenue for 1995, and EEPROM remained a distant fourth.

Market Share

Table 2 shows the 1995 nonvolatile market share by supplier, based on factory revenue. There has been considerable change in the 1995 overall rankings when compared with 1994. For the first time, a nonvolatile supplier that offers only one of these products was the overall winner in the nonvolatile revenue standings. Intel, by being the No. 1 flash supplier, took the overall nonvolatile market share leadership position. This highlights the growth and importance of this segment. Sharp fell from the No. 1 position in 1994 to second position, despite being the No. 1 mask ROM supplier and attaining seventh position in flash. Advanced Micro Devices came in at third position in the overall rankings, based on revenue. AMD was the second-largest flash revenue supplier and the third-largest EPROM supplier in 1995.

In fourth position was SGS-Thomson, down from second position in 1994. Although it was the No. 1 revenue earner in both EPROM and EEPROMs and ranked No. 5 in flash, it still dropped two vital positions. Also, it now lags AMD by some $114 million. Atmel, by contrast, has risen in the ranking in 1995—up to fifth position from seventh position in 1994. It is the No. 2 EEPROM supplier (behind SGS-Thomson) and gets fourth position in both the flash and EPROM market share rankings. Although Atmel still has to break the $500 million revenue point, it is well positioned to do so for 1996.

The three big Japanese nonvolatile suppliers constitute the next class of suppliers. Toshiba, NEC, and Fujitsu come in at sixth, seventh, and eighth position, respectively. All three companies have top 10 positions in three of the four nonvolatile family market share rankings, and their revenue from nonvolatile products was around $300 million. However, both Toshiba and NEC dropped one overall ranking position in 1995 from 1994. Fujitsu, by contrast, leaped from twelfth position into eighth position in 1995. This was helped by Fujitsu's No. 3 position for flash sales.

Table 2
1995 Top 10 Nonvolatile Suppliers by Revenue and Product Offering (Millions of Dollars)

1995 Rank	1994 Rank	Company	1995 Revenue	Flash Rank	EPROM Rank	EEPROM Rank	Mask ROM Rank
1	3	Intel	766	1	-	-	-
2	1	Sharp	724	7	-	-	1
3	4	AMD	701	2	3	-	-
4	2	SGS-Thomson	587	5	1	1	-
5	7	Atmel	477	4	4	2	-
6	5	Toshiba	389	6	10	-	2
7	6	NEC	339	10	-	8	3
8	12	Fujitsu	305	3	9	-	9
9	10	Texas Instruments	246	9	2	10	-
10	11	Macronix	236	-	7	-	6
		All Others	1,470				
		Total	6,241				

Source: Dataquest (August 1996)

The last two suppliers are Texas Instruments, at ninth position, and Macronix, at tenth. Both rose one place from 1994, and their nonvolatile revenue was around $250 million. TI, however, has coverage in flash, EPROM, and EEPROM, while Macronix covers EPROM and mask ROM only.

Revenue stratified for suppliers in 1995. Intel, Sharp, and AMD all posted revenue in excess of $700 million in the nonvolatile area. There was a gap of over $110 million separating AMD from the next segment. SGS-Thomson and Atmel were both in the $400-to-$600 million revenue stage. All other nonvolatile players earned less than $400 million from this segment. Traditionally, the nonvolatile suppliers that performed the best were those with good overall product coverage. The mold was broken in 1995. All the $700 million-plus companies are quite specialized, concentrating on one or two product segments and striving for market dominance there.

Market Share by Device Family

Flash

Flash grew revenue by almost 120 percent in 1995, making flash the second-highest revenue generator within the nonvolatile family. Table 3 shows the top five flash suppliers by revenue for 1995.

All achieved high revenue growth, with Fujitsu's climb from No. 6 to No. 3 translating into a 1,171 percent revenue growth from 1994 to 1995. NOR flash is dominated by technology alliances—Intel-Sharp versus AMD-Fujitsu. Combined, both alliances account for over 78 percent of the total worldwide flash market.

Table 3
1995 Market Share by Revenue for Flash (Millions of Dollars)

1995 Rank	1994 Rank	Company	1995 Revenue
1	1	Intel	766
2	2	AMD	527
3	6	Fujitsu	178
4	3	Atmel	177
5	5	SGS-Thomson	82
		All Others	212
		Total	1,942

Source: Dataquest (August 1996)

EPROM

For the EPROM segment, 1995 was a year of declining growth. The total market decreased its revenue from 1994 to 1995 by 8 percent. Table 4 shows the 1995 market share ranking by revenue for EPROMs.

Most top five suppliers fared badly, with the exception of TI and Atmel. TI remained pretty flat, growing by 1 percent, while Atmel achieved a 16 percent revenue increase despite not gaining any increase in ranking. SGS-Thomson, AMD, and National Semiconductor all lost market share in dollar terms, decreasing revenue by 15 percent, 19 percent, and 18 percent respectively.

Table 4
1995 Market Share by Revenue for EPROM (Millions of Dollars)

1995 Rank	1994 Rank	Company	1995 Revenue
1	1	SGS-Thomson	336
2	3	Texas Instruments	211
3	2	AMD	174
4	4	Atmel	148
5	5	National Semiconductor	98
		All Others	470
		Total	1,437

Source: Dataquest (August 1996)

EEPROM

The EEPROM market grew by some 6 percent in 1995. Table 5 shows the top five EEPROM suppliers by revenue for 1995. There was very little change in ranking from 1994, apart from the reshuffling at the No. 1 and No. 2 positions and at No. 4 and No. 5. SGS-Thomson knocked Atmel from the first position and managed a 47 percent revenue increase, compared with a growth of 10 percent posted by Atmel.

All other top five suppliers also recorded revenue growth higher than the worldwide market, including Xicor at 14 percent and National Semiconductor at 24 percent. Microchip Technology, which rose from fifth in 1994 to fourth in 1995, had a 49 percent increase in revenue—this translated into the highest revenue growth posted in the top five and top 10 by an EEPROM supplier.

Table 5
1995 Market Share by Revenue for EEPROM (Millions of Dollars)

1995 Rank	1994 Rank	Company	1995 Revenue
1	2	SGS-Thomson	169
2	1	Atmel	152
3	3	Xicor	100
4	5	Microchip Technology	82
5	6	National Semiconductor	62
		All Others	228
		Total	793

Source: Dataquest (August 1996)

Mask ROM

Table 6 shows the top five Mask ROM suppliers by revenue for 1995. Mask ROM revenue is shrinking, down 7 percent from 1994 to 1995.

For all top five suppliers except Sharp, revenue decreased or remained flat. Sharp, by contrast, grew revenue some 5 percent and increased market share from 28.9 percent to 32.7 percent in this shrinking market. Toshiba and NEC had flat revenue periods, while Samsung and Hitachi decreased by 21 percent and 2 percent, respectively.

Table 6
1995 Market Share by Revenue for Mask ROM (Millions of Dollars)

1995 Rank	1994 Rank	Company	1995 Revenue
1	1	Sharp	676
2	3	Toshiba	277
3	4	NEC	247
4	2	Samsung	231
5	5	Hitachi	159
		All Others	479
		Total	2,069

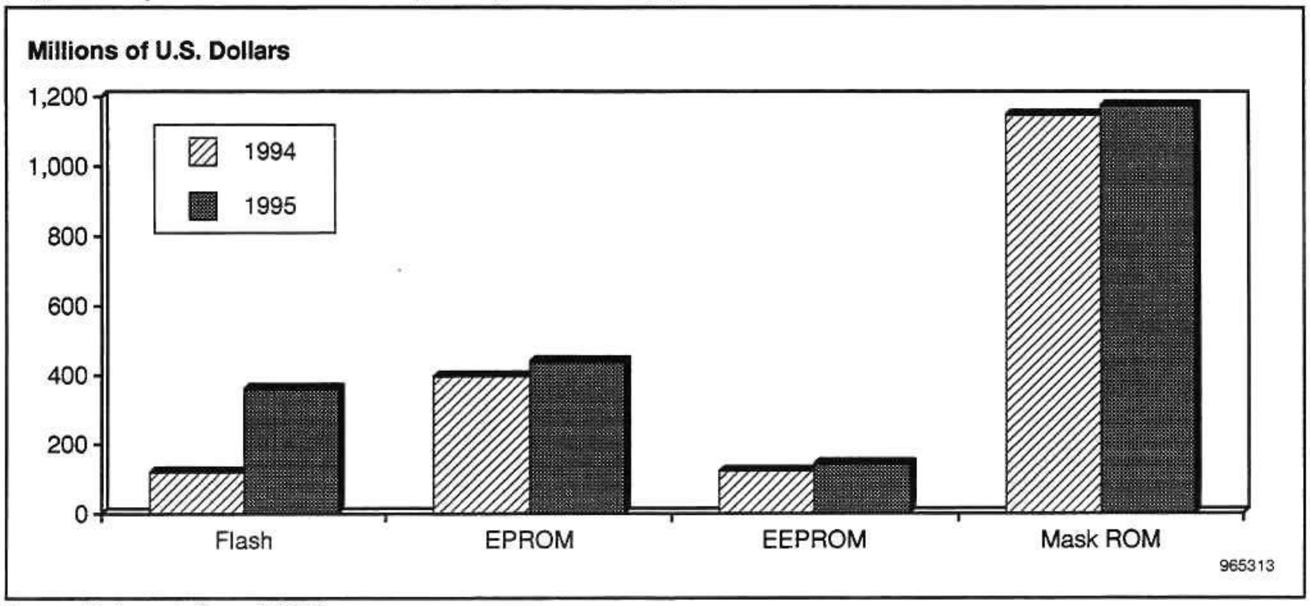
Source: Dataquest (August 1996)

Regionwide Nonvolatile Split by Device Type

Japan Region

Japan was the largest of all four regions in terms of nonvolatile revenue. Mask ROM accounted for over 55 percent of revenue, coming mainly from the region's game industry. Although mask ROM revenue increased from 1994 to 1995 (2.35 percent), it grew less than overall nonvolatile revenue (18.6 percent). Flash had the largest revenue increment, up over 200 percent from 1994. EEPROMs and EPROMs also increased their revenue last year, 17.2 percent and 10.9 percent respectively. In terms of revenue as a portion of the overall Japanese nonvolatile market for 1995, EEPROM was just less than 7 percent and EPROM was under 21 percent. Figure 3 shows the 1995 nonvolatile split by device family for the Japan region.

Figure 3
Japan Region Nonvolatile Split by Device Type

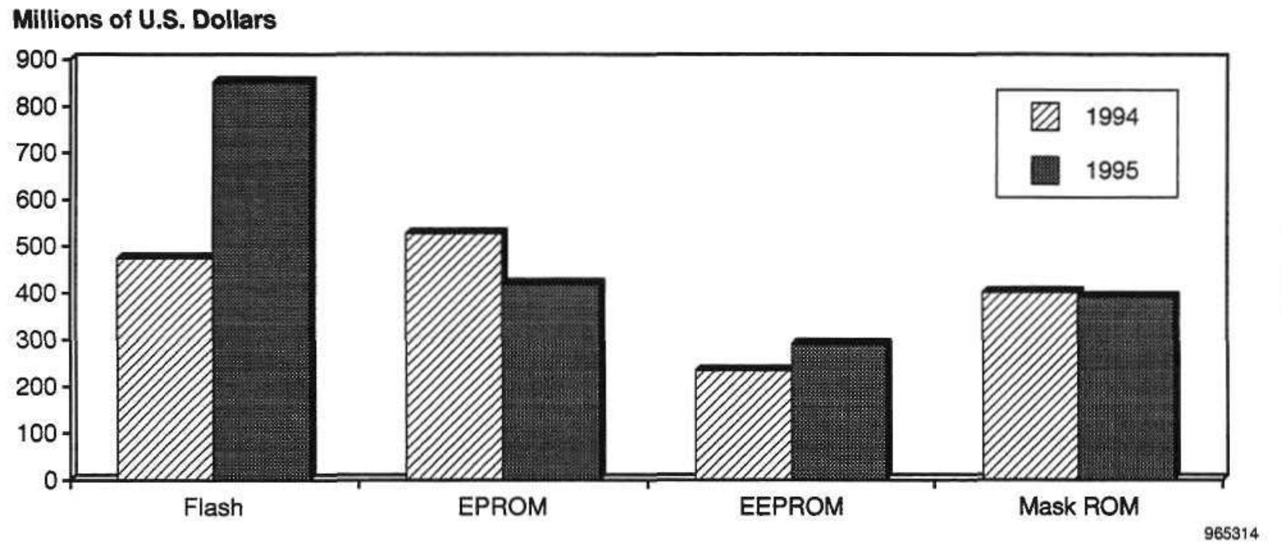


Source: Dataquest (August 1996)

Americas Region

Figure 4 shows the nonvolatile revenue by device family for 1995 in the Americas region. Flash was definitely in the revenue driving seat in the Americas region, with a 1995 revenue of some $852 million—the largest flash revenue of all the regions. It was largely driven by the PC segment and by some telecommunications applications. EPROM was the second-largest revenue contributor, worth 21.5 percent of the total nonvolatile market. However, EPROM revenue decreased by some 20.5 percent from 1994 to 1995. This indicates that the traditional EPROM applications are being switched over to flash. EEPROM revenue increased from 1994 to 1995, up 24.5 percent and worth about 15 percent of the nonvolatile market by revenue for 1995. Mask ROM, by contrast, decreased its revenue slightly from 1994 to 1995, down 2.5 percent, and accounted for 20 percent of the total nonvolatile market by revenue in the Americas region.

Figure 4
Americas Region Nonvolatile Split by Device Type

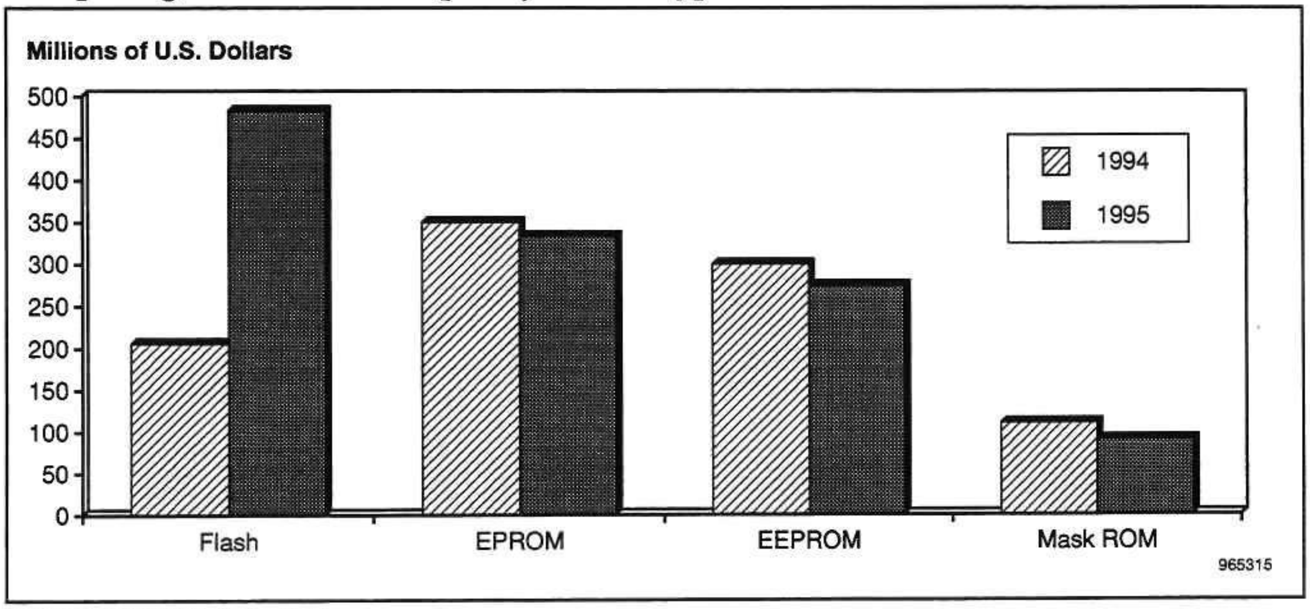


Source: Dataquest (August 1996)

Europe Region

Figure 5 shows the nonvolatile revenue by device family for the Europe region in 1995. With telecommunications so strong in Europe, it should be of little surprise that flash was ranked No. 1 in Europe, representing about 41 percent of the total nonvolatile European revenue. While this alone is significant, it actually translates into a 134 percent revenue increase from 1994. On a global scale, even though Europe was the second-smallest nonvolatile revenue region, its flash revenue was the second-highest in the world. By contrast, EPROM, EEPROM, and mask ROM were all down in revenue terms from 1994, worth 28 percent, 23 percent, and 8 percent, respectively.

Figure 5
Europe Region Nonvolatile Split by Device Type

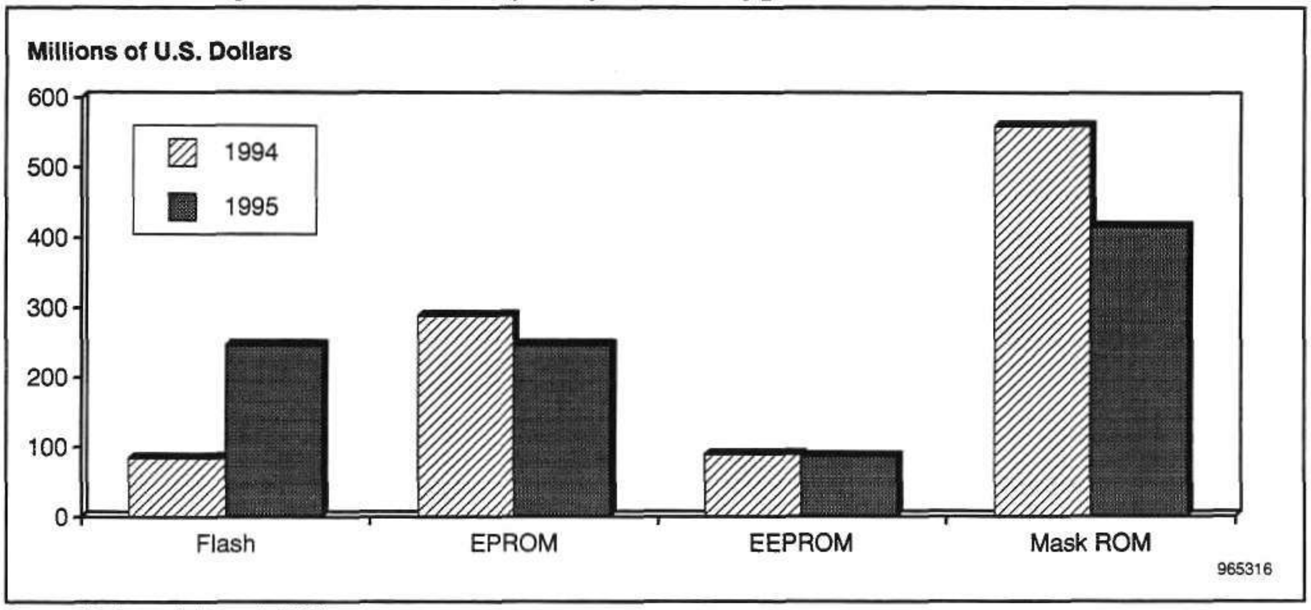


Source: Dataquest (August 1996)

Asia/Pacific Region

The 1995 nonvolatile revenue by device family for Asia Pacific is shown in Figure 6. Mask ROM was the dominant member of the nonvolatile group, accounting for about 42 percent of total nonvolatile revenue in this region. Flash and EPROM tied, each worth about 25 percent of the total nonvolatile market by revenue. However, while flash grew by 193 percent in terms of revenue from 1994 to 1995, EPROM shrank by 14.5 percent. This is indicative of the switchover from EPROM to flash for PC applications. EEPROM, however, trailed at about 9 percent.

Figure 6
Asia/Pacific Region Nonvolatile Split by Device Type



Source: Dataquest (August 1996)

Technology Trends

Flash

Trends in the flash market are as follows:

- Dominated by strong alliances—Intel and Sharp versus AMD and Fujitsu
- NOR technology still the strongest in revenue
- Smart Voltage NOR technology available from Intel, Sharp, and Micron Technology; Fujitsu and AMD offer True Low Voltage devices down to 2.7V
- NOR suppliers investigating NAND technology and vice versa
- Current applications: cellular phones, flash cards, and PC BIOS
- New applications: voice storage, cameras, auto navigation, and Personal Handyphones

EPROM

Trends in the EPROM market are as follows:

- Mature market, new applications converting to flash
- Fewer and fewer suppliers making high-density parts
- Traditional users: telecom (modems and cellular telephone handsets) and data processing (PC BIOS and rigid disk drive controllers)

EEPROM

Trends in the EEPROM market are as follows:

- The most niche-like area of nonvolatile but will have steady growth patterns
- Use of new higher-density parts increasing
- Applications varied: DRAM DIMMs, automobile airbags, communications (cellular mobile handsets and pagers), and various microcontroller-based applications
- Smart/memory cards growing in Europe

Mask ROM

Trends in the mask ROM market are as follows:

- Japanese consumer electronics market picking up, bolstering the segment
- No new markets developing—games still the mask ROM driver
- Some video games starting to use CD-ROM

Dataquest Perspective

The flash market remains an area of huge growth and interest as more and more applications move from EPROM and mask ROM to flash. Dataquest forecasts that this growth will continue to the year 2000. From a procurement point of view, the situation has improved dramatically from this time last year. The NOR flash market is dominated by alliances that determine the availability of a given technology—Smart Voltage from Intel/Sharp and True Low Voltage from AMD/Fujitsu. Overall availability has really improved as extra capacity has come on stream from both camps. Also, Micron will be coming on stream with Intel/Sharp technology, increasing the supply base potential. Flash pricing has also decreased greatly from 1995, and the forecast is for this reduction to continue. The general trend is for lower voltages and higher densities.

The picture for EPROM is not as healthy. The market is in gradual decline as the big users move to flash for the volume applications. However, at densities of 4Mb and above of EPROM, the situation is better, and Dataquest expect to see continued growth. Mask ROM, like EPROM, is in decline, both in units and revenue. Video game applications remain the sole demand driver; no new applications have come to light so far. Most densities are nearing the final stages of their life-cycle curve, and only densities at 32Mb and above are enjoying growth. Dataquest expect the overall trend downward to continue to the end of this decade. EEPROM did enjoy some growth in 1995, and Dataquest expect this trend of growth to continue. New applications such as handsets, pagers, smart cards and other microcontroller-based applications continue to fuel volume demand. Also, Dataquest sees that density, although still in kilobits, is slowly starting to increase.

From a procurement point of view, Dataquest would make the following recommendations. Flash offers the greatest negotiating flexibility—supply has freed up and prices are declining. However, at densities of 1Mb and below, care should be taken to monitor the supply base because suppliers are cutting back production. For EPROM and mask ROM, as demand is starting to decline, certain suppliers are beginning to cut back production and buyers should consult both the Dataquest life-cycle curves and the suppliers' production schedules to ensure continued supply. The outlook for EEPROM remains positive, with more and more niche applications developing.

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Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

The SRAM Supply Bucket Finally Fills and Overflows: SRAM Market Update

Abstract: *The static random access memory (SRAM) market remains linked to the PC industry and is now in the throes of a cache architecture change and oversupply. Although not as visible as its volatile cousin, the DRAM, SRAM has seen many of the same dramatic declines in price this year. This update focuses on the life cycles and future trends of these important memory devices and how the supply base is changing to meet market demands.*
By Mark Giudici

From Allocation to Abomination, SRAM Suppliers Scramble to Make Ends Meet

The need for cache memory in high performance PCs continues to mandate the direction of the overall SRAM market. The cache RAM requirements of the Pentium, PowerPC, and other high-end microprocessors remain strong, and suppliers have been more than eager to meet this demand.

Most of the market was in allocation for the fast (under 15ns) devices in 1995. With the advent of Intel's Triton chipset for Pentium processors, many SRAM suppliers (the high water mark was 23) went after a portion of the relatively small, but promising, market for 32Kx32 cache RAM that would support the Intel specification. This chipset required a 64-bit-wide input/output (I/O) channel that, in turn, had at least five potential 1Mb SRAM product architecture solutions. The chip deemed to be the economical solution for this next-generation chipset was the 32Kx32 15ns SRAM. Because of initial technical difficulties in manufacturing this part, most 1995 cache was of the older 32Kx8 density. For the few companies that could make the part, high prices were the reward that prevented large-scale,

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cost-based conversion. By the middle of the fourth quarter of 1995, most of the 32Kx32 suppliers had simultaneously improved their yields and were producing large amounts of this promising new part.

While system OEMs went through a year-end rush in 1995 to clean up financial statements by off-loading unneeded semiconductor inventory, most 32Kx32 suppliers came to market at the same time with their long-awaited chipset solutions. The ensuing combination of abundant SRAM supplies, lower demand, and fear of holding inventory caused the 32Kx32 and the related 8Kx32 market prices to free-fall from November 1995 through the second quarter of 1996 (much like the highly publicized 1Mx16 and 1Mbx4 DRAM parts during the same period). Many SRAM suppliers also make DRAM, so the drop in RAM pricing was a double blow for these suppliers in the first half of 1996.

The 1995 cache SRAM market, defined as 256K, 1Mb, 4Mb, and 16Mb devices at under 9ns to 35ns, is valued at $3.2 billion and is forecast to flatten out at $3.1 billion in 1997. Although the cache SRAM situation is most compelling, the total SRAM market includes many other devices at different configurations and access speeds. This document will cover the entire SRAM market, highlighting the technology trends, life-cycle product curve, and leading suppliers. This document will also show unit and dollar forecasts and provide a perspective.

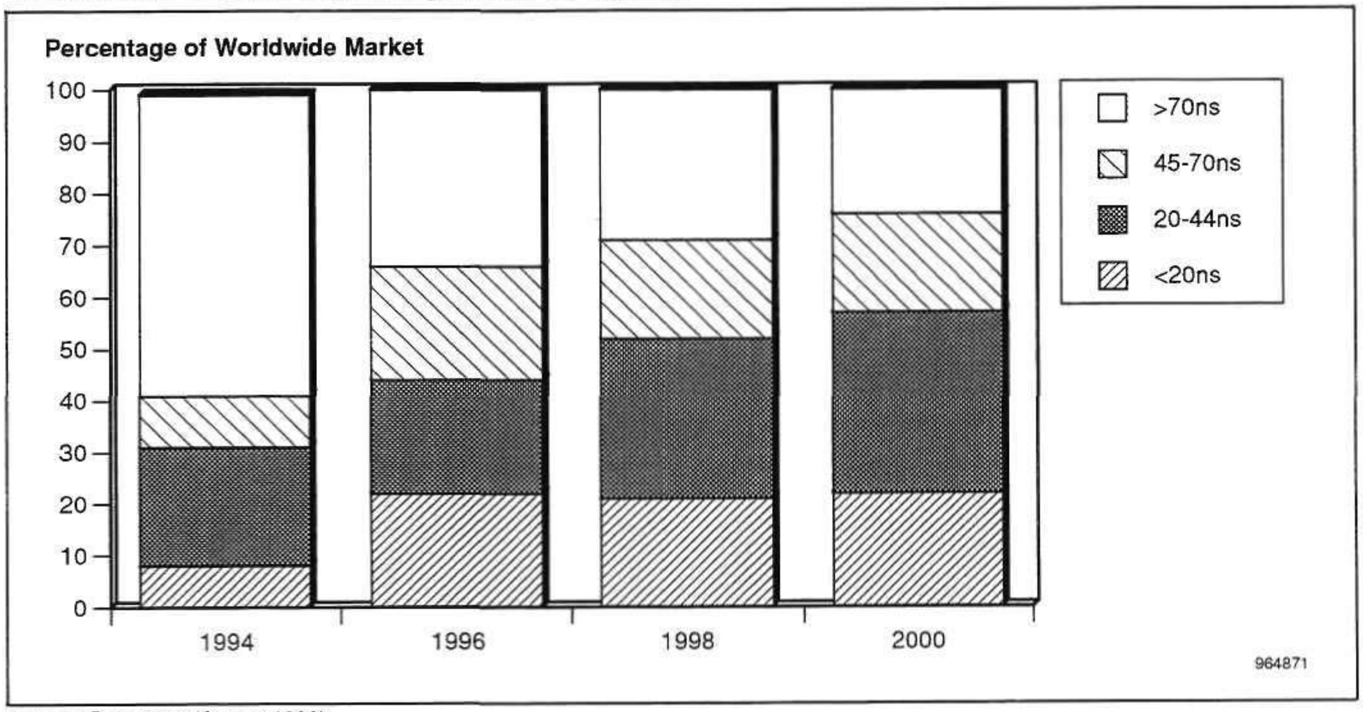
Density and Speed Trends

The SRAM market comprises many micromarkets delineated by total density, configuration, and speed. Specific applications, such as PCs, cellular phones, or consumer products, among others, drive demand for very particular devices. For example the 256K SRAM is most popular at speeds over 70ns and at under 20ns to 44ns, with minimal demand for speeds between 45 and 70ns.

The 1995 total SRAM market, valued at $6.2 billion, went up a whopping 39 percent from 1994 ($4.5 billion). Because of the strong demand for cache SRAM last year and the late-year oversupply, the overall average selling price (ASP) has increased only 3.4 percent, from $4.64 in 1994 to $4.80 in 1995. Dataquest still expects a rising ASP trend to accelerate because PC designs will require increased levels of high-speed, high-density, and relatively high-priced cache devices.

Figure 1 shows the trend in demand for the four main speed categories of SRAM. From 1994 to 1998, the two segments making up the faster-than-45ns devices (that is, cache applications) will grow from 31 percent of the market in 1994 to 52 percent in 1998. Over the same period, the slow SRAM market will decline from 58 percent in 1994 to less than 29 percent in 1998 because of the overall shift in demand for faster devices. The 45ns-to-70ns segment will grow and stabilize with the 4Mb SRAM market, as Dataquest expects there will be significant levels of demand for this speed at this density.

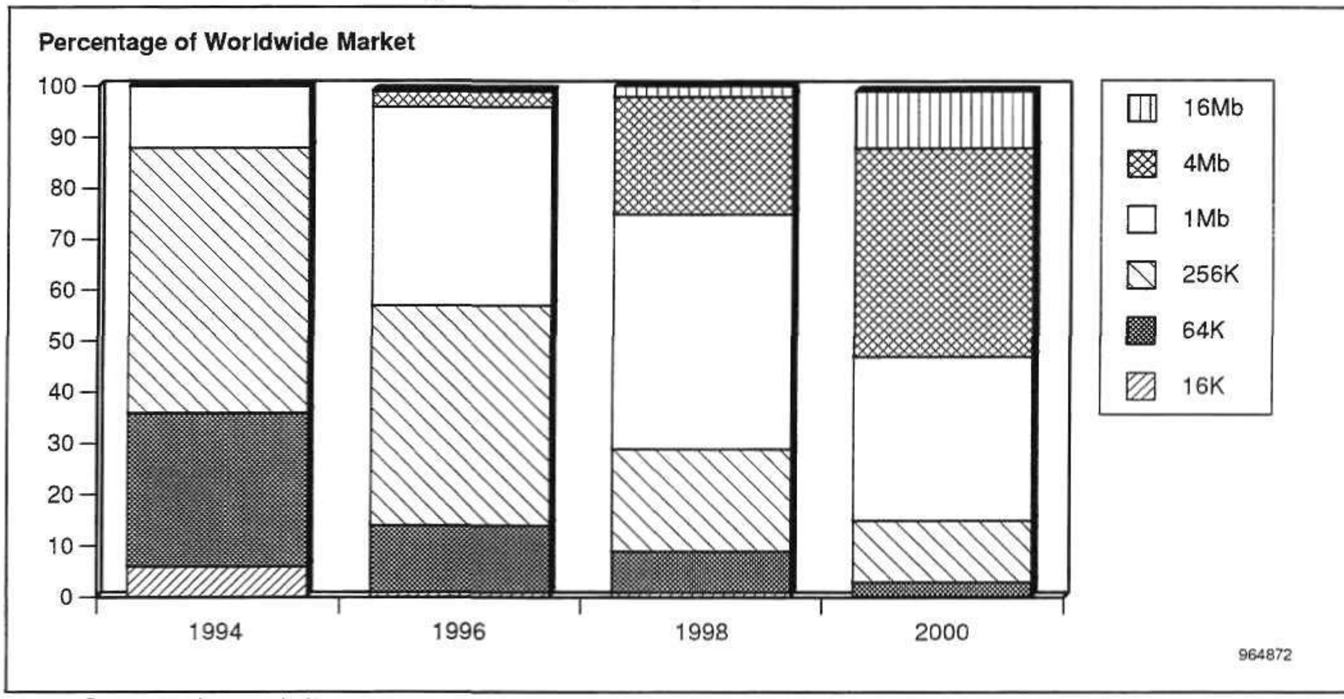
Figure 1
Worldwide SRAM Unit Shipments by Speed



Source: Dataquest (August 1996)

Figure 2 shows how the density of SRAM will change over time. In 1996, 57 percent of all SRAMs will be at the 256K density or less, while, by 1998, close to three-fourths (71 percent) of the market will be over 1Mb in density. Future system designers should keep this trend in mind when planning on SRAM requirements, because low-density SRAMs will be less available.

Figure 2
Worldwide SRAM Unit Shipments by Density

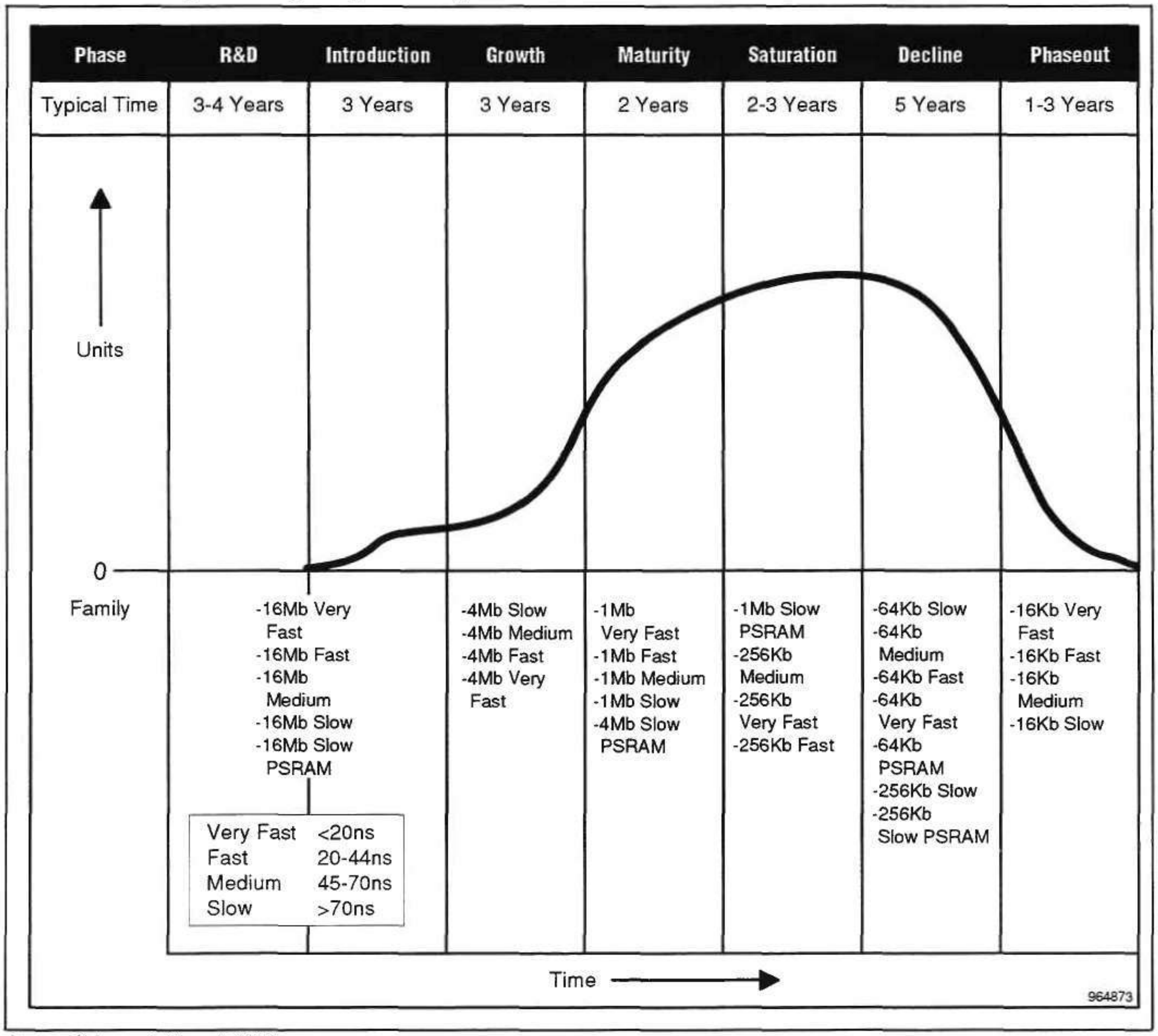


Source: Dataquest (August 1996)

SRAM Life Cycles

A pragmatic way to look at sourcing the components of a system is to place specific devices (in this case, SRAMs) on the IC life-cycle curve. An IC generally has a seven-stage life cycle: R&D, introduction, growth, maturity, saturation, decline, and phaseout. The following life-cycle curve is based on actual 1995 SRAM shipment volume. Because of the varied applications that utilize SRAM, the SRAM life cycle is about twice that of DRAM, or about 19 years (see Figure 3).

Figure 3
SRAM Life-Cycle Stages by Density



Source: Dataquest (August 1996)

Product/Supplier Matrix

The expanding combination of speed, density, and configurations of SRAM makes it very difficult to keep track of the worldwide SRAM supply base to ensure that all supply sources are explored. Compounding this situation is the tendency of many SRAM suppliers to focus on selected segments of the market. In an effort to reduce this confusion, Tables 1, 2, 3, 4, and 5 show which SRAM densities and speeds companies actually shipped in 1995. A check mark indicates that a supplier shipped parts at the specified density and speed, while a dash means that no parts were shipped.

Knowledge of where a particular device is in its life cycle is critical when deciding to design in or design out a device. Synchronizing system life cycles with semiconductor life cycles requires good coordination between system design engineering, component engineering, and procurement, ideally with each having equal weight in design/procurement decisions. The tails of the life-cycle curve generally equal limited supplies and high prices, while the devices in the middle of the curve are available in high volume and at lower prices.

Table 1
1995 Availability of 16K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Cypress Semiconductor	-	✓	✓	✓	-	-
Fujitsu	-	-	-	✓	-	-
Hitachi	-	-	✓	✓	✓	-
LG Semicon	-	-	-	-	✓	-
Mitsubishi	-	-	-	✓	-	-
Rohm	-	-	-	-	✓	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
SGS-Thomson	-	-	-	-	✓	-
Sharp	-	-	-	✓	✓	-
Sony	-	-	-	-	✓	-
United Microelectronics Corp.	-	-	✓	-	-	-

- = Not available
✓ = Available
Source: Dataquest (August 1996)

Table 2
1995 Availability of 64K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	✓	-	-	-	-
Cypress Semiconductor	-	✓	✓	✓	-	-
Fujitsu	-	-	✓	✓	✓	-
Hitachi	-	✓	✓	✓	✓	-
Hyundai	-	-	-	-	✓	-
Integrated Silicon Solution Inc.	-	✓	-	-	-	-
LG Semicon	-	-	-	-	✓	-
Micron Technology	-	✓	-	-	-	-
Mitsubishi	-	-	✓	✓	-	-
Mosel Vitelic	-	-	✓	-	✓	-
Motorola	-	✓	✓	-	-	-
NEC	-	-	-	✓	✓	✓
Rohm	-	-	-	-	✓	-
Samsung	-	-	✓	✓	-	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
SGS-Thomson	-	-	-	-	✓	-
Sharp	-	-	-	✓	✓	-
Sony	-	-	✓	-	✓	-
Texas Instruments	-	✓	✓	✓	-	-
Toshiba	-	-	✓	-	✓	-
United Microelectronics Corp.	-	-	✓	-	-	-
Winbond	-	-	-	✓	-	-

- = Not available
✓ = Available
Source: Dataquest (August 1996)

Table 3
1995 Availability of 256K SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	✓	✓	-	-	-
Cypress Semiconductor	-	✓	✓	✓	-	-
Fujitsu	✓	-	✓	-	✓	-
Hitachi	-	-	✓	✓	✓	✓
Hyundai	-	-	-	-	✓	-
Integrated Device Technology	-	✓	✓	-	-	-
Integrated Silicon Solution Inc.	-	✓	-	-	-	-
LG Semicon	-	-	-	-	✓	-
Matsushita	-	-	-	-	✓	-
Micron Technology	-	-	-	✓	-	-
Mitsubishi	-	✓	✓	-	✓	-
Mosel Vitelic	-	-	✓	-	✓	-
Motorola	✓	✓	✓	-	✓	-
NEC	✓	✓	✓	✓	✓	-
Paradigm	-	✓	✓	-	-	-
Samsung	-	-	✓	✓	-	-
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
SGS-Thomson	-	-	✓	-	-	-
Sharp	-	-	-	✓	✓	✓
Sony	-	-	✓	✓	✓	-
Toshiba	-	✓	✓	-	✓	✓
United Microelectronics Corp.	-	✓	✓	-	✓	-
Winbond	-	✓	✓	✓	-	-

- = Not available
✓ = Available
Source: Dataquest (August 1996)

Table 4
1995 Availability of 1Mb SRAMs by Speed

	0-9ns	10-19ns	20-44ns	45-70ns	>70ns (Standard)	Pseudo
Alliance Semiconductor	-	-	✓	-	-	-
Cypress Semiconductor	-	-	✓	-	-	-
Fujitsu	-	-	-	✓	✓	-
G Link	-	✓	-	-	✓	-
Hitachi	✓	✓	✓	✓	✓	✓
Integrated Device Technology	-	✓	-	-	-	-
Integrated Silicon Solution Inc.	✓	✓	-	-	-	-
LG Semicon	-	-	-	-	✓	-
Micron Technology	-	✓	-	-	-	-
Mitsubishi	-	-	-	✓	✓	-
Motorola	✓	✓	✓	-	-	-
NEC	-	✓	✓	✓	✓	✓
Oki	-	-	-	-	-	✓
Paradigm	-	✓	✓	-	-	-
Rohm	-	-	-	-	✓	-
Samsung	-	✓	✓	✓	-	✓
Sanyo	-	-	-	-	✓	-
Seiko Epson	-	-	-	-	✓	-
SGS-Thomson	-	-	✓	-	-	-
Sharp	-	-	✓	-	✓	-
Sony	-	✓	✓	✓	✓	-
Toshiba	-	✓	-	-	✓	✓
United Microelectronics Corp.	-	✓	-	-	-	-
Winbond	-	✓	-	-	-	-

- = Not available
✓ = Available
Source: Dataquest (August 1996)

Table 5
1995 Availability of 4Mb SRAMs by Speed

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

- = Not available
✓ = Available
Source: Dataquest (August 1996)

Supply Base Profiles

Major shifts were made in the top 10 SRAM suppliers in 1995 by companies that could provide fast cache devices, as shown in Table 6. The relentless progress of Samsung in the memory market means that this company now tops the list as the No. 1 worldwide SRAM supplier in 1995. After long planning to be the largest worldwide semiconductor supplier, Samsung now claims the top DRAM and SRAM supplier rankings. One of the big changes last year was the fall of Fujitsu, ranked seventh in 1994, out of the 1995 top 10 SRAM suppliers. Motorola Inc., Sony Corporation, Cypress Semiconductor, Winbond Electronics Corporation, and Integrated Device Technology, among others, grew extensively in 1995, thanks to the high level of cache SRAM demand.

Although Japanese companies still make up the largest regional supply base, with 45.5 percent of the market, this region had the lowest growth rate in 1995. Americas companies ranked second and grew a very strong 80 percent over 1994 levels. Third-ranked Asia/Pacific SRAM suppliers grew a healthy 57 percent in 1995, while the small European SRAM supply base more than doubled (113 percent) last year.

Table 6
Top 10 Companies' Factory Revenue from Shipments of Static RAM Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percentage Change	1995 Market Share (%)
1	2	Samsung	419	716	60	10.7
2	1	Hitachi	557	662	19	10.6
3	6	Motorola	329	510	55	8.2
4	5	Sony	349	445	28	7.1
5	4	NEC	353	421	19	6.7
6	3	Toshiba	376	417	11	6.7
7	10	Winbond	141	309	119	4.9
8	8	Mitsubishi	212	304	43	4.9
9	9	Cypress	194	303	56	4.8
10	12	Integrated Device Technology	139	285	105	4.6
		All Others	1,445	1,928	33	30.8
		Americas Companies	1,074	1,935	80	30.9
		Japanese Companies	2,505	2,844	14	45.5
		European Companies	24	51	113	0.8
		Asia/Pacific Companies	911	1,426	57	22.8
		Total Market	4,514	6,256	39	100.0

Source: Dataquest (August 1996)

Samsung

- Samsung grew 60 percent in 1995 to edge out Hitachi as the top-ranked SRAM supplier with 10.7 percent of the market.
- Successful conversion of older DRAM fabs to SRAM output keeps costs under control.
- The company sells SRAM bare die through a third-party die distributor, Chip Supply.

Hitachi

- Hitachi traded places with Samsung, taking the No. 2 position with 10.6 percent of worldwide SRAM sales.
- Hitachi announced in 1995 a 6ns 32Kx36 SRAM aimed at high-end servers and multiple-processor systems.

Motorola

- The company showed a big jump to the No. 3 position in 1995 from No. 6 last year—growing 55 percent over 1994.
- Motorola was a big benefactor of strong cache demand—sole-sourced, high-priced Motorola parts were the only solution in many situations.
- The company continues to use second-source SRAMs for some SRAM modules, keeping the lucrative high-speed business in-house.

Sony

- By growing 28 percent in 1995, Sony moved up to the No. 4 ranking of worldwide SRAM suppliers.
- Besides its standard SRAM product offerings, Sony introduced a high-performance family of synchronous SRAM aimed at the high-end, 64-bit RISC and complex-instruction-set computing (CISC) processor markets.
- Sony began shipment of the SCM586P series of secondary cache modules designed for use with Intel Pentium processors, Triton, OPTi, Viper, and VLSI Technology 82C590 chipsets.

NEC

- NEC introduced a 1Mb synchronous BiCMOS SRAM (in both 64Kx18 and 32Kx36 organizations) with access times as low as 3ns.
- NEC announced in the first quarter of 1995 an agreement whereby the company would supply Samsung with the equivalent of 100,000 4Mb SRAM devices per month in uncut wafer form for follow-on assembly and test in a Portuguese plant Samsung shares with Texas Instruments.

Toshiba

- Toshiba grew the least (11 percent) of those in the top 10 SRAM supply list and fell from the 1994's third rank position to No. 6 in 1995.
- Despite being one of the first companies to produce the 32Kx32 synchronous SRAM in volume, Toshiba was not able to remain in the top five supplier rankings in 1995.

Winbond Electronics

- Winbond grew a phenomenal 119 percent in 1995, the second consecutive year it made the top 10 SRAM supplier list, jumping from No. 10 to No. 7 in 1995.
- Winbond entered into an alliance with Toshiba whereby Toshiba provides the company with production technologies for 1Mb fast SRAM and 16Mb DRAM. Toshiba will import products from Winbond for sale into the Asian market under the Toshiba brand.

Mitsubishi

- Mitsubishi remained in the eighth position for SRAM sales by growing a healthy 43 percent over 1994 (the highest growth for a Japanese SRAM supplier).
- In third quarter 1995, the company announced that production would begin by fourth quarter 1995 of a pipelined 32Kx32 device that is pin-selectable for either PowerPC or Pentium processors.

Cypress Semiconductor

- Cypress maintained its ninth place SRAM supplier ranking by growing a respectable 56 percent in 1995.
- The main strength of Cypress comes from its 256K fast SRAM business. The company plans on ramping its Minnesota Fab 4 in 1996 with higher-density parts.

Integrated Device Technology

- Propelled by the surge in cache SRAM demand, IDT jumped into the No. 10 position of 1995 suppliers by growing 105 percent over 1994.
- IDT was one of the first to announce a 32Kx18 synchronous bursting cache SRAM for Pentium processors in first quarter 1995.

Dataquest Perspective

The SRAM market remains closely linked to the PC market and DRAM manufacturing capacity. As a result, supply and demand are often not in balance. Last year saw much of the SRAM market on allocation as suppliers scrambled to meet strong cache memory needs. Expectations of Windows 95 failed to materialize, and the inventory oversupply of chips at the user level did not leave the SRAM market unscathed. With prices falling over 50 percent since the fourth quarter of 1995, some cache SRAM suppliers are re-evaluating the future of staying in this ultracompetitive market. Availability for all SRAM remains very good at this writing and is expected to remain so for the next 6 to 12 months. Although not all users require wide bus synchronous SRAM, this segment of the market will continue to drive technology and density trends. Ensuring adequate supplies of older devices while new system designs take advantage of higher-density SRAM parts is a balancing game that procurement departments now have a little more time to play. The current buyer's market for SRAM should not lull users into thinking that long-term supplier relationships are no longer needed. Sharing future technology and product needs with suppliers will ensure users of competitive sources of future products while keeping current costs down.

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Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

DRAM Product/Market Update 1996: Is Allocation a Thing of the Past?

Abstract: *This article provides an insight to users of DRAM on how the current market oversupply is changing the traditional supply/demand equilibrium. The DRAM market rankings for 1995 by product density are examined, and the DRAM life-cycle chart for these products is updated and analyzed.*
By Evelyn Cronin

The State of the Market 1995: The Dynamics Are A'Changing

The current DRAM market is extremely volatile. For 1996 at least, allocation appears to be a thing of the past. There is an oversupply of both loose parts and modules at all capacities and densities, and prices have been falling all year. Spot market DRAM pricing has been very unstable as parties have been redistributing product. DRAM purchasers have changed the traditional ways of doing business—price negotiations, flexibility, cancellation terms, and inventory holding are all changing. The DRAM suppliers that are succeeding are those that built up relationships with their customers and can adapt to the changing market dynamics. The oversupply is encouraging the development of non-PC DRAM applications, which hitherto couldn't be exploited commercially because of the tight allocation situation.

The PC market is still the main DRAM consumer. Average DRAM densities per PC are increasing, and most PCs shipped in 1996 will be Pentium-class machines. However, despite the increase in the DRAM content per machine, the falling average selling prices (ASPs) have driven the value of the DRAM content per PC downward.

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DRAM technology is changing, as well. Fast page (FP) mode DRAM is being replaced by extended data out (EDO) DRAM. Yields on 1Mbx16 DRAM are universally good, and production volumes of this part have really ramped up in the past six months. 4Mb DRAM production volumes are stabilizing, with some suppliers cutting back on production.

It would appear that the oversupply will continue until the end of the year. We enter the second half of 1996 with strong rumors of 16Mb production cutbacks and news that some fab expansions are being delayed.

The Demand Side

Highlights from the demand side are:

- There is more than enough memory to meet current and projected demand in 1996.
- Price is falling constantly on both 4Mb and 16Mb chips and on modules.
- EDO DRAM is now a mainstream product and is fast replacing FP DRAM with no cost premium.
- PC shipments worldwide are forecast to grow at a single-digit rate in 1996 but most will be Pentium-class machines.
- PCs remain the single biggest DRAM-consuming segment.
- Windows 95 is increasing in popularity, and Windows NT will be released in the third quarter of 1996. These both require higher DRAM content per PC to offer performance benefits.
- Most PCs shipped have high multimedia content, which means they are memory-hungry.
- The constant DRAM price reductions have slashed the dollar value of DRAM. Thus, PC makers can ship more DRAM per system for less money.
- DRAM revenue growth in 1995 was a spectacular 81.5 percent, but this will not be repeated in 1996.

The Supply Side

Highlights from the supply side are:

- The worldwide oversupply is affecting all vendors.
- Margins are eroding as both contract and spot market prices continue to fall.
- Fab expansion and ramp-up plans are being postponed or delayed.
- Windows 95 is increasing in popularity and pushing up demand, but the supply needed to meet this anticipated demand increase has been live for six months.
- Technology is changing from FP to EDO to synchronous DRAM.
- Yields on the 1Mx16 16Mb have improved dramatically, and now this chip is in oversupply.
- 4Mb and 16Mb production is being cut back.

- Rumor has it that 64Mb is being delayed by most suppliers.
- The Taiwanese DRAM threat is causing some concern to U.S., Korean, and Japanese suppliers.
- U.S. complaints of dumping by foreign competitors have resumed.
- EDO life is being extended for PC applications because it offers better price/performance benefits than synchronous. Thus, the supply of synchronous DRAM is limited from most sources.

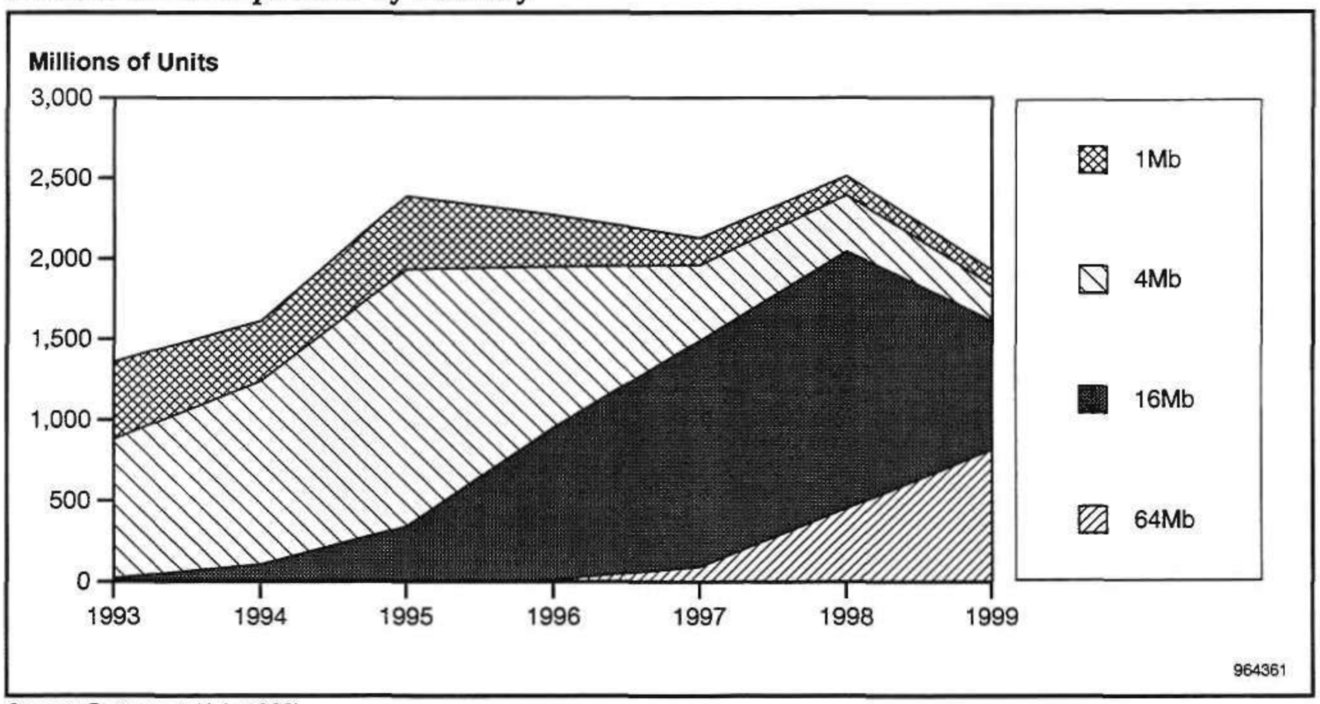
Dataquest has completed its third quarter 1996 price survey. The strong expectation is that price reductions will continue through 1996 and into 1997. This is good news for the buying communities but bad news for the vendor community. Falling prices affected margins and put research and development programs and fab expansion plans in jeopardy. This could lead to supply problems by the end of the century.

DRAM Unit Production and Life-Cycle Curve

Density

Figure 1 shows DRAM unit shipments by density. Looking at the historic unit shipment and forecast information reveals that 4Mb was the DRAM of choice for 1995. However, 16Mb production yields improved considerably in the second half of 1995, and Dataquest predict that the 16Mb DRAM will take over this role in 1996. Dataquest expects 16Mb to increase from 340 million units in 1995 to 940 million units in 1996. However, 4Mb production should fall from 1.601 billion units last year to 998 million units this year, while 1Mb will decline further from 433 million units in 1995 to 321 million units in 1996.

Figure 1
DRAM Unit Shipments by Density



Source: Dataquest (July 1996)

Figure 2 offers a broader perspective by placing the various DRAM densities and configurations in a life-cycle curve. Typically, for the 1Mb and above DRAM chip densities, the x1 and x4 configurations are produced first, with the x8 and the x16 configurations following later.

The 256Kb video RAM (VRAM) has moved this year from the decline stage to the phaseout stage, joining the 256Kb DRAM chip. The 1Mb DRAM and VRAM chips, at all configurations, are in the decline phase.

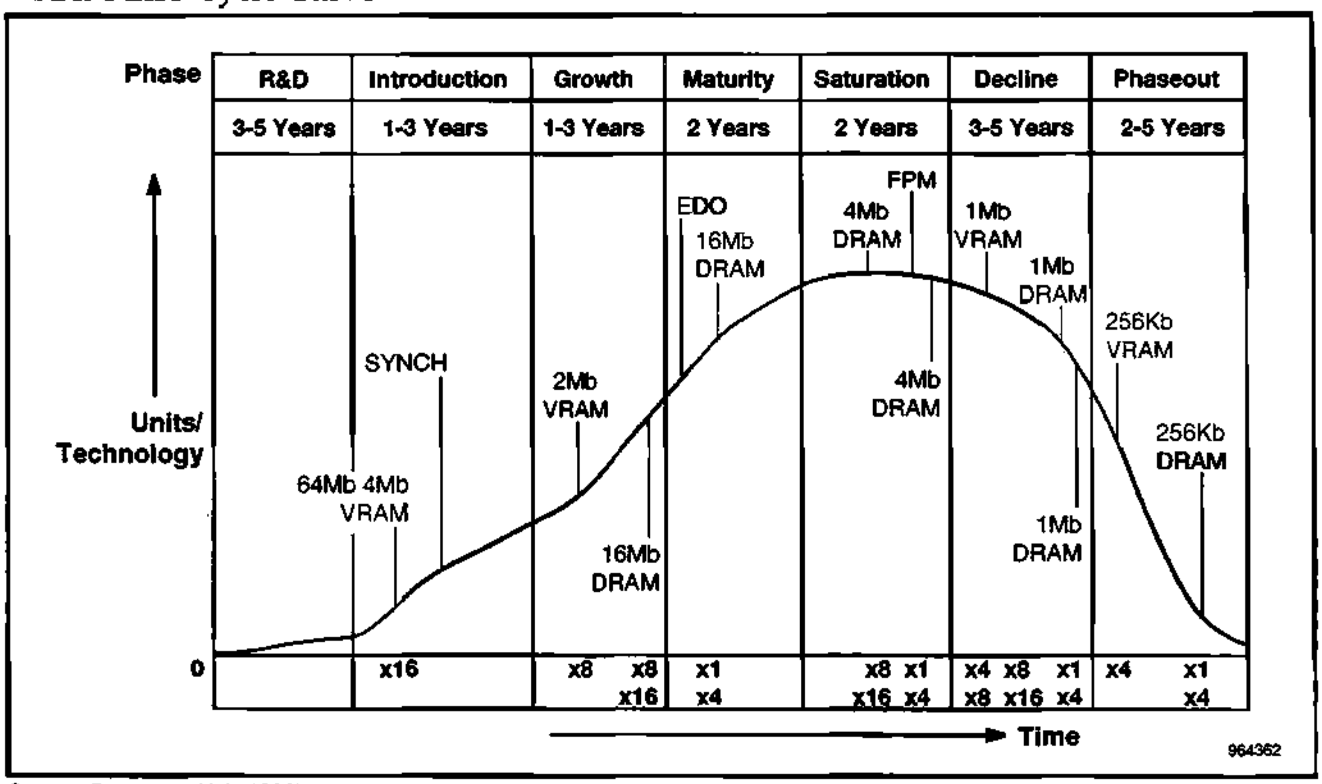
With production volumes reaching 1.601 billion units, 1995 was the year of the 4Mb DRAM. Dataquest predicts that this will fall in 1996. The x1 and x4 densities are edging toward the decline phase but, for 1996 at least, remain in the saturation phase. The x8 and x16 configurations, however, still have another year or so in the saturation phase.

There has been a rapid growth in the production volumes of 16Mb, especially at the x16 configuration, now that yields have improved. The x8 and x16 16Mb chips are moving quickly through the growth stage of the life-cycle curve. The x1 and x4 16Mb chip versions, however, are climbing up the maturity phase.

The 64Mb, at all configurations, still hovers at the edge of the introduction phase—remaining static since last year. The delay in the introduction of this chip is caused by the price erosion of the 4Mb and 16Mb chips—these are so price-competitive and so readily available that DRAM vendors are holding off introducing the 64Mb chip family.

Dataquest would recommend not using the 256Kb and 1Mb devices for new product designs. Also, the 64Mb device should be used only on new products with a very long life.

Figure 2
DRAM Life-Cycle Curve



Source: Dataquest (July 1996)

Technology Type

In terms of technology type, the three main types featured on this life-cycle curve are FP, EDO and synchronous DRAM. Both FP and EDO DRAM are asynchronous technologies. FP DRAM has been the main driver for all applications for the past number of years. However, it is being rapidly replaced for PC applications by EDO DRAM. From most DRAM vendors there is no price difference between FP and EDO; this has aided the adoption of EDO, because EDO offers performance benefits over FP in certain applications. Thus, FP DRAM sits at the saturation point of its life cycle. EDO DRAM grew last year and early this year, and now Dataquest has placed it at the start of its maturity stage.

As all versions of asynchronous DRAM will be in oversupply in 1996, Dataquest would recommend its continued use for cost-sensitive applications. Price reductions on 4Mb and 16Mb FP and EDO devices should remain for the foreseeable future as DRAM vendors strive to meet their customers' pricing expectations and endeavor to guarantee sales for their factory production output.

Dataquest sees that, in times of relative oversupply, PC users buy more DRAM modules than loose chips for base memory applications. In times of shortage, DRAM chips are purchased in greater volumes by PC manufacturers.

Synchronous DRAM, in its many guises, sits in the introduction phase of its life cycle. Although not being used in any significant volume by PC applications, it is being used for high-end workstations. Here, as interleaving is important, most manufacturers are moving straight from FP DRAM to synchronous DRAM. Synchronous DRAM is also being used by game applications because it offers enormous performance improvements.

Top DRAM Suppliers

The worldwide DRAM market grew 81.5 percent, by revenue, from 1994 to 1995, a truly remarkable rate. The 1995 ranking of top DRAM suppliers is shown in Table 1. Samsung retained its No. 1 position and grew a staggering 90.6 percent, widening the revenue gap between itself and NEC to $2 billion. NEC knocked Hitachi from the No. 2 spot, increasing revenue by over 90 percent. Hitachi came in at No. 3, posting a revenue growth of 74.2 percent, which is modest by comparison with the competition. Hyundai stormed in at fourth position, a climb of six places from last year. This equated to a revenue growth in excess of 190 percent from 1994 to 1995—the highest of all top 10 DRAM suppliers. Toshiba fell to fifth position in 1995, pushed down by Hyundai's rise, and its revenue growth was a mere 53.3 percent.

Texas Instruments, still the largest of the American DRAM companies, grew by over 109 percent from last year (the second-highest growth rate of the top 10). However, it fell from fifth to sixth position. This was a knock-on effect of Hyundai's leapfrog up the ranking table. TI's position is helped by the revenue from its licensing of its IC and packaging technology. LG Semicon (formerly Goldstar) retained seventh position, with its revenue growing by just under 80 percent. Micron Technology and Mitsubishi swapped

Table 1
DRAM Worldwide Market Share (Thousands of U.S. Dollars)

1994 Rank	1995 Rank	Company Name	1994 Revenue	1995 Revenue	1995 Market Share (%)
1	1	Samsung	3,459	6,592	15.6
3	2	NEC	2,407	4,592	10.9
2	3	Hitachi	2,434	4,239	10.0
10	4	Hyundai	1,360	3,950	9.4
4	5	Toshiba	2,255	3,458	8.2
5	6	Texas Instruments	1,639	3,429	8.1
7	7	LG Semicon.	1,391	2,500	5.9
9	8	Micron Technology	1,360	2,434	5.8
8	9	Mitsubishi	1,372	2,201	5.2
11	10	Fujitsu	1,173	2,051	4.9

Source: Dataquest (July 1996)

places from 1994 to 1995, with Micron rising to No. 8 and Mitsubishi dropping to ninth position. Micron's growth rate was a healthy 79 percent, and it retains its position as the second-largest American DRAM maker. Mitsubishi, by comparison, grew only 60.4 percent. Fujitsu came in at position No. 10, up from No. 11 in 1994, growing its revenue by nearly 75 percent.

All the Japanese suppliers benefited from the strong yen-dollar exchange rate in 1995.

Strategic RAM Alliances

First-tier semiconductor companies are banding together to develop new chips, hoping to save money and shorten the design cycle (see Table 2). The key areas that companies are focusing on are the 16Mb and, especially, the 64Mb and 256Mb. At 256Mb, development has been split into a number of strategic and powerful alliances: TI and Hitachi; Toshiba, Motorola, Siemens, and IBM; and Samsung and NEC.

NEC and Micron remain each other's OEMs, and NEC and Samsung have a fab agreement in Europe. Fujitsu has a fab agreement with Taiwanese giant Taiwan Semiconductor Manufacturing Company on 16Mb, and Fujitsu and Hyundai have a joint development partnership at 64Mb. Oki and Nan Ya Plastics have teamed up at the 64Mb densities with licensing and technology exchange agreements. Toshiba has a licensing and fab agreement with Winbond at 16Mb and a joint venture with IBM in 64Mb DRAM.

NMB Inc. bought United Memories, the design arm of Ramtron, which in turn spun off Enhanced Memory. IBM has a licensing agreement with United Memories on 4Mb and 16Mb DRAM. Mitsubishi announced its plans to invest in Powerchip Semiconductor Company, a joint Taiwanese-Japanese venture. This is mainly for 16Mb and 64Mb DRAM.

Table 2
Estimated Worldwide DRAM Technology Alliances as of June 1996

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances		64Mb DRAM Alliances		256Mb DRAM Alliances
Supplier	Second-Source Agreement	Fab Agreement	Joint-Venture Agreement	Fab Agreement	Joint-Venture Agreement	Development or Fab Agreement	Joint-Venture Agreement	Development or Fab Agreement	Technology Development
Fujitsu						TSMC (FA)	Hyundai (JD)		
Hitachi	LG Semicon (SS)			LG Semicon (FA)	LG Semicon (JV)	TI (JD)		TI (JD)	TI (JD)
IBM		Enhanced Memory (LA)	Micron (LA)	Kuroda Electric (FA)	Enhanced Memory (LA)	Siemens (JD)			Siemens/Toshiba (JD)
LG Semicon	Motorola (SS)	Mosel Vitelic (FA)	Hitachi (FA)	Siemens (FA)					
Micron	**NEC (OEM)**								
Sanyo (64Kx16 SS)		NEC (OEM)		NEC (OEM)	**Samsung (SDRAM JD)**				
Mitsubishi						Elitegroup/ Powerchip (JV)			
Motorola	LG Semicon (OEM)	Toshiba (FA)	**LG Semicon (OEM)**	Toshiba (FA)	**Toshiba (JV)**				
NEC	Micron (OEM)		**Micron (OEM)**	Samsung (FA in Europe)	**Micron (OEM)**				AT&T (JD)
NMB Inc.			**Ramtron (JD)**	Hitachi (FA)	**Ramtron (JV)**				
Oki			**SGS Thomson (JV)**	Mosel Vitelic (FA)	**Mosel Vitelic (JV)**		Nan Ya Plastics (LA, TE)		
Sanyo			**Mosaid (JV)**						
Samsung				Sony (FA)	**Oki (SDRAM JV)**	Sony (JD)			NEC (JD)

(Continued)

Table 2 (Continued)
Estimated Worldwide DRAM Technology Alliances as of June 1996

	1Mb DRAM Alliances		4Mb DRAM Alliances		16Mb DRAM Alliances		64Mb DRAM Alliances		256Mb DRAM Alliances
Supplier	Second-Source Agreement	Fab Agreement	Joint-Venture Agreement	Fab Agreement	Joint-Venture Agreement	Development or Fab Agreement	Joint-Venture Agreement	Development or Fab Agreement	Technology Development
Texas Instruments	Mitsubishi (SS)		HP-Canon (JV)						
Samsung (JV)									
Acer (JV)	Kobe Steel (FA)								
Samsung (FA)									
Acer (FA)	Hewlett-Packard Canon (JV)				Hitachi (JD)				
Thorn-EMI	NMB Inc. (LA)								
Toshiba	Motorola (SS)	Siemens (LA)	Motorola (JV)		Motorola (JV)	Winbond (LA, FA)	IBM (JV)		Motorola/ Siemens/IBM (JD)

LA = Licensing agreement: A company receives or issues a license to partner for an up-front fee or royalties.
SS = Second-source agreement: Two companies agree to develop consistent specifications to ensure a second source.
FA = Fab agreement.: A company offers fab capacity for a partner's product technology.
TE = Technology exchange: Two companies exchange technology, which may or may not include a transfer of money.
JV = Joint venture: Two companies form a new joint-venture company to develop, manufacture, and market new products.
JD = Joint development: Two companies agree to develop new products, which may or may not be marked separately.
OEM = OEM arrangement: A company sells product to an alliance partner that is sold under the partner's name.
Source: Dataquest (July 1996)

Supply Base

The following are some of the recent highlights of the top 10 worldwide DRAM suppliers.

Samsung

- The undisputed DRAM market leader, Samsung plans on being the worldwide semiconductor market leader within 10 years.
- Offers the full range of 16Mb and 64Mb densities and was market leader on synchronous DRAM also
- Has enormous fab capacity and expansion plans and is well positioned for 1996 and 1997, despite falling prices. Good reputation among its customers.

NEC

- A market and technology leader—was one of the first with volume 1Mx16 availability
- Offering full 16Mb and good 64Mb products. Has announced a fab agreement in Europe with Samsung.
- Well positioned with worldwide regional fabrication support and a loyal client base

Hitachi

- Market and technology leader, although it did have some initial problems with 1Mx16
- Offering wide range of 4Mb and 16Mb products and good 64Mb plans
- May have some problems in meeting the price requirements of 1996 as its generally offers conservative price reduction curves

Hyundai

- Hyundai had a tremendous year in 1995.
- Late with availability of EDO and synchronous DRAM but still dominant in FP technology—it will be playing technology catch-up this year and may suffer loss of market share
- Interested in emerging nonstandard DRAM (SynchLINK, RamLINK)

Toshiba

- Market and technology leader—consistently good yield on 1Mx16
- Technology and fab alliances with many companies at all densities
- North American presence masked by its alliance with Motorola

Texas Instruments

- No. 1 4Mb producer worldwide, good product mix at other densities
- TI is focused on its long-term strategic accounts only.
- DRAM is not TI's only income source. This gives TI protection during these volatile DRAM times.

LG Semicon

- Alliance with Motorola and Mosel Vitelic on 1Mb and with Hitachi on 4Mb but no alliances on any bigger densities
- Maintained its position from 1994 through 1995 and worked hard on customer support
- Faces market challenges in 1996 with its late availability of EDO modules and synchronous DRAM and with falling prices

Micron

- Had a good year in 1995, gaining market share and releasing shrunk-down 16Mb
- The gamble on going with burst EDO only didn't pay off, but Micron is now beginning to develop synchronous DRAM also.
- Dependency on DRAM for its revenue will make 1996 a challenging year

Mitsubishi

- Technology leader but slow to grow market share in 1994 and 1995, compared with the competition
- Strongly focusing on 16Mb, including 2Mx8, DRAM production
- An established DRAM supplier with a good client mix and product portfolio

Fujitsu

- A good year in 1995 for Fujitsu despite late availability of the 1Mx16 chip
- Very strong in synchronous DRAM, especially 16Mb and above densities
- Has good worldwide regional fabrication coverage and an established client base

Others

- Siemens will continue to be the strongest European DRAM maker (ranked No. 12 worldwide).
- IBM dropped out of the top 10, falling to eleventh position.
- Mosel Vitelic and other Taiwanese DRAM suppliers have started to make their presence felt, predominantly at 4Mb and 16Mb densities.

Supply Base Analysis by Density

Market leaders by density are shown in Table 3. The five top suppliers hold about 50 percent of the middensity 1Mb and 4Mb DRAM market. This is virtually unchanged from 1994. For the 16Mb density, however, the top five command over 60 percent of the total market. This is largely because these companies had good yield on these chips while their competitors struggled. For 1996, however, Dataquest expects this to change. Tables 3, 4, and 5 give more details on unit production by density.

Supply Base for 1Mb DRAMs

The rankings of 1Mb suppliers, by unit shipments, are shown in Table 4. Total units for 1995 were 433 million, down from 499 million in 1994. The peak year for 1Mb was 1991, with 831 million units shipped.

Table 3
1995 DRAM Market Leaders by Product Density (Based on Unit Shipments)

1995 Rank	1Mb	4Mb	16Mb
1	Toshiba	Texas Instruments	Samsung
2	Sanyo	Hitachi	NEC
3	Mitsubishi	Samsung	Toshiba
4	Hyundai	Hyundai	Hitachi
5	Samsung	Micron Technology	Hyundai
Market Share of Top Five (%)	55.3	49.9	61.7

Source: Dataquest (July 1996)

Table 4
1995 1Mb DRAM Supplier Base (Thousands of Units)

	Shipments	Rank
Toshiba	76,400	1
Sanyo	55,000	2
Mitsubishi	47,800	3
Hyundai	34,900	4
Samsung	25,310	5
Oki	24,090	6
Fujitsu	23,600	7
Siemens	22,250	8
Nippon Steel	20,060	9
LG Semicon	17,660	10
NEC	17,060	11
Matsushita	12,400	12
Micron Technology	12,170	13
Hitachi	10,080	14
IBM	8,650	15
Sharp	8,190	16
Mosel Vitelic	7,590	17
Motorola	5,297	18
Texas Instruments	4,729	19
Market Total	433,236	

Source: Dataquest July 1996

In 1996, there will be a more dramatic decrease in output from the majority of 1Mb DRAM manufacturers. However, few, if any, will fully abandon this density. For 1996, Dataquest forecasts that worldwide 1Mb DRAM shipments will be 321 million units. This will reduce dramatically in 1997.

Supply Base for 4Mb DRAMs

Table 5 shows the 1995 4Mb DRAM supplier base, by unit shipments. Total production for 1995 was 1,601 million units.

Dataquest forecasts that, in 1996, the 4Mb DRAM production total will fall to 998 million units. For 1997, this number will be more than halved as DRAM vendors move production over to 16Mb. This transition from 4Mb to 16Mb is being accelerated by the dramatic price reductions and the relative oversupply of the 16Mb chips.

Table 5
1995 4Mb DRAM Supplier Base (Thousands of Units)

	Shipments	Rank
Texas Instruments	170,696	1
Hitachi	160,500	2
Samsung	158,071	3
Hyundai	155,730	4
Micron Technology	153,800	5
NEC	150,335	6
Toshiba	105,250	7
LG Semicon	102,353	8
IBM	93,968	9
Fujitsu	77,700	10
Mitsubishi	58,950	11
Oki	58,000	12
Siemens	46,700	13
Motorola	29,434	14
Nippon Steel	28,700	15
Matsushita	28,400	16
Vanguard International	8,500	17
Mosel Vitelic	7,956	18
Sharp	6,300	19
Market Total	1,601,343	

Source: Dataquest July 1996

Supply Base for 16Mb DRAMs

The 16Mb ramp-up has been very dramatic. Volume of about 22 million units in 1993 increased to 108 million units in 1994 and to 340 million units in 1995.

Dataquest forecasts that the 16Mb worldwide production output will continue to increase, rising from an estimated 941 million units in 1996 to 1,402 million units in 1997. Dataquest believes that 1998 will be the saturation point for 16Mb, with estimated volumes at about 1,590 million units worldwide. The 16Mb will fall off after this point, as 64Mb takes a more dominant position.

Table 6 shows the 16Mb DRAM supplier base, based on unit shipments, for 1995.

Table 6
1995 16Mb DRAM Supplier Base (Thousands of Units)

	Shipments	Rank
Samsung	59,330	1
NEC	42,465	2
Toshiba	36,910	3
Hitachi	36,302	4
Hyundai	35,050	5
Mitsubishi	28,510	6
Texas Instruments	28,261	7
LG Semicon	20,860	8
Fujitsu	15,490	9
IBM	12,528	10
Siemens	8,100	11
Oki	5,800	12
Motorola	5,590	13
Micron Technology	3,619	14
Matsushita	1,430	15
Nippon Steel	120	16
Market Total	340,365	

Source: Dataquest July 1996

Nonstandard RAM

At this point, standard DRAM covers both FP and EDO asynchronous DRAM. The push for nonstandard RAM is coming mainly from multimedia and graphics applications that need memory capable of keeping up with fast 32-bit and 64-bit MPUs like the Pentium, PowerPC and other RISC-based systems. Last year, VRAM and static RAM (SRAM) were both expensive and in undersupply. This discouraged a lot of designers from using them for high-speed applications. However, over the past year, the prices on both VRAMs and SRAMs have decreased and availability has improved. This makes them more attractive for price-sensitive applications, even though they take up valuable board space. There are certain applications, however, that require quite specialized technology.

The following are some nonstandard RAMs, with descriptions.

- Rambus DRAM
  - This is licensed by 15 semiconductor companies and has been formally announced by Cirrus Logic, Hitachi, L. G. Semicon, LSI Logic, NEC, Oki, Samsung, and Toshiba. Access memory is rated at 500 MB/sec. Nintendo has announced its use of Rambus in 64-bit machines.
- Synchronous DRAM

This is much faster than conventional DRAM, 50 MHz to 100 MHz, and JEDEC and Intel standards have been established. Most DRAM companies are working on or have SDRAMs. It is likely to be the successor to EDO DRAM for base memory applications.

- MoSys Multibank
  - This is a unique architecture, with several firms reviewing it. Access memory is rated at 660 MB/sec. The graphics version is of most interest.
- Enhanced Memory Systems' (formerly Ramtron's) enhanced DRAM
  - Taiwan-based Digicom is selling fast memory for high-performance 486 PCs. IBM announced that it is manufacturing enhanced DRAMs for Enhanced Memory Systems. Ocean Information Systems currently is the lone major customer; this technology has limited acceptance elsewhere. NMB also acts as a foundry for Enhanced Memory.
- 3-D Memory
  - This is the Mitsubishi-proprietary design, of interest in graphics applications. Siemens and, possibly, Integrated Device Technology Inc. will act as foundries.
- Window RAM
  - This is similar to VRAM with unused features removed. Window RAM is being developed by a small number of suppliers.
- Embedded DRAM
  - This concept (where DRAM is embedded into an ASIC design) is receiving a lot of interest, mainly at 16Mb. Both NeoMagic and Silicon Magic have designs and are working with foundries.

Dataquest Perspective

DRAM suppliers had a phenomenal year in 1995. The worldwide market grew 81.5 percent in revenue from 1994 to 1995. Most suppliers grew by record-breaking levels—Hyundai alone grew over 190 percent and leap-frogged into the No. 4 position. Also, throughout 1995, demand exceeded supply, so that suppliers could control price and guarantee customer orders for their total production output.

However, by the end of 1995, the storm clouds were visible on the horizon. A large amount of new DRAM output came on line, boosting supply. Unfortunately, demand didn't increase at the same rate. The new concepts of DRAM oversupply and falling prices appeared. The pricing free fall that occurred in the first quarter of 1996 was, thankfully for all, short-lived. It was replaced by more controlled, constant downward price movements. Dataquest has just completed its third quarter 1996 price survey, mainly on FP and EDO DRAM chips and modules. The clear message from all participants is that prices are forecast to stay down for the next six quarters.

When EDO DRAM was initially launched, it was thought that it would act as a stopgap technology while the market moved from FP to synchronous DRAM. This has not been the case. The constant EDO DRAM price reductions now make it the DRAM solution of choice for most PC applications. Thus, it makes no sense to launch synchronous DRAM into the volume PC segment at present.

What Dataquest has seen, however, is the emergence of dual-technology motherboards. These are motherboards that support both asynchronous and synchronous DRAM, typically 4-SIMM, 2-DIMM machines. These boards provide the protection of a technology insurance for high-end machines for both manufacturer and end customer. However, for certain applications, usually where interleaving is important, the market has moved straight from FP to synchronous DRAM. The volume on these applications, however, is a lot less than that of the pure PC applications.

With falling prices and an oversupply in the DRAM market, the suppliers that succeed will be the ones with clear long-term focus and plans and that meet their customers' changing needs. This is payback time for all suppliers that didn't treat their customers right during the shortage. Buyers have long memories, and they are now in a position of choice. Buyers will choose to do business with the "best" suppliers—those that meet their requirements best. Inventory holding, flexible terms, cancellation windows, price negotiations, technology road maps (all these have changed. Suppliers must react to what their customers require if they are to survive and retain market share. If a supplier doesn't, then there is always a competitor in the wings waiting for a chance to shine.

Also, for suppliers, the DRAM market is no longer the margin-rich cash cow it once was. Suppliers must recoup development costs quickly. Thus, the need for a partnership/alliance approach is more important now than ever. A healthy number of alliances were announced in 1995—these were both fab and technology agreements. However, with the dropping of prices and the inability of DRAM demand to match supply, some suppliers have announced delays to their fab expansion plans. These delays affect primarily 16Mb DRAM chips. Suppliers that cut back on long-term expansion based on the volatility of the past six months will ultimately lose out. Although 1996 will be a tough year, demand will be there for the foreseeable future. Nonexpansion will lead to undersupply near the end of the decade and will limit market share and growth plans.

In 1997, oversupply will continue but at a lower rate as suppliers bring their production more in line with actual demand. Price reductions are set to continue at controlled rates during 1997 on both FP and EDO DRAM. Synchronous DRAM will start to take off in 1997 for PC applications. This will again separate the men from the boys of the DRAM supplier base, with some suppliers lagging pitifully far behind others, based on product road maps. Thus, 1997 will be another eventful year for suppliers and buyers. An interesting benefit of the current oversupply is the emergence and development of new DRAM-consuming applications.

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Dataquest

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Perspective

Semiconductor Supply and Pricing Worldwide

Dataquest Predicts

Third Quarter 1996 Quarterly Price Survey Highlights: Gradually Lower Prices Still on the Horizon

Abstract: *This Perspective reviews the latest quarterly semiconductor price forecast and highlights what recent changes to the market mean to semiconductor users.*
By Mark Giudici

Overview

The past six months have seen overall semiconductor prices decline between 20 percent and 30 percent, depending on the product. What first started as a year-end inventory correction/DRAM density crossover issue continues to cause price reductions (especially in memory—DRAM and SRAM) that belies the overall health of the market. The latest results of Dataquest's Quarterly North American Semiconductor Price Survey (QPS) show that overall price reductions will continue for the next six months but at a slower rate than the previous six months. DRAM and SRAM spot prices will continue to grab the trade journal headlines. The majority of the market, (contract buyers) however, will see gradual and relatively predictable price declines for the rest of this year as price/cost points are reached by both the spot and contract markets.

Price Forecast Highlights

Compared with Dataquest's March QPS, overall prices (memory and logic/microprocessors) have slid further. This is primarily because of the continued erosion of on-hand inventory at user sites and some slower-than-anticipated growth for the set-top box and selected network market segments. Figure 1 highlights the 4Mb and 16Mb DRAM price curves based

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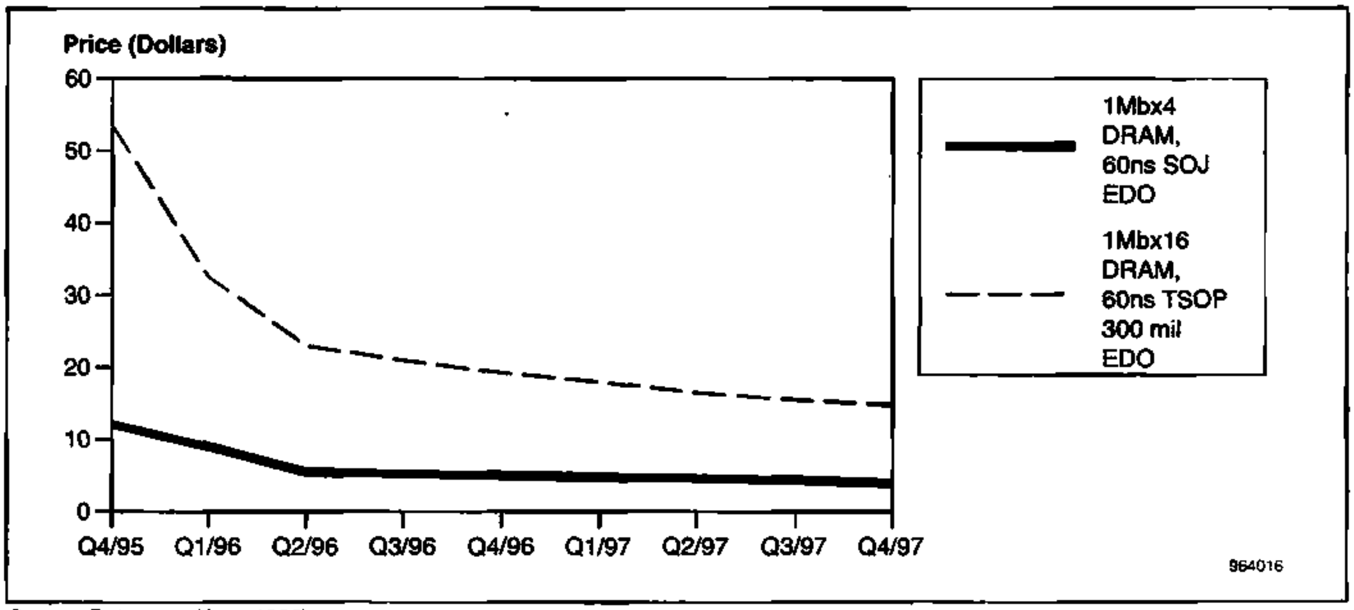
on the latest survey, showing how the dramatic price cuts of the recent past will moderate in the future. Overall demand for electronics (PCs in particular) remains strong, and Dataquest expects demand to remain that way for the rest of this year. A combination of semiconductor capacity containment, product mix shifts, and the potential of governmental action has slowed price decline rates for memory products in general.

Figure 1
Third Quarter DRAM Price Forecast (U.S. Dollars)



Source: Dataquest (June 1996)

Memories: The Price Impact of Micron's Request for an Antidumping Investigation

Micron Technology's May 31 request for an expedited review by the U.S. Department of Commerce of alleged dumping by Hyundai and LG Semicon is in direct response to the continued aggressive price erosion seen in the 4Mb and 16Mb DRAM markets. The impact on the contract price picture is effectively nil, but the DRAM spot market acted in true fashion by rising, on average, over 20 percent between May 29 (the Wednesday before the announcement) and June 3 (the Monday following the announcement). Micron has again effectively impacted the overall market by bringing the issue of cost back into the price picture. The specter of government involvement in company cost audits, pricing guidelines, and potential penalties is now causing many suppliers to ensure that prices and costs are in line with each other. This effect is the main cause for the moderate price declines shown in Table 1 in contract pricing of DRAMs for the rest of this year. Moderation in DRAM pricing is having a spillover effect on other memory devices, (that is, SRAM and flash) as suppliers look for ways to improve product mixes in order to increase profit levels.

Table 1
North American DRAM Contract Price Estimates—Third Quarter 1996 (U.S. Dollars)

Product	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96	1996
DRAM						
1Mbx4 EDO	12.13	9.00	5.50	5.25	5.00	6.19
1Mbx16 EDO	53.50	32.50	23.00	21.00	19.25	23.94
4Mbx4 EDO	47.80	32.50	23.00	21.00	19.25	23.94
2Mbx8 EDO	51.08	31.75	23.00	21.35	19.25	23.84

Source: Dataquest (June 1996)

The Cost Argument

As shown in Table 2, Dataquest's cost estimates for 4Mb and 16Mb DRAM remain below contract pricing trends. However, we have heard of spot market prices that have gone below these estimated costs. These estimates use average cost parameters. Individual company performance will obviously alter the model's result.

Table 2
DRAM Cost Models Assuming Average Yields, 1996 (U.S. Dollars)

	16 Mb DRAM	4Mb DRAM
Wafer Sort		
Geometry (Microns)	0.40	0.60
Die Area (Square Mils)	118,575	80,000
Gross Die per Wafer	318	283
Cost per Gross Die at Wafer Sort	7.47	1.98
Wafer Sort Yield (%)	55	92
Cost per Sorted Die	13.51	2.15
Assembly		
Assembly Yield (%)	99	99
Cost per Assembled Die	14.03	2.54
Final Test		
Final Test Yield (%)	90	91
Cost per Final Tested Unit	16.15	2.87
Mark, Pack, and Ship		
Cost at 99 Percent Yield (%)	0.16	0.03
Total Fabricated Cost per Net Unit	16.31	2.90
FMV Formula Adders		
R&D Expense (15 Percent)	2.45	0.43
SG&A Expense (10 Percent)	1.88	0.33
Profit (8 Percent)	1.65	0.29
Constructed Foreign Market Value (FMV)	22.28	3.96

Source: Dataquest (June 1996)

Microprocessors

The PC microprocessor (MPU) market continues to move as Intel desires. If Intel perceives a price/performance threat, either a new product/speed grouping or a dramatic price cut is announced that continues to keep competition at bay. This "trump card" strategy continues to allow competition, albeit on Intel's terms. The relatively predictable announcements of quarterly 5 percent-to-10 percent price cuts of the past have made way for more market-driven or yield-driven (read "aggressive") pricing as seen in Table 3. This newer pricing scheme allows for more competitive pricing of mainstream products and, to some extent, of leading-edge MPUs. This strategy assumes that forever increasing price/performance of MPUs will continue to spur continual increased demand. We will see if this new trend continues as peripheral products increasingly are required for systems to take full advantage of the raw horsepower of the MPU.

Table 3

Third Quarter 1996 Low-End Pentium Price Estimates (U.S. Dollars)

Product	Q4/95	Q1/96	Q2/96	Q3/96	Q4/96	1996
Pentium-75	150.00	100.00	90.00	80.00	80.00	87.50
Pentium-90	225.00	182.00	120.00	100.00	90.00	123.00
Pentium-100	281.00	199.00	120.00	100.00	90.00	127.25

Source: Dataquest (June 1996)

Good News/Bad News: Price Declines and Supplier Relations

Most purchasing managers are all too happy to see falling semiconductor prices return. This turn of events could cause some rifts in some strategic supplier relations for users. Questions of moving from quarterly to monthly (the extreme—semimonthly) price reviews and inventory management concerns have begun to wear thin on some semiconductor suppliers. Although spot market pricing of semiconductor commodities (estimated to be less than 20 percent of the market) is expected to remain below that of contract pricing for the next quarter, large users continue to look for ways to lower total costs. Long-term supply lines of products require equitable costing for both parties. With overall semiconductor supplies expected to continue to outpace demand for the rest of 1996, shared management of inventories by users and suppliers is being aggressively examined. Shorter delivery turnaround, electronic data interchange (EDI) inventory involvement by the supplier, and, at the extreme, physical inventory of a supplier held at the user site are among the plans being viewed by many as a way to keep total costs declining faster as actual price cuts slow.

Dataquest Predicts

Dataquest continues to see overall demand for semiconductors as relatively strong for the rest of this year. Overall end-system demand remains healthy. As the supply/demand equation continues to use price as the equilibrator, Dataquest expects the spot market to bottom out and rise toward cost-based price points. The narrowing of the gap between the spot market and contract prices will come as contract pricing gradually declines toward the cost floor, while selected spot prices will rise above that point. As in the past, efficiencies will continue to improve, pushing this cost point continually lower. The shift from market pricing (that is, from the third quarter of 1993 to the fourth quarter of 1995) to the current cost-based pricing model generally causes abrupt, large price swings. Once proximity to cost is near, pricing aligns itself with cost factors. Barring any dramatic shift in end-system demand, this gradual cost-based price outlook will remain the norm for the next one to 12 months.

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Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

ASIC Market: 1995 Is a Record-Breaking Year

Abstract: *After a record-breaking year with 29 percent growth for ASIC sales and with most suppliers experiencing huge growth rates, Dataquest examines the results of the 1995 ASIC market share rankings. This document 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 Evelyn Cronin

At various times 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 the costly state-of-the-art process technology. Not for the faint of heart, suppliers' price cut wounds are now healing. For the third year running, suppliers experienced increased volumes and profits in 1995 as users better understand the advantages and limitations of ASIC solutions. In fact, 1995 was a record-breaking boom year for nearly all suppliers, with some posting revenue growth up to 102 percent (Altera).

This document provides ASIC users 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 document 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 that 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 that are 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 MOS PLDs include field-programmable gate arrays, (FPGAs) and complex PLDs with densities up to 100,000-plus gates. Full-custom devices are ASICs customized using a full set of masks and using manual place and route.

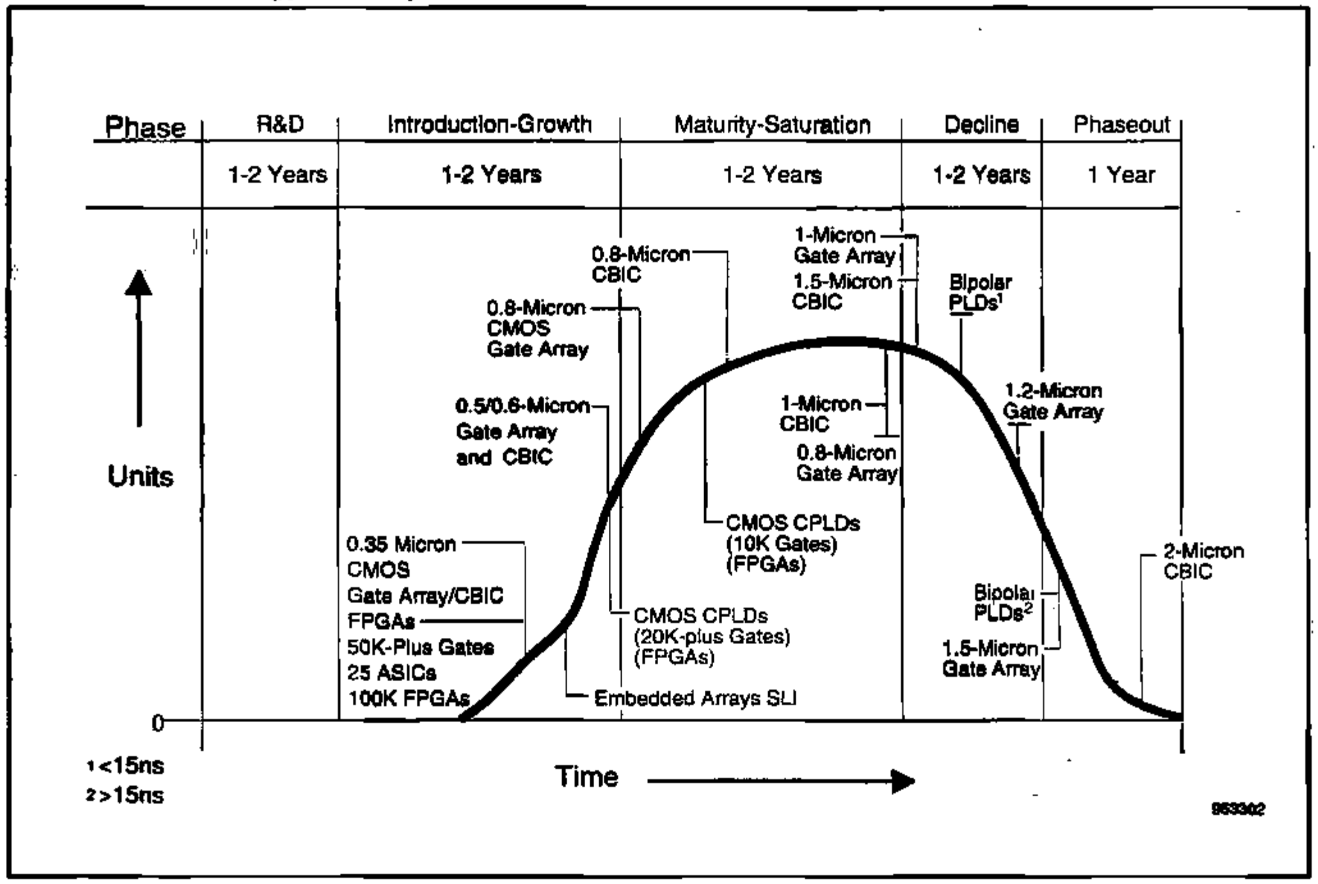
ASIC Technology Life Cycles

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, and complex and simple PLDs as of May 1996). 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. As seen in Figure 1, this arena consists primarily of submicron silicon technology and niche BiCMOS and gallium-arsenide (GaAs) families. Because of many factors (mainly cost), Dataquest expects CMOS to remain the predominant ASIC technology of the future. The battle over CMOS versus BiCMOS and GaAs 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

Figure 1
Product/Technology Life-Cycle Curve for the ASIC Market



Source: Dataquest (May 1996)

data processing and communications market in 1995. Every segment, save bipolar, grew at record levels—1995 was truly a boom year.

With the continued squeeze to reduce new product lead times for ASIC users, 1995 saw the development of ASIC core or macro libraries that are reused for new design. This process of building up a new ASIC design from existing predesigned cores is termed system-level integration (SLI). This has proved to be popular and has now been included in the introduction stage of the life-cycle curve.

Embedded arrays are also proving popular. For telecommunications, this often means that flash or fast SRAM is embedded into the ASIC. Again, it has been added to the life-cycle curve, in the introduction level, remaining slightly ahead of SLI on the curve.

Starting out at the introduction stage of the life cycle curve are 100,000-plus-gates FPGAs and CPLDs. The 0.35-micron CMOS gate arrays and CBICs and FPGAs with 50,000-plus gates are further up the introduction stage of the life cycle. The 0.5- and 0.6-micron gate arrays and CBICs are well inside the growth stage, with CMOS CPLDs' with 20,000-plus gates (FPGAs) almost at the end of the growth stage.

No new products have migrated into the maturity-decline stage of the life cycle. The 1.0-micron gate arrays and CBICs are nearing the end of this phase. BiCMOS technology is well into the saturation stage. Only the 0.8-micron CBICs and gate arrays, along with CMOS CPLDs' with 10,000-plus gates (FPGAs) remain in the maturity section.

The decline portion of the curve now contains fast (less than 15ns) PLDs, 1.0-micron gate arrays, and 1.5-micron CBICs, while the slower PLD products and 1.2-micron gate arrays barely remain in the decline segment.

The phaseout group now includes 1.5-micron gate arrays, slow (greater than 15ns) bipolar PLDs, and the 2.0-micron CBIC family. 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 rapid 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 analyses 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 1995 worldwide overall 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 1995 Ranking (Factory Revenue in Millions of U.S. Dollars)

Rank	Market Share (%)	Company	Gate Arrays MOS/ BiCMOS	CBIC MOS/ BiCMOS	PLDs MOS/ BiCMOS
1	10.1	NEC	1	6	-
2	9.3	Fujitsu	2	8	-
3	8.1	LSI Logic	3	2	-
4	6.5	Toshiba	4	10	-
5	5.8	Texas Instruments	5	4	10
6	5.6	AT&T	19	1	6
7	5.0	IBM	7	3	-
8	4.3	Hitachi	6	15	-
9	3.6	Xilinx	-	-	1
10	3.4	VLSI Technology	13	5	-
Segment Subtotals ($B)	-	-	5.98	5.75	1.70
Total Market ($B)	14.26	-	-	-	-

Note: The total market value includes some segments not shown.
Source: Dataquest (May 1996)

The year 1995 was an exceptional year for ASICs, with worldwide total sales (MOS/BiCMOS, bipolar, excluding full custom) growing a phenomenal 29 percent. The highest growth rate came from MOS/BiCMOS PLDs with revenue up 50 percent. This was followed by MOS/BiCMOS cell-based ICs, which grew nearly 40 percent, and MOS/BiCMOS gate arrays with 27 percent growth.

On a regional level the North American market grew a very respectable 21.9 percent, followed by Japan at 33.4 percent. However, Japan's dollar growth was inflated partially because of the yen's 8 percent rise in value in 1995. The Asia/Pacific companies exploded with growth pegged at 47.1 percent compared to 1994, while European companies grew a very healthy 29.7 percent in 1995. All in all, a very good year.

NEC

NEC retained the No. 1 position for worldwide ASIC sales for the second successive year, commanding a 10.1 percent market share and growing revenue by some 33 percent. NEC was the largest total gate array supplier, capturing over 16 percent of the market and achieving a healthy 37 percent increase in revenue. However, most of this revenue came from intracompany sales—it ranks No. 3 on the merchant market (behind LSI Logic and Toshiba). While NEC grew its revenue in CBICs by 58 percent (the second highest) and rose from No. 8 in 1994 to No. 6 in 1995, most of its revenue still came from intracompany business. It is only No. 7 on the merchant CBIC market. NEC acknowledge its internal sales dependency and is working hard to improve its external sales. It is working on building up its design libraries to increase its presence in the SLI sector, focusing on PC and workstation segments initially.

Fujitsu

Fujitsu stayed in the No. 2 position for 1994 for overall ASIC sales, growing revenue by 26 percent from 1994 and capturing over 9 percent of the worldwide market (an increase over the 8.8 percent seen in 1994). For MOS/BiCMOS gate arrays, Fujitsu retained its No. 2 position with 14 percent market share and grew a very healthy 31 percent. Most of Fujitsu's revenue came from intracompany sales largely driven by the Fujitsu group's monstrous growth in PCs within the Japanese market. Excluding intracompany sales, it only ranked No. 5 on the merchant market for gate array sales. On CBICs, Fujitsu grew an amazing 95 percent (the joint highest growth rate, shared with LSI Logic) to pull itself into the top 10—it came in at position No. 8. Once again, however, this came mainly from captive intracompany sales—it was No. 8 on the merchant market.

LSI Logic

While NEC and Fujitsu retained respectively the Nos. 1 and 2 positions, for overall ASIC sales, LSI Logic remains the No. 1 merchant market ASIC supplier and retained its overall No. 3 position worldwide. The year 1995 proved to be a groundbreaking year for LSI Logic, with ASIC revenue comfortably surpassing the $1 billion mark—actual revenue was $1.161 billion, a staggering 41 percent increase from 1994. Its commitment to supplying the market with the highest level of technology in both gate arrays and cell-based ICs is paying off. LSI Logic ranked No. 3 for MOS/BiCMOS gate array sales and was the No. 1 merchant market supplier in this category. An area of outstanding growth for LSI Logic was CBICs, where it rose from the No. 6 position in 1994 to No. 2 in 1995—growing its revenue by a staggering 95 percent. LSI Logic continued to offer leading-edge technology to system designers offering standard cell, gate array, embedded arrays, CBICs, and SLIs.

Toshiba

While Toshiba's ranking remained stable at the fourth position for 1995, its revenue shot up by 32 percent, coming in at $923 million, just shy of the $1 billion mark. Its focus has been to grow through focusing on customer (non-Toshiba) gate array requirements. This strategy of merchant market growth is paying off—Toshiba ranks No. 4 for MOS/BiCMOS gate arrays sale but is ranked No. 2 in the merchant market of this category behind LSI Logic. For CBICs, however, Toshiba dropped from ninth in 1994 to tenth position in 1995, but it did managed a healthy revenue increase (up 42 percent from 1994). Toshiba will continue to focus on cutting-edge, high-gate-count MOS and BiCMOS gate arrays for the merchant market. Additionally, Toshiba has signed a multiyear agreement for ASIC design planning methodologies for deep submicron geometries with Synopsys. Toshiba continues to offer a three-day turnaround for prototype gate arrays, which has heightened its visibility as both a volume and quick high-tech ASIC supplier.

Texas Instruments

Texas Instruments (TI) maintained its No. 5 ranking into 1995 for overall ASIC sales, growing market share and its revenue by 18 percent. TI's focus on CMOS and BiCMOS gate arrays has paid off, lifting it from the No. 7 position in 1994 to No. 5 in 1995 and increasing revenue in this category by a very healthy 38 percent and market share to 6.0 percent. On cell-based ICs, however, it fell to No. 4 (from No. 2 in 1994). TI will continue to remain focused on CBICs to gain a slice of this lucrative and fast-growing segment. In line with TI's emphasis on CMOS and BiCMOS technology for gate arrays and CBICs, it has no presence in bipolar gate arrays and CBICs in 1995. For PLDs, TI reduced its revenue by 47 percent in 1995 but managed to stay in the top 10 by coming in at No. 10, with most of the revenue coming from bipolar. This ranking reflects the sale of its complex PLD business to Actel in 1995.

AT&T

AT&T moved up the overall ASIC chart, coming in at the sixth position based on revenue sales for 1995. It grew revenue by 41 percent, the joint second-highest growth level of a top 10 player. While AT&T was well out of the top 10 for gate arrays sales for 1995, it grew revenue an incredible 900 percent to move from No. 34 position in 1994 to No. 18 position in 1995. This is largely because of its MOS/BiCMOS embedded arrays. However, it was in the area of CBICs that AT&T shined the brightest. It continued its assault on the merchant CBIC market, focusing on designs with high intellectual-property content in large unit volumes. Revenue grew a healthy, though not spectacular, 37 percent, and it captured over 11 percent of the market share. AT&T had another solid year in PLDs, rising to the No. 6 position and growing revenue by some 71 percent (the second-highest growth rate in this segment).

IBM

Despite dropping from No. 6 in 1994 to No. 7 in 1995 in overall ASIC sales, IBM 's sales grew by 17 percent, and it remained focused on very high-end ASIC solutions. It maintains its aim of supplying high-density, cost-effective CMOS gate arrays and cell-based ICs. However, in spite of IBM's goal of increasing its presence in the merchant ASIC market, the majority of its gate array sales still come from intracompany sales. IBM dropped to the No. 8 position in gate array sales for 1995, only managing an 8 percent growth increase in this category, and the captive intracompany sales accounted for the majority of its revenue. This put IBM in the unique position of being the only top 10 gate array supplier with single-digit sales growth. In CBICs, however, the picture was a lot brighter. IBM retained its No. 3 position for CBIC sales and grew revenue a healthy 25 percent as the company continued to focus on its high-density system-level designs. However, once again, the majority of its revenue came from intracompany sales.

Hitachi

Although Hitachi maintained the No. 8 position for overall ASIC sales worldwide for 1995, it recorded the lowest growth of all top 10 ASIC suppliers—a mere 8 percent. Gate arrays were still the greatest source of ASIC revenue for Hitachi, but despite a 13 percent revenue growth, it dropped from fifth position to sixth position for 1995. While Hitachi has been trying to grow its merchant gate array sales, the majority of the revenue still came from intracompany sales. This is something that Hitachi still strives to change. In cell-based ICs again Hitachi dropped a place, coming in at No. 15. This is an area Hitachi wants to grow, and it hopes to have success with its new family of high-density CBICs targeted for home-use information electronics and multimedia-compatible equipment applications.

Xilinx

Xilinx swapped positions with VLSI Technology, rising to ninth position for 1995 from tenth in 1994. It experienced the highest revenue growth of all of the top 10 players for 1995 (62 percent). Xilinx was also unique in the top 10 overall ASIC revenue ranking as it derived its entire revenue from PLD sales. Xilinx grew a whopping 62 percent there and captured over 30 percent of the worldwide market share. However, Altera is gaining ground with an outstanding (and unbeaten in 1995) growth of 102 percent. While PLDs traditionally tend to be low-gate-density solutions, Xilinx is pushing the boundaries by offering 40,000-gate FPGA devices.

VLSI Technology

VLSI Technology clung to a top 10 position, falling from ninth in 1994 to tenth in 1995 based on revenue. Market share, however, remained flat at 3.4 percent. VLSI had a weak year in MOS/BiCMOS gate array, dropping to No. 13 position. This is primarily because of its focus on CBICs, where it had a much stronger year. Also, Dataquest has excluded sales from Compass Design Automation tools from VLSI's 1995 revenue. For CBICs, VLSI grew an amazing 46 percent (this would have been nearly 75 percent had Compass' sales been included).

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 help in selecting suppliers for these devices.

Each segment contains a table showing the size of the market in terms of factory revenue during 1995 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 an extremely healthy 27 percent in 1995 after 1994's strong growth of 19 percent. The top five suppliers account for nearly 60 percent (58.7 percent) of the overall market, the same as in 1994. While Asia/Pacific companies recorded an outstanding 62 percent revenue growth, they still remained out of the top 10. Japanese companies achieved revenue growth of 32 percent (albeit, this was aided by yen appreciation) while Europe- and North America-based companies grew 24 percent and 16 percent, respectively.

The Workhorse Gate Array Technology Remains at 0.8- to 1.0-Micron

Figure 1 illustrates 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 over 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 (see Table 2). 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 on comparing 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.

Table 2
Supply Base for MOS/BiCMOS Gate Arrays (Percentage Share of Factory Revenue)

Company	Market Share (%)
NEC	16.1
Fujitsu	14.0
LSI Logic	11.3
Toshiba	11.3
Texas Instruments	6.0
Hitachi	5.8
IBM	5.1
Mitsubishi	4.4
Motorola	3.5
GEC Plessey	2.0
Others	20.5
Total	100.0

Note: The total market is valued at $5.98 billion.
Source: Dataquest May 1996

Supply Base for MOS/BiCMOS CBICs

Table 3 provides information on the market size and leading suppliers of MOS/BiCMOS CBICs. The year 1995 was hot for CBICs, with worldwide revenue growing a staggering 40 percent. While traditionally the North America-based companies dominated the top, the Japanese companies have entered this segment in a big way, primarily by meeting the consumer-led demands of their domestic market. In terms of revenue growth for 1995, Japanese companies led the way, growing 53 percent, followed by North America-based companies (with 36 percent growth) and Europe-based companies (up 33 percent from 1994).

Figure 1 shows 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 applications 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 1995. For PLDs, 1995 was a year of record growth, with revenue up 50.1 percent. Bipolar PLDs lost ground, with revenue falling 37 percent. However, MOS sales continued to grow. MOS/BiCMOS CPLDs grew an amazing 89.2 percent, and FPLDs recorded a 58.7 percent revenue increase. SPLDs, however, grew by a more modest 6.3 percent. This market has become even more top heavy, with more than 87 percent of the market consolidated in the top five companies, up from 81 percent in 1994.

Table 3
Supply Base for MOS/BiCMOS CBICs (Percentage Share of Factory Revenue)

Company	Market Share (%)
AT&T	11.3
LSI Logic	8.4
IBM	7.3
Texas Instruments	7.1
VLSI Technology	6.7
NEC	6.0
Hewlett-Packard	6.0
Fujitsu	5.5
Symbios	5.0
Toshiba	4.3
Others	32.4
Total	100.0

Note: The total market is valued at $5.75 billion.
Source: Dataquest May 1996

Table 4
Supply Base for MOS/BiCMOS PLDs (Percentage Share of Factory Revenue)

Company	Market Share (%)
Xilinx	30.6
Altera	23.6
AMD	15.9
Lattice	10.9
Actel	6.3
AT&T	4.2
Cypress Semiconductor	3.3
Atmel	1.1
International MOS Technology	1.0
Texas Instruments	0.9
Others	2.2
Total	100.0

Note: The total market is valued at $1.7 billion.
Source: Dataquest (May 1996)

Maturation has now taken over some segments of this market. The 2,000-to-10,000-gate-equivalent segment remains in the maturity phase as volumes ramp up for these devices as the 20,000-gate-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 or market-entry designs for larger-volume, higher-density gate arrays.

Dataquest Perspective

The record-breaking growth seen in the ASIC market in 1995 parallels the overall semiconductor boom. It also shows that most system designers are choosing ASIC solutions to meet their requirements.

The low-density (less than 20,000 gates) ASIC market is satisfied by PLDs, with higher-density (more than 100,000 gates) requirements using gate arrays and CBICs. Embedded arrays, for example, ASICs with fast SRAM or flash diffused into the array's base wafer, now have sales of over $700 million and are growing at over 30 percent each year. Similarly, SLI is taking off in a big way. This means that suppliers must build up value-added design cell libraries (either through development or acquisition) and sort out any intellectual property rights (IPR) issues.

Although 1995 was a boom year for ASICs, Dataquest predicts that 1996 will not grow at the same record-breaking level. Dataquest forecasts that semiconductors will grow below 8 percent for 1996 worldwide. While ASICs will grow at a higher level than this, there are certainly clouds on the horizon. In order for ASIC suppliers to weather the storm and remain profitable and successful, they must focus on their key strengths. With new ASIC-eating markets such as set-top boxes, telecom, and consumer applications growing, ASIC suppliers must align themselves with the right customer base that utilizes their core skills.

As product time to market reduces and with more and more front-end design moving to the suppliers, customers are evaluating their ASIC supplier on system knowledge, turnaround time, cell libraries, IPR, and cost. Suppliers that can meet these needs will increase market share at the expense of those that cannot.

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Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

April Procurement Pulse: Order Rates and Lead Times Fall Further while Inventories Rise

Abstract: *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 also notes price status by semiconductor product family and package type, as well as key problems facing semiconductor users.*
By Mark Giudici

Semiconductor Order Rate Forecast Is Lowest Recorded Since December 1992

As seen in Figure 1, the outlook for semiconductor order activity is expected to drop further relative to the past few months. This new low dollarized index is 49 percent lower than last month's index, reflecting lower than needed semiconductor purchases in dollars. It now appears that the buoyancy of the current electronics market is benefiting from overall price declines where steady unit volumes are being ordered at lower dollar outlays. The overall sample has seen price cuts in all areas tracked in this survey—DRAM, microprocessors, logic, flash memory, and SRAM. DRAM pricing for the overall sample fell 12 percent, on average, in March after a 19 percent average drop noted in February. The computer subset of the respondents also saw an 11 percent drop in DRAM pricing in March after a free fall averaging 33 percent in February. Although overall prices continue to decline, pricing for different semiconductor packaging (except for one respondent using TSOP) has reached parity. Improvement in availability is providing cost relief in many areas, and the outlook through the next six to nine months is for more of the same.

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Lead Times for Semiconductors Also Slip Below 10 Weeks

Figure 2 shows that the average lead time for respondents in March fell to 9.8 weeks, the lowest seen since September 1992! The rapid fall of average lead times correlates directly to increased availability of components relative to demand. The transition from a seller's to a buyer's market is nearing completion as procurement managers work aggressively to lower costs and improve supplier support levels, rather than focusing on product availability. Of the entire sample, only two respondents noted problems with products, those being ASICs and microprocessors. For the majority of the respondents and the overall market, problem products are a thing of the past, and sights are now set on predictable pricing. Over half of this month's respondents cited price fluctuations as the key issue now facing them. The spot market will continue to be volatile, vacillating around the declining contract price curve and causing uncertainty for some buyers. The overall trend, however, is for continued good availability, consistently declining prices, and short lead times (under 10 weeks) for the next six months.

Semiconductor Inventories Jump Up

Figures 3 and 4 show that, despite steady system demand, semiconductor inventory levels continue to rise, especially for the computer subset of Dataquest's sample. Even though order rates are forecast to decline as noted above, the upward trend in overall and computer semiconductor stocks generally precedes a slow downturn in overall system sales. The overall targeted and actual semiconductor inventory levels for March were 21.1 days and 26.1 days, respectively, compared with February's 18.7-day and 23.0-day inventory levels. The computer subset now exceeds the overall average, with target and actual inventory levels of 20.0 days and 27.3 days, compared with February levels of 15.0 and 19.3 days on hand. By historic standards, these semiconductor inventory levels are reaching the outer bounds of acceptability by financial departments. We expect to see some lowering of inventory levels in the near future to keep overall costs more controlled.

Dataquest Perspective

Availability of semiconductors has improved markedly since Dataquest's last report in January. Prices and lead times have declined, in part because of improved levels of supply, but also because of lower levels of expected demand. Although Dataquest forecast lower growth rates for PCs and other electronics products relative to 1995, the overall trend followed an upward growth slope. Some suppliers expected a steeper growth increase than is now shaping up, in aggregate balancing out the supply and demand equation that for over two years has favored suppliers. With inventory levels relatively high and semiconductor order rates relatively low, Dataquest expects to see more balance in these indexes in the next few months—especially as midyear financials gain attention. Allocations are, for the time being, yesterday's problem as suppliers now reluctantly follow prices down historic decline rates. Dataquest expects to see continued improvement in semiconductor availability through midsummer, when DRAM and microprocessor price elasticity may come into play by increasing overall unit demand. Declining prices will be with us, however, for the remainder of this year.

Figure 1
Averaged Monthly Semiconductor Orders

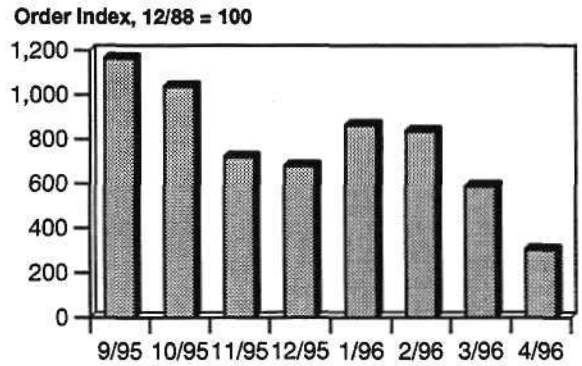


Figure 2
Averaged Semiconductor Lead Times

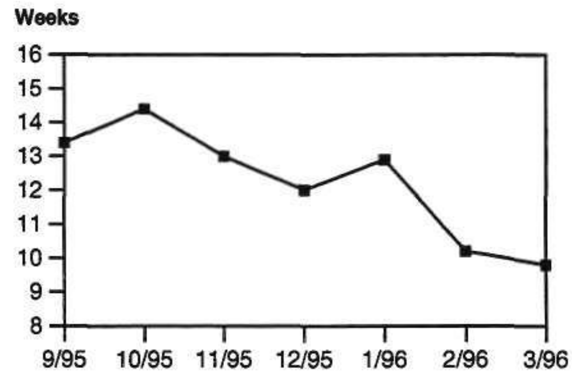


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

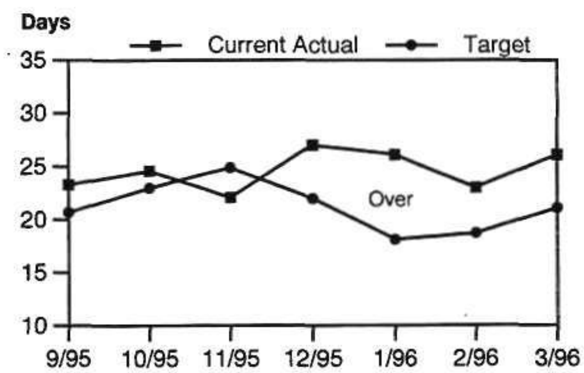
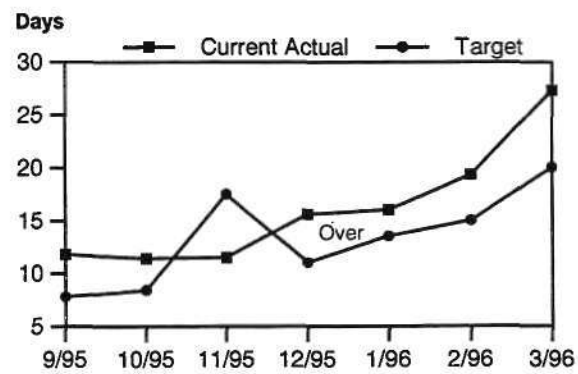


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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Source: Dataquest (April 1996)

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Market Analysis

1996 Semiconductor Cost Model Update

Abstract: *This article updates the Dataquest semiconductor cost model and IC package cost table. Detailed examples of the 16Mb DRAM and a typical gate array cost model that use the latest cost variables follow a brief review of the model's description.*
By Mark Giudici

DRAM and ASIC Cost Update 1996: Will Cost Again Affect Price?

Procurement departments often use cost model analysis in two ways: for near-term cost/price optimization and for aiding long-range system cost analysis. Also, using semiconductor cost models during years of technology transition (that is, DRAM density crossover) is often useful in positioning procurement strategies in line with a company's system offering. We are beginning to see signs of a transition from a seller's to a buyer's market as over two years of very strong capital equipment investment comes on line.

Dataquest Cost Model Synopsis

The Dataquest semiconductor cost model uses 16 variables of semiconductor manufacture (once past the processed wafer stage). These variables cover the main areas where costs accrue and processes improve. The variables with the most influence over cost are semiconductor process, wafer size, die size, sort yield, package type, and final test yield.

Cost Model Applications

Semiconductor cost models are predominantly used to compile costs for use in near-term contract negotiations. By identifying cost reduction areas,

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price negotiation results often benefit the parts buyer. Applying experience-curve theory to cost model applications can give both short- and long-term cost/price scenarios that can be a basis for strategic planning.

Strategic use of cost models in long-range planning has been underused because of the indirect influence of cost over price as the time horizon expands. Some users apply different learning curves to individual variables in the model in combination with price forecast analysis. In this way, one can better understand future trends and have alternative strategies at hand if any variable actually differs from its expected trend line. We suggest this use of cost modeling as a part of a proactive strategic procurement plan.

Cost versus Price

In a competitive market, semiconductor manufacturers pass cost reductions on to their customers. Therefore, a knowledge of semiconductor costs and cost trends is useful for projecting long-term procurement costs and selecting the most cost-effective semiconductor device for a particular application.

The cost/price relationship for semiconductor products varies from product to product, company to company, and with time as a function of business conditions. One way to perform cost/price to analysis is to monitor prices and costs over a period of several years for selected product types and identify the average gross margin for these types. By using this procedure, semiconductor users can develop a good feel for the cost/price relationship for the semiconductor products they buy.

Cost Factors

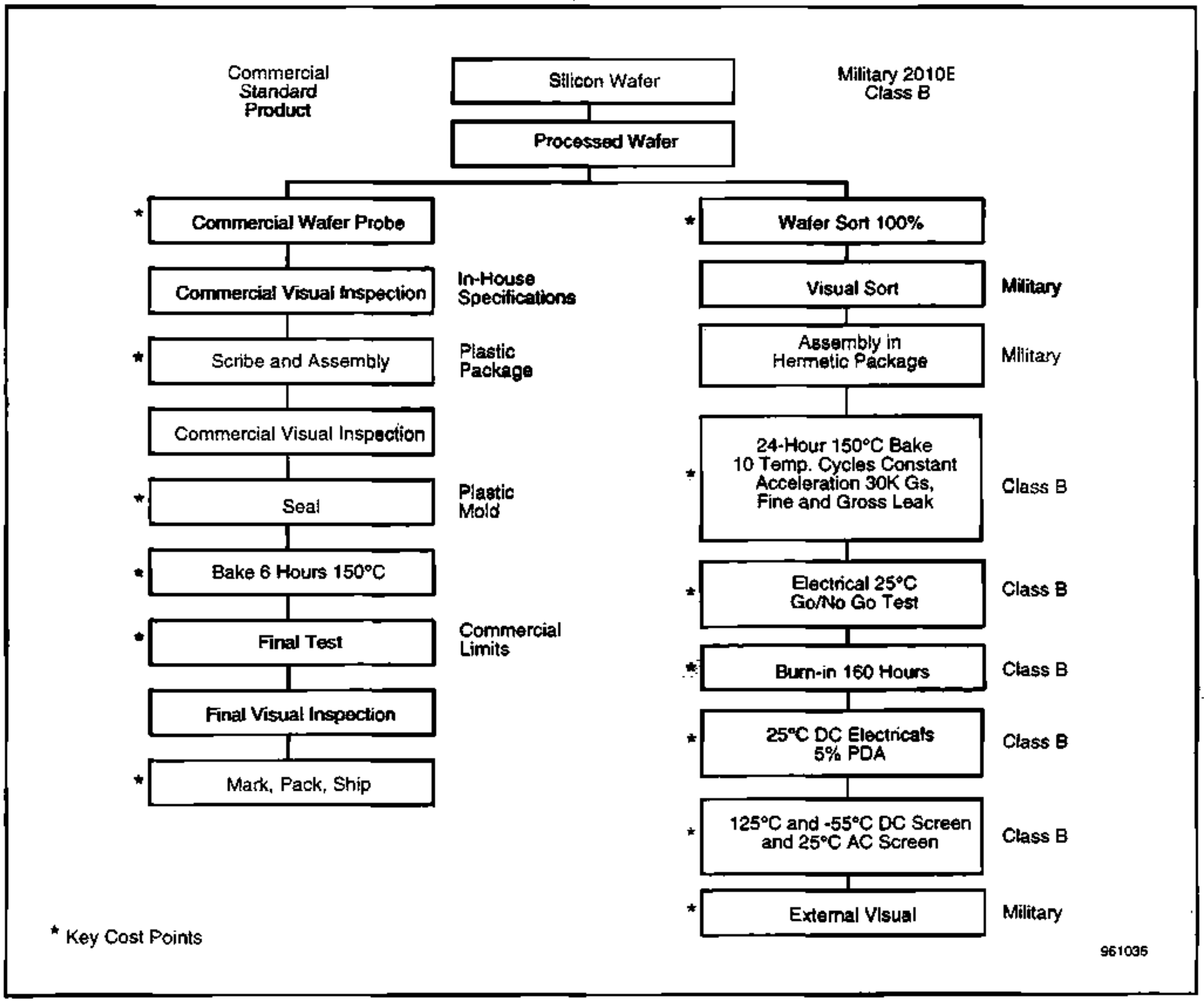
As mentioned above, the key factors affecting the cost of a finished semiconductor device are the semiconductor process, wafer size, die size, sort yield, package type, and final test yield. The cost of a semiconductor incrementally increases by adding the cost of each step in the manufacturing process to the finished product. Figure 1 illustrates the typical manufacturing process flow for semiconductor devices. Our cost model categorizes costs into the following four areas:

- Wafer processing and die sort
- Assembly
- Final test
- Screening, qualification, mark, pack, and ship

The manufacturing process begins with a raw, unprocessed silicon wafer that costs from under $15 (100 mm wafer) to about $120 (200 mm wafer). After completing more than 100 processing steps, the cost of a processed wafer is 10 to 30 times the initial cost of the unprocessed wafer. The wafer cost is a function of the following:

- The number of masks
- The photolithographic requirements of the process used
- The cleanroom environment required by the process

Figure 1
Commercial and MIL-STD Manufacturing Flow



Source: Dataquest (February 1996)

A complex relationship exists among all of these elements and the end cost of the product. Some of these interacting relationships involve the depreciation schedule of a fabrication plant (that is, a $500 million to $1 billion fab cost over a five-year period) in relation to wafer output, process learning curves within a fab, back-end test cost amortization, and royalty payments (if required) by process or device type.

The cost of a wafer increases with each layer required. Additional mask layers could introduce more defects and decrease yields. In general, more complex processes produce more expensive dies. Table 1 lists the typical number of mask layers for most common integrated circuit processes.

Wafer costs increase as device features become smaller. However, smaller features result in more die per wafer. Although the wafer cost will be higher, the cost per function per chip often will be lower because of the increased density.

Table 1
Number of IC Process Mask Layers

Process	Single-Layer Metal	Multilayer Metal
Schottky TTL	7	9
Bipolar Linear	7 to 9	9 to 11
ECL	8	10
NMOS	8	10
HMOS	9	11
CMOS	10	12 to 15
HCMOS	11	13 to 16
BiCMOS	14	16 to 20

Source: Dataquest (February 1996)

The class of fab or cleanroom environment has a very large impact on the final cost of a semiconductor device. As device features become smaller, circuits become more susceptible to yield loss because of particles in the fab environment (that is, a 0.5-micron particle would not be a major problem in a 1.0-micron fab line, but the same particle would be catastrophic in a 0.6-micron line).

Package Costs

The type of packaging a semiconductor device uses often makes up a large portion of the overall semiconductor cost. For example, going from a ceramic to a plastic package using the same die will often halve the manufacturing cost and related price. Table 2 shows the latest cost estimates for semiconductor packaging in 1996. This table highlights how different packaging options can alter finished semiconductor pricing.

Cost Model Formula

Dataquest's semiconductor cost model uses the variables and algorithms shown in Table 3 to estimate semiconductor costs. Because of the flexibility of the model, a variety of semiconductor devices can be costed out according to many of the key variables noted earlier (that is, die size, wafer size, process, and package, among others). For a detailed description of the cost model variables, please refer to the July 27, 1992, Semiconductor Procurement Worldwide Dataquest Perspective article on cost model analysis.

Cost Model Examples

Tables 4 and 5 illustrate how cost models can highlight the cost differentials of different semiconductor technologies. These models use best-case variables from information gathered in press and trade articles and forecast yield/cost improvements based on historical trends from previous products.

The above cost models illustrate how world-class manufacturers can experience manufacturing economies of scale as units ramp up in production volume. Comparing these models with actual market prices for the same period is useful in learning where a given supplier stands concerning technology and production efficiency.

Table 2
Total (Die-Free) Assembled Package Cost, 1996 (Dollars per Package) Volume Production, More than 100,000 Units

No. of Pins	Plastic DIP	CER DIP	Side-Braze	Ceramic PGA	Plastic PGA	Plastic Chip Carrier PLCC	Ceramic Chip Carrier (Leadless) LLCC	Ceramic Chip Carrier (Leaded) LCC	SOJ	SOIC	TSOP Type I	TSOP Type II	SSOP	Plastic QUAD	TQFP 1.4mm Body	TQFP 1mm Body	Ceramic QUAD	Metal QUAD	TAB Tape/ Site	Ceramic BGA	Plastic BGA Single-Layer	Plastic BGA Multilayer
8	0.07	0.21	1.25							0.06												
14	0.09	0.22	1.65					1.15		0.10	0.20											
16	0.11	0.26	1.65				0.90	1.20		0.11	0.20											
18	0.12	0.30	1.80			0.19	1.00	1.30		0.14												
20	0.15	0.30	2.10			0.19	1.10	1.45	0.28	0.15	0.29	0.55	0.21									
22	0.18	0.35	2.55				1.20		0.30	0.21	0.40											
24	0.20	0.41	2.85				1.30	1.75	0.34	0.22	0.47	0.55										
28	0.23	0.49	3.40			0.21	1.50	2.05	0.38	0.25	0.50	0.55	0.37									
32	0.32	0.68	3.95			0.29	1.70	2.40	0.40	0.35	0.55	0.63	0.43		0.46							
40	0.35	1.00	4.95				2.30	2.90	0.40	0.42	0.60	0.70		0.45								
44	0.36					0.31	2.45	3.25			0.72			0.50	0.58	0.60						
48	0.50		6.20				2.70						0.75	0.53	0.61							
52						0.45	3.10							0.60								
56													1.08									
64	0.60			4.65	1.52		3.75	4.55						0.64	0.68	0.75			0.92	1.12		
68		3.30		4.90	2.13	0.56	3.90							0.75			5.95		0.97	2.11		
84		4.00		6.05	4.39	0.68	4.80							0.90	0.70		6.92		1.20	4.54		
100				7.50	5.70		5.30							0.95	0.78	1.13	11.80	4.00	1.43			
128				9.50	7.42									1.30	1.70		13.60	6.78	1.83	8.06		
132				10.00	8.03									1.40	1.80		15.90		1.89			
144				10.90	9.58									1.55	1.98		17.50	8.93	2.25	11.09	2.95	4.52
160				15.20	10.64									1.80	1.99		19.50	9.75	3.74	12.80		
164																			3.84			
169																					3.60	5.91
184																			4.31	16.56		
196															2.55				4.59			
208				17.85	13.83									2.40	3.00		25.40	12.10	5.41	20.38		
225																					4.85	7.89
232														2.95				18.90	6.03			
240																		19.20	6.24	24.00		
244				21.30	16.23									3.25			30.90		6.34	25.38		
256					17.51									3.85	3.65		39.60	21.76	10.32	27.14	5.50	9.50
296				46.10															11.93			
304														5.80				24.47	12.25	33.44	6.75	10.64
308																			13.06			

(Continued)

Table 2 (Continued)
Total (Die-Free) Assembled Package Cost, 1996 (Dollars per Package) Volume Production, More than 100,000 Units

No. of Pins	Plastic DIP	CER DIP	Side-Braze	Ceramic PGA	Plastic PGA	Plastic Chip Carrier PLCC	Ceramic Chip Carrier (Leadless) LLCC	Ceramic Chip Carrier (Leaded) LCC	SOJ	SOIC	TSOP Type I	TSOP Type II	SSOP	Plastic QUAD	TQFP 1.4mm Body	TQFP 1mm Body	Ceramic QUAD	Metal QUAD	TAB Tape/Site	Ceramic BGA	Plastic BGA Single-Layer	Plastic BGA Multilayer
313																					6.90	
324				50.10																	7.00	11.95
352																					7.50	12.50
361																			18.77	40.61		
368																	390.00					
376				57.80															19.55			
442																	460.00					
475																			24.07	55.82		
480																					12.80	16.80
504				80.64	39.56												55.44	44.45	26.21	59.88	14.80	19.60
625																			32.50	76.25		
672																			34.94			
Package Materials																						
Lead-frame	C194	A42	A42	A42	Cu	C151	A42/ LDCC		C194	C194	A42/ Cu	A42/ Cu	Cu	A42	Cu	Cu	A42	Cu	Cu with Sn Plate	Cu Vias	Cu Vias	Cu Vias
Lead Form	TH	TH	TH	TH	J	J	Gull/ None		Gull /J	Gull/ J	Gull	Gull	Gull	Gull	Gull	Gull	Gull	Gull	Gull	Solder	Solder	Solder
Wire	Au	Al	Al	Au	Au	Au	Al		Au	Au	Au	Au	Au	Au	Al	Al	Al	Au	NA	Au	Au	Au
Lid	Epoxy	Ceramic	Au/ Kovar	Au/ Kovar	Au/ Epoxy	Epoxy	Au/Kovar		Epoxy	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy	Au/ Kovar	Al Cap	NA	Au/Pb-Sn	Au/ Pb-Sn	Au/Pb-Sn
Preform	NA	Glass	Au/ Sn	Au/Sn	NA	NA	Au/Sn		NA	NA	NA	NA	NA	NA	NA	NA	Au/Sn	NA	NA	NA	NA	NA

NA = Not applicable
Source: Dataquest (February 1996)

Table 3
Semiconductor Cost Model Algorithms or Variables

Section	Algorithm or Variable
Wafer Sort	
Wafer Size (Diameter in Inches)	=A
Capacity Utilization (%)	=B
Geometry (Microns)	=C
Processed Wafer Cost ($)	=D
Die Area (Square Mils)	=E
Active Area Factor	=F
Number of Masks (Type of Process)	=G
Defect Density per Square Inch/per Mask	=H
Gross Die per Wafer	=I =(0.75*pi*(A/2)^2*10^6)/E
Processed Wafer Cost per Gross Die ($)	=J =(D/I)
Test Cost per Hour ($)	=K
Wafers Tested per Hour	=L =1/(((#*I)/60)/60)
Wafer Sort Cost per Gross Die ($)	=M =(K/L)/I
Cost per Gross Die at Wafer Sort ($)	=N =(J+M)
Wafer Sort Yield (%)	=O =2.718^((-H*G)*E)
Cost per Sorted Die ($)	=P =N*100/O
Assembly	
Material Cost/Sorted Die + Package Cost ($)	=Q
Number of Package Pins	=R
Assembly Yield (%)	=S
Cost per Assembled Die ($)	=T =(P+Q)/S*100
Final Test	
Test Time per Die (Seconds)	=U
Cost per Hour of Testing	=V
Test Cost per Die ($)	=W =U*V/3600
Final Test Yield (%)	=X
Cost per Final Tested Unit ($)	=Y =(T+W)/X*100
Mark, Pack, and Ship	
Cost at 99 Percent Yield (%)	=Z =(Y*0.01)
Total Fabrication Cost per Unit ($)	=AA =Y+Z
Foreign Market Value (FMV) Formula Adders	
R&D Expense (15 Percent)	=AB =0.15*AA
SG&A Expense (10 Percent)	=AC =(AA+AB)*0.10
Profit (8 Percent)	=AD =(AA+AB+AC)*0.08
Constructed FMV	=AE =(AA+AB+AC+AD)

= Test seconds per die
Source: Dataquest (February 1996)

Table 4
1996 ASIC Cost Model (60,000 Gates; Excludes Nonrecurring Engineering Charges)

	PQFP-208 0.8 Micron CMOS	PQFP-208 0.6 Micron CMOS	PQFP-208 0.8 Micron CMOS	PQFP-208 0.6 Micron CMOS
Wafer Sort				
Wafer size (inches diameter)	6	6	8	8
Processed wafer cost ($)	500.00	550.00	1,352.00	1,550.00
Die area (square mils)	110,000	97,000	110,000	97,000
Number of Masks	16	16	16	16
Defect density per square inch per level	0.63	0.63	0.63	0.63
Gross die per wafer	231	262	411	466
Processed wafer cost per gross die ($)	2.1614	2.0965	3.2874	3.3235
Test cost per hour ($)	76.00	76.00	76.00	76.00
Wafers tested per hour	1.04	0.91	0.58	0.51
Wafer sort cost per gross die ($)	0.3167	0.3167	0.3167	0.3167
Cost per gross die at Wafer Sort ($)	2.4780	2.4132	3.6041	3.6401
Wafer sort yield (%)	58	62	58	62
Cost per sorted die ($)	4.2951	3.9194	6.2468	5.9122
Assembly				
Material cost/sorted die ($)	2.40	2.40	2.40	2.40
Number of pins	208	208	208	208
Assembly yield (%)	90	90	90	90
Cost per assembled die ($)	7.4389	7.0216	9.6076	9.2358
Final Test				
Test time per die (sec.)	10.00	10.00	10.00	10.00
Cost per hour of testing ($)	76.00	76.00	76.00	76.00
Test cost per die ($)	0.2476	0.2476	0.2476	0.2476
Final test yield (%)	90	90	90	90
Cost per final tested unit ($)	8.5406	8.0769	10.9502	10.5371
Mark, Pack, and Ship				
Cost @ 99% yield (%)	0.0854	0.0808	0.1095	0.1054
Total fabricated cost per net unit ($)	8.6260	8.1577	11.0597	10.6425
Price Formula Adders				
R & D expense (35%)	3.02	2.86	3.87	3.72
S G & A expense (15%)	1.75	1.65	2.24	2.16
Profit (30%)	4.02	3.80	5.15	4.96
Constructed Foreign Market Value (FMV)	17.41	16.46	22.32	21.48

Source: Dataquest (February 1996)

Table 5
1996 16Mb DRAM Cost Model

	1995	1996	1998	2000
Wafer Sort				
Wafer size (inches diameter)	8	8	8	8
Capacity Utilization (%)	100.00	100.00	100.00	100.00
Geometry (microns)	0.60	0.50	0.40	0.35
Processed wafer cost ($)	1,350	1,350	1,500	1,550
Die area (square mils)	155,000	139,800	118,575	94,860
Active area factor	1.00	1.00	1.00	1.00
Number of Masks	16	16	16	16
Defect density per square inch	0.063	0.063	0.063	0.063
Gross die per wafer	243	270	318	397
Processed wafer cost per gross die ($)	5.55	5.01	4.72	3.90
Test cost per hour ($)	110.00	110.00	110.00	110.00
Wafers tested per hour	0.08	0.11	0.13	0.10
Wafer sort cost per gross die ($)	5.50	3.67	2.75	2.75
Cost per gross die at Wafer Sort ($)	11.05	8.67	7.47	6.65
Wafer sort yield (%)	46	50	55	62
Cost per sorted die ($)	23.99	17.45	13.51	10.69
Assembly				
Material cost/sorted die—SOJ pkg.($)	0.38	0.38	0.38	0.38
Number of pins	26	26	26	26
Assembly yield (%)	99	99	99	99
Cost per assembled die ($)	24.61	18.01	14.03	11.18
Final Test				
Test time per die (sec.)	30.00	30.00	20.00	20.00
Cost per hour of testing ($)	90.00	90.00	90.00	90.00
Test cost per die ($)	0.75	0.75	0.50	0.50
Final test yield (%)	85	90	90	90
Cost per final tested unit ($)	29.84	20.84	16.15	12.98
Mark, Pack, and Ship				
Cost @ 99% yield (%)	0.30	0.21	0.16	0.13
Total fabricated cost per net unit ($)	30.14	21.05	16.31	13.11
FMV Formula Adders				
R & D expense (15%)	4.52	3.16	2.45	1.97
S G & A expense (10%)	3.47	2.42	1.88	1.51
Profit (8%)	3.05	2.13	1.65	1.33
Constructed Foreign Market Value (FMV)	41.17	28.76	22.28	17.90

Source: Dataquest (February 1996)

Dataquest Perspective

The individual unit cost of a semiconductor is the most tangible variable in the total cost of a semiconductor device. Understanding cost models and the variables that go into a model allows for more efficient and educated allocation of resources, both in planning and in the execution of those plans. By applying different assumptions to different variables in the model, one may uncover areas of cost not considered important initially. Often, many different "what if" scenarios are required to best use cost modeling in long-range system analysis. As different suppliers improve yields and lower costs, individual company price points can hint at efficiency gains or losses for differing technologies (ASICs) or the next-generation products.

Models are inherently flexible. If historical data differs from calculated model results, updates quickly correct inconsistencies. Checking and updating a model against known data ensures that the model is correct and current. Revisions to the existing algorithms to match reality better should be made only when basic changes occur, not for perturbations that deviate from the norm.

Those in procurement use cost modeling and experience-curve analysis for both short-term and long-term contract negotiations. The current transition in market dynamics from a seller's to a more balanced market again allows use of cost-base pricing. Good communication with suppliers regarding yield improvements or other cost savings in combination with cost model use can potentially allow price reductions for astute procurement groups. Periodic "reality checks" of the model assure planners that they used the best information available at the time. Using cost modeling in this way provides a tangible benchmark for procurement groups to use with their suppliers in terms of cost and price reduction for critical semiconductor parts.

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Perspective

Semiconductor Supply and Pricing Worldwide

Event Summary

Dataquest's Preliminary 1995 Memory Market Shares: Which Suppliers Have Momentum—and Why?

Abstract: *Dataquest's Semiconductor group analysts held a telebriefing in early January. The briefing highlighted the preliminary 1995 ranking of suppliers of DRAM, SRAM, flash, and MOS memory ICs. This report provides the opening statement and tables used in the briefing.*
By Ron Bohn, Jim Handy, and Mark Giudici

Introduction

Dataquest's Semiconductor group analysts held a telebriefing on January 5, 1996. The analysts who participated were Ronald Bohn and Jim Handy of the Memories Worldwide program and Mark Giudici of the Semiconductor Procurement Worldwide program.

Worldwide MOS Memory Market Ranking

Table 1 provides rankings of the top 10 MOS memory suppliers. (This table was not discussed during the telebriefing.) It serves as a backdrop for the rankings in the DRAM, SRAM, and flash markets.

Worldwide DRAM Market Ranking

Table 2 shows the preliminary 1995 worldwide market share ranking for DRAM suppliers. The table highlights supplier rankings and market share percentages.

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Table 1
Preliminary Leading Suppliers of MOS Memory (Billions of U.S. Dollars; Based on Estimated 1995 Worldwide Revenue)

1995 Rank	1994 Rank	Supplier	Revenue	1995 Market Share (%)
1	1	Samsung	7.34	13.2
2	3	NEC	5.43	9.7
3	2	Hitachi	5.38	9.6
4	4	Toshiba	4.32	7.8
5	10	Hyundai	3.99	7.2
6	5	Texas Instruments	3.80	6.8
7	8	LG Semicon	3.45	6.2
8	6	Fujitsu	2.63	4.7
9	7	Mitsubishi	2.55	4.6
10	11	Micron Technology	2.34	4.2
		Others	14.51	26.0
		Total	55.74	-

Source: Dataquest (January 1996)

Table 2
Preliminary Leading Suppliers of DRAM (Based on Estimated 1995 Worldwide Revenue)

1995 Rank	1994 Rank	Supplier	1995 Market Share (%)
1	1	Samsung	14.8
2	3	NEC	11.1
3	2	Hitachi	10.5
4	9	Hyundai	9.0
5	4	Toshiba	8.2
6	5	Texas Instruments	8.1
7	7	LG Semicon	7.8
8	10	Micron Technology	5.1
9	8	Mitsubishi	5.1
10	11	Fujitsu	4.9
11	6	IBM	4.7
12	12	Siemens	3.1
13	14	Oki	2.1
14	13	Motorola	1.6
15	16	MOSel/Vitelic	1.2
		Others	2.7

Source: Dataquest (January 1996)

Based on preliminary estimates, Table 2 shows that Samsung maintains first place among DRAM suppliers. NEC and Hitachi switched positions. NEC now ranks second worldwide, with Hitachi at third. Each of the top three suppliers holds more than 10 percent of worldwide DRAM market share.

Hyundai vaulted into fourth place, which is an impressive advance of five places versus 1994. Toshiba and Texas Instruments hold the fifth and sixth places, respectively, each one notch lower than last year. LG Semicon maintains the seventh-place position. Micron Technology now holds eighth place, an advance of two places. Mitsubishi ranks ninth. Fujitsu holds the 10th place ranking, a gain of one place.

IBM now ranks 11th, versus sixth for the previous year. We believe that during 1995 IBM emphasized production of other products, especially microprocessors. Siemens maintains the 12th-place ranking among DRAM suppliers. Oki and Motorola swapped positions, with Oki now 13th and Motorola 14th. MOSel/Vitelic now ranks as the world's 15th-largest supplier of DRAM.

The following suppliers showed the strongest 1995 growth in terms of DRAM revenue, in descending order: Hyundai, Nippon Steel Semiconductor (which ranks 17th among DRAM suppliers), LG Semicon, MOSel/Vitelic, Texas Instruments, NEC, Sanyo (ranked 18th), Samsung, Hitachi, and Fujitsu.

We should note several trends. In the DRAM business, the top companies gained market share. For example, for 1994, the top 10 DRAM suppliers held just under a 70 percent share of the market. For 1995, the top 10 suppliers now hold more than 80 percent of DRAM market share.

Japan-based companies hold 45 percent of the 1995 worldwide DRAM market share, just slightly less than the previous year. Japan-based suppliers have slowly lost market share for the past several years. North American companies hold 20 percent of the 1995 DRAM market, a decline of nearly 5 percent versus their 1994 share. By contrast, Asia/Pacific companies, led by the Korea-based suppliers, now hold nearly one-third of the DRAM market. During 1994, Asia/Pacific companies held one-fourth of the market. Taiwan-based suppliers are starting to emerge as a new Asia/Pacific source of DRAMs. European companies—which means Siemens—continue to hold 3 percent of the DRAM market.

The 1996 Outlook for PC and DRAM Markets

Before looking at other rankings, we want to discuss the state of the personal computer and DRAM markets at the outset of 1996. The backdrop is the spot market reports that command so much attention now. Some spot market reports indicate, for example, that the DRAM market has now moved into severe oversupply.

Dataquest's current assessment of 4Mb and 16Mb DRAM supply/demand continues to show a DRAM bit shortage for 1996. Dataquest expects a less severe shortage than in prior years, but DRAM demand should exceed bit shipments by 1.5 times for the full year of 1996. We should note that our previous forecasts had projected a 3 percent or 4 percent DRAM bit shortage for 1996.

For 1996, the DRAM supply/demand trends will become more complicated than ever. During 1995, a severe shortage existed for wide-configuration devices like the 1Mbx16 part. By contrast, the 4Mbx4 device was in more ample supply. This year, Dataquest expects the extended data out DRAM (EDO DRAM) technology to remain in persistent shortage. This certainly applies to highly desired configurations like the 1Mbx16 and the 2Mbx8. The 1Mbx4 EDO DRAM should also remain in tight supply until later this year.

DRAM suppliers have wildly varying strategies regarding the EDO ramp-up. Most suppliers are ramping up their 16Mb EDO technology now; however, some will ramp up one or two quarters from now. The 4Mb EDO outlook is more complicated. Some suppliers have already ramped up 4Mb EDO production. At the other extreme, some suppliers will not make 4Mb EDO parts. Also, other suppliers are still ramping up.

Dataquest believes that the PC market—driven by the move to Pentium PCs—is making an incredibly abrupt transition to the EDO DRAM technology. The transition started during the third quarter of 1995 and could be complete by this quarter or next quarter. As PC OEMs place big orders for EDO DRAM over the next several months, DRAM suppliers likely will be unable to satisfy demand completely.

By contrast, demand for the older fast page mode DRAM technology suddenly weakened during this recent transition. Fast page mode DRAM is geared for 486 PC applications. The slowdown in 486 PC shipments in the second half of 1995 caused a year-end 1995 fire sale for fast page mode DRAM. The sale continues today on the spot market.

Regarding the critical PC market, Dataquest views PC demand as reasonably strong. For example, Dataquest is revising upward its PC forecast. Shipments of PCs in 1995 were higher than we had forecast originally. For 1996, Dataquest now expects that worldwide PC shipments will grow at a rate of nearly 20 percent and exceed our original expectations of fewer than 70 million units. Our PC analysts report now that PC sales are doing well following the year-end 1995 holidays. We expect PCs in the channel to sell. We do not anticipate inventory buildups of PCs. We will monitor trends, however, Dataquest expects no distressing fire sales by PC OEMs this quarter.

SRAM Market Ranking

Table 3 presents the preliminary 1995 worldwide market share rankings for SRAM suppliers. The SRAM ranking includes revenue from all speed ranges of SRAM.

Table 3 shows that Samsung now holds first place in the worldwide SRAM market. Hitachi switched positions with Samsung and now ranks second among SRAM suppliers. Motorola advanced impressively and now holds the third-ranked position. Sony and NEC swapped ranking. Sony holds fourth position, with NEC at the fifth place. Toshiba slipped to sixth position for 1995 versus a third-place ranking in the prior year. United Microelectronics Corporation (UMC), a Taiwan-based company, surged into seventh position during 1995. UMC ranked 15th in 1994. Integrated Device

Table 3
Preliminary Leading Suppliers of SRAM
(Based on Estimated 1995 Worldwide Revenue)

1995 Rank	1994 Rank	Supplier	1995 Market Share (%)
1	2	Samsung	12.4
2	1	Hitachi	10.7
3	6	Motorola	8.0
4	5	Sony	7.5
5	4	NEC	6.6
6	3	Toshiba	6.4
7	15	United Microelectronics	5.2
8	12	Integrated Device Technology	4.8
9	8	Mitsubishi	4.7
10	7	Fujitsu	3.6
		Others	30.1

Source: Dataquest (January 1996)

Technology (IDT) now ranks eighth worldwide. This represents an advance of four places from the prior year. Mitsubishi holds the ninth position among SRAM suppliers. Fujitsu ranks 10th, which is three places lower than the previous year.

The SRAM supplier base is quite fragmented. For example, Table 3 shows that other suppliers account for more than 30 percent of SRAM market share.

North America SRAM Supplier Ranking

As noted, Dataquest's SRAM rankings include revenue from sales of slower-speed SRAM along with higher-speed SRAM. North America SRAM suppliers participate only in the high-speed SRAM segments. Table 4 shows the preliminary 1995 worldwide market share ranking for North America-based SRAM suppliers.

Table 4
Preliminary Leading North America-Based Suppliers of SRAM
(Based on Estimated 1995 Worldwide Revenue)

1995 Rank	1994 Rank	Supplier	1995 Market Share (%)
3	6	Motorola	8.0
8	12	Integrated Device Technology	4.8
11	9	Cypress Semiconductor	3.5
14	16	Alliance Semiconductor	3.2
16	13	Micron Technology	2.8
17	19	Integrated Silicon Solution Inc.	2.2
20	21	Paradigm	0.8

Source: Dataquest (January 1996)

We have already seen the ranking for Motorola and IDT. Table 4 shows that Cypress Semiconductor is the next-highest-ranked North America-based SRAM supplier. Our preliminary results show that Cypress slipped several slots and now holds the 11th position worldwide. We should note that Cypress' final ranking might be somewhat higher. For example, Cypress ships some SRAM in the form of SRAM modules, and our preliminary estimates put this SRAM revenue into a different memory segment.

Alliance Semiconductor is next. Alliance advanced two places and now ranks 14th worldwide. Micron Technology slipped several slots into the 16th place worldwide. For the past several years, Micron has emphasized DRAM production over SRAM. Integrated Silicon Solution Inc. (ISSI) advanced two positions and now ranks 17th worldwide. Paradigm gained one place and now holds 20th place worldwide. Of the North America-based companies, Alliance, ISSI, and Paradigm participated in initial public offerings over the past several years.

Based on our preliminary 1995 estimates, the following suppliers showed the strongest 1995 growth in SRAM revenue, in descending order: ISSI; UMC; Alliance Semiconductor; IDT; Samsung; Winbond Electronics, a Taiwan-based supplier; and Motorola.

A recent Dataquest telebriefing noted that a key 1996 trend to monitor is the emergence of high-speed 32Kbx32 SRAM. More than 15 suppliers now target the 32Kbx32 market. If this device gains rapid market acceptance, Dataquest believes that Samsung and Sony will gain market momentum in 1996. The acceptance of the 32Kbx32 device will come at the expense of the 32Kbx8 device. Also, Motorola maintains momentum in the ultrafast SRAM segment that serves workstation-type applications.

Flash Market Ranking

Table 5 presents the preliminary 1995 worldwide market share ranking for suppliers of flash memory.

The table shows that Intel and Advanced Micro Devices (AMD) continue to rank first and second, respectively, among the worldwide flash memory suppliers. Fujitsu, AMD's fab alliance partner, advanced three places and now ranks third worldwide. The Fujitsu-AMD Semiconductor Ltd. (FASL) fab in Japan generates their market momentum. Atmel ranks fourth worldwide, one place lower than the prior year. Sharp, Intel's alliance partner, advanced two places and now ranks fifth worldwide. Toshiba slipped several places and now holds the seventh position worldwide. The following suppliers each hold about 1 percent of flash market share: Oki, Macronix, TI, Samsung, and Mitsubishi.

The flash memory shortage will likely persist throughout most of 1996. Suppliers, led by AMD-Fujitsu and Intel-Sharp, are increasing flash capacity. Demand for flash, however, will likely exceed supply for the next year. We view 1997 as a transitional year for the flash market. By 1997, there will be a large increase in flash capacity. Supply-demand equilibrium in the flash market will likely occur during 1997.

The analysts then answered audience questions.

Table 5
Preliminary Leading Suppliers of Flash Memory (Based on Estimated 1995 Worldwide Revenue)

1995 Rank	1994 Rank	Supplier	1995 Market Share (%)
1	1	Intel	34.6
2	2	Advanced Micro Devices	29.2
3	6	Fujitsu	9.8
4	3	Atmel	6.3
5	7	Sharp	4.9
6	5	SGS-Thomson	4.4
7	4	Toshiba	3.7
8	12	Oki	1.3
9	15	Macronix	1.3
10	10	Texas Instruments	1.0
11	13	Samsung	0.9
12	8	Mitsubishi	0.9
		Others	1.7

Source: Dataquest (January 1996)

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Dataquest
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Perspective

Semiconductor Supply and Pricing Worldwide

Competitive Analysis

Dataquest's First Quarter 1996 Memory Price Forecast

Abstract: *This article discusses a telebriefing held on January 12, 1996. This telebriefing highlighted the First Quarter 1996 Quarterly Price Survey findings. The effect of spot market pricing on the survey and current price forecast is noted and discussed.*
By Mark Giudici, Ron Bohn, and Jim Handy

When Will Spot Market Prices Affect Contract Prices?

The following were the opening remarks of a January 12, 1996, telebriefing on the latest quarterly memory price forecast highlights.

The telebriefing covered the results of Dataquest's latest quarterly price survey and highlighted the resulting price forecast that will impact the electronics and semiconductor markets for the upcoming year. After the opening statement, questions were taken from the audience. The briefing was recorded. Each participant was given a caller ID number and, when asking a question, was identified by number rather than by name in order to maintain confidentiality.

The survey methodology involved polling both users and suppliers about their contract price expectations for the upcoming eight quarters. This forecast does not cover spot pricing. We conducted this survey in late November and finalized it during early to mid-December. We base these price estimates on inputs from many of the largest users and sellers of memory products.

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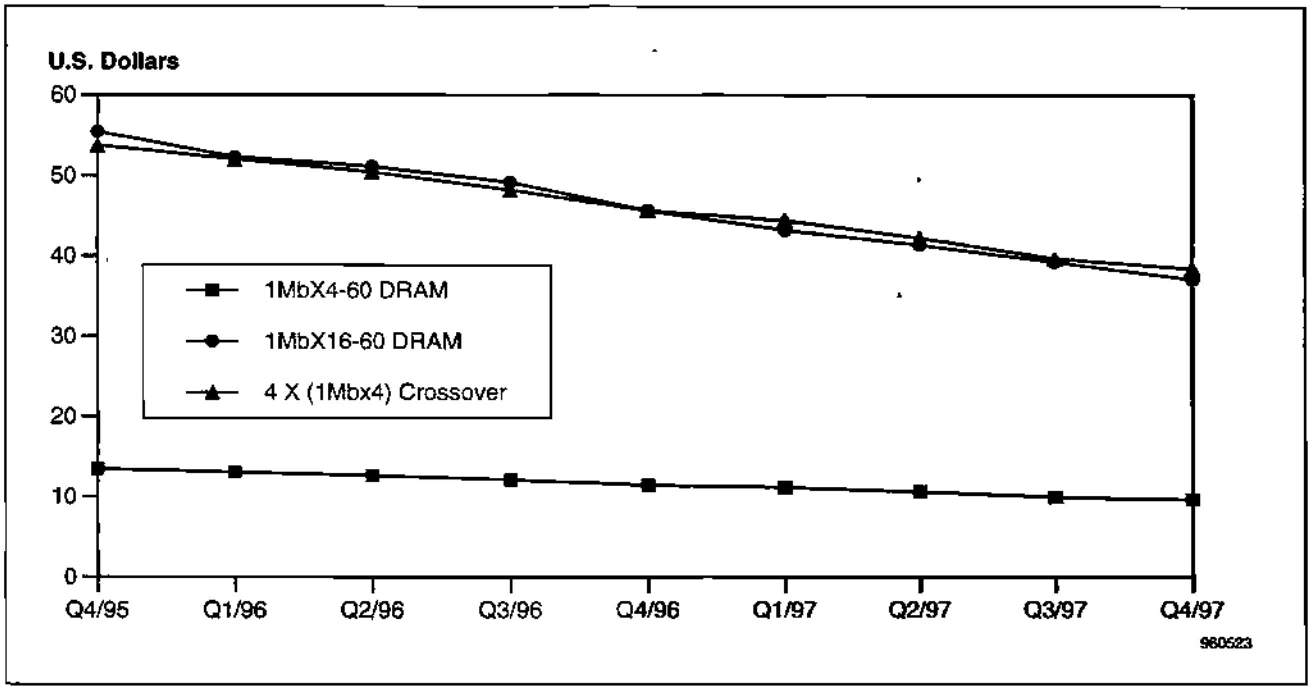
Before we go into detailed pricing, we will give a brief overview of the demand drivers behind these pricing trends and the current spot memory market. Worldwide PC unit shipments grew just under 25 percent in 1995. Dataquest expects the PC market to grow steadily to over 70 million units in 1996, and the cellular phone market should expand by close to 30 percent this year. The abrupt shift in spot market memory pricing during December appears to be a result of year-end inventory liquidation, primarily of fast page mode (FPM) DRAM and mixed-voltage Taiwanese SRAM. Alone, this situation would have not caused the dramatic price declines noted a month ago. The beginning of additional DRAM capacity coming into the market, a skittish stock market (with the inventory reduction tactic noted above), and a very sensitive spot market did the rest. We forecast contract pricing for these same devices to decline slightly in the first quarter, and most contracts do reflect moderate price relaxation after close to two years of flat-to-rising prices. A key issue in first quarter DRAM price negotiations is whether prices will decline by more than or less than 5 percent from fourth-quarter-1995 levels. In many cases, protracted first-quarter-1996 price negotiations are continuing, with buyers now more concerned about price than availability. We will look at some of the specific forecasts that came from our latest survey.

The first area to look at is the DRAM price situation. Figure 1 shows three lines from the fourth quarter of 1995 to the fourth quarter of 1997: the 1Mbx4 DRAM, the next-generation 1Mbx16 DRAM, and a four-times multiple of the 1Mbx4 highlighting the cost-per-bit crossover point. As the figure shows, throughout the 1996 and 1997, Dataquest expects the 1Mbx16 to closely track the 1Mbx4 device downward with no clear-cut crossover noted. This situation is primarily the result of the shift from FPM DRAM to extended data out (EDO) DRAM for current state-of-the-art computers. The elasticity of the market should absorb additional volumes of memory (both 4Mb and 16Mb) as prices gradually decline. This is because of new capacity coming into production that focuses on this lucrative product and because of current 4Mb suppliers shifting to the higher density, reducing overall 4Mb supply. The figure highlights first-quarter-1996 pricing of the 4Mb part at $13.00, declining to $11.40 in the fourth quarter of this year. The 1Mbx16 price in the first quarter averaged $52.00, and we forecast it to drop to $45.00 by the fourth quarter of 1996. We do not have a separate price breakout for FPM DRAM and EDO DRAM, but these prices reflect 60ns EDO pricing rather than FPM.

We foresee other 16Mb DRAM prices, such as the 4Mbx4 and the 2Mbx8, declining faster than the 1Mbx16 through 1996, in part because some suppliers get better yields for them. EDO DRAM pricing in many cases still receives a 5 percent-to-10 percent premium over FPM DRAM. Dataquest expects this price premium to disappear as the supply-demand balance point is reached. Synchronous DRAM prices, however, still hold a 15 percent-to-20 percent premium over other DRAM parts. We expect that by mid-1997, synchronous DRAM will be at price parity with FPM DRAM or EDO DRAM.

The next area to review is the SRAM market. Figure 2 highlights the pricing trends for the three major cache SRAM devices: the 32Kx8 15ns; the 128Kx8 15ns; and the 32Kx32 15ns. The figure shows that, although the older 32Kx8 device will remain relatively flat at around $4.00 or less, it will begin to get

Figure 1
DRAM Crossover Trends—4Mb to 16Mb



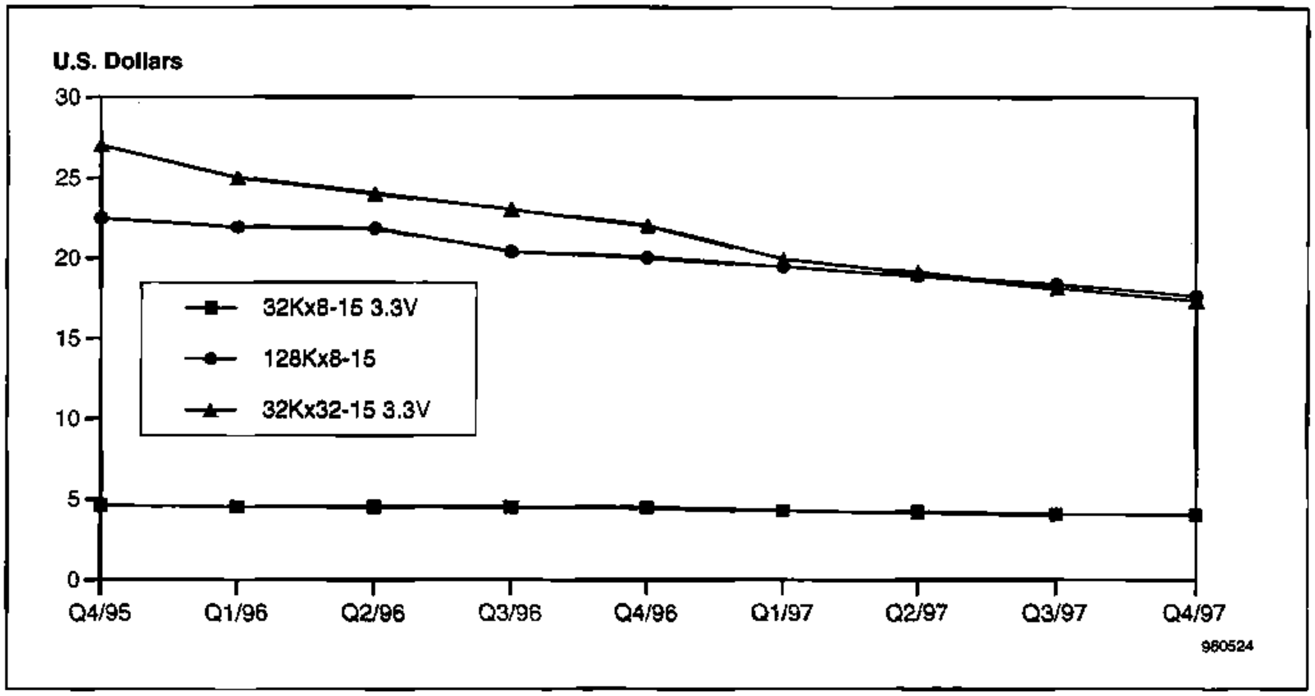
Source: Dataquest (January 1996)

price competition from the newer 32Kx32 SRAM by 1997. Dataquest is now trying to confirm word of very large levels of 32Kx32 SRAM coming to market. If this is substantiated, the figure shown would need to reflect the 32Kx32 price dropping below the 4x 32Kx8 multiple, possibly as soon as the second quarter of 1996. However, at the time of this survey and to date, Dataquest still sees the 32Kx8 fast SRAM as the cache of choice because of its availability and lower cost relative to other solutions. We will announce any changes as they become known.

The other SRAM products show relatively stable pricing over the upcoming quarters, despite word of very low spot pricing in Taiwan. In December, this primarily involved 486 system-specific mixed-voltage SRAM and was not generally applicable to a wider market. We do not expect pricing for slow 1Mb SRAM to fall much further in the upcoming quarters than the current $8.40 price.

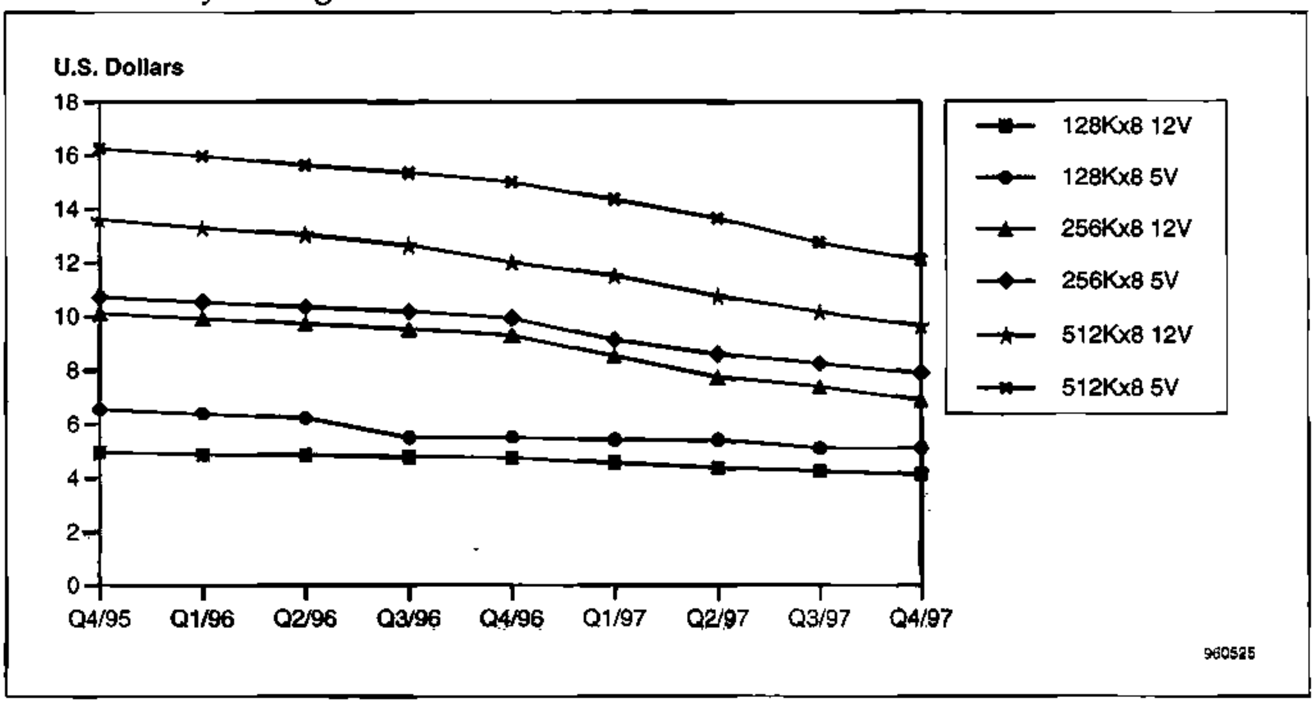
Figure 3 shows how voltage levels will continue to differentiate flash memory pricing for the next eight quarters. Low-voltage (5V) flash memory still commands a 5 percent-to-10 percent price premium over 12V or mixed-voltage products because portable and lower-voltage systems require these types of parts. The majority of the 12V and 5V market is still sourced by Intel and AMD, as noted in a previous telebriefing. However, the current lowest-voltage (3.3V) flash memory still comes predominantly from Atmel. Although all flash suppliers plan to expand capacity, Dataquest expects the flash market to remain in shortage for the rest of this year. Pricing for the 8Mb density remains close to the more popular 4Mb device.

Figure 2
Cache SRAM Pricing—256Kb and 1Mb



Source: Dataquest (January 1996)

Figure 3
Flash Memory Pricing—12V versus 5V



Source: Dataquest (January 1996)

Conclusion

We emphasize that this year will differ from last year—overall memory supplies should be more abundant. This will allow for an easing of prices that has not been seen for the past 18 months. Once the dust settles regarding inventory level and product mix corrections, the pervasiveness of semiconductors in electronics is once again expected to keep the backlogs of DRAM and flash suppliers solid for most of this year. The contract purchasing of memory ICs that we estimate represents close to 90 percent of the total memory market remains more stable than the skittish spot arena. The overall supply-demand memory picture, however, does appear to be in transition for the next six months.

For the first time in two years, Dataquest has forecast price declines in the DRAM and SRAM markets for the first half of the year. There definitely has been a sharp drop in spot market prices. There is a sharp difference in the contract DRAM market versus the cache SRAM market. In the DRAM market, the undesirable FPM product has gotten much spot market attention. Dataquest expects much stronger demand for the EDO product, resulting in relatively higher and more stable pricing. In the cache SRAM market, more and more suppliers are reporting large unit shipments of 32Kx32 parts. This is yet to be verified, but, if true, could put the cache market in oversupply, resulting in rapidly declining prices. The overall impact on the contract memory market of this spot softness appears to have slightly accelerated the forecast gradual price reductions, but not nearly to the extent to which the spot market moved. We do not expect the current round of DRAM contract price negotiations to be as low as spot market prices.

This ended the opening statement. The discussion was then opened for questions.

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Perspective

Semiconductor Supply and Pricing Worldwide

Market Analysis

First Quarter Procurement Pulse: Orders Pick Up, Lead Times Slip, and Inventories Rise Again

Abstract: *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 also notes price status by semiconductor product family and package type, as well as key problems facing semiconductor users. This article explains what changes in these parameters mean in relationship to the current market.*
By Mark Giudici

Semiconductor Order Rates Expected to Turn the Corner

Figure 1 shows that the estimated semiconductor order rates for January are expected to rise to above the 850 index. This is after four consecutive months of order rate declines. Although semiconductor order activity had slowed gradually, demand remains healthy for PCs, cellular, and peripheral equipment. While the index levels for November and December did remain relatively flat, the uptick in January order expectations reflects the overall strength of the market now that the year-end financials are in.

For the first time in over 12 months, respondents now see price decreases for DRAM (down 2.8 percent), while standard logic and microprocessors show price declines of 1.9 percent and 1.1 percent, respectively. The computer subset of the sample is expecting an average DRAM price cut of 6.6 percent in January. The well-reviewed supply-demand imbalance of the 1Mbx16 DRAM appears to be improving (especially in the spot market), but it is too soon to call this a buyers' market. The standard logic market has

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Figure 1
Averaged Monthly Semiconductor Orders

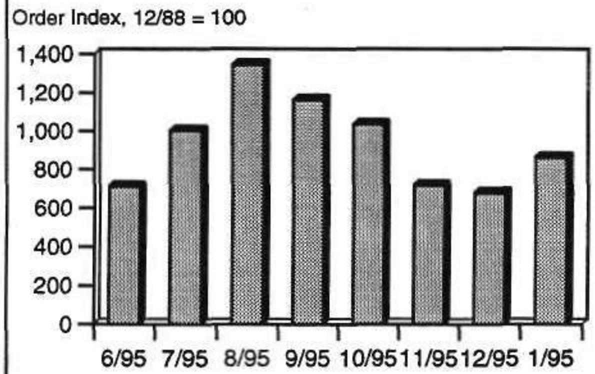


Figure 2
Averaged Semiconductor Lead Times

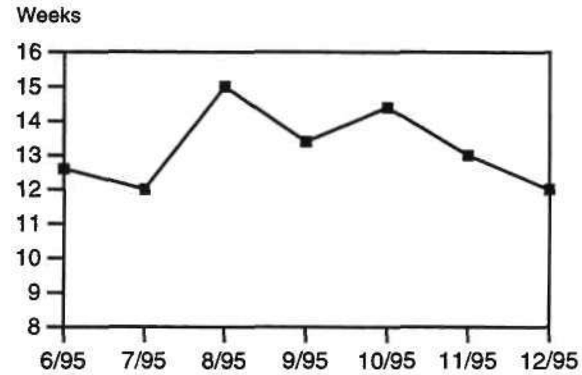


Figure 3
Actual vs. Target Inventory Levels
(All OEMs)

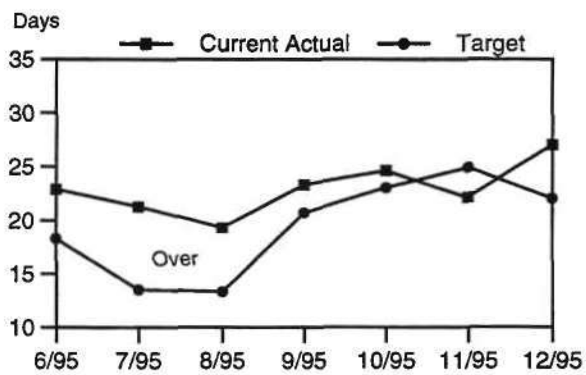
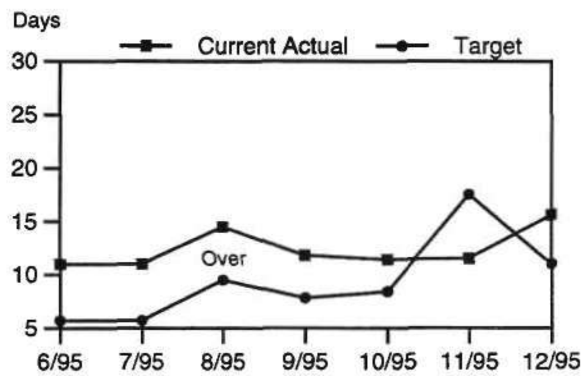


Figure 4
Actual vs. Target Inventory Levels
(Computer OEMs)



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Source: Dataquest (January 1996)

again 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 on a Downward Slide

Figure 2 shows that, after an October high point, the lead time picture has come down to the July 1995 level of 12.0 weeks. As mentioned in last quarter's update, this decline in lead times by no means signals a turn to a buyers' market but does suggest that supplies continue to improve somewhat for selected MPU, discrete, SRAM, and now DRAM parts. Allocation still remains the norm for most DRAM and flash memory products. While discrete semiconductor availability has improved, many respondents note problems with ASIC supplies (especially the flexibility of suppliers). Most of the other problem products remain memory-related (DRAM, flash, and under-15ns SRAM). Difficulties with linear and optoelectronic products and the perennial problem, the SOT23 discrete package, are also noted.

Semiconductor Inventories Under Control, With Small Fluctuations

Figures 3 and 4 illustrate that steady demand, improved lead times, and generally flat prices still result in focused inventory control (read cost control), yet the picture is in flux . Buyers are checking whether availability has improved enough to cut back on inventory levels relative to demand. The overall targeted and actual semiconductor inventory levels for December were 21.7 days and 27.2 days, respectively, compared with November's 24.9-day and 22.1-day inventory levels. The computer subset continues to be even more cost-conscious, with current target and actual inventory levels of 11.0 days and 15.6 days, compared with November inventory levels of 17.5 days targeted and 11.5 days on hand. By historical standards, semiconductor inventories remain controlled, again easing fears that any end-use demand fluctuations could cause an abrupt step-function decline in semiconductor sales.

Dataquest Perspective

Worldwide demand for electronics, and therefore semiconductors, remains steady despite some regional rumblings of oversupply and sporadic stock analyst pessimism. Dataquest's take: Year-end inventory corrections (not yet reflected in this report) resulted in increased spot market supplies of fast page mode DRAM and selected SRAM, which, combined with increased availability of some parts, resulted in a very volatile year-end spot market that is not expected to continue. Dataquest expects worldwide demand to remain steady through 1996. The large increases in semiconductor fab capacity being brought on line, combined with improved 1Mbx16 DRAM yields and constant demand for most end equipment, is resulting in improvements in price and lead times. In the unlikely event that the current spot market softness transfers to the contract market, we could expect to see an acceleration of the long-awaited gradual price declines through 1996. Continued vigilance over inventory levels with regular review of critical component suppliers remains the best way to take advantage of any supply improvements in the upcoming months.

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Market Trends

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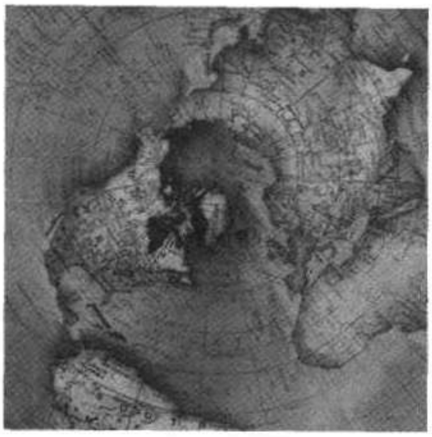

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Semiconductor Five-Year Forecast Trends—Spring 1996

Market Trends

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Table of Contents

		Page
1.	Introduction and Assumptions	1
	Forecast Summary	1
	Forecast Highlights	2
	Exchange Rates	3
2.	Worldwide Forecast by Product Family	5
	Worldwide Forecast Data	5
3.	Worldwide Semiconductor Forecast by Region	9
4.	Americas Forecast by Product Family	11
5.	Japan Forecast by Product Family	15
6.	Europe Forecast by Product Family	19
7.	Asia/Pacific Forecast by Product Family	23
8.	Forecast by Product	27
	Microcomponent ICs	27
	Memory ICs	28
	Logic ICs	29
	Analog ICs	29
	Total Monolithic ICs	29
	Discrete Devices	30
	Optical Semiconductors	31
9.	Forecast by Technology	33
	Digital MOS and Bipolar IC Forecast	33
Appendix A—Japanese Revenue History and Forecast in Yen		35
Appendix B—European Revenue History and Forecast in ECU		39
Appendix C—Definitions		43
Appendix D—Historical Exchange Rates		47

List of Figures

Figure		Page
2-1	Market Share by Product, 1995 and 2000	8
3-1	Semiconductor History and Forecast by Region	9
3-2	Regional Consumption as a Percentage of Total	10
4-1	Product Comparison, Americas Market, 1995 and 2000	14
5-1	Product Comparison, Japanese Market, 1995 and 2000	18
6-1	Product Comparison, European Market, 1995 and 2000	22
7-1	Product Comparison, Asia/Pacific Market, 1995 and 2000	26
8-1	Worldwide Semiconductor Forecast by Product	27
9-1	MOS versus Bipolar Forecast	33
A-1	Comparison of Revenue Shipment Growth in the Japan Region—Dollars versus Yen	35
B-1	Comparison of Revenue Shipment Growth in European Region—Dollars versus ECU	39

List of Tables

Table		Page
1-1	Changes in 1996 Forecast	2
2-1	Worldwide Semiconductor Growth by Product Type	5
2-2	Worldwide Semiconductor Market, Six-Year Revenue History, 1990-1995	6
2-3	Worldwide Semiconductor Market, Five-Year Revenue Forecast, 1995-2000	6
2-4	Worldwide Semiconductor Market, Historic Revenue Growth, 1990-1995	7
2-5	Worldwide Semiconductor Market, Forecast Five-Year Revenue Growth	7
3-1	Total Semiconductor Consumption by Region, Five-Year Revenue Forecast, 1995-2000	10
3-2	Total Semiconductor Growth Forecast by Region	10
4-1	Americas Semiconductor Market, Six-Year Revenue History, 1990-1995	12
4-2	Americas Semiconductor Market, Five-Year Revenue Forecast 1995-2000	12
4-3	Americas Semiconductor Market, Historic Revenue Growth, 1990-1995	13
4-4	Americas Semiconductor Market, Forecast Five-Year Revenue Growth	13
5-1	Japanese Semiconductor Market, Six-Year Revenue History, 1990-1995	16
5-2	Japanese Semiconductor Market, Five-Year Revenue Forecast, 1995-2000	16
5-3	Japanese Semiconductor Market, Historic Revenue Growth, 1990-1995	17
5-4	Japanese Semiconductor Market, Forecast Five-Year Revenue Growth	17
6-1	European Semiconductor Market, Six-Year Revenue History, 1990-1995	20
6-2	European Semiconductor Market, Five-Year Revenue Forecast, 1995-2000	20
6-3	European Semiconductor Market, Historic Revenue Growth, 1990-1995	21
6-4	European Semiconductor Market, Forecast Five-Year Revenue Growth	21
7-1	Asia/Pacific Semiconductor Market, Six-Year Revenue History, 1990-1995	24
7-2	Asia/Pacific Semiconductor Market, Five-Year Revenue Forecast, 1995-2000	24
7-3	Asia/Pacific Semiconductor Market, Historic Revenue Growth, 1990-1995	25
7-4	Asia/Pacific Semiconductor Market, Forecast Five-Year Revenue Growth	25

List of Tables (Continued)

Table		Page
8-1	Microcomponent IC Market, Five-Year Revenue Forecast, 1995-2000	28
8-2	Memory IC Market by Region, Five-Year Revenue Forecast, 1995-2000	28
8-3	Logic IC Market by Region, Five-Year Revenue Forecast, 1995-2000	29
8-4	Analog IC Market by Region, Five-Year Revenue Forecast, 1995-2000	30
8-5	Total Monolithic IC Market by Region, Five-Year Revenue Forecast, 1995-2000	30
8-6	Discrete Device Market by Region, Five-Year Revenue Forecast, 1995-2000	30
8-7	Optical Semiconductor Market by Region, Five-Year Revenue Forecast, 1995-2000	31
9-1	Semiconductor Market by Process Technology, Six-Year Revenue History, 1990-1995	34
9-2	Semiconductor Market by Process Technology, Five-Year Revenue Forecast, 1995-2000	34
A-1	Japanese Semiconductor Market, Six-Year Yen Revenue History, 1990-1995	36
A-2	Japanese Semiconductor Market, Five-Year Yen Revenue Forecast, 1995-2000	36
A-3	Japanese Semiconductor Market, Yen Revenue Growth, 1990-1995	37
A-4	Japanese Semiconductor Market, Forecast Five-Year Yen Revenue Growth, 1995-2000	37
B-1	European Semiconductor Market, Six-Year ECU Revenue History, 1990-1995	40
B-2	European Semiconductor Market, Five-Year ECU Revenue Forecast, 1995-2000	40
B-3	European Semiconductor Market, Historic Revenue Growth, 1990-1995	41
B-4	European Semiconductor Market, Forecast Five-Year ECU Revenue Growth, 1995-2000	41
D-1	Exchange Rates	47

Chapter 1
Introduction and Assumptions

Dataquest Semiconductor Group analysts provide a semiconductor device revenue forecast twice a year, in April and October. These revenue forecasts, which cover a five-year horizon, comprise forecasts for the major product families and the four main geographic semiconductor-consuming regions. This document, completed in April 1996, is the latest of these forecasts. Although revenue is subject to the vagaries of exchange rate variations, it is the most useful means to consolidate the forecasts of widely differing products and the most meaningful measure of markets and companies. Unit forecasts, which underlie the microcomponent and memory IC forecasts, are dollarized to arrive at the revenue forecast presented here. Average annual exchange rates are used for revenue history, and the most recent "average" exchange rate is extended into the five-year forecast horizon. Dataquest does not forecast exchange rates.

The forecast is presented in two local currencies in Appendixes A and B, in yen for the Japanese market forecast in Appendix A and in ECU for the European market forecast in Appendix B. The Americas market and the Asia/Pacific-ROW market are forecast only in U.S. dollars.

In 1996, the "North America" market has been expanded to include the total North and South America region and will be known as the "Americas" region from this point forward. This matches the divisions found in Dataquest's 1995 market share data.

Forecast Summary

The PC market, now the dominant market for semiconductors, grew nearly 26 percent in 1995. Semiconductors grew by 37 percent as demand continued to outstrip supply and DRAM average selling prices (ASPs) continued strong, at $25 per megabyte. DRAM revenue growth, which was 66 percent in 1993 and 60 percent in 1994, reached 81 percent in 1995. The brakes on this growth were applied early in 1996 as ASPs tumbled. The declining DRAM ASPs lead a number of factors that have aligned to take our 1996 forecast down to a surprising 7.6 percent growth. Beside DRAM, some other factors causing our 1996 forecast to drop under 8 percent are excess inventories, slowing markets, and a stronger yen. Inventory problems occurred as the fourth quarter PC market was well below expectations, leaving the first half of 1996 struggling with an inventory correction. Triggered by this correction, DRAM prices tumbled with prices per megabyte going from $25 in 1995 to under $15 early in 1996. Although we had anticipated DRAM price erosion in 1996, this price erosion occurred far sooner and faster than we had forecast last fall.

It is important to recognize that these corrections do not signal an evaporating market. Although the semiconductor end markets have slowed, they are still healthy. Dataquest's PC unit forecast for 1996 is still at 19 percent worldwide. If these problems were not severely impacting revenue, we would still be forecasting growth between 15 percent to 22 percent. Table 1-1 shows the impact of the major downside factors on our 1996 forecast.

Table 1-1
Changes in 1996 Forecast (Percent)

	October 1995 Forecast	This Forecast	Change to Dollar Growth (%)	Change to 1996 Worldwide Forecast (%)
DRAM Revenue Growth (%)	33	1*	-32	-8
Non-DRAM Product Growth (%)	18	14*	-4	-3
Yen/Dollar Exchange Rate	93.90	107.05	-12	-3
Total Growth in 1996 (%)	22.1	7.6	-14.5	-14.5

*Excludes change in yen/dollar exchange rate
Source: Dataquest (May 1996)

Both DRAM and Japan represent about one-fourth of the total semiconductor market, so their impact on the worldwide 1996 forecast shows up proportionately in the right column. If the 1996 yen-dollar exchange rate does not differ from 1995, the 3 percent change to the worldwide forecast would bring it back to double digits. If DRAM prices rebound more than expected, the growth could move the forecast up into the "normal" 15 percent range. This forecast is highly leveraged off of the fortunes of these two items.

Forecast Highlights

The following are the highlights of this forecast:

- Growth in 1996 drops under 8 percent after 37 percent growth in 1995.
- The PC market slows in 1996 to 19 percent unit growth versus 26 percent in 1995.
- The MPU market slows along with PC market. Price reductions bring 96 growth down to 17 percent.
- The DRAM price per bit will decline nearly 50 percent in 1996. Even with a high rate of bit growth, revenue growth will be nonexistent.
- Non-DRAM products will grow by 14 percent in 1996, growth consistent with historical rates.
- The Asia/Pacific regional market will exceed Japan in 1998 and will grow to 25 percent of the world market in 2000.
- The Americas forecast has decreased. Even with a 17 percent 1995 through 2000 compound annual growth rate (CAGR), the Americas will lose 1 percent of the world market (to 33.7 percent) by 1999 as Americas growth slows.
- Like the Americas, the European market's growth has been revised downward to a 17 percent CAGR from 1995 through 2000. Nonetheless, the European market share will remain at 18 percent over the forecast period.

We expect the semiconductor market to pass the $300 billion mark in 2000, as the adjustments seen in 1996 will not greatly impact the long-term growth of the market.

Exchange Rates

The following exchange rates are used for the 1994 through 1999 forecast:

- ¥107.05 per dollar
- ECU 0.774 per dollar

The following chapters will discuss the forecast by product and region in more detail.

Chapter 2
Worldwide Forecast by Product Family

The growth by product in 1995 as well as the past five-year CAGR and forecast 1995-through-2000 CAGR is shown in Table 2-1.

Memory ICs will show much slower growth as the five-year compounded growth rate of 16 percent brings memory IC growth back in line. Micro-component growth, as well, will slow as the Americas market grows more slowly and prices stabilize. Logic ICs and analog ICs are settling into 14 percent growth rates, growth more consistent with the growth of electronic equipment markets. Discrete devices have gained greater growth potential with the lead of power and radio frequency (RF) transistors. Despite the growth potential of logic ICs, analog ICs, discrete devices, and optical semiconductors and the slowdown of memory IC growth, micro-component and memory ICs will continue to increase their share of the semiconductor market at the expense of these other categories.

The tables on the following pages provide the complete five-year forecast by product type for the worldwide semiconductor market.

Worldwide Forecast Data

Tables 2-2 through 2-5 provide the five-year forecast by product type for the worldwide semiconductor market.

Table 2-1
Worldwide Semiconductor Growth by Product Type (Revenue in Millions of Dollars)

	1995 Revenue	1994-1995 Growth (%)	CAGR (%) 1990-1995 Actual	CAGR (%) 1995-2000 Forecast
Microcomponents	34,513	30.7	29.2	17.6
Memory Total	55,421	64.4	34.6	16.5
Logic/ASIC Total	22,961	22.0	13.5	13.8
Analog ICs	17,607	15.4	14.8	14.7
Monolithic IC Total	130,502	38.5	24.8	16.1
Hybrid ICs	1,935	16.2	8.5	1.4
Total ICs	132,437	38.2	24.4	15.9
Discrete Devices	14,023	30.3	12.8	11.6
Optical Semiconductors	4,811	23.7	14.8	12.1
Total Semiconductor	151,271	36.9	22.6	15.4

Source: Dataquest (May 1996)

Table 2-2
Worldwide Semiconductor Market, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	9,584	11,774	14,359	19,947	26,408	34,513	29.2
Memory Total	12,559	13,197	15,626	23,550	33,704	55,421	34.6
Bipolar Memory	431	356	318	244	199	160	-18.0
MOS Memory	12,128	12,841	15,308	23,306	33,505	55,261	35.4
Logic/ASIC Total	12,182	12,972	12,918	15,956	18,821	22,961	13.5
Bipolar Logic	3,742	3,272	2,875	2,835	2,713	2,337	-9.0
MOS Logic	8,440	9,700	10,043	13,121	16,108	20,624	19.6
Analog ICs	8,845	9,517	10,180	12,513	15,263	17,607	14.8
Monolithic IC Total	43,170	47,460	53,083	71,966	94,196	130,502	24.8
Hybrid ICs	1,289	1,395	1,335	1,463	1,665	1,935	8.5
Total ICs	44,459	48,855	54,418	73,429	95,861	132,437	24.4
Discrete Devices	7,674	8,035	8,155	9,083	10,763	14,023	12.8
Optical Semiconductors	2,412	2,804	2,688	3,006	3,889	4,811	14.8
Total Semiconductor	54,545	59,694	65,261	85,518	110,513	151,271	22.6

Source: Dataquest (May 1996)

Table 2-3
Worldwide Semiconductor Market, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	34,513	39,945	46,524	54,885	65,532	77,645	17.6
Memory Total	55,421	55,749	64,213	75,098	93,666	118,680	16.5
Bipolar Memory	160	119	108	93	79	71	-15.0
MOS Memory	55,261	55,630	64,105	75,005	93,587	118,609	16.5
Logic/ASIC Total	22,961	24,910	27,692	31,906	37,212	43,748	13.8
Bipolar Logic	2,337	2,012	1,644	1,415	1,219	1,066	-14.5
MOS Logic	20,624	22,898	26,048	30,491	35,993	42,682	15.7
Analog ICs	17,607	19,562	21,698	25,147	29,531	34,911	14.7
Monolithic IC Total	130,502	140,166	160,127	187,036	225,941	274,984	16.1
Hybrid ICs	1,935	1,947	2,009	2,030	2,055	2,075	1.4
Total ICs	132,437	142,113	162,136	189,066	227,996	277,059	15.9
Discrete Devices	14,023	15,300	16,517	18,481	21,044	24,251	11.6
Optical Semiconductors	4,811	5,199	5,588	6,286	7,207	8,526	12.1
Total Semiconductor	151,271	162,612	184,241	213,833	256,247	309,836	15.4

Source: Dataquest (May 1996)

Table 2-4
Worldwide Semiconductor Market, Historic Revenue Growth, 1990-1995 (Percentage Revenue Growth over Preceding Year)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	22.7	22.9	22.0	38.9	32.4	30.7	29.2
Memory Total	-20.8	5.1	18.4	50.7	43.1	64.4	34.6
Bipolar Memory	-6.3	-17.4	-10.7	-23.3	-18.4	-19.6	-18.0
MOS Memory	-21.3	5.9	19.2	52.2	43.8	64.9	35.4
Logic/ASIC Total	3.4	6.5	-0.4	23.5	18.0	22.0	13.5
Bipolar Logic	-2.9	-12.6	-12.1	-1.4	-4.3	-13.9	-9.0
MOS Logic	6.5	14.9	3.5	30.6	22.8	28.0	19.6
Analog ICs	13.5	7.6	7.0	22.9	22.0	15.4	14.8
Monolithic IC Total	-0.2	9.9	11.8	35.6	30.9	38.5	24.8
Hybrid ICs	-5.8	8.2	-4.3	9.6	13.8	16.2	8.5
Total ICs	-0.3	9.9	11.4	34.9	30.5	38.2	24.4
Discrete Devices	4.8	4.7	1.5	11.4	18.5	30.3	12.8
Optical Semiconductors	0.2	16.3	-4.1	11.8	29.4	23.7	14.8
Total Semiconductor	0.4	9.4	9.3	31.0	29.2	36.9	22.6

Source: Dataquest (May 1996)

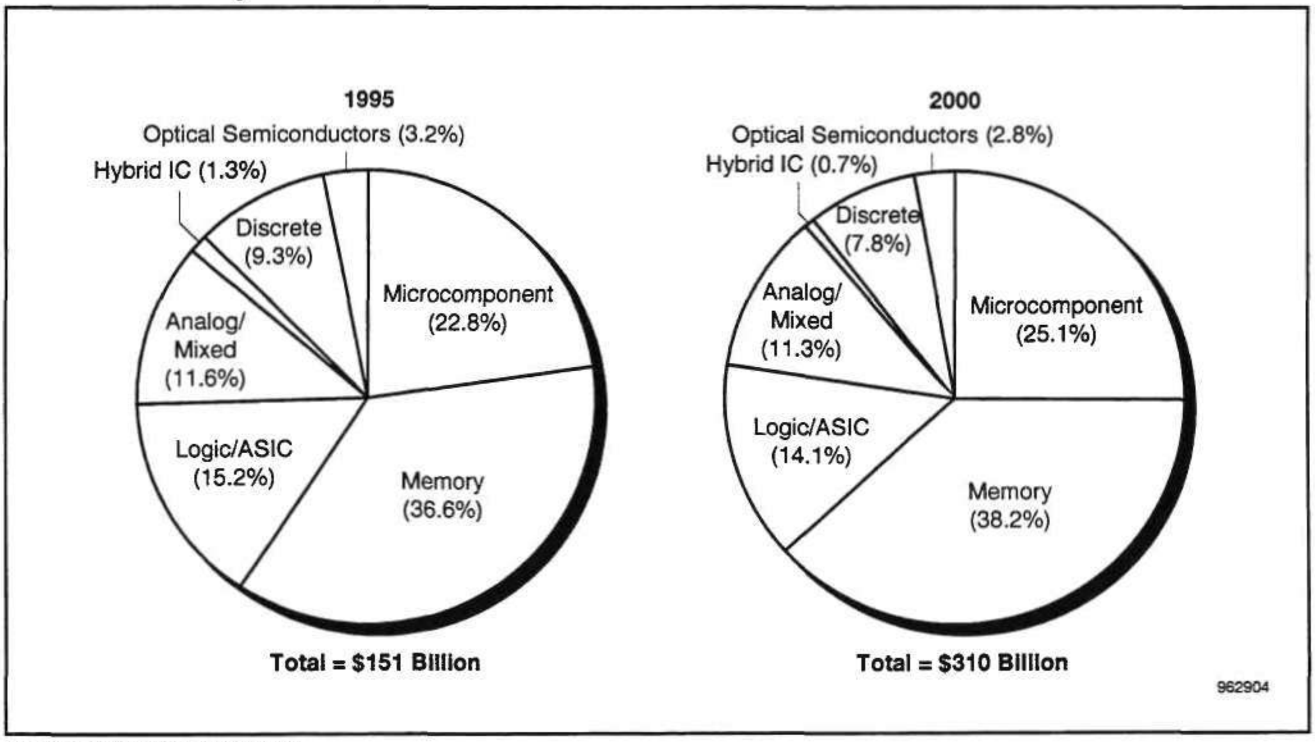
Table 2-5
Worldwide Semiconductor Market, Forecast Five-Year Revenue Growth (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	30.7	16.1	16.5	18.0	19.4	18.5	17.6
Memory Total	64.4	0.6	15.2	17.0	24.7	26.7	16.5
Bipolar Memory	-19.6	-25.6	-9.2	-13.9	-15.1	-10.1	-15.0
MOS Memory	64.9	0.7	15.2	17.0	24.8	26.7	16.5
Logic/ASIC Total	22.0	8.5	11.2	15.2	16.6	17.6	13.8
Bipolar Logic	-13.9	-13.9	-18.3	-13.9	-13.9	-12.6	-14.5
MOS Logic	28.0	11.0	13.8	17.1	18.0	18.6	15.7
Analog ICs	15.4	11.1	10.9	15.9	17.4	18.2	14.7
Monolithic IC Total	38.5	7.5	14.2	16.8	20.8	21.7	16.1
Hybrid ICs	16.2	0.6	3.2	1.0	1.2	1.0	1.4
Total ICs	38.2	7.4	14.1	16.6	20.6	21.5	15.9
Discrete Devices	30.3	9.1	8.0	11.9	13.9	15.2	11.6
Optical Semiconductors	23.7	8.1	7.5	12.5	14.7	18.3	12.1
Total Semiconductor	36.9	7.6	13.3	16.1	19.8	20.9	15.4

Source: Dataquest (May 1996)

The impact of these varying rates of growth by product is shown in Figure 2-1. In 1995, the PC-driven combination of microcomponent and memory ICs gained market share rapidly, going from 54 percent of the worldwide market in 1994 to almost 60 percent of the market in 1995. In 1992, memory and microcomponent ICs combined to share only 46 percent of the semiconductor market. This gain in market share driven by PC growth will slow. As the figure shows, memories and microcomponents will only gain a 3 percent share in the coming five-year period, after gaining 12 percent in the past five years. All other semiconductor categories, logic ICs, analog ICs, discrete devices and optical semiconductors, will lose market share, but at a slower pace than in the past.

Figure 2-1
Market Share by Product, 1995 and 2000



Source: Dataquest (May 1996)

Chapter 3
Worldwide Semiconductor Forecast by Region

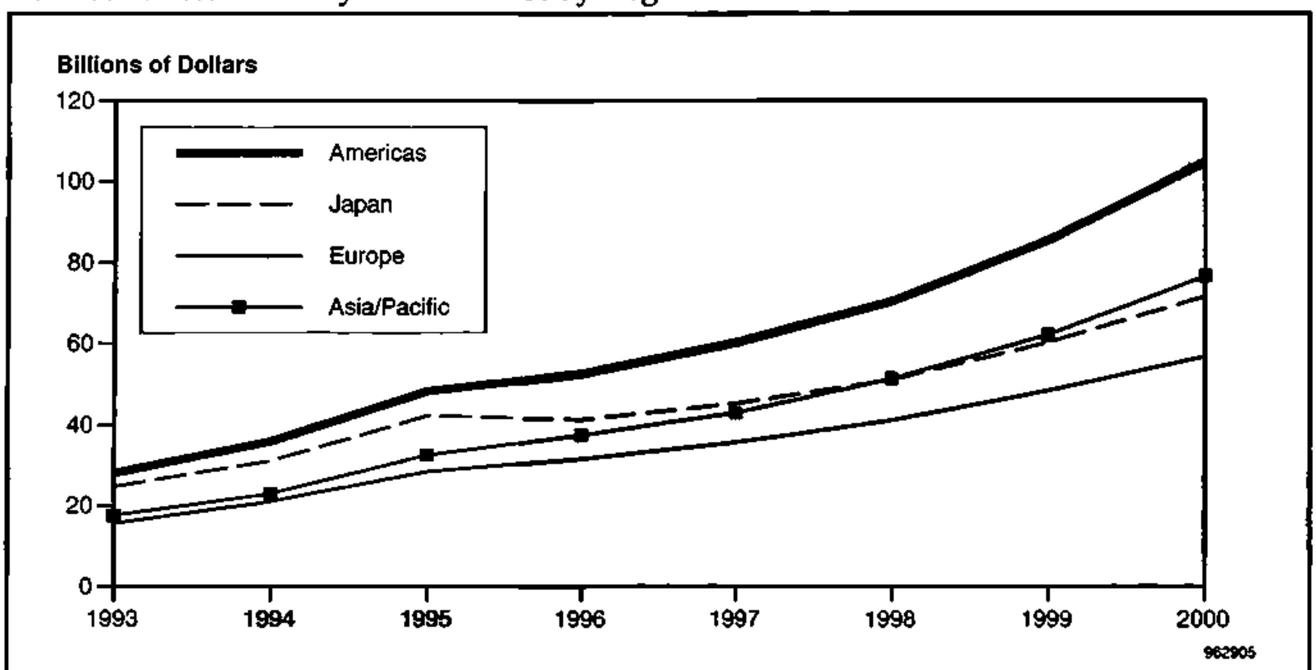
The worldwide revenue forecast is broken into the four constituent regional revenue shipment forecasts in Figure 3-1. A significant feature of this figure is the passing of Japan by Asia/Pacific in revenue by 1998.

The 1993-through-1995 period showed remarkable consistency in the growth of all regions; the three-year compounded growth rates for the Americas, Japan, Europe, and Asia/Pacific regions were 33 percent, 27 percent, 32 percent, and 39 percent, respectively. In the coming five years, these growth rates will drop by half, and regional differences will become more pronounced. Although we have forecast differing growth rates by region, the forecast still does not suggest a major downturn in the coming five years, only a period of adjustment. The negative growth shown for Japan in 1996 is because of an expected dollar devaluation; the growth would be nearly 12 percent in yen.

The regional revenue data for the five-year semiconductor forecast is listed in Table 3-1 and the annual growth by region in Table 3-2.

The effect of this forecast on the share of the total market by region is provided in Figure 3-2, where the lower anticipated growth for the Japanese market results in a continuing decline of the Japanese market share of the total market. The decline in the Japanese market is neatly mirrored by the rise in the Asia/Pacific market; these changes are tightly related with the shift of Japanese manufacturing to Asia/Pacific sites enhancing the growth of Asian markets.

Figure 3-1
Semiconductor History and Forecast by Region



Source: Dataquest (May 1996)

Table 3-1
Total Semiconductor Consumption by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	48,349	52,478	60,217	70,352	85,481	104,579	16.7
Japan	42,164	41,244	45,286	51,144	60,212	71,693	11.2
Europe	28,341	31,479	35,734	41,079	48,433	56,828	14.9
Asia/Pacific	32,417	37,411	43,004	51,258	62,121	76,736	18.8
Semiconductor Total	151,271	162,612	184,241	213,833	256,247	309,836	15.4

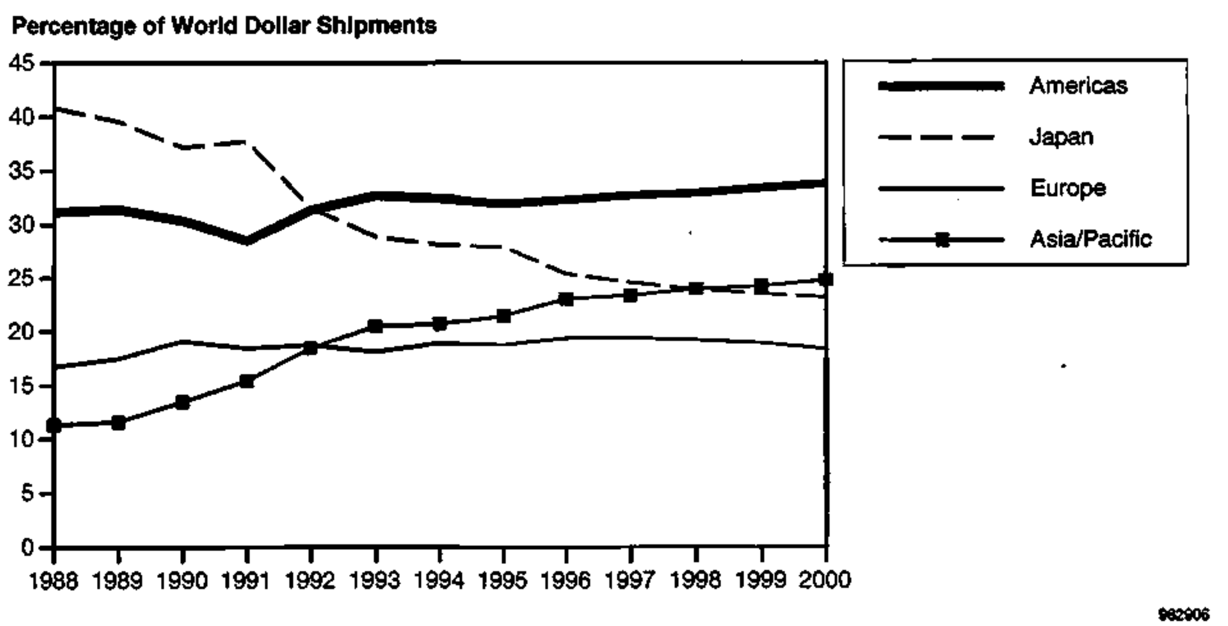
Source: Dataquest (May 1996)

Table 3-2
Total Semiconductor Growth Forecast by Region (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	35.2	8.8	14.7	16.8	21.5	22.3	16.7
Japan	36.0	-2.2	9.8	12.9	17.7	19.1	11.2
Europe	35.6	11.1	13.5	15.0	17.9	17.3	14.9
Asia/Pacific	42.0	15.4	15.0	19.2	21.2	23.5	18.8
Semiconductor Total	36.9	7.6	13.3	16.1	19.8	20.9	15.4

Source: Dataquest (May 1996)

Figure 3-2
Regional Consumption as a Percentage of Total



Source: Dataquest (May 1996)

Chapter 4
Americas Forecast by Product Family

The five-year forecast for the Americas market (the more inclusive successor to the North America region) is based on the following assumptions:

- The Americas PC market is slowing. Windows 95 didn't materialize as *the* strong driver of growth. Many businesses are waiting for Windows NT before the next big hardware/software upgrade cycle. This slowing of PC demand in the business community coupled with a saturation of the home PC market has left the forecast unit growth in 1996 at 13 percent. The lowered growth expectation has impacted all PC-related business (more than 50 percent of the Americas semiconductor market).
- Pentium processors pushed up microprocessor (MPU) revenue strongly in 1995. With Intel's Pentium price reductions, a slowing Americas market, and no looming Pentium Pro changeover in 1996, MPU market growth is expected to drop to about half of 1995's 24 percent growth.
- High-ASP semiconductors, such as x86 processors and single in-line memory modules (SIMMs), will continue to be strongly consumed in the Americas and added to PCs or motherboards manufactured in the Asia/Pacific region.
- Price reductions in Pentium processors and free-falling DRAM prices will accelerate the consumption of higher-performance MPUs and larger DRAM configurations. The same money will buy twice the PC in 1996; a prospect that may develop new customers but that also runs the risk of alienating home PC consumers who may tire of the treadmill nature of PC buying and six-month obsolescence.
- Because of the strong computer market, microcomponent and memory ICs grew from 61 percent of semiconductor revenue in the Americas market in 1994 to 68 percent in 1995, a somewhat unnatural spurt of growth that will not be repeated in 1996. We expect this share to drop to 67 percent in 1996, because memory IC revenue growth will lag all other major device families. By the year 2000, microcomponent and memory ICs will account for 70 percent of semiconductor revenue in the Americas, a slow ramp from 1995's 68 percent.
- DRAM price-per-bit declines of 40 percent to 50 percent will be offset by increased bit demand, but this will barely keep DRAM revenue growth positive in 1996.
- Discrete device growth (22 percent in 1994 and 30 percent in 1995) increasingly comes from the use of power MOS field-effect transistors (MOSFETs) and insulated gate bipolar transistors (IGBTs) in switching power supplies and peripheral drivers and the increasing use of RF devices. MOSFETs and IGBTs showed 37 percent and 59 percent growth in 1995, respectively. These devices will continue to post double-digit growth in 1996.

Tables 4-1 through 4-4 provide details of the Americas semiconductor market.

Table 4-1
Americas Semiconductor Market, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	3,381	3,916	5,282	7,620	9,839	12,421	29.7
Memory Total	4,485	4,641	5,837	8,868	12,535	20,530	35.6
Bipolar Memory	160	131	130	83	66	55	-19.2
MOS Memory	4,325	4,510	5,707	8,785	12,469	20,475	36.5
Logic/ASIC Total	4,101	4,070	4,287	5,549	6,323	7,528	12.9
Bipolar Logic	1,417	1,200	1,102	1,090	901	741	-12.2
MOS Logic	2,684	2,870	3,185	4,459	5,422	6,787	20.4
Analog ICs	2,404	2,397	2,689	3,304	3,820	3,995	10.7
Monolithic IC Total	14,371	15,024	18,095	25,341	32,517	44,474	25.3
Hybrid ICs	245	245	309	288	347	378	9.1
Total ICs	14,616	15,269	18,404	25,629	32,864	44,852	25.1
Discrete Devices	1,611	1,389	1,603	1,811	2,212	2,870	12.2
Optical Semiconductors	313	332	423	486	697	627	14.9
Total Semiconductor	16,540	16,990	20,430	27,926	35,773	48,349	23.9

Source: Dataquest (May 1996)

Table 4-2
Americas Semiconductor Market, Five-Year Revenue Forecast 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	12,421	14,073	16,182	18,779	21,950	25,575	15.5
Memory Total	20,530	21,145	24,297	28,647	36,710	47,307	18.2
Bipolar Memory	55	40	33	27	20	17	-20.9
MOS Memory	20,475	21,105	24,264	28,620	36,690	47,290	18.2
Logic/ASIC Total	7,528	8,400	9,581	11,074	12,887	15,320	15.3
Bipolar Logic	741	675	576	504	422	360	-13.4
MOS Logic	6,787	7,725	9,005	10,570	12,465	14,960	17.1
Analog ICs	3,995	4,575	5,315	6,232	7,329	8,652	16.7
Monolithic IC Total	44,474	48,193	55,375	64,732	78,876	96,854	16.8
Hybrid ICs	378	345	352	370	385	400	1.1
Total ICs	44,852	48,538	55,727	65,102	79,261	97,254	16.7
Discrete Devices	2,870	3,225	3,650	4,190	4,895	5,700	14.7
Optical Semiconductors	627	715	840	1,060	1,325	1,625	21.0
Total Semiconductor	48,349	52,478	60,217	70,352	85,481	104,579	16.7

Source: Dataquest (May 1996)

Table 4-3
Americas Semiconductor Market, Historic Revenue Growth, 1990-1995 (Percentage Revenue Growth over Preceding Year)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	20.9	15.8	34.9	44.3	29.1	26.2	29.7
Memory Total	-24.6	3.5	25.8	51.9	41.4	63.8	35.6
Bipolar Memory	-11.1	-18.1	-0.8	-36.2	-20.5	-16.7	-19.2
MOS Memory	-25.1	4.3	26.5	53.9	41.9	64.2	36.5
Logic/ASIC Total	5.8	-0.8	5.3	29.4	13.9	19.1	12.9
Bipolar Logic	-2.6	-15.3	-8.2	-1.1	-17.3	-17.8	-12.2
MOS Logic	10.9	6.9	11.0	40.0	21.6	25.2	20.4
Analog ICs	8.0	-0.3	12.2	22.9	15.6	4.6	10.7
Monolithic IC Total	-3.2	4.5	20.4	40.0	28.3	36.8	25.3
Hybrid ICs	-3.5	0	26.1	-6.8	20.5	8.9	9.1
Total ICs	-3.2	4.5	20.5	39.3	28.2	36.5	25.1
Discrete Devices	-1.7	-13.8	15.4	13.0	22.1	29.7	12.2
Optical Semiconductors	-4.9	6.1	27.4	14.9	43.4	-10.0	14.9
Total Semiconductor	-3.1	2.7	20.2	36.7	28.1	35.2	23.9

Source: Dataquest (May 1996)

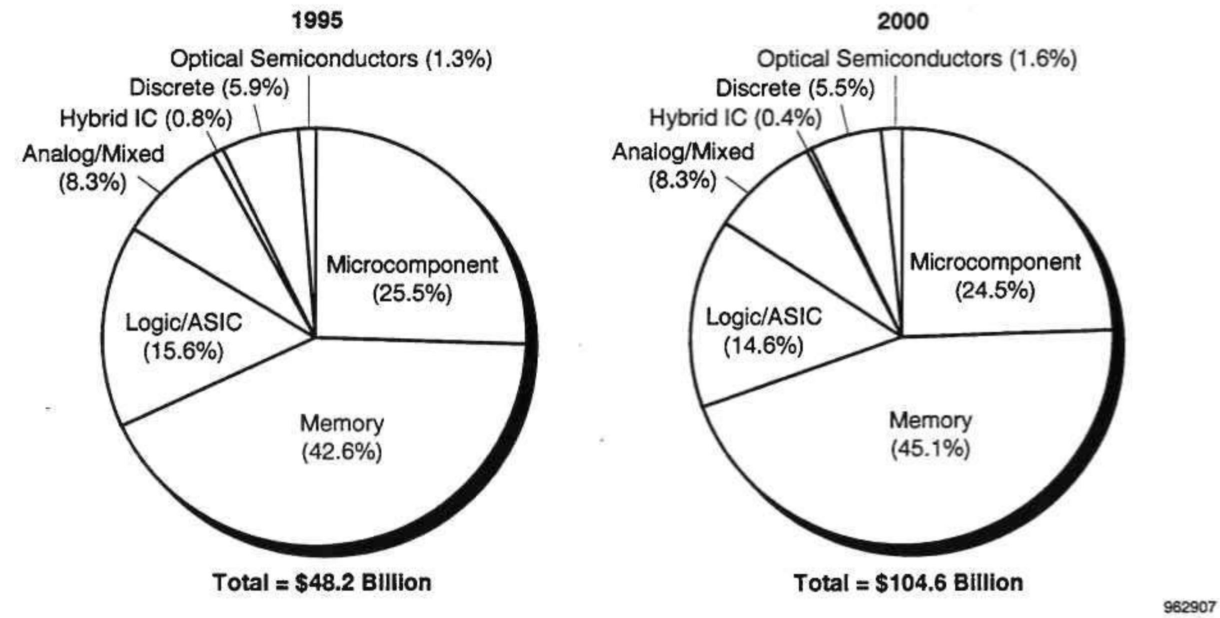
Table 4-4
Americas Semiconductor Market, Forecast Five-Year Revenue Growth (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	26.2	14.2	15.0	16.0	16.9	16.5	15.5
Memory Total	63.8	3.0	14.9	17.9	28.1	28.9	18.2
Bipolar Memory	-16.7	-27.3	-17.5	-18.2	-25.9	-15.0	-20.9
MOS Memory	64.2	3.1	15.0	18.0	28.2	28.9	18.2
Logic/ASIC Total	19.1	11.6	14.1	15.6	16.4	18.9	15.3
Bipolar Logic	-17.8	-8.9	-14.7	-12.5	-16.3	-14.7	-13.4
MOS Logic	25.2	13.8	16.6	17.4	17.9	20.0	17.1
Analog ICs	4.6	14.5	16.2	17.3	17.6	18.1	16.7
Monolithic IC Total	36.8	8.6	14.9	16.9	21.9	22.8	16.8
Hybrid ICs	8.9	-8.7	2.0	5.1	4.1	3.9	1.1
Total ICs	36.5	8.5	14.8	16.8	21.7	22.7	16.7
Discrete Devices	29.7	12.4	13.2	14.8	16.8	16.4	14.7
Optical Semiconductors	-10.0	14.0	17.5	26.2	25.0	22.6	21.0
Total Semiconductor	35.2	8.8	14.7	16.8	21.5	22.3	16.7

Source: Dataquest (May 1996)

The effect of the Americas forecast on the relative consumption by product is shown in Figure 4-1. With 68 percent of the revenue in the Americas stemming from microcomponents and memories, the Americas market is highly dependent on the health of data processing. With lowered growth expectations in these two product types, we expect that market shares will hold more constant than in the past, with microcomponents actually losing 1 percent over the next five years. Logic ICs will lose a 1 percent share as bipolar logic declines.

Figure 4-1
Product Comparison, Americas Market, 1995 and 2000



Source: Dataquest (May 1996)

Chapter 5
Japan Forecast by Product Family

The five-year semiconductor forecast for the Japanese market is based on the following assumptions:

- Growth had been accelerating in Japan after the disastrous revenue decline in 1992, but this three-year growth period is slowing. A 36 percent dollar growth in 1995 will be followed by a 2 percent decline in 1996. Although the past three years have had dollar revenue enhancements because of the yen-to-dollar depreciation, the 1996 forecast includes a dollar appreciation of 14 percent, turning a 12 percent yen-based growth in 1996 to a 2 percent decline in dollars.
- The Japanese market is fundamentally sound. PC growth in Japan will drop from the 58 percent seen in 1995 to above 30 percent. The continued migration of electronic equipment manufacturing to Asia/Pacific sites is a factor that will reduce revenue growth over the forecast period, but this migration has been somewhat stunted by constraints in growing Asian infrastructures. The result of this migration is that the Japanese market will drop from 28 percent of worldwide shipments in 1994 to slightly over 23 percent in the year 2000, a lower loss of share than our past forecasts, because depreciation is expected to slow the rate of migration.
- Microcomponents will show Japan's strongest product growth in 1996 as the MPU category is dominated by the dollar-based x86 devices from Intel. The other product categories, more strongly supplied by domestic suppliers in yen-based revenue, are impacted by the devalued dollar exchange rate. The weak 1996/1995 growth of MCU, analog, optical semiconductor, and discrete is due to sluggish consumer equipment production.
- Microcomponents show the strongest five-year compounded growth in Japan. The 21 percent compounded growth forecast for PC shipments in Japan provides comparable growth for the MPU category.
- MCU, analog IC, and optical semiconductor growth in Japan will be reduced by the offshore production shift of consumer electronics, the biggest application for these devices in Japan.
- MOS memory revenue will decline by 16 percent in dollars (negative 4 percent in yen). Even with strong PC growth, the bit growth will be insufficient to bring revenue into positive growth as ASPs drop by half. DRAM consumption in Japan has been pumped up by robust growth in SIMM production, which will be impacted by any possible slowdown in worldwide PC shipments. Prices are weakening for other memory products like SRAM, flash, and MROMs.
- Optical semiconductors showed a 32 percent growth in 1995, a considerable increase over the 21 percent seen in 1994. An explosive increase in the consumption of optically oriented computer peripherals such as CD-ROM players, scanners, and laser/LED printers has helped to fuel this growth over the past two years. This growth will be blunted in 1996 and beyond as this multimedia frenzy slows. It is not expected that new growth opportunities in DVD will be seen in the optical semiconductor category until the end of the forecast period (the year 2000).

Tables 5-1 through 5-4 provide details on the Japanese semiconductor market.

Table 5-1
Japanese Semiconductor Market, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	2,974	3,579	3,269	3,987	5,603	7,829	21.4
Memory Total	4,390	4,393	4,175	5,697	7,344	12,337	23.0
Bipolar Memory	194	165	138	127	98	82	-15.8
MOS Memory	4,196	4,228	4,037	5,570	7,246	12,255	23.9
Logic/ASIC Total	4,931	5,351	4,849	5,712	7,111	8,772	12.2
Bipolar Logic	1,441	1,277	1,016	1,001	1,118	988	-7.3
MOS Logic	3,490	4,074	3,833	4,711	5,993	7,784	17.4
Analog ICs	2,723	3,094	2,903	3,278	4,048	4,744	11.7
Monolithic IC Total	15,018	16,417	15,196	18,674	24,106	33,682	17.5
Hybrid ICs	776	860	750	820	889	1,034	5.9
Total ICs	15,794	17,277	15,946	19,494	24,995	34,716	17.1
Discrete Devices	2,969	3,432	3,077	3,423	3,916	4,681	9.5
Optical Semiconductors	1,494	1,787	1,556	1,728	2,097	2,767	13.1
Total Semiconductor	20,257	22,496	20,579	24,645	31,008	42,164	15.8

Source: Dataquest (May 1996)

Table 5-2
Japanese Semiconductor Market, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	7,829	8,558	10,130	12,001	14,286	16,934	16.7
Memory Total	12,337	10,409	11,853	13,481	17,163	22,162	12.4
Bipolar Memory	82	63	60	55	49	45	-11.3
MOS Memory	12,255	10,346	11,793	13,426	17,114	22,117	12.5
Logic/ASIC Total	8,772	8,934	9,663	10,919	12,501	14,180	10.1
Bipolar Logic	988	824	637	546	486	437	-15.1
MOS Logic	7,784	8,110	9,026	10,373	12,015	13,743	12.0
Analog ICs	4,744	4,801	4,846	5,331	5,922	6,612	6.9
Monolithic IC Total	33,682	32,702	36,492	41,732	49,872	59,888	12.2
Hybrid ICs	1,034	1,045	1,075	1,075	1,075	1,075	0.8
Total ICs	34,716	33,747	37,567	42,807	50,947	60,963	11.9
Discrete Devices	4,681	4,708	4,845	5,232	5,813	6,641	7.2
Optical Semiconductors	2,767	2,789	2,874	3,105	3,452	4,089	8.1
Total Semiconductor	42,164	41,244	45,286	51,144	60,212	71,693	11.2

Source: Dataquest (May 1996)

Table 5-3
Japanese Semiconductor Market, Historic Revenue Growth, 1990-1995 (Percentage Revenue Growth over Preceding Year)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	11.7	20.3	-8.7	22.0	40.5	39.7	21.4
Memory Total	-24.6	0.1	-5.0	36.5	28.9	68.0	23.0
Bipolar Memory	1.6	-14.9	-16.4	-8.0	-22.8	-16.3	-15.8
MOS Memory	-25.5	0.8	-4.5	38.0	30.1	69.1	23.9
Logic/ASIC Total	2.7	8.5	-9.4	17.8	24.5	23.4	12.2
Bipolar Logic	-1.1	-11.4	-20.4	-1.5	11.7	-11.6	-7.3
MOS Logic	4.3	16.7	-5.9	22.9	27.2	29.9	17.4
Analog ICs	-0.4	13.6	-6.2	12.9	23.5	17.2	11.7
Monolithic IC Total	-6.2	9.3	-7.4	22.9	29.1	39.7	17.5
Hybrid ICs	-7.7	10.8	-12.8	9.3	8.4	16.3	5.9
Total ICs	-6.3	9.4	-7.7	22.3	28.2	38.9	17.1
Discrete Devices	-3.6	15.6	-10.3	11.2	14.4	19.5	9.5
Optical Semiconductors	-3.7	19.6	-12.9	11.1	21.4	32.0	13.1
Total Semiconductor	-5.7	11.1	-8.5	19.8	25.8	36.0	15.8

Source: Dataquest (May 1996)

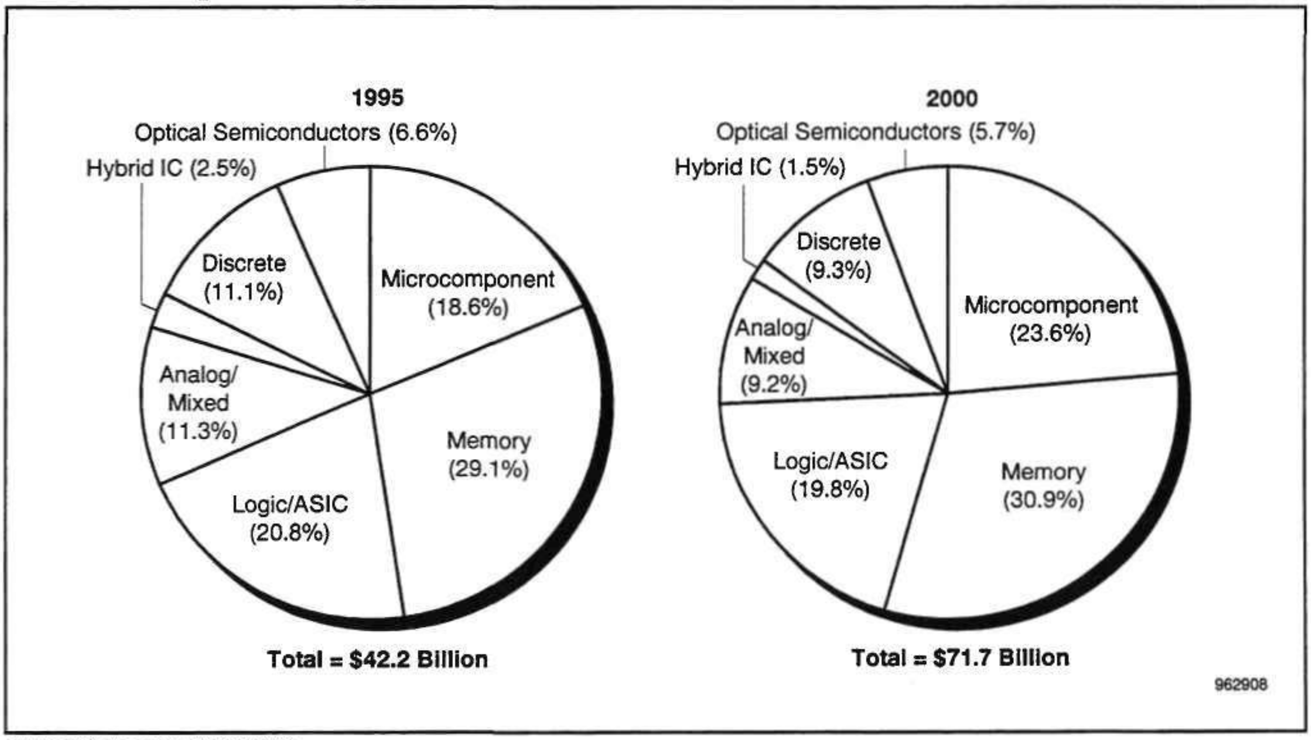
Table 5-4
Japanese Semiconductor Market, Forecast Five-Year Revenue Growth (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	39.7	9.3	18.4	18.5	19.0	18.5	16.7
Memory Total	68.0	-15.6	13.9	13.7	27.3	29.1	12.4
Bipolar Memory	-16.3	-23.2	-4.8	-8.3	-10.9	-8.2	-11.3
MOS Memory	69.1	-15.6	14.0	13.8	27.5	29.2	12.5
Logic/ASIC Total	23.4	1.8	8.2	13.0	14.5	13.4	10.1
Bipolar Logic	-11.6	-16.6	-22.7	-14.3	-11.0	-10.1	-15.1
MOS Logic	29.9	4.2	11.3	14.9	15.8	14.4	12.0
Analog ICs	17.2	1.2	0.9	10.0	11.1	11.7	6.9
Monolithic IC Total	39.7	-2.9	11.6	14.4	19.5	20.1	12.2
Hybrid ICs	16.3	1.1	2.9	0	0	0	0.8
Total ICs	38.9	-2.8	11.3	13.9	19.0	19.7	11.9
Discrete Devices	19.5	0.6	2.9	8.0	11.1	14.2	7.2
Optical Semiconductors	32.0	0.8	3.0	8.0	11.2	18.5	8.1
Total Semiconductor	36.0	-2.2	9.8	12.9	17.7	19.1	11.2

Source: Dataquest (May 1996)

Figure 5-1 illustrates the effect of the Japanese market forecast on the relative consumption by product. The figure highlights three main trends. First, microcomponents are expected to track PC growth in Japan. Second, memory IC price erosion will hold memory growth down over the forecast period. Third, the non-DRAM, non-MPU devices will decline in market share as these devices increasingly move toward offshore equipment production. With a memory and microcomponent market share that is 20 percent less than that of the Americas, the Japanese market has had less dependence on the PC. Personal computers will make strong gains in the Japanese market in the coming years.

Figure 5-1
Product Comparison, Japanese Market, 1995 and 2000



Source: Dataquest (May 1996)

Chapter 6

Europe Forecast by Product Family

The five-year semiconductor forecast for the European market, shown on the following pages, is based on these assumptions:

- With two consecutive years of growth exceeding 35 percent, the European market has shown considerably more strength than we had expected. This growth, based on the PC and personal communications booms, is expected to moderate in 1996.
- The European PC market, which grew by 25 percent in 1995, is still expected to do more than 20 percent in 1996. Declining prices for DRAM will limit the semiconductor ride on this boom, however.
- DRAM revenue will be flat in 1996. Double-digit growth will return in 1997, although at a compounded rate below 20 percent. The more stable prices seen in 1997 will result in DRAM revenue growth consistent with PC unit growth (17 percent).
- MCU growth continued strongly into 1995, with revenue growth exceeding 40 percent. ASP erosion and a slowing of demand will limit revenue growth in 1996, and beyond, to less than 20 percent.
- Shortages in discrete products enhanced the market in 1994 and 1995 as ASPs were kept high. In 1995, a 45 percent annual growth more than doubled the 19 percent seen in 1994. Discrete growth will drop into lower growth in 1996 (10 percent) and beyond (11 percent CAGR, 1995 through 2000).

Tables 6-1 through 6-4 provide details on the European semiconductor market.

Figure 6-1 illustrates the consumption by product changes for the European market over the forecast period. Unlike past years of memory and microcomponent market incursion, the product mix remains fairly consistent over the forecast period. By the year 2000, microcomponents and memory ICs are expected to account for 62 percent of semiconductor shipment revenue, up slightly from the 60 percent of 1995. The growth in microcomponents derives from all segments of the microcomponent category, the MPUs and microperipherals (MPRs) in computers and the microcontroller (MCU) and digital signal processor (DSP) ICs used in communications and consumer products.

Table 6-1
European Semiconductor Market, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	1,802	2,082	2,723	4,037	5,408	7,009	31.2
Memory Total	2,105	2,172	2,698	4,067	6,602	9,990	36.5
Bipolar Memory	55	43	38	27	28	19	-19.2
MOS Memory	2,050	2,129	2,660	4,040	6,574	9,971	37.2
Logic/ASIC Total	1,882	2,085	2,137	2,299	2,659	3,243	11.5
Bipolar Logic	510	443	388	363	329	291	-10.6
MOS Logic	1,372	1,642	1,749	1,936	2,330	2,952	16.6
Analog ICs	2,169	2,184	2,249	2,736	3,370	4,127	13.7
Monolithic IC Total	7,958	8,523	9,807	13,139	18,039	24,369	25.1
Hybrid ICs	157	178	151	179	178	239	8.8
Total ICs	8,115	8,701	9,958	13,318	18,217	24,608	24.8
Discrete Devices	1,895	1,828	1,826	1,769	2,108	3,053	10.0
Optical Semiconductors	405	485	434	374	575	680	10.9
Total Semiconductor	10,415	11,014	12,218	15,461	20,900	28,341	22.2

Source: Dataquest (May 1996)

Table 6-2
European Semiconductor Market, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	7,009	8,503	9,775	11,365	13,454	15,437	17.1
Memory Total	9,990	10,321	11,962	13,917	16,728	19,919	14.8
Bipolar Memory	19	13	13	10	9	8	-15.9
MOS Memory	9,971	10,308	11,949	13,907	16,719	19,911	14.8
Logic/ASIC Total	3,243	3,621	3,974	4,540	5,250	6,175	13.7
Bipolar Logic	291	251	203	174	151	134	-14.4
MOS Logic	2,952	3,370	3,771	4,366	5,099	6,041	15.4
Analog ICs	4,127	4,630	5,306	6,049	7,149	8,580	15.8
Monolithic IC Total	24,369	27,075	31,017	35,871	42,581	50,111	15.5
Hybrid ICs	239	249	245	248	258	263	1.9
Total ICs	24,608	27,324	31,262	36,119	42,839	50,374	15.4
Discrete Devices	3,053	3,367	3,603	3,985	4,491	5,178	11.1
Optical Semiconductors	680	788	869	975	1,103	1,276	13.4
Total Semiconductor	28,341	31,479	35,734	41,079	48,433	56,828	14.9

Source: Dataquest (May 1996)

Table 6-3
European Semiconductor Market, Historic Revenue Growth, 1990-1995 (Percentage Revenue Growth over Preceding Year)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	25.0	15.5	30.8	48.3	34.0	29.6	31.2
Memory Total	-15.4	3.2	24.2	50.7	62.3	51.3	36.5
Bipolar Memory	-22.5	-21.8	-11.6	-28.9	3.7	-32.1	-19.2
MOS Memory	-15.2	3.9	24.9	51.9	62.7	51.7	37.2
Logic/ASIC Total	-3.4	10.8	2.5	7.6	15.7	22.0	11.5
Bipolar Logic	-8.3	-13.1	-12.4	-6.4	-9.4	-11.6	-10.6
MOS Logic	-1.4	19.7	6.5	10.7	20.4	26.7	16.6
Analog ICs	39.4	0.7	3.0	21.7	23.2	22.5	13.7
Monolithic IC Total	7.0	7.1	15.1	34.0	37.3	35.1	25.1
Hybrid ICs	15.4	13.4	-15.2	18.5	-0.6	34.3	8.8
Total ICs	7.2	7.2	14.4	33.7	36.8	35.1	24.8
Discrete Devices	20.4	-3.5	-0.1	-3.1	19.2	44.8	10.0
Optical Semiconductors	14.4	19.8	-10.5	-13.8	53.7	18.3	10.9
Total Semiconductor	9.7	5.8	10.9	26.5	35.2	35.6	22.2

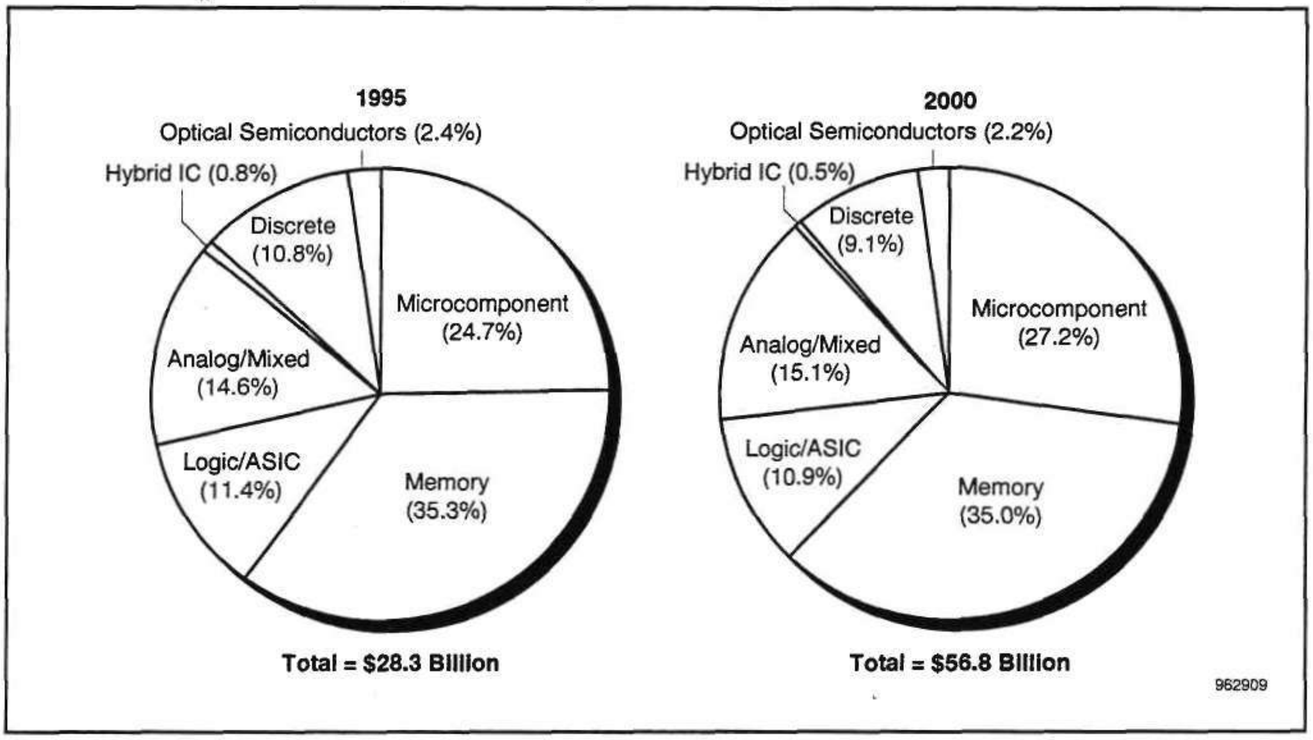
Source: Dataquest (May 1996)

Table 6-4
European Semiconductor Market, Forecast Five-Year Revenue Growth (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	29.6	21.3	15.0	16.3	18.4	14.7	17.1
Memory Total	51.3	3.3	15.9	16.3	20.2	19.1	14.8
Bipolar Memory	-32.1	-31.6	0	-23.1	-10.0	-11.1	-15.9
MOS Memory	51.7	3.4	15.9	16.4	20.2	19.1	14.8
Logic/ASIC Total	22.0	11.7	9.7	14.2	15.6	17.6	13.7
Bipolar Logic	-11.6	-13.7	-19.1	-14.3	-13.2	-11.3	-14.4
MOS Logic	26.7	14.2	11.9	15.8	16.8	18.5	15.4
Analog ICs	22.5	12.2	14.6	14.0	18.2	20.0	15.8
Monolithic IC Total	35.1	11.1	14.6	15.6	18.7	17.7	15.5
Hybrid ICs	34.3	4.2	-1.6	1.2	4.0	1.9	1.9
Total ICs	35.1	11.0	14.4	15.5	18.6	17.6	15.4
Discrete Devices	44.8	10.3	7.0	10.6	12.7	15.3	11.1
Optical Semiconductors	18.3	15.9	10.3	12.2	13.1	15.7	13.4
Total Semiconductor	35.6	11.1	13.5	15.0	17.9	17.3	14.9

Source: Dataquest (May 1996)

Figure 6-1
Product Comparison, European Market, 1995 and 2000



Source: Dataquest (May 1996)

Chapter 7
Asia/Pacific Forecast by Product Family

The five-year forecast for the Asia/Pacific region shown on the following pages is based on the following assumptions:

- The PC business was slower than expected in 1995 and will slow again in 1996. DRAM, SRAM, and MPU growth have been reduced in 1996. The combined MOS memory growth will decline to 10 percent after 74 percent in 1995. Microcomponent growth will drop from 30 percent in 1995 to 21 percent in 1996.
- Decreasing ASPs, down 40 percent over those of 1995, will offset much of the bit growth in Asia/Pacific, reducing DRAM revenue growth below 10 percent in 1996.
- SRAM ASPs are declining, but not falling. SRAM revenue growth will drop to less than half of the 60 percent growth seen in 1995.
- Asia/Pacific's microprocessor market is almost totally dominated by x86 architectures. With ever-shortening PC life cycles, most PC products are shipped without the MPU on-board—92 percent of motherboards, 83 percent of desktop PCs, and 80 percent of notebook computers from Taiwan are shipped this way. This trend will continue over the forecast period.
- China and the southern Asia/Pacific regions have shown strong growth in telecom and consumer equipment. High-end telecommunications equipment is being built in China, and the shipment of pagers and cellular phones continues to expand.
- A strengthening yen continues to drive electronic equipment production out of Japan and into the Asia/Pacific region. This production shift enhances the Asia/Pacific growth that comes with the growth of its own consuming markets. As a semiconductor consuming region, Asia/Pacific will pass Japan in 1998.

Tables 7-1 through 7-4 provide details on the Asia/Pacific semiconductor market.

Figure 7-1 shows the impact of the five-year product forecast on the relative shares of the total Asia/Pacific market. The combined memory-microcomponent IC share increased from 56 percent of the market in 1994 to 61 percent in 1995. Like the three other geographical regions, Asia/Pacific will see little gain in the memory-microcomponent market (to 64 percent in 2000) as prices correct and the PC market slows. Analog and logic ICs, less affected by price erosion, will maintain market position.

Table 7-1
Asia/Pacific Semiconductor Market, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	1,427	2,197	3,085	4,303	5,558	7,254	38.4
Memory Total	1,579	1,991	2,916	4,918	7,223	12,564	51.4
Bipolar Memory	22	17	12	7	7	4	-28.9
MOS Memory	1,557	1,974	2,904	4,911	7,216	12,560	51.8
Logic/ASIC Total	1,268	1,466	1,645	2,396	2,728	3,418	21.9
Bipolar Logic	374	352	369	381	365	317	-3.3
MOS Logic	894	1,114	1,276	2,015	2,363	3,101	28.2
Analog ICs	1,549	1,842	2,339	3,195	4,025	4,741	25.1
Monolithic IC Total	5,823	7,496	9,985	14,812	19,534	27,977	36.9
Hybrid ICs	111	112	125	176	251	284	20.7
Total ICs	5,934	7,608	10,110	14,988	19,785	28,261	36.6
Discrete Devices	1,199	1,386	1,649	2,080	2,527	3,419	23.3
Optical Semiconductors	200	200	275	418	520	737	29.8
Total Semiconductor	7,333	9,194	12,034	17,486	22,832	32,417	34.6

Source: Dataquest (May 1996)

Table 7-2
Asia/Pacific Semiconductor Market, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	7,254	8,811	10,437	12,740	15,842	19,699	22.1
Memory Total	12,564	13,874	16,101	19,053	23,065	29,292	18.4
Bipolar Memory	4	3	2	1	1	1	-24.2
MOS Memory	12,560	13,871	16,099	19,052	23,064	29,291	18.5
Logic/ASIC Total	3,418	3,955	4,474	5,373	6,574	8,073	18.8
Bipolar Logic	317	262	228	191	160	135	-15.7
MOS Logic	3,101	3,693	4,246	5,182	6,414	7,938	20.7
Analog ICs	4,741	5,556	6,231	7,535	9,131	11,067	18.5
Monolithic IC Total	27,977	32,196	37,243	44,701	54,612	68,131	19.5
Hybrid ICs	284	308	337	337	337	337	3.5
Total ICs	28,261	32,504	37,580	45,038	54,949	68,468	19.4
Discrete Devices	3,419	4,000	4,419	5,074	5,845	6,732	14.5
Optical Semiconductors	737	907	1,005	1,146	1,327	1,536	15.8
Total Semiconductor	32,417	37,411	43,004	51,258	62,121	76,736	18.8

Source: Dataquest (May 1996)

Table 7-3
Asia/Pacific Semiconductor Market, Historic Revenue Growth, 1990-1995 (Percentage Revenue Growth over Preceding Year)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	57.2	54.0	40.4	39.5	29.2	30.5	38.4
Memory Total	-1.6	26.1	46.5	68.7	46.9	73.9	51.4
Bipolar Memory	22.2	-22.7	-29.4	-41.7	0	-42.9	-28.9
MOS Memory	-1.9	26.8	47.1	69.1	46.9	74.1	51.8
Logic/ASIC Total	9.7	15.6	12.2	45.7	13.9	25.3	21.9
Bipolar Logic	-3.1	-5.9	4.8	3.3	-4.2	-13.2	-3.3
MOS Logic	16.1	24.6	14.5	57.9	17.3	31.2	28.2
Analog ICs	21.5	18.9	27.0	36.6	26.0	17.8	25.1
Monolithic IC Total	17.8	28.7	33.2	48.3	31.9	43.2	36.9
Hybrid ICs	-19.0	0.9	11.6	40.8	42.6	13.1	20.7
Total ICs	16.8	28.2	32.9	48.2	32.0	42.8	36.6
Discrete Devices	16.7	15.6	19.0	26.1	21.5	35.3	23.3
Optical Semiconductors	16.3	0	37.5	52.0	24.4	41.7	29.8
Total Semiconductor	16.8	25.4	30.9	45.3	30.6	42.0	34.6

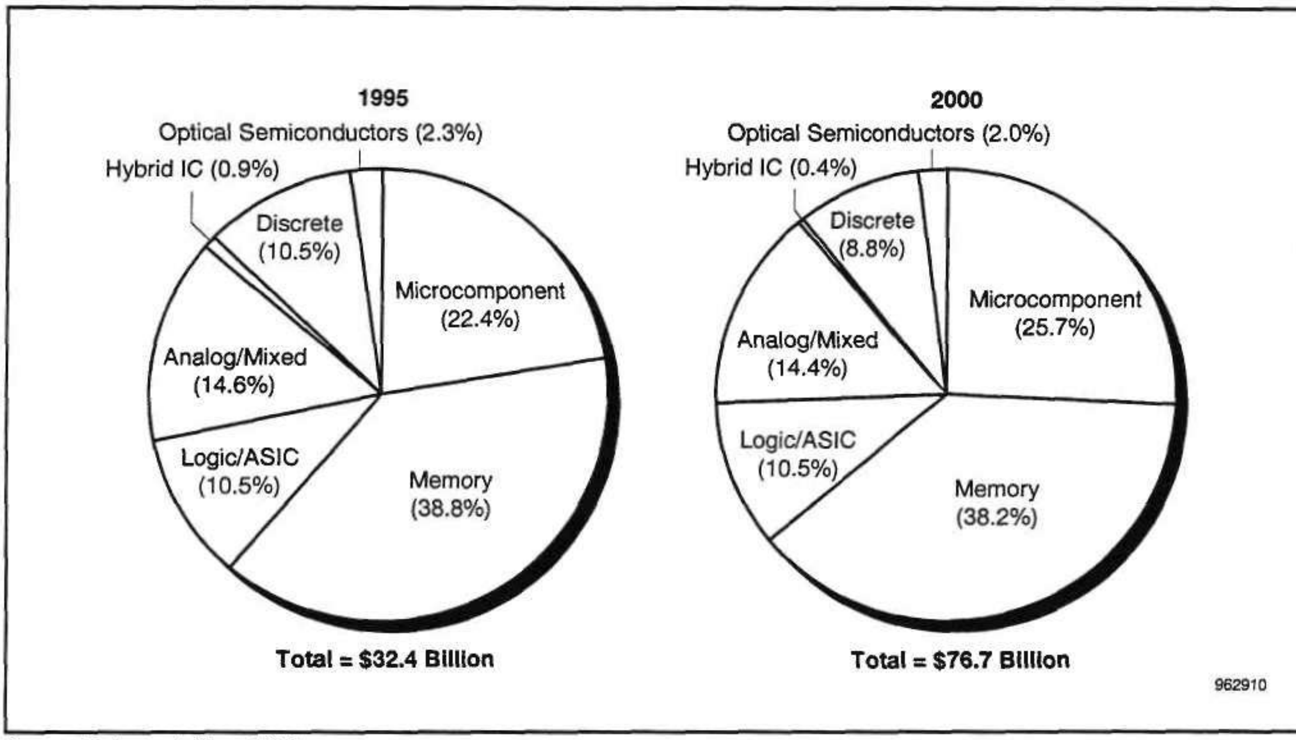
Source: Dataquest (May 1996)

Table 7-4
Asia/Pacific Semiconductor Market, Forecast Five-Year Revenue Growth (Percentage Revenue Growth over Preceding Year)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	30.5	21.5	18.5	22.1	24.3	24.3	22.1
Memory Total	73.9	10.4	16.1	18.3	21.1	27.0	18.4
Bipolar Memory	-42.9	-25.0	-33.3	-50.0	0	0	-24.2
MOS Memory	74.1	10.4	16.1	18.3	21.1	27.0	18.5
Logic/ASIC Total	25.3	15.7	13.1	20.1	22.4	22.8	18.8
Bipolar Logic	-13.2	-17.4	-13.0	-16.2	-16.2	-15.6	-15.7
MOS Logic	31.2	19.1	15.0	22.0	23.8	23.8	20.7
Analog ICs	17.8	17.2	12.1	20.9	21.2	21.2	18.5
Monolithic IC Total	43.2	15.1	15.7	20.0	22.2	24.8	19.5
Hybrid ICs	13.1	8.5	9.4	0	0	0	3.5
Total ICs	42.8	15.0	15.6	19.8	22.0	24.6	19.4
Discrete Devices	35.3	17.0	10.5	14.8	15.2	15.2	14.5
Optical Semiconductors	41.7	23.1	10.8	14.0	15.8	15.7	15.8
Total Semiconductor	42.0	15.4	15.0	19.2	21.2	23.5	18.8

Source: Dataquest (May 1996)

Figure 7-1
Product Comparison, Asia/Pacific Market, 1995 and 2000



Source: Dataquest (May 1996)

Chapter 8

Forecast by Product

Chapter 2 provided a brief discussion of the semiconductor product families. This chapter focuses on the individual products and summarizes the regional splits for each product category.

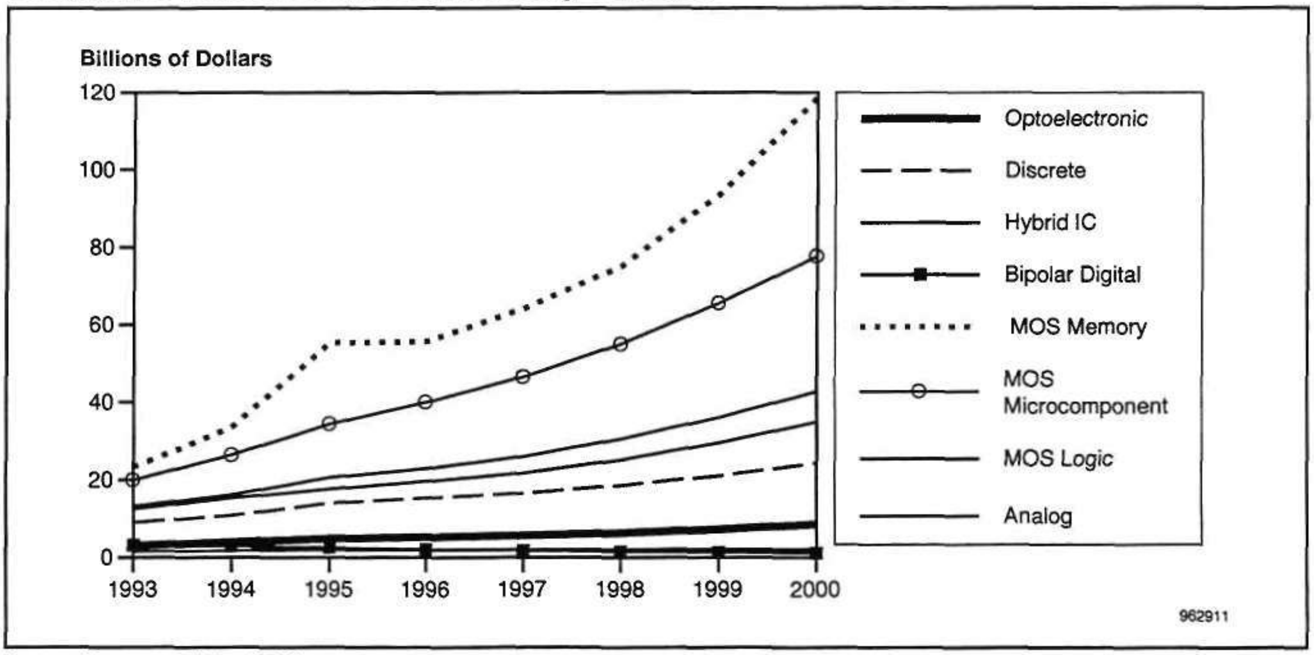
Figure 8-1 graphs the worldwide forecast by category for the forecast period. A major change to the forecast is the flat memory growth seen in 1996—a departure from last year's forecast, where we expected decelerating growth, but growth nevertheless. After this three-year correction period, memory revenue will again outpace microcomponent revenue growth, widening the gap toward the end of the forecast period.

Each of these major product categories is discussed in the following sections, and a regional forecast table is provided.

Microcomponent ICs

After six consecutive years of growth exceeding 20 percent, microcomponent growth is slowing. Growth will drop below 20 percent in 1996 and remain in the high teens for the duration of the forecast. The PC market is slowing somewhat and will post growth under 20 percent worldwide over the coming five years. Microprocessor ASPs will not rise as rapidly as in the recent past, and the slowing growth of PCs and multimedia peripherals will limit microperipheral growth. Communications and digital entertainment will keep DSP growth above 20 percent compounded. Microcontrollers continue to find new homes in every conceivable electronic product and will help hold the microcomponent CAGR near 18 percent. Table 8-1 shows the microcomponent growth by region for the coming five years, with some product detail presented below.

Figure 8-1
Worldwide Semiconductor Forecast by Product



Source: Dataquest (May 1996)

Table 8-1
Microcomponent IC Market, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	12,421	14,073	16,182	18,779	21,950	25,575	15.5
Japan	7,829	8,558	10,130	12,001	14,286	16,934	16.7
Europe	7,009	8,503	9,775	11,365	13,454	15,437	17.1
Asia/Pacific	7,254	8,811	10,437	12,740	15,842	19,699	22.1
Microcomponent IC Total	34,513	39,945	46,524	54,885	65,532	77,645	17.6

Source: Dataquest (May 1996)

Memory ICs

By accounting for 28 percent of total semiconductor revenue, DRAM has had an enormous effect on total semiconductor growth. With an 82 percent DRAM revenue growth in 1995, the semiconductor market grew by 37 percent; excluding DRAM revenue growth, all other semiconductor products showed a combined growth of 25 percent. In 1996, Dataquest anticipates no DRAM growth, a problem that will limit total semiconductor growth to 8 percent even as non-DRAM devices will grow by 14 percent on average.

Memory IC demand will continue unabated in 1996. The only difference is that we are in oversupply and prices have declined precipitously. The year 1996 marks the end of the DRAM shortage and the return to the "normal" declining price-per-bit scenario. Bit growth is expected to be substantial but not sufficient to counter the large price-per-bit declines that have dropped price-per-megabyte below $14. A compounded revenue growth rate of 17 percent for DRAM over the 1995-through-2000 period, although a drop from the past five years, will allow DRAM to grow faster than the semiconductor market and account for more than 30 percent of the semiconductor revenue in the year 2000. The five-year compounded growth for memory ICs has dropped to 16.5 percent. Despite a drop in revenue in Japan in 1996, all four regions will show double-digit CAGRs over the forecast period. Table 8-2 shows the memory IC forecast by region.

Table 8-2
Memory IC Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	20,530	21,145	24,297	28,647	36,710	47,307	18.2
Japan	12,337	10,409	11,853	13,481	17,163	22,162	12.4
Europe	9,990	10,321	11,962	13,917	16,728	19,919	14.8
Asia/Pacific	12,564	13,874	16,101	19,053	23,065	29,292	18.4
Memory IC Total	55,421	55,749	64,213	75,098	93,666	118,680	16.5

Source: Dataquest (May 1996)

Logic ICs

Logic ICs include a broad and dissimilar set of products. These products can be cut by standard or ASIC, bipolar or MOS. A traditional cut used in this forecast is that of process technology—bipolar logic and MOS logic, which more or less track an "old versus new" division. After a two-year respite from rapidly declining revenue in 1993 and 1995, bipolar logic returned to a 14 percent decline in 1995, a "normal" rate that we expect to continue into 1996 and beyond.

MOS logic showed a 28 percent growth in revenue in 1995 after 27 percent in 1994. We expect growth to drop to eleven percent in 1996 and then settle into a long-term 16 percent growth rate driven by the still strong MOS programmable logic device (PLD), MOS gate array, and MOS cell-based products. MOS ASIC is the major driver of the MOS logic category. The total logic data combines both bipolar and MOS logic, giving an aggregate growth of 22 percent for 1995 and a five-year CAGR of 14 percent over the forecast period. Table 8-3 gives the combined logic forecast.

Analog ICs

Consumer entertainment products, being largely audio and video, are intrinsically analog in nature and have typically consumed about 40 percent of all analog ICs. The big declines seen in 1992 in the consumer market, especially in Japan and Europe, severely impacted the growth of analog ICs, resulting in a growth of only 6 percent. Since 1992, analog ICs have shown a consistent 23 percent annual growth. In 1995, we saw a drop from this trend, with a 15 percent growth.

Analog ICs show a very equal distribution among the four regions, with the Americas having the smallest share at 23 percent and Japan the largest at 27 percent. This distribution is changing as consumer equipment manufacturing increasingly migrates to Asia/Pacific sites. The increasing presence of analog ICs in computer and communications applications is stabilizing growth in the Americas and Europe. Table 8-4 shows the analog IC growth rate by region over the forecast period.

Total Monolithic ICs

The combination of microcomponent, memory, logic, and analog ICs gives the total monolithic IC market. The five-year forecast for this summary category is shown in Table 8-5.

Table 8-3
Logic IC Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	7,528	8,400	9,581	11,074	12,887	15,320	15.3
Japan	8,772	8,934	9,663	10,919	12,501	14,180	10.1
Europe	3,243	3,621	3,974	4,540	5,250	6,175	13.7
Asia/Pacific	3,418	3,955	4,474	5,373	6,574	8,073	18.8
Logic IC Total	22,961	24,910	27,692	31,906	37,212	43,748	13.8

Source: Dataquest (May 1996)

Table 8-4
Analog IC Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	3,995	4,575	5,315	6,232	7,329	8,652	16.7
Japan	4,744	4,801	4,846	5,331	5,922	6,612	6.9
Europe	4,127	4,630	5,306	6,049	7,149	8,580	15.8
Asia/Pacific	4,741	5,556	6,231	7,535	9,131	11,067	18.5
Analog IC Total	17,607	19,562	21,698	25,147	29,531	34,911	14.7

Source: Dataquest (May 1996)

Table 8-5
Total Monolithic IC Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	44,474	48,193	55,375	64,732	78,876	96,854	16.8
Japan	33,682	32,702	36,492	41,732	49,872	59,888	12.2
Europe	24,369	27,075	31,017	35,871	42,581	50,111	15.5
Asia/Pacific	27,977	32,196	37,243	44,701	54,612	68,131	19.5
Monolithic IC Total	130,502	140,166	160,127	187,036	225,941	274,984	16.1

Source: Dataquest (May 1996)

Discrete Devices

Discrete devices showed a 30 percent revenue growth in 1995. Although the discrete device category has been losing market share because of the relentless integration of components, this category remains viable because power and RF devices are not readily integrated. Power transistors represent about one-third of discrete revenue and are expected to lead the discrete growth with a 14 percent CAGR. Table 8-6 gives the discrete forecast by region. The growing use of power discrete devices in power control and communications applications in the Americas has brought the compounded Americas growth rate back into double digits.

Table 8-6
Discrete Device Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	2,870	3,225	3,650	4,190	4,895	5,700	14.7
Japan	4,681	4,708	4,845	5,232	5,813	6,641	7.2
Europe	3,053	3,367	3,603	3,985	4,491	5,178	11.1
Asia/Pacific	3,419	4,000	4,419	5,074	5,845	6,732	14.5
Discrete Devices Total	14,023	15,300	16,517	18,481	21,044	24,251	11.6

Source: Dataquest (May 1996)

Optical Semiconductors

Even more than analog ICs or discrete devices, optical semiconductors find their primary market in consumer entertainment products. With scanners and copiers using charge-coupled devices (CCDs), CD-ROMs using laser diodes, and optical-fiber data links using semiconductor receivers and transmitters, the data processing market is showing an increasing impact on the optical semiconductor market. This impact was seen as a 24 percent revenue growth in 1995. Growth in 1996 is anticipated to be 8 percent as the computer peripherals and consumer markets slow. Laser diodes have continued to lead the growth in this category; 1996 shows a 36 percent revenue growth for this product type. The optical semiconductor forecast by region is given in Table 8-7.

Table 8-7
Optical Semiconductor Market by Region, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Americas	627	715	840	1,060	1,325	1,625	21.0
Japan	2,767	2,789	2,874	3,105	3,452	4,089	8.1
Europe	680	788	869	975	1,103	1,276	13.4
Asia/Pacific	737	907	1,005	1,146	1,327	1,536	15.8
Optical Semiconductors Total	4,811	5,199	5,588	6,286	7,207	8,526	12.1

Source: Dataquest (May 1996)

Chapter 9

Forecast by Technology

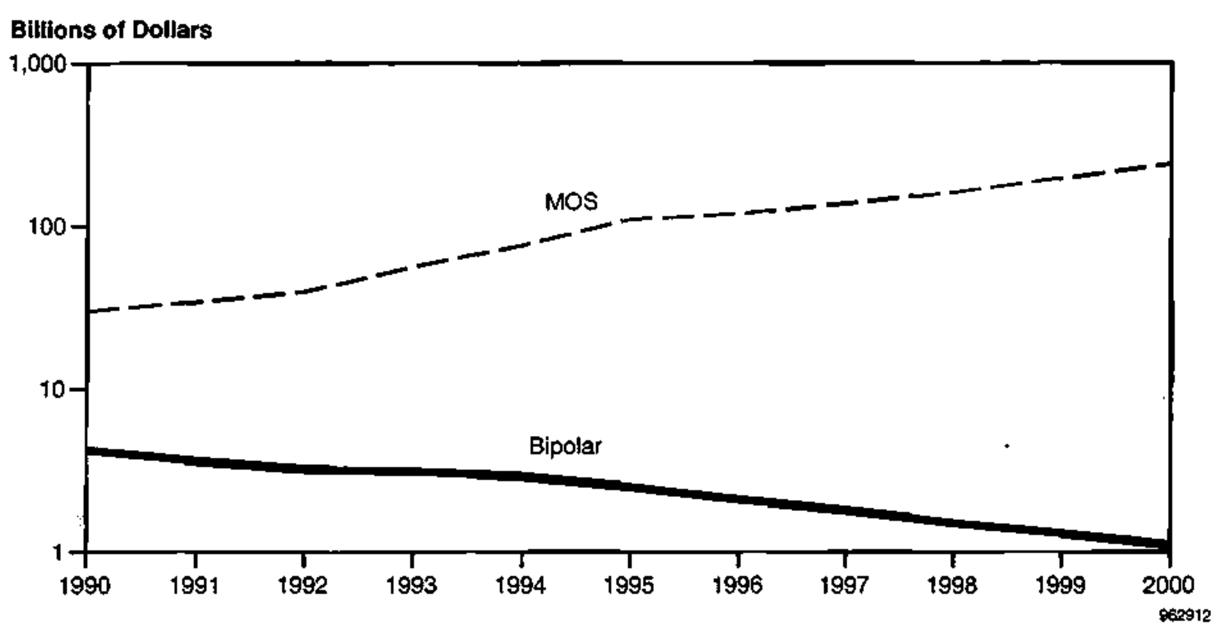
Digital MOS and Bipolar IC Forecast

The five-year IC forecast includes the process categories of MOS digital and bipolar digital ICs. This process split is still important for the logic IC category but is of decreasing importance for the memory IC category. For microcomponent ICs, the bipolar subsegment has become fairly irrelevant and is no longer reported or forecast separately.

The forecast data for digital ICs, by process, is plotted in Figure 9-1. The graph shows that the bipolar portion of the digital IC market is declining at a 12 percent CAGR over the forecast period. By the year 2000, bipolar digital ICs will have declined to less than 0.5 percent of the total digital IC market.

Tables 9-1 and 9-2 show the five-year history and forecast, respectively, for the bipolar and MOS portions of the three main digital IC categories. It can be seen that, as a memory IC process technology, bipolar has been in a rapid slide that is slowing as revenue becomes insignificant. Bipolar logic ICs accounted for 14 percent of logic IC revenue in 1994. By 2000, it is expected that bipolar logic will represent less than 3 percent of the logic IC revenue.

Figure 9-1
MOS versus Bipolar Forecast



Source: Dataquest (May 1996)

Table 9-1
Semiconductor Market by Process Technology, Six-Year Revenue History, 1990-1995 (Revenue in Millions of Dollars)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Bipolar Total	4,173	3,628	3,193	3,079	2,912	2,497	-9.8
Bipolar Memory	431	356	318	244	199	160	-18.0
Bipolar Logic	3,742	3,272	2,875	2,835	2,713	2,337	-9.0
MOS Total	30,152	34,315	39,710	56,374	76,021	110,298	29.6
MOS Micro	9,584	11,774	14,359	19,947	26,408	34,513	29.2
MOS Memory	12,128	12,841	15,308	23,306	33,505	55,261	35.4
MOS Logic	8,440	9,700	10,043	13,121	16,108	20,624	19.6
Total Digital IC	34,325	37,943	42,903	59,453	78,933	112,895	26.9

Source: Dataquest (May 1996)

Table 9-2
Semiconductor Market by Process Technology, Five-Year Revenue Forecast, 1995-2000 (Revenue in Millions of Dollars)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Bipolar Total	2,497	2,131	1,752	1,508	1,298	1,137	-14.6
Bipolar Memory	160	119	108	93	79	71	-15.0
Bipolar Logic	2,337	2,012	1,644	1,415	1,219	1,066	-14.5
MOS Total	110,298	118,473	136,677	160,381	195,112	238,936	16.7
MOS Micro	34,513	39,945	46,524	54,885	65,532	77,645	17.6
MOS Memory	55,261	55,630	64,105	75,005	93,587	118,609	16.5
MOS Logic	20,624	22,898	26,048	30,491	35,993	42,682	15.7
Total Digital IC	112,895	120,604	138,429	161,889	196,410	240,073	16.3

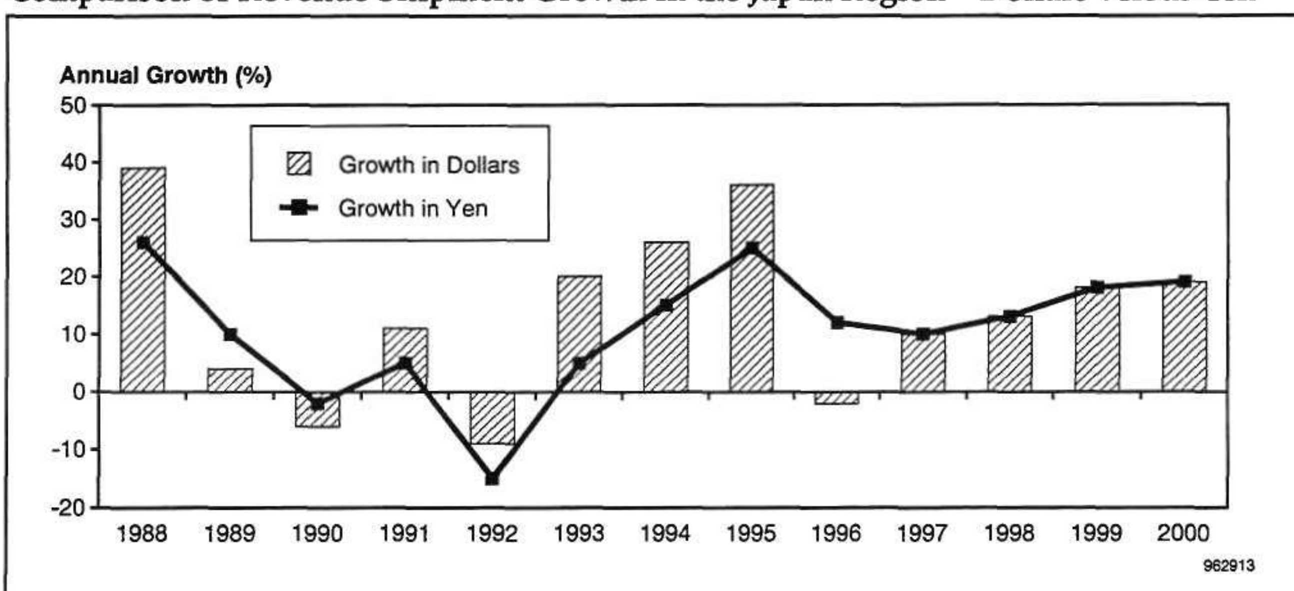
Source: Dataquest (May 1996)

Appendix A
Japanese Revenue History and Forecast in Yen

Revenue growth in shipments to the Japan region differs according to whether the dollar or yen is used as the currency basis. As the dollar has typically weakened against the yen, Japanese growth has often been inflated by this exchange rate change. Figure A-1 shows the annual growth in each of these two currencies over both the historical 1988-through-1995 period and the forecast 1996-through-2000 period. Because Dataquest does not forecast exchange rates, the forecast growth rates are the same.

The following tables show the yen-based revenue shipment data for the Japan region. Tables A-1 and A-2 provide the Japanese revenue history and forecast, respectively, in yen. The historical exchange rates are shown at the bottom of these tables. Tables A-3 and A-4 show the annual growth associated with the year-to-year revenue growth. The rate of dollar appreciation against the yen for the period from 1990 through 1995 is shown at the bottom of Table A-3. Over the past five years, the dollar has declined in value, inflating the revenue growth of the Japanese market in dollars.

Figure A-1
Comparison of Revenue Shipment Growth in the Japan Region—Dollars versus Yen



Source: Dataquest (May 1996)

Table A-1
Japanese Semiconductor Market, Six-Year Yen Revenue History, 1990-1995 (Revenue in Billions of Yen)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	428	487	413	443	570	735	11.4
Memory Total	632	597	528	634	748	1,158	12.9
Bipolar Memory	28	22	17	14	10	8	-22.7
MOS Memory	604	575	510	619	738	1,151	13.8
Logic/ASIC Total	710	728	613	635	724	824	3.0
Bipolar Logic	208	174	128	111	114	93	-14.9
MOS Logic	503	554	485	524	610	731	7.8
Analog ICs	392	421	367	365	412	445	2.6
Monolithic IC Total	2,163	2,233	1,922	2,077	2,454	3,163	7.9
Hybrid ICs	112	117	95	91	91	97	-2.8
Total ICs	2,274	2,350	2,016	2,168	2,545	3,260	7.5
Discrete Devices	428	467	389	381	399	440	0.6
Optical Semiconductors	215	243	197	192	213	260	3.8
Total Semiconductor	2,917	3,059	2,602	2,741	3,157	3,959	6.3
Yen/U.S.$ Exchange Rate	144.00	136.00	126.45	111.20	101.81	93.90	

Source: Dataquest (May 1996)

Table A-2
Japanese Semiconductor Market, Five-Year Yen Revenue Forecast, 1995-2000 (Revenue in Billions of Yen)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	735	916	1,084	1,285	1,529	1,813	19.8
Memory Total	1,158	1,114	1,269	1,443	1,837	2,372	15.4
Bipolar Memory	8	7	6	6	5	5	-9.0
MOS Memory	1,151	1,108	1,262	1,437	1,832	2,368	15.5
Logic/ASIC Total	824	956	1,034	1,169	1,338	1,518	13.0
Bipolar Logic	93	88	68	58	52	47	-12.8
MOS Logic	731	868	966	1,110	1,286	1,471	15.0
Analog ICs	445	514	519	571	634	708	9.7
Monolithic IC Total	3,163	3,501	3,906	4,467	5,339	6,411	15.2
Hybrid ICs	97	112	115	115	115	115	3.5
Total ICs	3,260	3,613	4,022	4,582	5,454	6,526	14.9
Discrete Devices	440	504	519	560	622	711	10.1
Optical Semiconductors	260	299	308	332	370	438	11.0
Total Semiconductor	3,959	4,415	4,848	5,475	6,446	7,675	14.2
Yen/U.S.$ Exchange Rate	93.90	107.05	107.05	107.05	107.05	107.05	

Source: Dataquest (May 1996)

Table A-3
Japanese Semiconductor Market, Yen Revenue Growth, 1990-1995 (Percentage Revenue Growth in Yen)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	16.6	13.7	-15.1	7.3	28.7	28.9	11.4
Memory Total	-21.3	-5.5	-11.6	20.0	18.0	54.9	12.9
Bipolar Memory	6.0	-19.7	-22.2	-19.1	-29.4	-22.8	-22.7
MOS Memory	-22.2	-4.8	-11.2	21.3	19.1	56.0	13.8
Logic/ASIC Total	7.2	2.5	-15.7	3.6	14.0	13.8	3.0
Bipolar Logic	3.2	-16.3	-26.0	-13.4	2.3	-18.5	-14.9
MOS Logic	8.9	10.2	-12.5	8.1	16.5	19.8	7.8
Analog ICs	3.9	7.3	-12.8	-0.7	13.1	8.1	2.6
Monolithic IC Total	-2.2	3.2	-13.9	8.1	18.2	28.9	7.9
Hybrid ICs	-3.7	4.7	-18.9	-3.9	-0.7	7.3	-2.8
Total ICs	-2.2	3.3	-14.2	7.5	17.4	28.1	7.5
Discrete Devices	0.6	9.2	-16.6	-2.2	4.7	10.2	0.6
Optical Semiconductors	0.5	13.0	-19.0	-2.3	11.1	21.7	3.8
Total Semiconductor	-1.6	4.9	-14.9	5.3	15.2	25.4	6.3
U.S.$ Appreciation versus Yen	4.35	-5.56	-7.02	-12.06	-8.44	7.77	-8.20

Source: Dataquest (May 1996)

Table A-4
Japanese Semiconductor Market, Forecast Five-Year Yen Revenue Growth, 1995-2000 (Percentage Revenue Growth in Yen)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	28.9	24.6	18.4	18.5	19.0	18.5	19.8
Memory Total	54.9	-3.8	13.9	13.7	27.3	29.1	15.4
Bipolar Memory	-22.8	-12.4	-4.8	-8.3	-10.9	-8.2	-9.0
MOS Memory	56.0	-3.8	14.0	13.8	27.5	29.2	15.5
Logic/ASIC Total	13.8	16.1	8.2	13.0	14.5	13.4	13.0
Bipolar Logic	-18.5	-4.9	-22.7	-14.3	-11.0	-10.1	-12.8
MOS Logic	19.8	18.8	11.3	14.9	15.8	14.4	15.0
Analog ICs	8.1	15.4	0.9	10.0	11.1	11.7	9.7
Monolithic IC Total	28.9	10.7	11.6	14.4	19.5	20.1	15.2
Hybrid ICs	7.3	15.2	2.9	0	0	0	3.5
Total ICs	28.1	10.8	11.3	13.9	19.0	19.7	14.9
Discrete Devices	10.2	14.7	2.9	8.0	11.1	14.2	10.1
Optical Semiconductors	21.7	14.9	3.0	8.0	11.2	18.5	11.0
Total Semiconductor	25.4	11.5	9.8	12.9	17.7	19.1	14.2
U.S.$ Appreciation versus Yen	-7.77	14.00	0	0	0	0	2.66

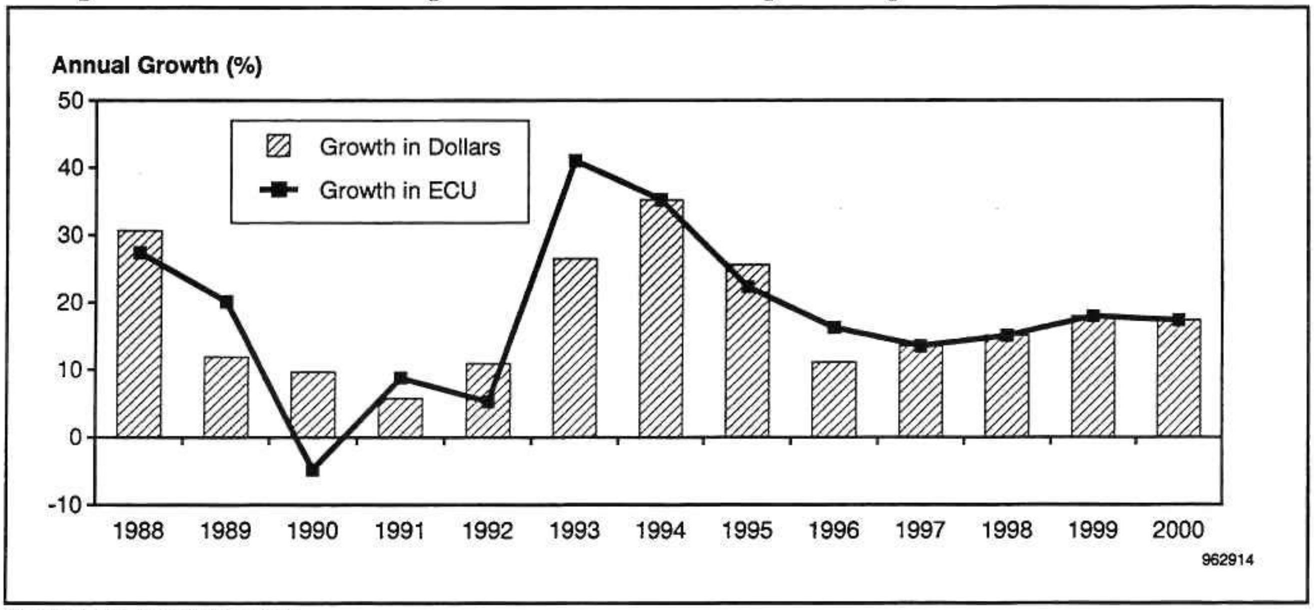
Source: Dataquest (May 1996)

Appendix B
European Revenue History and Forecast in ECU

Revenue growth in shipments to the European region differs whether the dollar or ECU is used as the currency basis. The dollar has not had any consistent long-term change with the ECU; the exchange rate in 1995 was essentially the same as in 1990, although there were annual fluctuations. Figure B-1 shows the annual growth in each of these two currencies over both the historical 1988-through-1995 period and the forecast 1996-through-2000 period. Because Dataquest does not forecast exchange rates, the forecast growth rates are the same.

Tables B-1 and B-2 provide the European revenue history and forecast in ECU. The historical exchange rates are shown at the bottom of these tables. Tables B-3 and B-4 show the annual growth associated with the year-to-year revenue growth. The rate of dollar appreciation against the ECU for the period from 1990 through 1995 is shown at the bottom of Table B-3. Over the past seven years, the exchange rate has shown little fluctuation, on average.

Figure B-1
Comparison of Revenue Shipment Growth in European Region—Dollars versus ECU



Source: Dataquest (May 1996)

Table B-1
European Semiconductor Market, Six-Year ECU Revenue History, 1990-1995 (Revenue in Millions of ECU)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	1,420	1,689	2,097	3,464	4,543	5,425	30.7
Memory Total	1,659	1,761	2,077	3,489	5,546	7,732	36.1
Bipolar Memory	43	35	29	23	24	15	-19.4
MOS Memory	1,615	1,727	2,048	3,466	5,522	7,718	36.7
Logic/ASIC Total	1,483	1,691	1,645	1,973	2,234	2,510	11.1
Bipolar Logic	402	359	299	311	276	225	-10.9
MOS Logic	1,081	1,332	1,347	1,661	1,957	2,285	16.1
Analog ICs	1,709	1,771	1,732	2,347	2,831	3,194	13.3
Monolithic IC Total	6,271	6,912	7,551	11,273	15,153	18,862	24.6
Hybrid ICs	124	144	116	154	150	185	8.4
Total ICs	6,395	7,057	7,668	11,427	15,302	19,047	24.4
Discrete Devices	1,493	1,483	1,406	1,518	1,771	2,363	9.6
Optical Semiconductors	319	393	334	321	483	526	10.5
Total Semiconductor	8,207	8,932	9,408	13,266	17,556	21,936	21.7
ECU/U.S.$ Exchange Rate	0.788	0.811	0.77	0.858	0.84	0.774	

Source: Dataquest (May 1996)

Table B-2
European Semiconductor Market, Five-Year ECU Revenue Forecast, 1995-2000 (Revenue in Millions of ECU)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	5,425	6,887	7,918	9,206	10,898	12,504	18.2
Memory Total	7,732	8,360	9,689	11,273	13,550	16,134	15.8
Bipolar Memory	15	11	11	8	7	6	-15.1
MOS Memory	7,718	8,349	9,679	11,265	13,542	16,128	15.9
Logic/ASIC Total	2,510	2,933	3,219	3,677	4,253	5,002	14.8
Bipolar Logic	225	203	164	141	122	109	-13.6
MOS Logic	2,285	2,730	3,055	3,536	4,130	4,893	16.5
Analog ICs	3,194	3,750	4,298	4,900	5,791	6,950	16.8
Monolithic IC Total	18,862	21,931	25,124	29,056	34,491	40,590	16.6
Hybrid ICs	185	202	198	201	209	213	2.9
Total ICs	19,047	22,132	25,322	29,256	34,700	40,803	16.5
Discrete Devices	2,363	2,727	2,918	3,228	3,638	4,194	12.2
Optical Semiconductors	526	638	704	790	893	1,034	14.5
Total Semiconductor	21,936	25,498	28,945	33,274	39,231	46,031	16.0
ECU/U.S.$ Exchange Rate	0.774	0.81	0.81	0.81	0.81	0.81	

Source: Dataquest (May 1996)

Table B-3
European Semiconductor Market, Historic Revenue Growth, 1990-1995 (Revenue Growth in ECU)

	1990	1991	1992	1993	1994	1995	CAGR (%) 1990-1995
Microcomponents	8.5	18.9	24.2	65.2	31.2	19.4	30.7
Memory Total	-26.6	6.2	17.9	68.0	58.9	39.4	36.1
Bipolar Memory	-32.8	-19.5	-16.1	-20.8	1.5	-37.5	-19.4
MOS Memory	-26.4	6.9	18.6	69.2	59.3	39.8	36.7
Logic/ASIC Total	-16.2	14.0	-2.7	19.9	13.2	12.4	11.1
Bipolar Logic	-20.4	-10.6	-16.8	4.2	-11.3	-18.5	-10.9
MOS Logic	-14.5	23.2	1.1	23.3	17.8	16.7	16.1
Analog ICs	21.0	3.6	-2.2	35.6	20.6	12.8	13.3
Monolithic IC Total	-7.1	10.2	9.2	49.3	34.4	24.5	24.6
Hybrid ICs	0.2	16.7	-19.5	32.1	-2.6	23.7	8.4
Total ICs	-7.0	10.4	8.7	49.0	33.9	24.5	24.4
Discrete Devices	4.5	-0.7	-5.2	8.0	16.7	33.4	9.6
Optical Semiconductors	-0.7	23.2	-15.0	-4.0	50.5	9.0	10.5
Total Semiconductor	-4.8	8.8	5.3	41.0	32.3	24.9	21.7
U.S.$ Appreciation versus ECU	-13.22	2.92	-5.06	11.43	-2.10	-7.86	-0.36

Source: Dataquest (May 1996)

Table B-4
European Semiconductor Market, Forecast Five-Year ECU Revenue Growth, 1995-2000 (Percentage Revenue Growth in ECU)

	1995	1996	1997	1998	1999	2000	CAGR (%) 1995-2000
Microcomponents	19.4	27.0	15.0	16.3	18.4	14.7	18.2
Memory Total	39.4	8.1	15.9	16.3	20.2	19.1	15.8
Bipolar Memory	-37.5	-28.4	0	-23.1	-10.0	-11.1	-15.1
MOS Memory	39.8	8.2	15.9	16.4	20.2	19.1	15.9
Logic/ASIC Total	12.4	16.8	9.7	14.2	15.6	17.6	14.8
Bipolar Logic	-18.5	-9.7	-19.1	-14.3	-13.2	-11.3	-13.6
MOS Logic	16.7	19.5	11.9	15.8	16.8	18.5	16.5
Analog ICs	12.8	17.4	14.6	14.0	18.2	20.0	16.8
Monolithic IC Total	24.5	16.3	14.6	15.6	18.7	17.7	16.6
Hybrid ICs	23.7	9.0	-1.6	1.2	4.0	1.9	2.9
Total ICs	24.5	16.2	14.4	15.5	18.6	17.6	16.5
Discrete Devices	33.4	15.4	7.0	10.6	12.7	15.3	12.2
Optical Semiconductors	9.0	21.3	10.3	12.2	13.1	15.7	14.5
Total Semiconductor	24.9	16.2	13.5	15.0	17.9	17.3	16.0
U.S.$ Appreciation versus ECU	-7.86	4.65	0	0	0	0	0.91

Source: Dataquest (May 1996)

Appendix C
Definitions

Analog ICs

Analog ICs are a group of semiconductors that deal with electrical signals and electrical power. Analog components carry information as voltage, current, frequency, phase, duty cycle, or other electronic parameters. Because they are not based on number values, analog information is not limited to a finite range of values and has no inherent quantization noise or quantization error. The downside is that analog signal information exists in the time domain and can be corrupted as the information-carrying parameter is influenced by noise, drift, bandwidth, and component instability—all the vagaries of time.

Bipolar

These are semiconductor devices that use bipolar transistors rather than MOS transistors. Bipolar transistors are found in both ICs and discrete products. Bipolar transistors are so named because they carry electricity with two different types of "carriers"—holes and electrons.

Digital ICs

Digital ICs handle numbers in the binary format of ones and zeros. Digital ICs comprise logic, microcomponent, and memory ICs. The number-handling nature of digital electronics makes the data more immune to physical changes in the electronic components.

Discrete Devices

A discrete semiconductor is defined as a single semiconductor component such as a transistor, diode, or thyristor. Although multiple devices may be present in a package, they are still considered discretes if they have no internal functional interconnection and are applied in the same manner as other discrete devices. Some discrete devices may actually be similar to ICs in having integrated protection and sensing circuitry. Even if a device is an integrated circuit, it will be considered a discrete if it is used like one.

Hybrid IC

A hybrid is an IC that mixes semiconductor technology with other electronic technologies in a single package. It is this mixing of technologies within the IC package that gives these products the "hybrid" IC name. Other technologies include thin and thick film resistors and chip capacitors. A multiple-chip IC is not a true hybrid IC and is counted in the monolithic IC category. The mixing of technologies is most often done for analog hybrid ICs. Because of this, hybrid ICs are often added to monolithic analog IC revenue to provide the total analog IC market.

IC

An integrated circuit is a chip in which multiple transistors and diodes are interconnected to perform an electronic function. The function-specific nature of an IC differentiates it from the nonspecific array of discrete transistors.

Logic

This is an electronic function where bits (one and zeros) are processed. This bit processing is defined by hardwiring, mask programming, or field programming. Microcomponents and memory ICs are logic ICs, but they are logic ICs that are either dedicated to a function (such as microperipherals and memory ICs) or are software programmable (such as microprocessors and microcontrollers). Logic ICs also include customer-specific logic ICs.

Microcomponent

A microcomponent is a digital IC that can be programmable such as a microprocessor (MPU), microcontroller (MCU), digital signal processor (DSP), or an application-specific logic device that provides a supporting function to an MPU, MCU, or DSP.

Monolithic IC

A monolithic IC is an IC formed on a single chip of semiconducting material. This designation has been applied more broadly to mean any device, even a multiple-chip packaged device, that does not contain other, nonsemiconductor, components. This differentiates monolithic ICs from hybrid ICs that may also be multiple-chip, but represent a "hybrid" in the sense of mixing other technologies within the IC package, such as film resistors or chip capacitors.

MOS

MOS is an acronym for metal oxide semiconductor, a type of transistor used in ICs and discrete devices. Although the actual device may use different materials than metal or oxide, this acronym is used to define the whole family of similar processes that provide an insulated gate field-effect transistor (FET). MOSFETs, like all field-effect transistors, differ from bipolar devices in having an insulated gate and only a single carrier of electrical current (either electrons or holes). MOSFETs are found in both N and P channel varieties. A special IC process combines both the N and P channel device in a complementary configuration, an arrangement known as CMOS.

Memory IC

Memory ICs are ICs that can store and retrieve logic bits. Two major memory types are read-only memories (ROM), preloaded with data, or random-access memories (RAM), where data can be both stored and accessed. RAM subcategories include DRAM and SRAM. Memory ICs that do not lose their data when power is removed are called nonvolatile memories. DRAM and SRAM do not retain data when power is removed from the device. ROM, EPROM, EEPROM, and flash memory ICs are non-volatile memory devices.

Optical Semiconductors

These devices are the semiconductor subset of optoelectronic products. This family includes light-sensing products such as photosensors and CCDs as well as light-emitting devices such as LEDs and lasers. Optocouplers and interrupters use both functions.

Semiconductors

These electronic components are manufactured by introducing impurities into a semiconductor material to create special current conducting devices such as diodes, bipolar transistors, and MOS transistors. Semiconducting material is so named because its conducting capability falls between the range of insulators and metallic conductors.

Appendix D
Historical Exchange Rates

Table D-1 shows 10 years of exchange rates of the yen and ECU versus the U.S. dollar. The appreciation of the dollar against these local currencies is given in the last two columns.

Table D-1
Exchange Rates

Year	Yen per U.S.$	ECU per U.S.$	U.S.$ Growth versus Yen (%)	U.S.$ Growth versus ECU (%)
1980	227	-	3.6	-
1981	221	-	-2.7	-
1982	248	-	12.2	-
1983	235	-	-5.2	-
1984	237	-	0.9	-
1985	238	-	0.4	-
1986	167	-	-29.8	-
1987	144	-	-13.8	-
1988	130	0.846	-9.7	-2.5
1989	138	0.908	6.2	7.3
1990	144	0.788	4.3	-13.2
1991	136	0.811	-5.6	2.9
1992	126.5	0.770	-7.0	-5.0
1993	111.2	0.858	-12.1	11.4
1994	101.8	0.840	-8.4	-2.1
1995	93.90	0.774	-7.8	-7.9

Source: Dataquest (May 1996)

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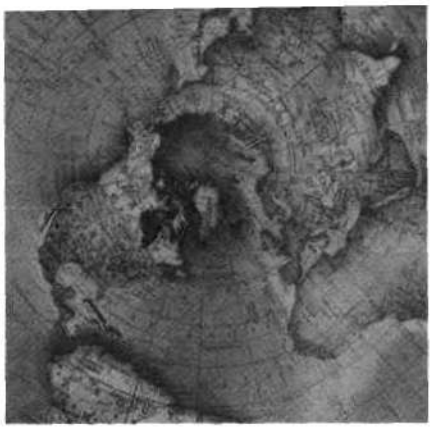

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North American Semiconductor Price Outlook—First Quarter 1997

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SPSG-WW-MS-9605
Publication Date: January 6, 1997
Filing: Market Statistics

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Table 15
Estimated Gate Array Pricing—North American Production Bookings
(Volume: 20,000 Units, Based on Utilized Gates Only; NRE = Netlist to Prototype, Millicents per Gate)

Gate Count Technology	10-29.99K Gates 1997	1998	1999	30-59.99K Gates 1997	1998	1999	60-99.99K Gates 1997	1998	1999	Lead Time (Weeks)
CMOS (Average)										Production:
1.0 Micron	31.00	27.00	25.00	30.00	26.00	23.00	28.00	25.00	22.00	6-12
0.8 Micron	27.00	23.00	22.00	23.00	20.00	18.00	23.00	19.00	17.00	6-12
0.6/0.5 Micron	25.00	21.00	19.00	18.00	16.00	15.00	17.00	15.00	14.00	6-12
0.3 Micron	NR	NR	24.00	NR	NR	20.00	16.00	14.00	13.00	6-12
										Prototypes:
NRE CMOS Average Charge ($K)	44.00	44.00	43.00	54.00	52.00	52.00	74.00	73.00	73.00	2-8

Gate Count Technology	100-299.99K Gates 1997	1998	1999	≥300K Gates 1997	1998	1999	Lead Time (Weeks)
CMOS (Average)							Production:
1.0 Micron	NR	NR	33.00	NR	NR	36.00	6-12
0.8 Micron	24.00	21.00	19.00	NR	NR	34.00	6-12
0.6/0.5 Micron	18.00	16.00	15.00	20.00	17.00	16.00	6-12
0.3 Micron	17.00	15.00	14.00	19.00	16.00	15.00	6-12
							Prototypes:
NRE CMOS Average Charge ($K)	107.00	106.00	105.00	123.00	120.00	120.00	2-8

NR = Not relevant
Notes: The actual NRE charge may vary from these because of device amortization, testing, intellectual property rights, and other factors.
Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, and volume discount. These prices are intended for use as price guidelines. For volumes of 100,000 units or greater, discount the above prices by a further 40 percent to 60 percent.
For high-density solutions with volumes greater than 150,000 units or for low-density solutions with volumes greater than 500 units, CBICs may be more cost-effective than gate arrays.
Source: Dataquest (December 1996)

Table 16
Estimated CBIC Pricing—North American Production Bookings
(Volume: 20,000 Units, Based on Utilized Gates Only; NRE = Netlist to Prototype, Millicents per Gate)

	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Time
Gate Count Technology	1997	1998	1999	1997	1998	1999	1997	1998	1999	(Weeks)
CMOS										Production:
1.0 Micron	37.00	30.00	27.00	33.00	28.00	24.00	31.00	27.00	25.00	7-13
0.8 Micron	31.00	26.00	25.00	24.00	21.00	19.00	25.00	21.00	19.00	7-13
0.6/0.5 Micron	26.00	22.00	19.00	21.00	18.00	17.00	20.00	17.00	16.00	7-13
0.3 Micron	NR	NR	21.00	NR	NR	20.00	19.00	15.00	14.00	NR
										Prototypes:
NRE CMOS Average Charge ($K)	68.00	67.00	65.00	72.00	72.00	71.00	83.00	83.00	83.00	4-8

	100-299K Gates			≥300K Gates			Lead Time
Gate Count Technology	1997	1998	1999	1997	1998	1999	(Weeks)
CMOS							Production:
1.0 Micron	NR	NR	30.00	NR	NR	38.00	7-13
0.8 Micron	26.00	22.00	20.00	NR	NR	36.00	7-13
0.6/0.5 Micron	22.00	19.00	18.00	24.00	21.00	19.00	7-13
0.3 Micron	21.00	17.00	16.00	22.00	19.00	18.00	7-13
							Prototypes:
NRE CMOS Average Charge ($K)	133.00	132.00	132.00	163.00	161.00	160.00	4-8

NR = Not relevant

Notes: The actual NRE charge may vary from these because of device amortization, testing, intellectual property rights, and other factors.

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, and volume discount. These prices are intended for use as price guidelines. For volumes of 100,000 units or greater, discount the above prices by a further 40 percent to 60 percent.

For high-density solutions with volumes greater than 150,000 units or for low-density solutions with volumes greater than 500 units, CBICs may be more cost-effective than gate arrays.

Source: Dataquest (December 1996)

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

Product	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
64Kx8 PDIP/PLCC	3.00	2.75	2.60	2.50	2.40	2.56	2.35	2.30	2.20	2.10	2.24	5
64Kx8 TSOP	3.25	3.00	2.85	2.75	2.65	2.81	2.60	2.55	2.45	2.35	2.49	5
128Kx8 PDIP/PLCC	2.85	2.65	2.55	2.45	2.40	2.51	2.35	2.30	2.20	2.10	2.24	3
128Kx8 TSOP 12V	2.98	2.85	2.75	2.65	2.60	2.71	2.55	2.50	2.40	2.30	2.44	5
128Kx8 TSOP 5V	5.05	3.90	3.70	3.60	3.50	3.68	3.45	3.40	3.30	3.15	3.33	3
256Kx8 TSOP 12V	6.13	5.80	5.60	5.40	5.20	5.50	5.15	5.00	4.75	4.60	4.88	5
256Kx8 TSOP/5V	6.00	5.50	5.30	5.00	4.80	5.15	4.70	4.50	4.30	4.10	4.40	3
512Kx8 PDIP/PLCC	7.68	6.00	5.60	5.30	5.00	5.48	4.80	4.60	4.45	4.25	4.53	2
512Kx8 TSOP 12V	7.90	6.25	5.80	5.50	5.10	5.66	5.00	4.80	4.70	4.50	4.75	4
512Kx8 TSOP/5V	8.90	6.35	5.90	5.60	5.30	5.79	5.10	4.90	4.70	4.50	4.80	4
1Mbx8 TSOP/12V	10.32	10.10	9.75	9.30	8.60	9.44	8.00	7.90	7.65	7.50	7.76	4
1Mbx8 TSOP/5V	11.50	10.20	9.80	9.50	8.85	9.59	8.20	8.00	7.70	7.50	7.85	4
2Mbx8 TSOP/12V	21.41	18.15	17.60	16.95	15.95	17.16	15.35	14.70	14.10	13.55	14.43	4
2Mbx8 TSOP/5V	21.75	18.50	17.75	17.00	16.15	17.35	15.50	14.90	14.30	13.70	14.60	4

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1996)

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

Product	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
64Kx8 PDIP/PLCC	2.56	2.24	2.15	2.09	2.00
64Kx8 TSOP	2.81	2.49	2.30	2.18	2.10
128Kx8 PDIP/PLCC	2.51	2.24	2.12	2.02	1.98
128Kx8 TSOP 12V	2.71	2.44	2.32	2.25	2.20
128Kx8 TSOP 5V	3.68	3.33	3.16	3.06	3.00
256Kx8 TSOP 12V	5.50	4.88	4.63	4.49	4.40
256Kx8 TSOP/5V	5.15	4.40	4.00	3.76	3.61
512Kx8 PDIP/PLCC	5.48	4.53	4.12	3.87	3.72
512Kx8 TSOP 12V	5.66	4.75	4.32	4.06	3.90
512Kx8 TSOP/5V	5.79	4.80	4.37	4.02	3.78
1Mbx8 TSOP/12V	9.44	7.76	7.06	6.50	6.11
1Mbx8 TSOP/5V	9.59	7.85	7.14	6.57	6.18
2Mbx8 TSOP/12V	17.16	14.43	12.98	11.68	10.52
2Mbx8 TSOP/5V	17.35	14.60	13.14	11.83	10.64

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1996)

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	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
128Kx8	1.90	1.74	1.65	1.60	1.56	1.64	1.54	1.52	1.48	1.45	1.50	4-8
64Kx16	2.00	2.00	1.98	1.97	1.97	1.98	1.95	1.93	1.93	1.92	1.93	4-8
256Kx8	2.25	2.20	2.19	2.17	2.17	2.18	2.15	2.15	2.14	2.14	2.15	4-8
512Kx8	3.20	3.10	2.90	2.70	2.50	2.80	2.35	2.30	2.24	2.19	2.27	4-8
256Kx16[1]	3.20	3.10	2.90	2.70	2.50	2.80	2.35	2.28	2.21	2.14	2.25	4-8
1Mbx8[2]	4.20	4.00	3.80	3.65	3.49	3.74	3.29	3.19	3.16	3.05	3.17	4-8
1Mbx16	7.00	6.00	5.20	4.10	3.80	4.78	3.57	3.46	3.36	3.26	3.41	4-8
2Mbx8	7.00	5.87	5.13	4.02	3.70	4.68	3.50	3.38	3.30	2.18	3.09	4-8

[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 1996)

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	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
128Kx8	1.64	1.50	1.47	1.44	1.44
64Kx16	1.98	1.93	1.92	1.92	1.93
256Kx8	2.18	2.15	2.13	2.12	2.10
512Kx8	2.80	2.27	2.24	2.21	2.19
256Kx16[1]	2.80	2.25	2.22	2.19	2.18
1Mbx8[2]	3.74	3.17	3.09	3.05	3.00
1Mbx16	4.78	3.41	3.35	3.28	3.22
2Mbx8	4.68	3.09	3.05	3.02	3.00

[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 1996)

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

Product	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
32Kx8	1.80	1.75	1.75	1.70	1.70	1.73	1.65	1.65	1.60	1.60	1.63	2
64Kx8	1.90	1.85	1.85	1.80	1.80	1.83	1.75	1.75	1.70	1.70	1.73	2
128Kx8	2.60	2.50	2.40	2.30	2.20	2.40	2.10	2.10	2.00	2.00	2.05	2
256Kx8	3.80	3.70	3.60	3.50	3.40	3.55	3.30	3.30	3.20	3.20	3.25	2
128Kx16	5.80	5.00	4.80	4.60	4.40	4.70	4.20	4.00	3.80	3.60	3.90	2
512Kx8	6.85	6.30	5.90	5.60	5.40	5.93	5.20	5.00	4.80	4.60	4.90	2
256Kx16	9.00	8.50	8.00	7.50	7.00	7.75	6.50	6.00	5.50	5.00	5.75	2

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 1996)

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	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
32Kx8	1.73	1.63	1.60	1.58	1.58
64Kx8	1.83	1.73	1.69	1.66	1.64
128Kx8	2.40	2.05	2.00	1.94	1.91
256Kx8	3.55	3.25	3.15	3.08	3.01
128Kx16	4.70	3.90	3.79	3.65	3.55
512Kx8	5.93	4.90	4.75	4.62	4.30
256Kx16	7.75	5.75	4.95	4.70	4.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1996)

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)

	1996	1997				1997	1998				1998	Lead Time
Product	Q4	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	(Weeks)
16Kx4 35ns	2.30	2.29	2.26	2.24	2.21	2.25	2.15	2.19	2.09	2.13	2.14	2
8Kx8 25ns	1.43	1.43	1.52	1.52	1.52	1.50	1.49	1.49	1.47	1.47	1.48	2
8Kx8 100-120ns	1.48	1.48	1.48	1.49	1.49	1.49	1.40	1.40	1.37	1.36	1.38	2
64Kx4 10ns	6.50	7.00	6.68	6.38	6.13	6.54	5.83	6.04	5.66	5.87	5.85	6
64Kx4 25ns	2.19	2.13	2.13	2.08	2.08	2.10	2.02	2.04	1.95	1.97	1.99	6
32Kx8 12ns	1.93	1.80	1.80	1.72	1.63	1.74	1.48	1.48	1.48	1.48	1.48	4
32Kx9 12ns Burst	4.45	3.90	3.71	3.48	3.39	3.62	3.35	3.30	3.26	3.22	3.28	4
32K x 8 15ns 5V	1.35	1.34	1.34	1.27	1.26	1.30	1.30	1.29	1.29	1.29	1.29	4
32K x 8 15ns 3.3V	1.37	1.33	1.38	1.36	1.35	1.36	1.33	1.32	1.32	1.31	1.32	4
32Kx8 25ns	1.32	1.32	1.33	1.26	1.26	1.29	1.29	1.28	1.28	1.28	1.28	4
32Kx8 70-100ns SOJ	1.76	1.63	1.55	1.50	1.46	1.53	1.35	1.33	1.32	1.31	1.33	3
64Kx8 12ns Burst	17.50	14.80	13.95	13.25	12.90	13.73	1.40	13.33	12.55	11.84	9.78	4
256Kx4 20ns	5.50	5.83	5.50	5.33	5.08	5.44	4.92	4.92	4.83	4.83	4.88	4
128K x 8 15ns	5.56	5.36	4.96	4.83	4.44	4.90	4.30	4.16	4.09	3.95	4.13	4
128K x 8 20ns	5.50	5.23	4.87	4.68	4.58	4.84	4.23	4.22	4.12	4.10	4.17	4
128Kx8 25ns	5.50	5.23	4.87	4.68	4.58	4.84	4.23	4.22	4.12	4.10	4.17	4
128Kx8 70-100ns SOJ	5.00	4.86	4.61	4.54	4.38	4.60	4.28	4.14	3.99	3.81	4.06	3
32Kx32 15ns 3.3V PQFP	3.48	3.47	3.35	3.33	3.20	3.34	3.07	3.02	2.88	2.85	2.95	5
32Kx32 8ns 3.3V PB Synch	3.52	3.38	3.20	3.12	3.01	3.18	2.89	2.88	2.76	2.69	2.80	5

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 1996)

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	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
16Kx4 35ns	2.25	2.14	2.11	2.08	2.06
8Kx8 25ns	1.50	1.48	1.46	1.46	1.48
8Kx8 100-120ns	1.49	1.38	1.33	1.29	1.27
64Kx4 10ns	6.54	5.85	5.79	5.67	5.63
64Kx4 25ns	2.10	1.99	1.92	1.85	1.81
32Kx8 12ns	1.74	1.48	1.51	1.54	1.60
32Kx9 12ns Burst	3.62	3.28	3.35	3.40	3.45
32K x 8 15ns 5V	1.30	1.29	1.35	1.40	1.40
32K x 8 15ns 3.3V	1.36	1.32	1.32	1.40	1.40
32Kx8 25ns	1.29	1.28	1.30	1.35	1.45
32Kx8 70-100ns SOJ	1.53	1.33	1.35	1.40	1.40
64Kx8 12ns Burst	13.73	9.78	7.00	6.33	5.90
256Kx4 20ns	5.44	4.88	4.42	4.10	3.93
128K x 8 15ns	4.90	4.13	3.94	3.82	3.76
128K x 8 20ns	4.84	4.17	3.95	3.85	3.81
128Kx8 25ns	4.84	4.17	3.98	3.89	3.85
128Kx8 70-100ns SOJ	4.60	4.20	4.00	3.91	3.88
32Kx32 15ns 3.3V PQFP	3.34	2.95	2.50	2.50	2.50
32Kx32 8ns 3.3V PB Synch	3.18	2.80	2.35	2.33	2.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as price guidelines.
Source: Dataquest (December 1996)

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

Product	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
8Mbx36 SIMM 60ns 5V EDO	178.54	166.40	160.45	155.03	150.41	158.07	144.60	143.26	141.24	138.29	141.85	2-6
1Mbx64 60ns 3.3V EDO	45.00	46.34	44.86	43.50	42.34	44.26	41.45	41.94	41.45	40.97	41.45	2-6
2Mbx64 60ns 3.3V EDO	90.00	97.33	89.33	86.67	84.27	89.40	79.73	78.62	77.60	76.61	78.14	2-6
4Mbx64 60ns 3.3V EDO	180.00	182.67	177.33	172.53	169.12	175.41	153.75	155.70	153.71	151.79	153.74	2-6
256Kx4 VRAM 70ns SOJ	5.73	5.75	5.72	5.71	5.69	5.72	5.64	5.58	5.53	5.48	5.56	2-6
128Kx8 VRAM 70ns SOJ	5.93	5.93	5.91	5.90	5.89	5.90	5.83	5.77	5.72	5.66	5.74	2-6
256Kx16 VRAM 70ns SOP	12.00	11.33	10.67	10.33	9.97	10.58	9.25	9.01	8.78	8.55	8.90	2-6
256Kx32 66-MHz 3.3V SGRAM	14.38	13.63	12.88	11.63	10.38	12.13	8.26	8.20	8.09	8.03	8.14	2-6

*Contract volume is at least 100,000 per order, except for 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 (December 1996)

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

Product	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
1Mbx1 DRAM 70-80ns (DIP/SOJ) 5V	2.23	2.21	2.12	2.03	1.95
256Kx4 DRAM 60ns SOJ 5V	2.09	2.01	1.93	1.85	1.78
4Mbx1 DRAM 70ns SOJ 5V	2.66	2.41	2.32	2.22	2.13
1Mbx4 DRAM 60ns SOJ 5V FPM	2.42	2.24	2.15	2.07	1.98
1Mbx4 DRAM 60ns SOJ 5V EDO	2.43	2.24	2.15	2.07	1.98
512Kx8 DRAM 70ns 5V	2.62	2.32	2.22	2.14	2.05
256Kx16 DRAM 70ns SOJ 5V	3.33	3.06	2.93	2.82	2.70
4Mb x 4 DRAM 60 ns SOJ 5V FPM	8.55	7.83	7.52	7.22	6.93
4MbX4 DRAM 60ns SOJ 5V EDO	8.55	7.83	7.52	7.22	6.93
1Mbx16 DRAM 60ns TSOP 5V FPM	8.54	7.51	7.21	6.92	6.64
1Mbx16 DRAM 60ns TSOP 5V EDO	8.54	7.38	7.08	6.80	6.53
2Mbx8 DRAM 60ns TSOP 5V FPM	8.43	7.34	7.04	6.76	6.49
16Mbx4 DRAM SOJ 60ns 3.3V EDO	76.72	51.27	35.00	27.01	25.84
16Mbx4 DRAM SOJ 3.3V SDRAM	73.65	44.31	31.00	27.00	25.11
1Mbx32 SIMM 60ns 5V FPM	18.99	16.99	16.31	15.65	15.03
1Mbx36 SIMM 60ns 5V FPM	21.00	18.81	18.06	17.34	16.64
2Mbx32 SIMM 60ns 5V FPM	34.09	30.51	29.29	28.12	26.99
2Mbx36 SIMM 60ns 5V FPM	38.91	34.53	33.15	31.83	30.55
4Mbx32 SIMM 60ns 5V FPM	71.25	63.83	61.28	58.83	56.48
4Mbx36 SIMM 60ns 5V FPM	78.09	69.21	66.44	63.79	61.23
8Mbx32 SIMM 60ns 5V FPM	142.41	127.35	122.26	117.37	112.67
8Mbx36 SIMM 60ns 5V FPM	157.93	141.88	136.20	130.75	125.52
1Mbx32 SIMM 60ns 5V EDO	18.69	16.83	16.16	15.51	14.89
1Mbx36 SIMM 60ns 5V EDO	22.21	19.97	19.17	18.40	17.66
2Mbx32 SIMM 60ns 5V EDO	34.15	30.93	29.69	28.50	27.36
2Mbx36 SIMM 60ns 5V EDO	39.02	34.45	33.07	31.75	30.48
4Mbx32 SIMM 60ns 5V EDO	71.53	63.77	61.21	58.77	56.42
4Mbx36 SIMM 60ns 5V EDO	78.19	69.17	66.41	63.75	61.20
8Mbx32 SIMM 60ns 5V EDO	144.65	127.35	122.25	117.36	112.67
8Mbx36 SIMM 60ns 5V EDO	158.07	141.85	136.18	130.73	125.50
1Mbx64 60ns 3.3V EDO	44.26	41.45	32.97	29.00	27.46
2Mbx64 60ns 3.3V EDO	89.40	78.14	61.01	58.21	56.09
4Mbx64 60ns 3.3V EDO	175.41	153.74	123.00	117.09	111.97
256Kx4 VRAM 70ns SOJ	5.72	5.56	5.34	5.12	4.92
128Kx8 VRAM 70ns SOJ	5.90	5.74	5.51	5.29	5.08
256Kx16 VRAM 70ns SOP	10.58	8.90	8.54	8.20	7.87
256Kx32 66-MHz 3.3V SGRAM	12.13	8.14	5.88	5.40	5.10

*Contract volume is at least 100,000 per order, except for 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 (December 1996)

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

Product	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
68EC020-25 PQFP	8.00	8.00	8.00	8.00	8.00
68EC030-25 PQFP	18.88	18.75	18.75	18.75	18.75
68040-25	23.75	22.00	22.00	22.00	22.00
68LC040-25 CQFP 184	23.75	22.00	22.00	22.00	22.00
Pentium-75	41.25	40.00	40.00	40.00	40.00
Pentium-90	48.75	45.00	45.00	45.00	45.00
Pentium-100 3.3V	61.25	50.00	50.00	50.00	50.00
Pentium-100 2.9V	90.00	90.00	90.00	90.00	90.00
Pentium-120 3.3V	83.75	80.00	80.00	80.00	80.00
Pentium-120 2.9V	122.50	120.00	120.00	120.00	120.00
Pentium-133 3.3V	92.50	75.00	75.00	75.00	75.00
Pentium-133 2.9V	176.25	170.00	170.00	170.00	170.00
Pentium-150 3.3V	135.00	120.00	120.00	120.00	120.00
Pentium-150 2.9V	223.75	220.00	220.00	220.00	220.00
Pentium-166 3.3V	168.75	110.00	110.00	110.00	110.00
Pentium-200 3.3V	280.00	145.00	145.00	145.00	145.00
Pentium Pro-166C	600.00	600.00	600.00	600.00	600.00
Pentium Pro-180	318.75	270.00	270.00	270.00	270.00
Pentium Pro-200 256K Cache	418.75	350.00	350.00	350.00	350.00
Pentium Pro-200 512K Cache	944.00	700.00	700.00	700.00	700.00
PowerPC 601-80	68.50	68.00	68.00	68.00	68.00
PowerPC 601-100	76.25	75.00	75.00	75.00	75.00
PowerPC 603-80	60.50	60.00	60.00	60.00	60.00
PowerPC 603-133	100.00	75.00	75.00	75.00	75.00

Notes: Pricing excludes accessory parts like floating point and memory management.
Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1996)

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

Product	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ) 5V	2.25	2.24	2.23	2.23	2.23	2.23	2.22	2.21	2.20	2.19	2.21	6-8
256Kx4 DRAM 60ns SOJ 5V	2.15	2.12	2.08	2.07	2.08	2.09	2.02	2.01	2.01	1.99	2.01	6-8
4Mbx1 DRAM 70ns SOJ 5V	2.97	2.72	2.67	2.64	2.62	2.66	2.58	2.39	2.38	2.30	2.41	2-6
1Mbx4 DRAM 60ns SOJ 5V FPM	2.81	2.40	2.45	2.44	2.40	2.42	2.39	2.18	2.20	2.20	2.24	2-6
1Mbx4 DRAM 60ns SOJ 5V EDO	2.84	2.42	2.45	2.44	2.40	2.43	2.38	2.18	2.20	2.20	2.24	2-6
512Kx8 DRAM 70ns 5V	3.29	2.82	2.69	2.56	2.43	2.62	2.33	2.33	2.31	2.31	2.32	2-6
256Kx16 DRAM 70ns SOJ 5V	3.67	3.36	3.40	3.34	3.24	3.33	3.17	3.10	3.00	2.95	3.06	2-6
4Mb x 4 DRAM 60 ns SOJ 5V FPM	10.20	9.00	8.67	8.38	8.17	8.55	7.96	7.84	7.79	7.73	7.83	2-6
4MbX4 DRAM 60ns SOJ 5V EDO	10.16	9.00	8.67	8.38	8.17	8.55	7.96	7.84	7.79	7.73	7.83	2-6
1Mbx16 DRAM 60ns TSOP 5V FPM	9.00	8.94	8.74	8.44	8.06	8.54	7.75	7.56	7.43	7.29	7.51	2-6
1Mbx16 DRAM 60ns TSOP 5V EDO	9.00	8.93	8.73	8.44	8.04	8.54	7.75	7.50	7.25	7.02	7.38	2-6
2Mbx8 DRAM 60ns TSOP 5V FPM	9.56	9.06	8.65	8.04	7.96	8.43	7.53	7.36	7.27	7.18	7.34	2-6
16Mbx4 DRAM SOJ 60ns 3.3V EDO	100.00	86.88	78.75	73.75	67.50	76.72	60.00	54.50	50.25	40.33	51.27	2-6
16Mbx4 DRAM SOJ 3.3V SDRAM	85.00	85.83	81.25	68.50	59.00	73.65	51.25	45.75	41.75	38.50	44.31	2-6
1Mbx32 SIMM 60ns 5V FPM	22.63	20.07	19.32	18.62	17.94	18.99	17.44	17.18	16.79	16.53	16.99	2-6
1Mbx36 SIMM 60ns 5V FPM	26.00	22.75	21.50	20.25	19.50	21.00	19.00	19.00	18.75	18.50	18.81	2-6
2Mbx32 SIMM 60ns 5V FPM	38.25	35.87	34.85	33.50	32.15	34.09	31.12	30.43	30.42	30.07	30.51	2-6
2Mbx36 SIMM 60ns 5V FPM	41.93	40.80	39.22	38.63	37.00	38.91	34.87	34.62	34.55	34.10	34.53	2-6
4Mbx32 SIMM 60ns 5V FPM	79.73	75.07	72.37	70.00	67.58	71.25	64.98	64.55	63.57	62.23	63.83	2-6
4Mbx36 SIMM 60ns 5V FPM	84.85	82.60	80.43	76.25	73.08	78.09	70.73	69.55	68.88	67.70	69.21	2-6
8Mbx32 SIMM 60ns 5V FPM	159.47	150.13	144.73	139.60	135.16	142.41	129.97	128.51	126.48	124.46	127.35	2-6
8Mbx36 SIMM 60ns 5V FPM	175.87	166.00	160.34	155.01	150.37	157.93	144.65	143.22	141.29	138.34	141.88	2-6
1Mbx32 SIMM 60ns 5V EDO	20.38	19.62	19.08	18.37	17.69	18.69	17.19	17.05	16.67	16.41	16.83	2-6
1Mbx36 SIMM 60ns 5V EDO	24.89	23.08	22.75	21.90	21.12	22.21	20.80	20.60	19.40	19.06	19.97	2-6
2Mbx32 SIMM 60ns 5V EDO	36.63	35.97	35.02	33.50	32.12	34.15	31.09	31.02	30.95	30.65	30.93	2-6
2Mbx36 SIMM 60ns 5V EDO	42.19	41.02	39.45	38.62	36.98	39.02	34.87	34.59	34.30	34.05	34.45	2-6
4Mbx32 SIMM 60ns 5V EDO	80.16	75.98	72.63	70.00	67.49	71.53	64.85	64.44	63.56	62.21	63.77	2-6
4Mbx36 SIMM 60ns 5V EDO	85.26	82.85	80.67	76.23	73.02	78.19	70.59	69.52	68.88	67.70	69.17	2-6
8Mbx32 SIMM 60ns 5V EDO	166.08	151.85	146.55	141.90	138.29	144.65	129.97	128.53	126.44	124.46	127.35	2-6

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

Product	1997 Year	1998 Year	1999 Year	2000 Year	2001 Year
74LS TTL					
74LS00	0.13	0.13	0.13	0.13	0.13
74LS74	0.16	0.16	0.15	0.15	0.15
74LS138	0.17	0.17	0.16	0.15	0.15
74LS244	0.24	0.24	0.24	0.24	0.24
74AC TTL					
74AC00	0.17	0.15	0.13	0.13	0.12
74AC74	0.21	0.18	0.16	0.15	0.15
74AC138	0.29	0.27	0.25	0.24	0.22
74AC244	0.40	0.35	0.31	0.28	0.27
74F TTL					
74F00	0.14	0.13	0.13	0.12	0.12
74F74	0.15	0.15	0.14	0.14	0.14
74F138	0.18	0.18	0.17	0.17	0.17
74F244	0.22	0.22	0.21	0.20	0.20
74HC CMOS					
74HC00	0.11	0.11	0.11	0.11	0.11
74HC74	0.16	0.15	0.14	0.14	0.13
74HC138	0.17	0.17	0.16	0.16	0.16
74HC244	0.21	0.21	0.21	0.21	0.21
74ALS TTL					
74ALS00	0.14	0.14	0.13	0.13	0.13
74ALS74	0.16	0.16	0.16	0.15	0.15
74ALS138	0.21	0.20	0.20	0.20	0.20
74ALS244	0.30	0.26	0.25	0.24	0.24
74AS TTL					
74AS00	0.19	0.19	0.19	0.19	0.19
74AS74	0.19	0.19	0.19	0.20	0.20
74AS138	0.40	0.40	0.40	0.40	0.40
74AS244	0.63	0.62	0.61	0.61	0.61
74BC*					
74BC00	0.20	0.18	0.17	0.16	0.16
74BC244	0.53	0.46	0.43	0.42	0.41
74BC373	0.55	0.48	0.45	0.43	0.42
74ACT244	0.42	0.38	0.35	0.33	0.32
74ACT245	0.46	0.40	0.37	0.35	0.34
74ABT244	0.58	0.51	0.47	0.42	0.40
74ABT245	0.63	0.55	0.51	0.49	0.48

*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 1996)

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

	1996	1997				1997	1998				1998	Lead Time
Product	Q4	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year	(Weeks)
68EC020-25 PQFP	9.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	4-8
68EC030-25 PQFP	21.00	19.00	19.00	18.75	18.75	18.88	18.75	18.75	18.75	18.75	18.75	4-8
68040-25	30.00	25.00	24.00	24.00	22.00	23.75	22.00	22.00	22.00	22.00	22.00	4-8
68LC040-25 CQFP 184	30.00	25.00	24.00	24.00	22.00	23.75	22.00	22.00	22.00	22.00	22.00	4-8
Pentium-75	50.00	45.00	40.00	40.00	40.00	41.25	40.00	40.00	40.00	40.00	40.00	4-8
Pentium-90	60.00	50.00	50.00	50.00	45.00	48.75	45.00	45.00	45.00	45.00	45.00	4-8
Pentium-100 3.3V	75.00	75.00	60.00	60.00	50.00	61.25	50.00	50.00	50.00	50.00	50.00	4-8
Pentium-100 2.9V	100.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	4-8
Pentium-120 3.3V	117.00	95.00	80.00	80.00	80.00	83.75	80.00	80.00	80.00	80.00	80.00	4-8
Pentium-120 2.9V	144.00	130.00	120.00	120.00	120.00	122.50	120.00	120.00	120.00	120.00	120.00	4-8
Pentium-133 3.3V	175.00	110.00	100.00	85.00	75.00	92.50	75.00	75.00	75.00	75.00	75.00	4-8
Pentium-133 2.9V	244.00	190.00	175.00	170.00	170.00	176.25	170.00	170.00	170.00	170.00	170.00	4-8
Pentium-150 3.3V	225.00	150.00	150.00	120.00	120.00	135.00	120.00	120.00	120.00	120.00	120.00	4-8
Pentium-150 2.9V	329.00	235.00	220.00	220.00	220.00	223.75	220.00	220.00	220.00	220.00	220.00	4-8
Pentium-166 3.3V	350.00	225.00	170.00	125.00	125.00	161.25	110.00	110.00	110.00	110.00	110.00	4-8
Pentium-200 3.3V	450.00	400.00	400.00	175.00	145.00	280.00	145.00	145.00	145.00	145.00	145.00	4-8
Pentium Pro-166C	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	4-8
Pentium Pro-180	400.00	350.00	325.00	300.00	300.00	318.75	270.00	270.00	270.00	270.00	270.00	4-8
Pentium Pro-200 256K Cache	500.00	475.00	400.00	400.00	400.00	418.75	350.00	350.00	350.00	350.00	350.00	4-8
Pentium Pro-200 512K Cache	1,035.00	993.00	993.00	895.00	895.00	944.00	700.00	700.00	700.00	700.00	700.00	4-8
PowerPC 601-80	80.00	70.00	68.00	68.00	68.00	68.50	68.00	68.00	68.00	68.00	68.00	4-8
PowerPC 601-100	90.00	80.00	75.00	75.00	75.00	76.25	75.00	75.00	75.00	75.00	75.00	4-8
PowerPC 603-80	75.00	61.00	61.00	60.00	60.00	60.50	60.00	60.00	60.00	60.00	60.00	4-8
PowerPC 603-133	125.00	125.00	115.00	80.00	80.00	100.00	75.00	75.00	75.00	75.00	75.00	4-8

Notes: Pricing excludes accessory parts like floating point and memory management.
Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (December 1996)

North American Semiconductor Price Outlook: First Quarter 1997

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 Supply and Pricing Worldwide (SPSG) 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 SPSG clients that use the SPSG online service, the prices presented here correlate with the quarterly and long-range price tables dated September 1996 in the SPSG 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	1996 Q4	1997 Q1	Q2	Q3	Q4	1997 Year	1998 Q1	Q2	Q3	Q4	1998 Year	Lead Time (Weeks)
74LS TTL												
74LS00	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	2-6
74LS74	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	2-6
74LS138	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.17	2-6
74LS244	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	2-6
74AC TTL												
74AC00	0.17	0.17	0.17	0.17	0.17	0.17	0.15	0.15	0.15	0.14	0.15	2-6
74AC74	0.21	0.21	0.21	0.21	0.21	0.21	0.19	0.19	0.18	0.17	0.18	2-6
74AC138	0.31	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.27	0.27	0.27	2-6
74AC244	0.43	0.40	0.40	0.40	0.40	0.40	0.36	0.36	0.35	0.35	0.35	2-6
74F TTL												
74F00	0.14	0.14	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	2-6
74F74	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	2-6
74F138	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	2-6
74F244	0.23	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	2-6
74HC CMOS												
74HC00	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	2-6
74HC74	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	2-6
74HC138	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	2-6
74HC244	0.23	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	2-6
74ALS TTL												
74ALS00	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	2-6
74ALS74	0.18	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	2-6
74ALS138	0.23	0.22	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20	2-6
74ALS244	0.31	0.30	0.30	0.30	0.30	0.30	0.27	0.27	0.26	0.26	0.26	2-6
74AS TTL												
74AS00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	2-6
74AS74	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	2-6
74AS138	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	2-6
74AS244	0.65	0.63	0.63	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	2-6
74BC*												
74BC00	0.23	0.20	0.20	0.20	0.20	0.20	0.19	0.19	0.18	0.17	0.18	2-6
74BC244	0.55	0.53	0.53	0.53	0.53	0.53	0.48	0.47	0.46	0.44	0.46	2-6
74BC373	0.57	0.55	0.55	0.55	0.55	0.55	0.50	0.49	0.46	0.46	0.48	2-6
74ACT244	0.45	0.43	0.43	0.41	0.41	0.42	0.39	0.38	0.38	0.36	0.38	2-6
74ACT245	0.48	0.46	0.46	0.46	0.46	0.46	0.41	0.41	0.40	0.38	0.40	2-6
74ABT244	0.60	0.58	0.58	0.58	0.58	0.58	0.52	0.52	0.51	0.48	0.51	2-6
74ABT245	0.65	0.63	0.63	0.63	0.63	0.63	0.57	0.56	0.55	0.52	0.55	2-6

*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 1996)

Table of Contents

Page

North American Semiconductor Price Outlook: First Quarter 1997 1
Methodology and Sources 1
Price Variations 1

List of Tables

Table		Page
1	Estimated Standard Logic Price Trends—North American Bookings	2
2	Estimated Long-Range Standard Logic Price Trends—North American Bookings	3
3	Estimated Microprocessor Price Trends—North American Bookings	4
4	Estimated Long-Range Microprocessor Price Trends—North American Bookings	5
5	Estimated DRAM Price Trends—North American Bookings	6
6	Estimated Long-Range DRAM Price Trends—North American Bookings	8
7	Estimated Static RAM Price Trends—North American Booking	9
8	Estimated Long-Range Static RAM Price Trends—North American Bookings	10
9	Estimated ROM Price Trends—North American Bookings	11
10	Estimated Long-Range ROM Price Trends—North American Bookings	11
11	Estimated EPROM Price Trends—North American Bookings	12
12	Estimated Long-Range EPROM Price Trends—North American Bookings	12
13	Estimated Flash Memory Price Trends—North American Bookings	13
14	Estimated Long-Range Flash Memory Price Trends—North American Bookings	14
15	Estimated Gate Array Pricing—North American Production Bookings	15
16	Estimated CBIC Pricing—North American Production Bookings	16

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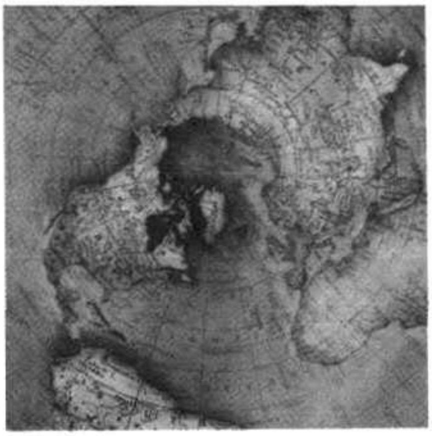

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North American Semiconductor Price Outlook: Fourth Quarter 1996

Market Statistics

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Product Code: SPSG-WW-MS-9604
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Table of Contents

	Page
Methodology and Sources	1
Price Variations	1

List of Tables

Table		Page
1	Estimated Standard Logic Price Trends—North American Bookings	2
2	Estimated Long-Range Standard Logic Price Trends—North American Bookings	4
3	Estimated Microprocessor Price Trends—North American Bookings	6
4	Estimated Long-Range Microprocessor Price Trends—North American Bookings	7
5	Estimated DRAM Price Trends—North American Bookings	8
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8	Estimated Long-Range Static RAM Price Trends—North American Bookings	11
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12	Estimated Long-Range EPROM Price Trends—North American Bookings	15
13	Estimated Flash Memory Price Trends—North American Bookings	16
14	Estimated Long-Range Flash Memory Price Trends—North American Bookings	17
15	Estimated Gate Array Pricing—North American Production Bookings	18
16	Estimated CBIC Pricing—North American Production Bookings	19

Note: All tables show estimated data.

North American Semiconductor Price Outlook: Fourth 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 Supply and Pricing Worldwide (SPSG) 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.

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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	0.14	0.14	0.14	0.13	0.14	0.13	0.13	0.13	0.13	0.13	2-6
74LS74	0.16	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	2-6
74LS138	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	2-6
74LS244	0.26	0.26	0.25	0.24	0.24	0.25	0.24	0.24	0.24	0.24	0.24	2-6
74AC TTL												
74AC00	0.20	0.19	0.18	0.18	0.17	0.18	0.17	0.17	0.17	0.17	0.17	2-6
74AC74	0.23	0.23	0.22	0.22	0.21	0.22	0.21	0.21	0.21	0.21	0.21	2-6
74AC138	0.33	0.33	0.31	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.31	2-6
74AC244	0.45	0.45	0.44	0.44	0.43	0.44	0.43	0.42	0.41	0.40	0.42	2-6
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	2-6
74F74	0.17	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.15	0.15	0.15	2-6
74F138	0.21	0.20	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.18	0.18	2-6
74F244	0.26	0.25	0.24	0.23	0.23	0.24	0.23	0.23	0.23	0.23	0.23	2-6
74HC CMOS												
74HC00	0.18	0.15	0.13	0.13	0.12	0.13	0.12	0.12	0.12	0.12	0.12	2-6
74HC74	0.19	0.18	0.16	0.16	0.16	0.17	0.16	0.16	0.16	0.16	0.16	2-6
74HC138	0.21	0.21	0.19	0.19	0.18	0.19	0.18	0.18	0.17	0.17	0.18	2-6
74HC244	0.30	0.28	0.25	0.25	0.23	0.25	0.23	0.23	0.23	0.23	0.23	2-6
74ALS TTL												
74ALS00	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	2-6
74ALS74	0.21	0.20	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.18	0.18	2-6
74ALS138	0.32	0.29	0.27	0.25	0.23	0.26	0.23	0.23	0.23	0.23	0.23	2-6
74ALS244	0.41	0.39	0.36	0.33	0.31	0.35	0.30	0.30	0.30	0.30	0.30	2-6

(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	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	2-6
74AS74	0.22	0.21	0.20	0.20	0.19	0.20	0.19	0.19	0.19	0.19	0.19	2-6
74AS138	0.47	0.44	0.42	0.42	0.40	0.42	0.40	0.40	0.40	0.40	0.40	2-6
74AS244	0.71	0.67	0.65	0.65	0.65	0.66	0.63	0.63	0.63	0.63	0.63	2-6
74BC*												
74BC00	0.25	0.23	0.23	0.23	0.23	0.23	0.21	0.21	0.21	0.21	0.21	2-8
74BC244	0.59	0.55	0.55	0.55	0.55	0.55	0.53	0.53	0.53	0.53	0.53	2-8
74BC373	0.61	0.57	0.57	0.57	0.57	0.57	0.55	0.55	0.55	0.55	0.55	2-8
74ACT244	0.47	0.45	0.45	0.45	0.45	0.45	0.43	0.43	0.43	0.43	0.43	2-8
74ACT245	0.51	0.48	0.48	0.48	0.48	0.48	0.46	0.46	0.46	0.46	0.46	2-8
74ABT244	0.63	0.60	0.60	0.60	0.60	0.60	0.58	0.58	0.58	0.58	0.58	2-8
74ABT245	0.67	0.65	0.65	0.65	0.65	0.65	0.63	0.63	0.63	0.63	0.63	2-6

*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 1996)

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	0.14	0.13	0.13	0.13	0.12
74LS74	0.17	0.16	0.15	0.15	0.14
74LS138	0.18	0.17	0.15	0.15	0.14
74LS244	0.25	0.24	0.24	0.24	0.24
74AC TTL					
74AC00	0.18	0.17	0.17	0.17	0.17
74AC74	0.22	0.21	0.21	0.21	0.21
74AC138	0.32	0.31	0.30	0.30	0.30
74AC244	0.44	0.42	0.40	0.40	0.40
74F TTL					
74F00	0.14	0.14	0.14	0.13	0.13
74F74	0.16	0.15	0.15	0.15	0.14
74F138	0.19	0.18	0.18	0.18	0.17
74F244	0.24	0.23	0.23	0.23	0.23
74HC CMOS					
74HC00	0.13	0.12	0.12	0.12	0.12
74HC74	0.17	0.16	0.16	0.16	0.16
74HC138	0.19	0.18	0.18	0.18	0.18
74HC244	0.25	0.23	0.23	0.23	0.23
74ALS TTL					
74ALS00	0.16	0.16	0.16	0.16	0.16
74ALS74	0.19	0.18	0.18	0.18	0.18
74ALS138	0.26	0.23	0.23	0.23	0.23
74ALS244	0.35	0.30	0.30	0.30	0.30
74AS TTL					
74AS00	0.19	0.19	0.19	0.19	0.18
74AS74	0.20	0.19	0.19	0.19	0.19
74AS138	0.42	0.40	0.40	0.40	0.38
74AS244	0.66	0.63	0.63	0.61	0.61

(Continued)

Table 2 (Continued)
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
74BC*					
74BC00	0.23	0.21	0.21	0.21	0.21
74BC244	0.55	0.53	0.53	0.53	0.51
74BC373	0.57	0.55	0.55	0.55	0.53
74ACT244	0.45	0.43	0.43	0.43	0.40
74ACT245	0.48	0.46	0.46	0.46	0.44
74ABT244	0.60	0.58	0.58	0.56	0.56
74ABT245	0.65	0.63	0.63	0.61	0.59

*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 1996)

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

Product	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year
68EC020-25 PQFP	9.00	9.00	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00
68EC030-25 PQFP	21.00	21.00	21.00	21.00	21.00	19.00	19.00	19.00	19.00	19.00
68040-25	105.00	80.00	40.00	30.00	63.75	25.00	25.00	25.00	25.00	25.00
68LC040-25 CQFP 184	50.00	40.00	35.00	30.00	38.75	25.00	25.00	25.00	25.00	25.00
80486DX2-66	55.00	42.00	27.00	27.00	37.75	24.00	24.00	24.00	24.00	24.00
80486DX4-75	90.00	75.00	40.00	40.00	61.25	35.00	35.00	35.00	35.00	35.00
Pentium-75	100.00	90.00	60.00	50.00	75.00	45.00	45.00	40.00	40.00	42.50
Pentium-90	182.00	120.00	70.00	60.00	108.00	50.00	50.00	50.00	45.00	48.75
Pentium-100	199.00	120.00	75.00	75.00	65.00	60.00	60.00	60.00	60.00	60.00
Pentium-120	NA	NA	125.00	125.00	NA	95.00	85.00	80.00	80.00	85.00
Pentium-133	NA	NA	175.00	175.00	NA	110.00	100.00	90.00	75.00	93.75
Pentium-150	NA	NA	225.00	225.00	NA	150.00	150.00	120.00	120.00	135.00
Pentium-166	NA	NA	350.00	350.00	NA	250.00	170.00	140.00	140.00	175.00
Pentium-200	NA	NA	450.00	450.00	NA	400.00	400.00	350.00	300.00	362.50
Pentium Pro-166C	NA	NA	600.00	600.00	NA	600.00	600.00	600.00	600.00	600.00
Pentium Pro-180	NA	NA	470.00	400.00	NA	350.00	325.00	325.00	325.00	331.25
Pentium Pro-200	NA	NA	550.00	500.00	NA	475.00	450.00	450.00	400.00	443.75
PowerPC 601-66	105.00	80.00	68.00	60.00	78.25	55.00	55.00	55.00	55.00	55.00
PowerPC 601-80	125.00	95.00	85.00	80.00	96.25	70.00	70.00	70.00	70.00	70.00
PowerPC 601-100	155.00	140.00	90.00	90.00	118.75	85.00	85.00	85.00	85.00	85.00
PowerPC 603-80	105.00	95.00	80.00	75.00	88.75	61.00	61.00	61.00	61.00	61.00

NA = Not available
Notes: Pricing excludes accessory parts like floating point and memory management.
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 1996)

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
68EC020-25 PQFP	9.00	8.00	8.00	8.00	8.00
68EC030-25 PQFP	21.00	19.00	19.00	19.00	19.00
68040-25	63.75	25.00	25.00	25.00	25.00
68LC040-25 CQFP 184	38.75	25.00	25.00	25.00	25.00
80486DX2-66	37.75	24.00	24.00	24.00	24.00
80486DX4-75	61.25	35.00	35.00	35.00	35.00
Pentium-75	75.00	42.50	40.00	40.00	40.00
Pentium-90	108.00	48.75	45.00	45.00	45.00
Pentium-100	65.00	60.00	60.00	60.00	60.00
Pentium-120	NA	85.00	70.00	70.00	70.00
Pentium-133	NA	93.75	75.00	75.00	75.00
Pentium-150	NA	135.00	100.00	90.00	90.00
Pentium-166	NA	175.00	120.00	108.00	108.00
Pentium-200	NA	362.50	255.00	230.00	207.00
Pentium Pro-166C	NA	600.00	480.00	432.00	388.80
Pentium Pro-180	NA	331.25	295.00	283.00	271.00
Pentium Pro-200	NA	443.75	384.00	369.00	354.00
PowerPC 601-66	78.25	55.00	55.00	55.00	55.00
PowerPC 601-80	96.25	70.00	70.00	70.00	70.00
PowerPC 601-100	118.75	85.00	85.00	85.00	85.00
PowerPC 603-80	88.75	61.00	61.00	61.00	61.00

NA = Not available

Notes: Pricing excludes accessory parts like floating point and memory management.

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 1996)

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

Product	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
1Mbx1 DRAM 70-80ns (DIP/SOJ)	3.34	3.12	2.74	2.39	2.89	2.36	2.34	2.32	2.31	2.33	2-6
256Kx4 DRAM 60ns SOJ	3.18	2.99	2.46	2.32	2.74	2.30	2.29	2.27	2.26	2.28	2-6
4Mbx1 DRAM 70ns SOJ	9.49	5.35	3.75	3.07	5.42	3.04	2.95	2.94	2.92	2.96	2-6
1Mbx4 DRAM 60ns SOJ FPM	8.28	4.61	3.13	3.05	4.77	2.90	2.83	2.81	2.78	2.83	2-6
1Mbx4 DRAM 60ns SOJ EDO	8.29	4.92	3.13	3.04	4.84	2.90	2.81	2.79	2.74	2.81	2-6
512Kx8 DRAM 70ns	9.10	5.50	4.13	3.05	5.44	2.88	2.88	2.86	2.85	2.87	2-6
256Kx16 DRAM 70ns SOJ	8.78	5.88	4.01	3.63	5.58	3.46	3.46	3.46	3.44	3.46	2-6
4Mbx 4 DRAM 70ns SOJ 300 mil	37.89	18.00	12.50	10.75	19.79	9.50	9.25	9.05	8.98	9.20	2-6
1Mbx16 DRAM 60ns TSOP 300 mil FPM	36.17	17.83	11.33	10.45	18.95	9.46	9.20	9.05	8.95	9.17	2-6
1Mbx16 DRAM 60ns TSOP 300 mil EDO	36.17	17.83	11.33	10.43	18.94	9.42	9.18	9.00	8.92	9.13	2-6
2Mbx8 DRAM 60ns TSOP 300 mil	32.56	20.63	11.65	10.75	18.90	10.00	9.61	9.39	9.09	9.52	2-6
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	21.25	14.95	9.56	9.05	13.70	8.72	8.56	8.50	8.43	8.55	2-6
4Mbx9 SIMM 2 (4Mbx4) +1 (4Mbx1)	73.25	40.99	29.61	25.76	42.40	23.23	22.71	22.29	22.14	22.59	2-6
1Mbx36 SIMM 9 (1Mbx4)	90.00	43.39	30.10	29.38	48.22	28.03	27.40	27.22	26.95	27.40	2-6
1Mbx32 SIMM 8 (1Mbx4)	69.46	38.65	26.83	26.19	40.28	24.99	24.43	24.27	24.03	24.43	2-6
1Mbx32 SIMM 2 (1Mbx16)	58.70	37.53	24.52	22.76	35.88	20.78	20.26	19.96	19.76	20.19	2-6
2Mbx32 SIMM 16 (1Mbx4)	114.00	75.64	52.01	50.73	73.10	48.33	47.21	46.89	46.41	47.21	2-6
2Mbx32 SIMM 4 (1Mbx16)	114.54	73.32	47.31	43.79	69.74	39.83	38.79	38.19	37.79	38.65	2-6
2Mbx36 SIMM 18 (1Mbx4)	180.00	84.86	58.27	56.83	94.99	54.13	52.87	52.51	51.97	52.87	2-6
2Mbx36 SIMM 4 (1Mbx16) +2 (1Mbx4)	176.50	82.48	53.51	49.83	90.58	45.57	44.39	43.75	43.29	44.25	2-6
256Kx4 VRAM 70ns SOJ	6.00	6.00	5.85	5.60	5.86	5.50	5.43	5.41	5.38	5.43	2-6
128Kx8 VRAM 70ns SOJ	6.25	6.25	6.00	5.90	6.10	5.85	5.81	5.80	5.77	5.81	2-6
256Kx16 VRAM 70ns SOP	21.20	16.93	13.00	12.00	15.78	11.50	11.00	11.00	10.96	11.12	2-6

*Contract volume is at least 100,000 per order, except for 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 1996)

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)	2.89	2.33	2.03	1.93	1.83
256Kx4 DRAM 60ns SOJ	2.74	2.28	2.00	1.90	1.80
4Mbx1 DRAM 70ns SOJ	5.42	2.96	2.59	2.46	2.33
1Mbx4 DRAM 60ns SOJ FPM	4.77	2.83	2.47	2.35	2.23
1Mbx4 DRAM 60ns SOJ EDO	4.84	2.81	2.46	2.33	2.22
512Kx8 DRAM 70ns	5.44	2.87	2.52	2.39	2.27
256Kx16 DRAM 70ns SOJ	5.58	3.46	3.04	2.89	2.75
4Mbx 4 DRAM 70ns SOJ 300 mil	19.79	9.20	7.96	7.57	7.19
1Mbx16 DRAM 60ns TSOP 300 mil FPM	18.95	9.17	7.96	7.57	7.19
1Mbx16 DRAM 60ns TSOP 300 mil EDO	18.94	9.13	7.92	7.52	7.15
2Mbx8 DRAM 60ns TSOP 300 mil	18.90	9.52	8.26	7.85	7.46
1Mbx9 SIMM 2 (1Mbx4) +1 (1Mbx1)	13.70	8.55	7.48	7.11	6.75
4Mbx9 SIMM 2 (4Mbx4) +1 (4Mbx1)	42.40	22.59	19.62	18.63	17.70
1Mbx36 SIMM 9 (1Mbx4)	48.22	27.40	23.95	22.76	21.62
1Mbx32 SIMM 8 (1Mbx4)	40.28	24.43	21.36	20.29	19.28
1Mbx32 SIMM 2 (1Mbx16)	35.88	20.19	17.56	16.69	15.85
2Mbx32 SIMM 16 (1Mbx4)	73.10	47.21	41.26	39.20	37.24
2Mbx32 SIMM 4 (1Mbx16)	69.74	38.65	33.61	31.93	30.33
2Mbx36 SIMM 18 (1Mbx4)	94.99	52.87	46.21	43.90	41.70
2Mbx36 SIMM 4 (1Mbx16) +2 (1Mbx4)	90.58	44.25	38.50	36.58	34.75
256Kx4 VRAM 70ns SOJ	5.86	5.43	4.76	4.19	3.69
128Kx8 VRAM 70ns SOJ	6.10	5.81	5.10	4.49	3.95
256Kx16 VRAM 70ns SOP	15.78	11.12	9.68	8.52	7.50

*Contract volume is at least 100,000 per order, except for 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 1996)

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	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
16Kx4 35ns	2.87	2.73	2.66	2.60	2.72	2.58	2.52	2.48	2.42	2.50	2
8Kx8 25ns	2.07	1.95	1.57	1.50	1.77	1.50	1.50	1.75	1.75	1.63	2
8Kx8 100-120ns	1.95	1.85	1.54	1.45	1.70	1.46	1.46	1.48	1.48	1.47	2
64Kx4 10ns	8.00	7.00	7.00	6.50	7.13	7.00	7.00	7.00	7.00	7.00	6
64Kx4 25ns	3.68	2.50	2.75	2.88	2.95	2.75	2.75	2.67	2.67	2.71	6
32Kx8 12ns	3.75	2.33	2.34	2.51	2.73	2.29	2.16	2.19	2.12	2.19	5
32Kx9 12ns Burst	9.00	7.00	3.00	4.50	5.88	4.00	3.75	3.50	3.50	3.69	6
32K x 8, 15ns, 5V	2.33	1.95	1.73	1.84	1.96	1.75	1.73	1.89	1.89	1.82	5
32K x 8, 15ns, 3.3V	2.75	2.22	1.60	1.47	2.01	1.55	1.47	1.70	1.70	1.60	5
32Kx8 25ns	2.30	2.08	1.55	1.40	1.83	1.73	1.73	1.84	1.84	1.79	5
32Kx8 70-100ns SOJ	2.62	2.47	2.10	2.03	2.31	1.93	1.91	1.89	1.84	1.89	3
64Kx8 12ns Burst	24.00	21.50	19.00	17.50	20.50	14.90	14.20	14.13	13.25	14.12	4
256Kx4 20ns	14.33	12.14	10.92	9.95	11.84	9.15	8.80	8.05	7.75	8.44	6
128K x 8 15ns	14.63	13.57	10.38	10.44	12.25	9.67	9.17	8.58	8.21	8.91	5
128K x 8 20ns	14.13	12.32	9.98	10.03	11.61	9.31	8.76	8.22	7.85	8.53	5
128Kx8 25ns	13.13	12.07	9.79	9.79	11.19	9.10	8.63	8.06	7.72	8.38	5
128Kx8 70-100ns SOJ	7.18	6.21	5.83	5.49	6.17	5.30	5.15	5.06	4.97	5.12	3
32Kx32 15ns, 3.3V PQFP	10.89	6.10	4.80	4.88	6.67	4.94	4.69	4.58	4.25	4.61	6
32Kx32 8ns 3.3V PBSynch	14.00	4.50	4.90	4.08	6.87	3.76	3.56	3.31	3.18	3.45	6

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 1996)

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	2.72	2.50	2.30	2.18	2.07
8Kx8 25ns	1.77	1.63	1.66	1.58	1.50
8Kx8 100-120ns	1.70	1.47	1.41	1.34	1.27
64Kx4 10ns	7.13	7.00	6.65	6.32	6.00
64Kx4 25ns	2.95	2.71	2.53	2.41	2.29
32Kx8 12ns	2.73	2.19	2.01	1.91	1.82
32Kx9 12ns Burst	5.88	3.69	3.33	3.16	3.00
32K x 8, 15ns, 5V	1.96	1.82	1.80	1.71	1.62
32K x 8, 15ns, 3.3V	2.01	1.60	1.62	1.53	1.46
32Kx8 25ns	1.83	1.79	1.75	1.66	1.58
32Kx8 70-100ns SOJ	2.31	1.89	1.75	1.66	1.58
64Kx8 12ns Burst	20.50	14.12	12.59	11.96	11.36
256Kx4 20ns	11.84	8.44	7.36	6.99	6.64
128K x 8 15ns	12.25	8.91	7.80	7.41	7.04
128K x 8 20ns	11.61	8.53	7.46	7.08	6.73
128Kx8 25ns	11.19	8.38	7.34	6.97	6.62
128Kx8 70-100ns SOJ	6.17	5.12	4.72	4.49	4.26
32Kx32 15ns, 3.3V PQFP	6.67	4.61	4.04	3.84	3.64
32Kx32 8ns 3.3V PBSynch	6.87	3.45	3.02	2.87	2.73

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 1996)

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	1.95	1.95	1.90	1.90	1.90	1.91	1.80	1.70	1.70	1.60	1.70	4-8
64Kx16	2.10	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	4-8
256Kx8	2.60	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	4-8
512Kx8	3.50	3.20	3.20	3.20	3.20	3.20	3.10	2.90	2.70	2.50	2.80	4-8
256Kx16[1]	3.50	3.20	3.20	3.20	3.20	3.20	3.10	2.90	2.70	2.50	2.80	4-8
1Mbx8[2]	5.00	4.50	4.40	4.30	4.20	4.35	4.10	4.00	3.70	3.50	3.83	4-8
1Mbx16	7.80	7.29	7.15	7.00	7.00	7.11	6.00	5.20	4.10	3.80	5.10	4-8
2Mbx8	7.80	7.29	7.15	7.00	7.00	7.11	6.00	5.20	4.10	3.80	4.78	4-8

[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 1996)

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	1.91	1.70	1.60	1.60	1.70
64Kx16	2.00	2.00	2.00	2.00	2.15
256Kx8	2.25	2.25	2.25	2.40	2.40
512Kx8	3.20	2.80	2.50	2.50	2.50
256Kx16[1]	3.20	2.80	2.50	2.50	2.50
1Mbx8[2]	4.35	3.83	3.50	3.40	3.30
1Mbx16	7.11	5.10	3.80	3.70	3.60
2Mbx8	7.11	4.78	3.80	3.70	3.60

[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 1996)

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

Product	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
32Kx8	1.95	1.95	2.10	2.10	2.03	2.14	2.17	2.20	2.25	2.19	4-8
64Kx8	2.15	2.15	2.20	2.20	2.18	2.30	2.30	2.30	2.30	2.30	4-8
128Kx8	3.00	2.80	2.80	2.75	2.84	2.65	2.65	2.55	2.55	2.60	4-8
256Kx8	4.70	4.30	4.20	4.20	4.35	4.20	4.10	4.10	4.00	4.10	4-8
128Kx16	6.70	6.70	6.70	6.70	6.70	6.60	6.60	6.60	6.60	6.60	4-8
512Kx8	7.60	7.30	7.05	6.85	7.20	6.75	6.60	6.50	6.35	6.55	4-8
256Kx16	11.20	10.90	10.75	10.65	10.88	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 (September 1996)

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	2.03	2.19	1.90	2.00	2.00
64Kx8	2.18	2.30	2.40	2.50	2.50
128Kx8	2.84	2.60	2.75	2.95	2.95
256Kx8	4.35	4.10	4.00	3.75	3.75
128Kx16	6.70	6.60	4.50	4.20	4.00
512Kx8	7.20	6.55	6.20	6.00	5.80
256Kx16	10.88	9.99	8.25	8.00	7.80

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 1996)

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

Product	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
64Kx8 PDIP/PLCC	3.96	3.50	3.20	3.00	3.42	2.90	2.80	2.70	2.60	2.75	4
64Kx8 TSOP	4.20	3.75	3.45	3.25	3.66	3.15	3.05	2.95	2.85	3.00	4
128Kx8 PDIP/PLCC	3.80	3.50	3.00	2.85	3.29	2.75	2.65	2.55	2.50	2.61	2-4
128Kx8 TSOP 12V	4.00	3.70	3.22	3.00	3.48	2.95	2.85	2.73	2.70	2.81	2-4
128Kx8 TSOP 5V	6.08	5.70	5.35	5.05	5.54	4.20	4.00	3.80	3.70	3.93	2
256Kx8 TSOP 12V	9.40	6.75	6.38	6.13	7.17	6.00	5.75	5.60	5.40	5.69	2-4
256Kx8 TSOP/5V	9.80	7.30	7.50	6.50	6.27	6.05	5.70	5.40	5.10	5.56	2-4
512Kx8 PDIP/PLCC	13.00	11.50	8.43	7.68	10.15	6.25	5.60	5.30	5.00	5.54	2-4
512Kx8 TSOP 12V	14.00	11.30	8.00	7.90	10.30	7.00	6.73	6.59	6.41	6.68	2-4
512Kx8 TSOP/5V	14.50	11.50	9.65	8.90	11.14	6.55	5.90	5.60	5.30	5.84	2-4
1Mbx8 TSOP/12V	17.00	11.00	10.50	10.32	12.21	10.15	9.89	9.76	9.41	9.80	2-4
1Mbx8 TSOP/5V	18.38	14.35	12.00	11.25	13.99	10.70	10.15	9.50	8.88	9.81	2-4
2Mbx8 TSOP/12V	37.00	35.75	25.11	21.41	29.82	18.27	17.81	17.00	16.43	17.38	2-4
2Mbx8 TSOP/5V	34.80	29.33	26.50	21.75	28.10	19.00	17.90	17.00	16.13	17.51	2-4

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 1996)

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	3.42	2.75	2.34	2.11	1.90
64Kx8 TSOP	3.66	3.00	2.57	2.31	2.08
128Kx8 PDIP/PLCC	3.29	2.61	2.25	2.03	1.82
128Kx8 TSOP 12V	3.48	2.81	2.43	2.19	1.97
128Kx8 TSOP 5V	5.54	3.93	3.33	3.00	2.70
256Kx8 TSOP 12V	7.17	5.69	4.86	4.37	3.94
256Kx8 TSOP/5V	6.27	5.56	4.59	4.13	3.72
512Kx8 PDIP/PLCC	9.24	5.54	4.50	4.05	3.89
512Kx8 TSOP 12V	10.15	6.68	5.77	5.19	4.98
512Kx8 TSOP/5V	10.30	5.84	4.77	4.29	4.12
1Mbx8 TSOP/12V	12.21	9.80	8.47	7.88	7.80
1Mbx8 TSOP/5V	13.99	9.81	7.99	7.43	7.36
2Mbx8 TSOP/12V	29.82	17.38	14.79	14.34	13.77
2Mbx8 TSOP/5V	28.10	17.51	14.51	14.08	13.51

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 1996)

Table 15
Estimated Gate Array Pricing—North American Production Bookings
(Volume: 20,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype; Millicents per Gate)

	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Time
Gate Count Technology	1996	1997	1998	1996	1997	1998	1996	1997	1998	(Weeks)
CMOS (Average)										Production:
1.0 Micron	38.00	31.00	27.00	36.00	30.00	26.00	35.00	28.00	25.00	6-12
0.8 Micron	32.00	27.00	23.00	26.00	23.00	20.00	28.00	23.00	19.00	6-12
0.6/0.5 Micron	29.00	25.00	21.00	22.00	18.00	16.00	21.00	17.00	15.00	6-12
0.3 Micron	NR	NR	NR	NR	NR	NR	22.00	16.00	14.00	6-12
										Prototypes:
NRE CMOS Average Charge ($K)	45.00	44.00	44.00	55.00	54.00	52.00	75.00	74.00	73.00	2-8

	100-299.99K Gates			≥300K Gates			
Gate Count Technology	1996	1997	1998	1996	1997	1998	Lead Time (Weeks)
CMOS (Average)							Production:
1.0 Micron	NR	NR	NR	NR	NR	NR	6-12
0.8 Micron	30.00	24.00	21.00	NR	NR	NR	6-12
0.6/0.5 Micron	23.00	18.00	16.00	25.00	20.00	17.00	6-12
0.3 Micron	24.00	17.00	15.00	26.00	19.00	16.00	6-12
							Prototypes:
NRE CMOS Average Charge ($K)	109.00	107.00	106.00	125.00	123.00	120.00	2-8

NR = Not relevant

Notes: The actual NRE charge may vary from these because of device amortization, testing, intellectual property rights, and other factors.

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, and volume discount. These prices are intended for use as price guidelines. For volumes of 100k units or greater, discount the above prices by a further 40 percent to 60 percent.

For high-density solutions and a volume of greater than 150,000 units or for low-density solutions with volumes greater than 500 units, CBICs may be more cost-effective than gate arrays.

Source: Dataquest (September 1996)

Table 16
Estimated CBIC Pricing—North American Production Bookings
(Volume: 20,000 Units; Based on Utilized Gates Only; NRE = Netlist to Prototype; Millicents per Gate)

	10-29.99K Gates			30-59.99K Gates			60-99.99K Gates			Lead Time
Gate Count Technology	**1996**	**1997**	**1998**	**1996**	**1997**	**1998**	**1996**	**1997**	**1998**	**(Weeks)**
CMOS										Production:
1.0 Micron	46.00	37.00	30.00	41.00	33.00	28.00	39.00	31.00	27.00	7-13
0.8 Micron	39.00	31.00	26.00	30.00	24.00	21.00	31.00	25.00	21.00	7-13
0.6/0.5 Micron	33.00	26.00	22.00	26.00	21.00	18.00	25.00	20.00	17.00	7-13
0.3 Micron	NR	NR	NR	NR	NR	NR	25.00	19.00	15.00	NR
										Prototypes:
NRE CMOS Average Charge ($K)	70.00	68.00	67.00	73.00	72.00	72.00	84.00	83.00	83.00	4-8

	100-299K Gates			≥300K Gates			
Gate Count Technology	**1996**	**1997**	**1998**	**1996**	**1997**	**1998**	**Lead Time (Weeks)**
CMOS							Production:
1.0 Micron	NR	NR	NR	NR	NR	NR	6-12
0.8 Micron	33.00	26.00	22.00	NR	NR	NR	6-12
0.6/0.5 Micron	27.00	22.00	19.00	30.00	24.00	21.00	6-12
0.3 Micron	27.00	21.00	17.00	28.00	22.00	19.00	6-12
							Prototypes:
NRE CMOS Average Charge ($K)	133.00	133.00	132.00	165.00	163.00	161.00	2-8

NR = Not relevant

Notes: The actual NRE charge may vary from these because of device amortization, testing, intellectual property rights, and other factors.

Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as intellectual property rights, alliances, service, package types, and volume discount. These prices are intended for use as price guidelines. For volumes of 100k units or greater, discount the above prices by a further 40 percent to 60 percent.

For high-density solutions and a volume of greater than 150,000 units or for low-density solutions with volumes greater than 500 units, CBICs may be more cost-effective than gate arrays.

Source: Dataquest (September 1996)

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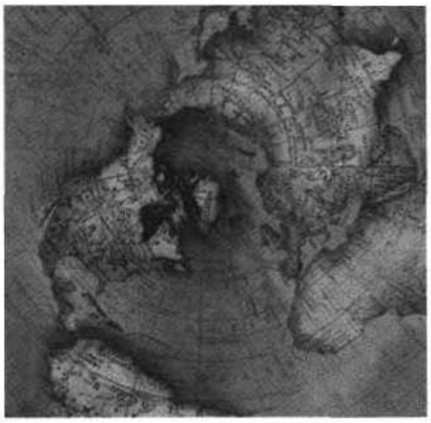

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North American Semiconductor Price Outlook: Third Quarter

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
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Table of Contents

	Page
North American Semiconductor Price Outlook: Third Quarter 1996.....	1
Methodology and Sources	1
Price Variations	1

List of Tables

Table		Page
1	Estimated Standard Logic Price Trends—North American Bookings	2
2	Estimated Long-Range Standard Logic Price Trends—North American Bookings	4
3	Estimated Microprocessor Price Trends—North American Bookings	5
4	Estimated Long-Range Microprocessor Price Trends—North American Bookings	7
5	Estimated DRAM Price Trends—North American Bookings	8
6	Estimated Long-Range DRAM Price Trends—North American Bookings	9
7	Estimated Static RAM Price Trends—North American Bookings	10
8	Estimated Long-Range Static RAM Price Trends—North American Bookings	11
9	Estimated ROM Price Trends—North American Bookings	12
10	Estimated Long-Range ROM Price Trends—North American Bookings	13
11	Estimated EPROM Price Trends—North American Bookings	14
12	Estimated Long-Range EPROM Price Trends—North American Bookings	15
13	Estimated Flash Memory Price Trends—North American Bookings	16
14	Estimated Long-Range Flash Memory Price Trends—North American Bookings	17
15	Estimated Gate Array Pricing—North American Production Bookings	18
16	Estimated CBIC Pricing—North American Production Bookings	19
17	Estimated CMOS PLD Price per Unit—North American Bookings	20
18	Estimated Long-Range CMOS PLD Price per Unit—North American Bookings	21

Note: All tables show estimated data.

North American Semiconductor Price Outlook: Third Quarter

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 Supply and Pricing Worldwide (SPSG) program 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 SPSG clients that use the SPSG online service, the prices presented here correlate with the quarterly and long-range price tables dated June 1996 in the SPSG 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 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
74LS TTL												
74LS00	0.15	0.14	0.14	0.14	0.13	0.14	0.13	0.13	0.13	0.13	0.13	2-6
74LS74	0.16	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	2-6
74LS138	0.18	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.17	2-6
74LS244	0.26	0.26	0.25	0.24	0.24	0.25	0.24	0.24	0.24	0.24	0.24	2-6
74AC TTL												
74AC00	0.20	0.19	0.18	0.18	0.17	0.18	0.17	0.17	0.17	0.17	0.17	2-6
74AC74	0.23	0.23	0.22	0.22	0.21	0.22	0.21	0.21	0.21	0.21	0.21	2-6
74AC138	0.33	0.33	0.31	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.31	2-6
74AC244	0.45	0.45	0.44	0.44	0.43	0.44	0.43	0.42	0.41	0.40	0.42	2-6
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	2-6
74F74	0.17	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.15	0.15	0.15	2-6
74F138	0.21	0.20	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.18	0.18	2-6
74F244	0.26	0.25	0.24	0.23	0.23	0.24	0.23	0.23	0.23	0.23	0.23	2-6
74HC CMOS												
74HC00	0.18	0.15	0.13	0.13	0.12	0.13	0.12	0.12	0.12	0.12	0.12	2-6
74HC74	0.19	0.18	0.16	0.16	0.16	0.17	0.16	0.16	0.16	0.16	0.16	2-6
74HC138	0.21	0.21	0.19	0.19	0.18	0.19	0.18	0.18	0.17	0.17	0.18	2-6
74HC244	0.30	0.28	0.25	0.25	0.23	0.25	0.23	0.23	0.23	0.23	0.23	2-6
74ALS TTL												
74ALS00	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	2-6
74ALS74	0.21	0.20	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.18	0.18	2-6
74ALS138	0.32	0.29	0.27	0.25	0.23	0.26	0.23	0.23	0.23	0.23	0.23	2-6
74ALS244	0.41	0.39	0.36	0.33	0.31	0.35	0.30	0.30	0.30	0.30	0.30	2-6

(Continued)

Table 1 (Continued)
Estimated Standard Logic Price Trends—North American Bookings
(Volume: 100,000 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	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	2-6
74AS74	0.22	0.21	0.20	0.20	0.19	0.20	0.19	0.19	0.19	0.19	0.19	2-6
74AS138	0.47	0.44	0.42	0.42	0.40	0.42	0.40	0.40	0.40	0.40	0.40	2-6
74AS244	0.71	0.67	0.65	0.65	0.65	0.66	0.63	0.63	0.63	0.63	0.63	2-6
74BC*												
74BC00	0.25	0.23	0.23	0.23	0.23	0.23	0.21	0.21	0.21	0.21	0.21	2-8
74BC244	0.59	0.55	0.55	0.55	0.55	0.55	0.53	0.53	0.53	0.53	0.53	2-8
74BC373	0.61	0.57	0.57	0.57	0.57	0.57	0.55	0.55	0.55	0.55	0.55	2-8
74ACT244	0.47	0.45	0.45	0.45	0.45	0.45	0.43	0.43	0.43	0.43	0.43	2-8
74ACT245	0.51	0.48	0.48	0.48	0.48	0.48	0.46	0.46	0.46	0.46	0.46	2-8
74ABT244	0.63	0.60	0.60	0.60	0.60	0.60	0.58	0.58	0.58	0.58	0.58	2-8
74ABT245	0.67	0.65	0.65	0.65	0.65	0.65	0.63	0.63	0.63	0.63	0.63	2-6

*Pricing for 74BC excludes 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 1996)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
74LS TTL					
74LS00	0.14	0.13	0.13	0.13	0.12
74LS74	0.17	0.16	0.15	0.15	0.14
74LS138	0.18	0.17	0.15	0.15	0.14
74LS244	0.25	0.24	0.24	0.24	0.24
74AC TTL					
74AC00	0.18	0.17	0.17	0.17	0.17
74AC74	0.22	0.21	0.21	0.21	0.21
74AC138	0.32	0.31	0.30	0.30	0.30
74AC244	0.44	0.42	0.40	0.40	0.40
74F TTL					
74F00	0.14	0.14	0.14	0.13	0.13
74F74	0.16	0.15	0.15	0.15	0.14
74F138	0.19	0.18	0.18	0.18	0.17
74F244	0.24	0.23	0.23	0.23	0.23
74HC CMOS					
74HC00	0.13	0.12	0.12	0.12	0.12
74HC74	0.17	0.16	0.16	0.16	0.16
74HC138	0.19	0.18	0.18	0.18	0.18
74HC244	0.25	0.23	0.23	0.23	0.23
74ALS TTL					
74ALS00	0.16	0.16	0.16	0.16	0.16
74ALS74	0.19	0.18	0.18	0.18	0.18
74ALS138	0.26	0.23	0.23	0.23	0.23
74ALS244	0.35	0.30	0.30	0.30	0.30
74AS TTL					
74AS00	0.19	0.19	0.19	0.19	0.18
74AS74	0.20	0.19	0.19	0.19	0.19
74AS138	0.42	0.40	0.40	0.40	0.38
74AS244	0.66	0.63	0.63	0.61	0.61
74BC*					
74BC00	0.23	0.21	0.21	0.21	0.21
74BC244	0.55	0.53	0.53	0.53	0.51
74BC373	0.57	0.55	0.55	0.55	0.53
74ACT244	0.45	0.43	0.43	0.43	0.40
74ACT245	0.48	0.46	0.46	0.46	0.44
74ABT244	0.60	0.58	0.58	0.56	0.56
74ABT245	0.65	0.63	0.63	0.61	0.59

*Pricing for 74BC excludes 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 1996)

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	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	2-6
68020-16 PQFP	18.50	17.50	17.50	16.00	16.00	16.75	15.00	15.00	15.00	15.00	15.00	2-6
68EC020-16 PQFP	9.50	8.75	8.75	8.75	8.75	8.75	8.00	8.00	8.00	8.00	8.00	2-6
68EC020-25 PQFP	10.00	9.00	9.00	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00	2-6
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	2-6
68040-25	140.00	105.00	80.00	70.00	60.00	78.75	60.00	60.00	60.00	60.00	60.00	2-6
68LC040-25 CQFP 184	65.00	50.00	40.00	35.00	30.00	38.75	25.00	25.00	25.00	25.00	25.00	2-6
386SL-25 PQFP	40.00	29.00	25.00	25.00	25.00	26.00	25.00	25.00	25.00	25.00	25.00	2-6
AM386-40 PQFP[1]	22.00	20.00	19.00	19.00	19.00	19.25	18.00	18.00	18.00	18.00	18.00	2-6
80486SX-25 PQFP	35.00	30.00	25.00	25.00	20.00	25.00	20.00	20.00	20.00	20.00	20.00	2-6
80486DX-33 PQFP	65.00	55.00	45.00	35.00	30.00	41.25	25.00	25.00	25.00	25.00	25.00	2-6
80486DX-50	95.00	79.00	60.00	49.00	39.00	56.75	31.00	31.00	31.00	31.00	31.00	2-6
80486DX2-50 PQFP	49.00	41.00	30.00	25.00	20.00	29.00	20.00	20.00	20.00	20.00	20.00	2-6
80486DX2-66	65.00	55.00	42.00	32.00	28.00	39.25	25.00	25.00	25.00	25.00	25.00	2-6
80486DX4-75	100.00	90.00	75.00	65.00	55.00	71.25	50.00	50.00	45.00	45.00	47.50	2-6
Pentium-75	150.00	100.00	90.00	80.00	80.00	87.50	70.00	70.00	60.00	60.00	65.00	2-6
Pentium-90	225.00	182.00	120.00	100.00	90.00	123.00	80.00	80.00	70.00	70.00	75.00	2-6
Pentium-100	281.00	199.00	120.00	100.00	90.00	127.25	80.00	80.00	70.00	70.00	75.00	2-6
PowerPC-601-66	111.00	105.00	80.00	70.00	70.00	81.25	60.00	60.00	60.00	60.00	60.00	2-6
PowerPC-601-80	159.00	125.00	95.00	90.00	85.00	98.75	80.00	80.00	80.00	80.00	80.00	2-6
PowerPC-601-100	273.00	235.00	175.00	150.00	120.00	170.00	100.00	100.00	80.00	80.00	90.00	2-6
Power PC 603-80	108.00	105.00	95.00	85.00	75.00	90.00	60.00	60.00	60.00	60.00	60.00	2-6
29000-25[2]	49.00	45.00	40.00	35.00	35.00	38.75	30.00	30.00	30.00	30.00	30.00	2-6
88100-25[2]	40.00	39.00	35.00	35.00	35.00	36.00	30.00	30.00	30.00	30.00	30.00	2-6
R4000SC-50	375.00	350.00	315.00	285.00	255.00	301.25	220.00	185.00	140.00	120.00	166.25	2-6

(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)
R4400SC-75	515.00	450.00	410.00	375.00	325.00	390.00	295.00	250.00	210.00	185.00	235.00	2-6
SPARC-25[2]	45.00	39.00	35.00	35.00	35.00	36.00	30.00	30.00	30.00	30.00	30.00	2-6
80960CA-25	55.00	50.00	50.00	45.00	45.00	47.50	40.00	40.00	40.00	40.00	40.00	2-6

[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 (June 1996)

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	16.75	15.00	15.00	NA	NA
68EC020-16 PQFP	8.75	8.00	7.00	NA	NA
68EC020-25 PQFP	9.00	8.00	7.00	NA	NA
68EC030-25 PQFP	21.00	19.00	17.00	NA	NA
68040-25	78.75	60.00	50.00	NA	NA
68LC040-25 CQFP 184	38.75	25.00	NA	NA	NA
386SL-25 PQFP	26.00	25.00	NA	NA	NA
AM386-40 PQFP[1]	19.25	18.00	NA	NA	NA
80486SX-25 PQFP	25.00	20.00	NA	NA	NA
80486DX-33 PQFP	41.25	25.00	NA	NA	NA
80486DX-50	56.75	31.00	NA	NA	NA
80486DX2-50 PQFP	29.00	20.00	NA	NA	NA
80486DX2-66	39.25	25.00	NA	NA	NA
80486DX4-75	71.25	47.50	NA	NA	NA
Pentium-75	87.50	65.00	55.00	NA	NA
Pentium-90	123.00	75.00	60.00	NA	NA
Pentium-100	127.25	75.00	50.00	NA	NA
PowerPC-601-66	81.25	60.00	45.00	NA	NA
PowerPC-601-80	98.75	80.00	70.00	NA	NA
PowerPC-601-100	170.00	90.00	80.00	70.00	NA
Power PC 603-80	90.00	60.00	NA	NA	NA
29000-25[2]	38.75	30.00	NA	NA	NA
88100-25[2]	36.00	30.00	NA	NA	NA
R4000SC-50	301.25	166.25	115.00	NA	NA
R4400SC-75	390.00	235.00	185.00	NA	NA
SPARC-25[2]	36.00	30.00	NA	NA	NA
80960CA-25	47.50	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 guidelines.
Source: Dataquest (June 1996)

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)	3.76	3.46	3.24	3.21	3.24	3.29	3.41	3.45	3.55	3.57	3.50	2-6
256Kx4 DRAM 60ns SOJ	3.80	3.46	3.24	3.22	3.25	3.29	3.44	3.48	3.59	3.61	3.53	2-6
4Mbx1 DRAM 70ns SOJ	12.33	9.39	5.75	5.50	5.25	6.47	5.00	4.80	4.65	4.30	4.69	2-6
1Mbx4 DRAM 60ns SOJ, FPM	12.13	8.98	5.50	5.25	5.00	6.18	4.80	4.59	4.35	3.95	4.42	2-6
1Mbx4 DRAM 60ns SOJ, EDO	12.13	9.00	5.50	5.25	5.00	6.19	4.80	4.59	4.35	3.95	4.42	2-6
512Kx8 DRAM 70ns	15.10	9.10	6.90	6.50	6.20	7.18	6.06	5.70	5.25	5.00	5.50	2-6
256Kx16 DRAM 70ns SOJ	14.69	9.55	7.15	6.90	6.60	7.55	6.45	6.30	6.06	5.70	6.13	2-6
4Mbx4 DRAM 70ns SOJ, 300 mil	47.80	32.50	23.00	21.00	19.25	23.94	18.00	16.50	15.50	14.75	16.19	2-6
1Mbx16 DRAM 60ns TSOP, 300 mil, FPM	53.20	32.50	23.00	21.00	19.25	23.94	18.00	16.50	15.50	14.75	16.19	2-6
1Mbx16 DRAM 60ns TSOP, 300 mil, EDO	53.50	32.50	23.00	21.00	19.25	23.94	18.00	16.50	15.50	14.75	16.19	2-6
2Mbx8 DRAM 60ns TSOP, 300 mil	51.08	31.75	23.00	21.35	19.25	23.84	18.25	17.00	16.00	15.00	16.56	2-6
1Mbx9 SIMM 2(1Mbx4)+1(1Mbx1)	32.55	21.25	14.95	14.39	13.90	16.12	13.66	13.26	12.86	12.04	12.96	2-6
4Mbx9 SIMM 2(4Mbx4)+1(4Mbx1)	112.50	94.63	54.34	49.88	45.94	61.19	43.05	39.69	37.43	35.49	38.92	2-6
1Mbx36 SIMM 9(1Mbx4)	118.74	81.25	51.98	49.61	47.25	57.52	45.36	43.38	41.11	37.33	41.79	2-6
1Mbx32 SIMM 8(1Mbx4)	107.50	80.91	46.20	44.10	42.00	53.30	40.32	38.56	36.54	33.18	37.15	2-6
1Mbx32 SIMM 2(1Mbx16)	114.00	81.39	48.30	44.10	40.43	53.55	37.80	34.65	32.55	30.98	33.99	2-6
2Mbx32 SIMM 16(1Mbx4)	214.00	160.70	86.63	82.69	78.75	97.45	75.60	72.29	68.51	62.21	69.65	2-6
2Mbx32 SIMM 4(1Mbx16)	206.53	161.08	96.60	88.20	80.85	106.68	75.60	69.30	65.10	61.95	67.99	2-6
2Mbx36 SIMM 18(1Mbx4)	233.67	193.94	103.95	99.23	94.50	122.90	90.72	86.75	82.22	74.66	83.59	2-6
2Mbx36 SIMM 4(1Mbx16)+2(1Mbx4)	223.80	176.50	108.15	99.23	91.35	118.81	85.68	78.94	74.24	70.25	77.27	2-6
256Kx4 VRAM 70ns SOJ	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	2-6
128Kx8 VRAM 70ns SOJ	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	2-6
256Kx16 VRAM 70ns SOP	24.25	21.20	18.80	18.00	17.50	18.88	16.60	15.50	14.80	13.90	15.20	2-6

*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 1996)

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

Product	1996	1997	1998	1999	2000
1Mbx1 DRAM 70-80ns (DIP/SOJ)	3.29	3.50	3.60	3.60	3.60
256Kx4 DRAM 60ns SOJ	3.29	3.53	3.62	3.65	3.65
4Mbx1 DRAM 70ns SOJ	6.47	4.69	4.22	3.80	3.42
1Mbx4 DRAM 60ns SOJ, FPM	6.18	4.42	3.98	3.58	3.22
1Mbx4 DRAM 60ns SOJ, EDO	6.19	4.42	3.98	3.58	3.22
512Kx8 DRAM 70ns	7.18	5.50	4.95	4.46	4.01
256Kx16 DRAM 70ns SOJ	7.55	6.13	5.51	4.96	4.47
4Mbx4 DRAM 70ns SOJ, 300 mil	23.94	16.19	14.57	13.11	11.80
1Mbx16 DRAM 60ns TSOP, 300 mil, FPM	23.94	16.19	14.57	13.11	11.80
1Mbx16 DRAM 60ns TSOP, 300 mil, EDO	23.94	16.19	14.57	13.11	11.80
2Mbx8 DRAM 60ns TSOP, 300 mil	25.37	16.56	14.91	13.42	12.07
1Mbx9 SIMM 2(1Mbx4)+1(1Mbx1)	16.12	12.96	11.66	10.50	9.45
4Mbx9 SIMM 2(4Mbx4)+1(4Mbx1)	61.19	38.92	35.02	31.52	28.37
1Mbx36 SIMM 9(1Mbx4)	57.52	41.79	37.61	33.85	30.47
1Mbx32 SIMM 8(1Mbx4)	53.30	37.15	33.43	30.09	27.08
1Mbx32 SIMM 2(1Mbx16)	53.55	33.99	30.59	27.53	24.78
2Mbx32 SIMM 16(1Mbx4)	97.45	69.65	62.69	56.42	50.78
2Mbx32 SIMM 4(1Mbx16)	106.68	67.99	61.19	55.07	49.56
2Mbx36 SIMM 18(1Mbx4)	122.90	83.59	75.23	67.70	60.93
2Mbx36 SIMM 4(1Mbx16)+2(1Mbx4)	118.81	77.27	69.55	62.59	56.33
256Kx4 VRAM 70ns SOJ	6.00	6.00	5.40	4.86	4.37
128Kx8 VRAM 70ns SOJ	6.25	6.25	5.63	5.06	4.56
256Kx16 VRAM 70ns SOP	18.88	15.20	14.42	12.98	11.68

*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 1996)

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	2.90	2.87	2.73	2.66	2.60	2.72	2.58	2.52	2.48	2.42	2.50	4-8
8Kx8 25ns	2.75	2.35	2.35	2.35	2.35	2.35	2.25	2.25	2.25	2.25	2.25	4-8
8Kx8 100-120ns	1.85	1.75	1.65	1.65	1.65	1.68	1.55	1.55	1.50	1.50	1.53	4-8
64Kx4 10ns	10.00	8.00	7.00	7.00	6.00	7.00	6.00	6.00	5.00	5.00	5.50	4-8
64Kx4 25ns	4.50	4.35	4.25	4.15	4.05	4.20	4.00	3.90	3.80	3.70	3.85	4-8
32Kx8 12ns	6.10	5.25	4.75	4.25	3.75	4.50	3.00	2.50	2.50	2.25	2.56	4-8
32Kx9 12ns Burst	13.00	9.00	7.00	4.75	4.50	6.31	4.00	3.75	3.50	3.50	3.69	4-8
32Kx8, 15ns, 5V	3.50	2.90	2.75	2.55	2.25	2.61	2.00	2.07	2.07	2.07	2.05	4-8
32Kx8, 15ns, 3.3V	4.00	3.25	2.95	2.70	2.40	2.83	2.40	2.40	2.40	2.40	2.40	4-8
32Kx8 25ns	3.65	2.60	2.50	2.05	2.00	2.29	2.00	2.00	2.00	2.00	2.00	4-8
32Kx8 70-100ns SOJ	3.40	2.75	2.60	2.40	2.25	2.50	2.15	2.10	2.10	2.00	2.09	2-4
64Kx18 12ns Burst	35.00	27.00	24.00	22.00	20.00	23.25	18.00	17.00	16.00	14.00	16.25	4-8
256Kx4 20ns	18.00	16.50	14.42	13.00	12.25	14.04	11.25	11.00	10.25	10.00	10.63	4-8
128Kx8, 15ns	20.00	16.50	15.88	13.33	12.33	14.51	11.50	11.00	10.50	10.00	10.75	2-4
128Kx8 20ns	18.00	16.00	14.13	12.67	11.83	13.66	11.17	10.67	10.17	9.67	10.42	4-8
128Kx8 25ns	16.50	14.67	13.64	12.00	11.13	12.86	10.56	10.13	9.69	9.29	9.92	2-4
128Kx8 70-100ns SOJ	8.25	7.90	6.96	6.71	6.17	6.94	6.05	5.80	5.73	5.63	5.80	2-4
32Kx32 15ns, 3.3V PQFP	24.00	14.33	7.15	6.50	6.25	8.56	6.00	5.50	5.00	4.50	5.25	2-4

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 1996)

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	2.72	2.50	2.50	2.60	2.70
8Kx8 25ns	2.35	2.25	2.25	2.30	2.50
8Kx8 100-120ns	1.68	1.53	1.75	2.00	2.20
64Kx4 10ns	7.00	5.50	4.75	4.75	5.00
64Kx4 25ns	4.20	3.85	3.75	3.75	3.75
32Kx8 12ns	4.50	2.56	2.50	2.50	2.50
32Kx9 12ns Burst	6.31	3.69	3.50	3.50	3.50
32Kx8, 15ns, 5V	2.61	2.05	2.00	2.00	2.00
32Kx8, 15ns, 3.3V	2.83	2.40	2.20	2.10	2.00
32Kx8 25ns	2.29	2.00	2.00	2.00	2.00
32Kx8 70-100ns SOJ	2.50	2.09	2.05	2.05	2.05
64Kx18 12ns Burst	23.25	16.25	14.00	12.00	10.00
256Kx4 20ns	14.04	10.63	8.33	6.55	5.00
128Kx8, 15ns	14.51	10.75	7.85	5.85	5.00
128Kx8 20ns	13.66	10.42	8.42	6.25	5.40
128Kx8 25ns	12.86	9.92	8.29	6.20	5.35
128Kx8 70-100ns SOJ	6.94	5.80	5.12	5.00	5.00
32Kx32 15ns, 3.3V PQFP	8.56	5.25	5.00	5.00	5.00

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

Source: Dataquest (June 1996)

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	1.95	1.90	1.90	1.90	1.91	1.80	1.70	1.70	1.60	1.70	4-8
64Kx16 ROM	2.10	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	4-8
256Kx8 ROM	2.60	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	4-8
512Kx8 ROM	3.50	3.20	3.20	3.20	3.20	3.20	3.10	2.90	2.70	2.50	2.80	4-8
256Kx16 ROM[1]	3.50	3.20	3.20	3.20	3.20	3.20	3.10	2.90	2.70	2.50	2.80	4-8
1Mbx8 ROM[2]	5.00	4.50	4.40	4.30	4.20	4.35	4.10	4.00	3.70	3.50	3.83	4-8
1Mbx16 ROM	7.80	7.29	7.15	7.00	7.00	7.11	6.00	5.20	4.10	3.80	5.10	4-8
2Mbx8 ROM	7.80	7.29	7.15	7.00	7.00	7.11	6.00	5.20	4.10	3.80	4.78	4-8

[1] 256Kx16 ROM: 150ns and above, 40-pin PDIP

[2] 1Mbx8 ROM: 150ns and above, 32-pin SOP

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

Source: Dataquest (June 1996)

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	1.91	1.70	1.60	1.60	1.70
64Kx16 ROM	2.00	2.00	2.00	2.00	2.15
256Kx8 ROM	2.25	2.25	2.25	2.40	2.40
512Kx8 ROM	3.20	2.80	2.50	2.50	2.50
256Kx16 ROM[1]	3.20	2.80	2.50	2.50	2.50
1Mbx8 ROM[2]	4.35	3.83	3.50	3.40	3.30
1Mbx16 ROM	7.11	5.10	3.80	3.70	3.60
2Mbx8 ROM	7.11	4.78	3.80	3.70	3.60

[1] 256Kx16 ROM: 150ns and above, 40-pin PDIP

[2] 1Mbx8 ROM: 150ns and above, 32-pin SOP

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

Source: Dataquest (June 1996)

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	1.95	1.95	2.10	2.10	2.03	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	3.00	2.80	2.80	2.75	2.84	2.65	2.65	2.55	2.55	2.60	4-8
256Kx8 EPROM	4.85	4.70	4.30	4.20	4.20	4.35	4.20	4.10	4.10	4.00	4.10	4-8
128Kx16 EPROM	6.80	6.70	6.70	6.70	6.70	6.70	6.60	6.60	6.60	6.60	6.60	4-8
512Kx8 EPROM	8.30	7.60	7.30	7.05	6.85	7.20	6.75	6.60	6.50	6.35	6.55	4-8
256Kx16 EPROM	11.45	11.20	10.90	10.75	10.65	10.88	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 guidelines.

Source: Dataquest (June 1996)

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	2.03	2.19	1.90	2.00	2.00
64Kx8 EPROM	2.18	2.30	2.40	2.50	2.50
128Kx8 EPROM	2.84	2.60	2.75	2.95	2.95
256Kx8 EPROM	4.35	4.10	4.00	3.75	3.75
128Kx16 EPROM	6.70	6.60	4.50	4.20	4.00
512Kx8 EPROM	7.20	6.55	6.20	6.00	5.80
256Kx16 EPROM	10.88	9.99	8.25	8.00	7.80

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 1996)

Table 13
Estimated Flash Memory Price Trends—North American Bookings
(12V; 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	3.75	3.60	3.50	3.70	3.40	3.30	3.20	3.00	3.23	4-8
64Kx8, TSOP	4.20	4.20	3.80	3.60	3.50	3.40	3.40	3.30	3.20	3.00	3.25	4-8
128Kx8, PDIP/PLCC	4.39	4.27	3.65	3.40	3.30	3.65	3.20	3.10	3.00	2.90	3.05	4-8
128Kx8, TSOP, 12V	4.61	4.48	4.37	3.93	3.82	4.15	3.65	3.57	3.44	3.44	3.53	4-8
128Kx8, TSOP, 5V	6.12	5.80	5.25	4.95	4.75	5.19	4.60	4.50	4.40	4.30	4.45	4-8
256Kx8, TSOP, 12V	10.15	8.98	8.75	8.62	8.47	8.71	8.02	7.55	7.26	6.88	7.43	8
256Kx8, TSOP, 5V	10.74	9.80	9.40	9.20	9.10	9.38	8.70	8.20	7.90	7.52	8.08	8
512Kx8, PDIP/PLCC	7.50	7.00	6.50	6.00	5.80	6.33	5.60	5.40	5.25	5.20	5.36	4-8
512Kx8, TSOP, 12V	13.15	12.60	12.50	11.80	11.50	12.10	11.10	10.65	9.85	9.30	10.23	8
512Kx8, TSOP, 5V	15.90	14.50	14.30	13.90	12.75	13.86	12.10	11.80	10.50	10.00	11.10	6-8
1Mbx8 TSOP, 12V	18.00	17.00	16.90	16.50	15.90	16.58	15.75	15.00	14.60	13.75	14.78	6-8
1Mbx8 TSOP, 5V	23.10	20.60	19.55	18.80	18.25	19.30	16.60	15.45	14.51	13.65	15.05	6-8
2Mbx8 TSOP, 12V	39.00	37.00	35.75	34.50	30.50	34.44	28.15	25.30	23.95	22.70	25.03	6-8
2Mbx8 TSOP, 5V	45.00	40.00	39.10	36.50	33.50	37.28	31.60	28.90	24.70	23.20	27.10	6-8

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

Source: Dataquest (June 1996)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
64Kx8, PDIP/PLCC	3.70	3.23	3.00	2.50	2.50
64Kx8, TSOP	3.40	3.25	3.00	2.50	2.50
128Kx8, PDIP/PLCC	3.65	3.05	2.75	2.75	2.50
128Kx8, TSOP, 12V	4.15	3.53	2.80	2.60	2.50
128Kx8, TSOP, 5V	5.19	4.45	4.00	3.65	2.75
256Kx8, TSOP, 12V	8.71	7.43	5.25	4.00	3.50
256Kx8, TSOP, 5V	9.38	8.08	6.50	4.25	3.80
512Kx8, PDIP/PLCC	6.33	5.36	4.20	3.75	3.60
512Kx8, TSOP, 12V	12.10	10.23	7.20	5.00	3.75
512Kx8, TSOP, 5V	13.86	11.10	8.50	6.25	5.25
1Mbx8 TSOP, 12V	16.58	14.78	12.00	9.00	6.50
1Mbx8 TSOP, 5V	19.30	15.05	12.00	9.00	6.50
2Mbx8 TSOP, 12V	34.44	25.03	17.00	12.00	9.00
2Mbx8 TSOP, 5V	37.28	27.10	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 guidelines.

Source: Dataquest (June 1996)

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 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			10-19.99K Gates			Lead Time
Gate Count Technology	1996	1997	1998	1996	1997	1998	(Weeks)
CMOS							Production:
1.0 Micron	50.00	48.00	46.00	42.00	39.00	36.00	8-10
0.8 Micron	39.00	36.00	34.00	39.00	36.00	33.00	8-10
0.6/0.5 Micron	44.00	42.00	39.00	39.00	36.00	32.00	8-10
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	25.00	25.00	25.00	43.00	43.00	43.00	6-8
0.8 Micron	29.00	29.00	29.00	40.00	40.00	38.00	6-8
0.6/0.5 Micron	31.00	30.00	29.00	39.00	39.00	38.00	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	NA

	20-29.99K Gates			30-59.9K Gates			60-100K Gates			Lead Time
Gate Count Technology	1996	1997	1998	1996	1997	1998	1996	1997	1998	(Weeks)
CMOS										Production:
1.0 Micron	43.00	41.00	38.00	45.00	43.00	40.00	43.00	41.00	40.00	8-10
0.8 Micron	35.00	31.00	28.00	33.00	31.00	30.00	35.00	31.00	28.00	8-10
0.6/0.5 Micron	34.00	31.00	27.00	28.00	27.00	25.00	29.00	27.00	26.00	8-10
0.3 Micron	NA	NA	NA	NA	NA	NA	30.00	25.00	23.00	8-10
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	52.00	52.00	52.00	59.00	59.00	59.00	80.00	80.00	80.00	6-8
0.8 Micron	50.00	50.00	50.00	57.00	57.00	57.00	75.00	75.00	75.00	6-8
0.6/0.5 Micron	45.00	45.00	45.00	55.00	55.00	55.00	75.00	75.00	75.00	6-8
0.3 Micron	NA	NA	NA	NA	NA	NA	80.00	80.00	80.00	6-8

NA = Not available
Notes: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines. Volume prices: For 100,000 units or greater, discount the above prices by 30 percent to 40 percent.
Source: Dataquest (June 1996)

Table 16
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 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			10-19.99K Gates			Lead Time
Gate Count Technology	1996	1997	1998	1996	1997	1998	(Weeks)
CMOS							Production:
1.0 Micron	54.00	52.00	50.00	46.00	42.00	38.00	8-10
0.8 Micron	41.00	39.00	36.00	40.00	36.00	33.00	8-10
0.6/0.5 Micron	46.00	44.00	42.00	41.00	37.00	33.00	8-10
0.3 Micron	NA	NA	NA	NA	NA	NA	NA
NRE Charges ($1,000)							
CMOS							Prototypes:
1.0 Micron	46.00	46.00	46.00	67.00	65.00	65.00	12-18
0.8 Micron	51.00	51.00	51.00	67.00	65.00	65.00	9-18
0.6/0.5 Micron	57.00	57.00	57.00	73.00	72.00	71.00	14-21
0.3 Micron	NA	NA	NA	NA	NA	NA	NA

	20-29.99K Gates			30-59.9K Gates			60-100K Gates			Lead Time
Gate Count Technology	1996	1997	1998	1996	1997	1998	1996	1997	1998	(Weeks)
CMOS										Production:
1.0 Micron	53.00	51.00	50.00	54.00	52.00	50.00	56.00	54.00	52.00	8-10
0.8 Micron	37.00	35.00	33.00	37.00	34.00	32.00	41.00	37.00	34.00	8-10
0.6/0.5 Micron	36.00	33.00	32.00	33.00	31.00	29.00	31.00	29.00	28.00	8-10
0.3 Micron	NA	NA	NA	NA	NA	NA	32.00	28.00	26.00	8-10
NRE Charges ($1,000)										
CMOS										Prototypes:
1.0 Micron	70.00	70.00	70.00	75.00	75.00	75.00	95.00	95.00	95.00	6-10
0.8 Micron	70.00	70.00	70.00	75.00	75.00	74.00	90.00	90.00	90.00	4-7
0.6/0.5 Micron	70.00	70.00	70.00	75.00	73.00	70.00	90.00	90.00	90.00	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	95.00	95.00	95.00	6-8

NA = Not available
Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount. These prices are intended for use as guidelines.
Source: Dataquest (June 1996)

Table 17
Estimated CMOS PLD Price per Unit—North American Bookings
(Volume: 10,000 per Year; Package: PDIP or PLCC; Dollars)

Pin Count	Speed* (ns)	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (Weeks)
≤20													
	6.1-7.5	2.40	2.20	2.10	2.10	2.10	2.13	2.00	2.00	2.00	2.00	2.00	4-8
	7.6-10.0	1.55	1.40	1.30	1.20	1.20	1.28	1.20	1.10	1.10	1.10	1.13	4-8
	10.1-14.99	1.25	1.20	1.15	1.10	1.10	1.14	1.10	1.00	1.00	1.00	1.03	4-8
	15 - <25	0.68	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	4-8
	≥25	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	4-8
24													
	6.1-7.5	3.00	2.90	2.80	2.70	2.70	2.78	2.70	2.60	2.60	2.60	2.63	4-8
	7.6-10.0	2.50	2.35	2.25	1.90	1.90	2.10	1.90	1.80	1.80	1.75	1.81	4-8
	10.1-14.99	1.65	1.60	1.50	1.50	1.40	1.50	1.40	1.35	1.35	1.35	1.36	4-8
	15 - <25	0.91	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	4-8
	≥25	0.77	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	4-8
24 (22V10)													
	6.1-7.5	6.38	6.25	6.00	5.80	5.60	5.91	5.50	5.50	5.30	5.30	5.40	4-8
	7.6-10.0	3.60	3.52	3.40	3.20	3.20	3.33	3.20	3.20	3.10	3.10	3.15	4-8
	15 - <25	2.35	2.35	2.30	2.20	2.20	2.26	2.20	2.20	2.20	2.20	2.20	4-8
	≥25	1.40	1.35	1.30	1.30	1.30	1.31	1.20	1.20	1.20	1.20	1.20	4-8

*Nanosecond speed is the TPD for the combinatorial device.

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

Source: Dataquest (June 1996)

Table 18
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	2.13	2.00	2.00	2.00	2.00
	7.6-10.0	1.28	1.13	1.10	1.10	1.10
	10.1-14.99	1.14	1.03	1.00	1.00	1.00
	15 - <25	0.65	0.65	0.65	0.65	0.65
	≥25	0.65	0.65	0.65	0.65	0.65
24						
	6.1-7.5	2.78	2.63	2.60	2.60	2.60
	7.6-10.0	2.10	1.81	1.75	1.75	1.75
	10.1-14.99	1.50	1.36	1.35	1.35	1.35
	15 - <25	0.90	0.90	0.90	0.90	0.90
	≥25	0.75	0.75	0.75	0.75	0.75
24 (22V10)						
	6.1-7.5	5.91	5.40	5.30	5.30	5.30
	7.6-10.0	3.33	3.15	3.10	3.10	3.10
	15 - <25	2.26	2.20	2.20	2.20	2.20
	≥25	1.31	1.20	1.30	1.30	1.30

*Nanosecond speed is the TPD for the combinatorial device.

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

Source: Dataquest (June 1996)

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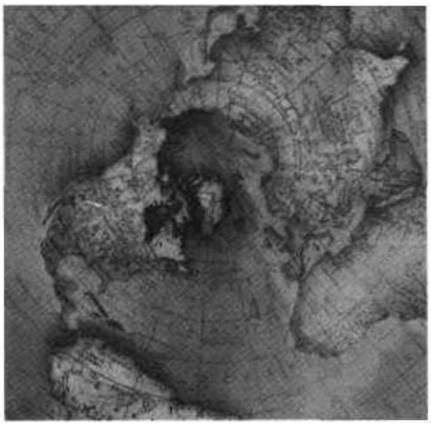

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North American Semiconductor Price Outlook: Second Quarter 1996

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SPSG-WW-MS-9601
Publication Date: March 18, 1996
Filing: Market Statistics

North American Semiconductor Price Outlook: Second Quarter 1996

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Table of Contents

	Page
North American Semiconductor Price Outlook:	
Second Quarter 1996	1
Methodology and Sources	1
Price Variations	1

List of Tables

Table		Page
1	Estimated Standard Logic Price Trends—North American Bookings	2
2	Estimated Long-Range Standard Logic Price Trends—North American Bookings	4
3	Estimated Microprocessor Price Trends—North American Bookings	5
4	Estimated Long-Range Microprocessor Price Trends—North American Bookings	7
5	Estimated DRAM Price Trends—North American Bookings	8
6	Estimated Long-Range DRAM Price Trends—North American Bookings	10
7	Estimated Static RAM Price Trends—North American Bookings	11
8	Estimated Long-Range Static RAM Price Trends—North American Bookings	12
9	Estimated ROM Price Trends—North American Bookings	13
10	Estimated Long-Range ROM Price Trends—North American Bookings	14
11	Estimated EPROM Price Trends—North American Bookings	15
12	Estimated Long-Range EPROM Price Trends—North American Bookings	16
13	Estimated Flash Memory Price Trends—North American Bookings	17
14	Estimated Long-Range Flash Memory Price Trends—North American Bookings	18
15	Estimated Gate Array Pricing (5K to 19.99K Gates)—North American Production Bookings	19
16	Estimated Gate Array Pricing (20K to 100K Gates)—North American Production Bookings	20
17	Estimated CBIC Pricing (5K to 19.99K Gates)—North American Production Bookings	21
18	Estimated CBIC Pricing (20K to 100K Gates)—North American Production Bookings	22
19	Estimated CMOS PLD Price per Unit—North American Bookings	23
20	Estimated Long-Range CMOS PLD Price per Unit—North American Bookings	24

Note: All tables show estimated data.

North American Semiconductor Price Outlook: Second 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 Supply and Pricing Worldwide (SPSG) program 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 SPSG clients that use the SPSG online service, the prices presented here correlate with the quarterly and long-range price tables dated September 1995 in the SPSG 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 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 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 (March 1996)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings (Volume: 100,000 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 (March 1996)

(Continued)

Table 3
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 per Year; Dollars)
(Package: 8-Bit/16-Bit Devices—PDIPP; 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	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4-6
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	4-6
68EC020-16 PQFP	9.50	8.75	8.75	8.75	8.75	8.75	8.00	8.00	8.00	8.00	8.00	4-6
68EC020-25 PQFP	10.00	9.00	9.00	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00	4-6
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	4-6
68040-25	140.00	105.00	90.00	80.00	70.00	86.25	60.00	60.00	60.00	60.00	60.00	4-6
68LC040-25 CQFP 184	65.00	55.00	48.00	40.00	35.00	44.50	29.00	29.00	29.00	29.00	29.00	4-6
386SL-25 PQFP	40.00	29.00	29.00	29.00	29.00	29.00	25.00	25.00	25.00	25.00	25.00	4-6
AM386-40 PQFP[1]	22.00	20.00	20.00	20.00	20.00	20.00	18.00	18.00	18.00	18.00	18.00	4-6
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	4-6
80486DX-33 PQFP	65.00	55.00	45.00	35.00	30.00	41.25	25.00	25.00	25.00	25.00	25.00	4-6
80486DX-50	95.00	80.00	65.00	50.00	40.00	58.75	35.00	35.00	35.00	35.00	35.00	4-6
80486DX2-50 PQFP	49.00	41.00	32.00	25.00	20.00	29.50	20.00	20.00	20.00	20.00	20.00	4-6
80486DX2-66	65.00	55.00	45.00	35.00	30.00	41.25	25.00	25.00	25.00	25.00	25.00	4-6
80486DX4-75	100.00	90.00	80.00	70.00	60.00	75.00	55.00	55.00	55.00	55.00	55.00	4-6
Pentium-66	134.00	100.00	90.00	90.00	90.00	92.50	70.00	70.00	70.00	70.00	70.00	4-8
Pentium-75	150.00	100.00	90.00	90.00	90.00	92.50	70.00	70.00	70.00	70.00	70.00	4-8
Pentium-90	225.00	182.00	138.00	105.00	105.00	132.50	90.00	90.00	90.00	90.00	90.00	4-8
Pentium-100	281.00	199.00	150.00	125.00	125.00	149.75	115.00	115.00	115.00	115.00	115.00	4-8
PowerPC 601-66	111.00	105.00	90.00	90.00	90.00	93.75	70.00	70.00	70.00	70.00	70.00	4-8
PowerPC 601-80	159.00	125.00	105.00	95.00	90.00	103.75	90.00	90.00	90.00	90.00	90.00	4-8
PowerPC 601-100	273.00	235.00	195.00	150.00	120.00	175.00	120.00	120.00	120.00	120.00	120.00	4-8
Power PC 603-80	108.00	105.00	95.00	85.00	77.00	90.50	60.00	60.00	60.00	60.00	60.00	4-8
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	4-6

(Continued)

Table 3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 per Year; Dollars)
(Package: 8-Bit/16-Bit Devices—PDIPP; 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]	40.00	39.00	39.00	39.00	39.00	39.00	35.00	35.00	35.00	35.00	35.00	4-6
R4000SC-50	375.00	360.00	345.00	330.00	320.00	338.75	300.00	225.00	170.00	125.00	205.00	4-8
R4400SC-75	515.00	475.00	450.00	420.00	395.00	435.00	370.00	350.00	320.00	295.00	333.75	4-8
SPARC-25[1]	45.00	42.00	42.00	42.00	42.00	42.00	35.00	35.00	35.00	35.00	35.00	4-6
80960CA-25	55.00	50.00	50.00	45.00	45.00	47.50	40.00	40.00	40.00	40.00	40.00	4-6

[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 1996)

Table 4
Estimated Long-Range Microprocessor Price Trends—North American Bookings (Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 Year; Dollars) (Package: 8-Bit/16-Bit Devices—PDIPP; 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	9.00	8.00	7.00	NA	NA
68EC030-25 PQFP	21.00	19.00	17.00	NA	NA
68040-25	86.25	60.00	50.00	NA	NA
68LC040-25 CQFP 184	44.50	29.00	NA	NA	NA
386SL-25 PQFP	29.00	25.00	NA	NA	NA
AM386-40 PQFP[1]	20.00	18.00	NA	NA	NA
80486SX-25 PQFP	26.25	20.00	NA	NA	NA
80486DX-33 PQFP	41.25	25.00	NA	NA	NA
80486DX-50	58.75	35.00	NA	NA	NA
80486DX2-50 PQFP	29.50	20.00	NA	NA	NA
80486DX2-66	41.25	25.00	NA	NA	NA
80486DX4-75	75.00	55.00	50.00	NA	NA
Pentium-66	92.50	70.00	60.00	NA	NA
Pentium-75	92.50	70.00	60.00	NA	NA
Pentium-90	132.50	90.00	70.00	NA	NA
Pentium-100	149.75	115.00	100.00	70.00	50.00
PowerPC-601-66	93.75	70.00	50.00	NA	NA
PowerPC-601-80	103.75	90.00	85.00	75.00	NA
PowerPC-601-100	175.00	120.00	99.00	85.00	75.00
Power PC 603-80	90.50	60.00	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	338.75	205.00	155.00	120.00	99.00
R4400SC-75	435.00	333.75	295.00	235.00	192.00
SPARC-25[2]	42.00	35.00	NA	NA	NA
80960CA-25	47.50	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 guidelines.
Source: Dataquest (March 1996)

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)	3.77	3.44	3.44	3.44	3.44	3.44	3.45	3.45	3.45	3.45	3.45	4-8
256Kbx4 DRAM 60ns SOJ	3.80	3.43	3.45	3.49	3.50	3.47	3.60	3.61	3.63	3.65	3.62	4-8
4Mbx1 DRAM 70ns SOJ	12.33	8.45	7.61	6.84	6.16	7.26	5.85	5.56	5.28	5.02	5.43	4-8
1Mbx4 DRAM 60ns SOJ FPM	12.26	8.50	7.65	6.89	6.20	7.31	5.89	5.59	5.31	5.05	5.46	4-8
1Mbx4 DRAM 60ns SOJ EDO	12.13	8.55	7.70	6.93	6.23	7.35	5.92	5.63	5.34	5.08	5.49	4-8
512Kbx8 DRAM 70ns	15.10	8.81	7.93	7.14	6.42	7.57	6.10	5.80	5.51	5.23	5.66	10-12
256Kbx16 DRAM 70ns SOJ	14.69	10.00	9.00	8.10	7.29	8.60	6.93	6.58	6.25	5.94	6.42	4-8
4Mbx4 DRAM 70ns SOJ 300 mil	46.50	33.42	30.08	27.07	24.36	28.73	23.15	21.99	20.89	19.84	21.47	8-12
1Mbx16 DRAM 60ns TSOP 300 mil FPM	53.20	34.43	30.98	27.88	25.10	29.60	23.84	22.65	21.52	20.44	22.11	6-12
1Mbx16 DRAM 60ns TSOP 300 mil EDO	53.50	34.63	31.16	28.05	25.24	29.77	23.98	22.78	21.64	20.56	22.24	8-12
2Mbx8 DRAM 60ns TSOP 300mil	51.08	34.50	31.05	27.95	25.15	29.66	23.89	22.70	21.56	20.49	22.16	8-12
1Mbx9 SIMM 2 (1Mbx4) + 1 (1Mbx1)	32.55	21.15	19.39	17.81	16.38	18.68	15.75	15.14	14.56	14.01	14.87	4-8
4Mbx9 SIMM 2 (4Mbx4) + 1 (4Mbx1)	116.00	82.96	76.17	70.13	64.61	73.47	62.51	60.18	57.97	55.92	59.14	8-12
1Mbx36 SIMM 9 (1Mbx4)	118.74	79.26	71.33	64.20	57.78	68.14	54.89	52.15	49.54	47.06	50.91	6-12
1Mbx32 SIMM 8 (1Mbx4)	107.50	70.45	63.41	57.07	51.36	60.57	48.79	46.35	44.03	41.83	45.25	4-8
1Mbx32 SIMM 2 (1Mbx16)	114.00	71.33	64.20	57.78	52.00	61.33	49.40	46.93	44.58	42.36	45.82	6-12
2Mbx32 SIMM 16 (1Mbx4)	214.00	143.64	129.28	116.35	104.71	123.49	99.48	94.50	89.78	85.29	92.26	8-12
2Mbx32 SIMM 4 (1Mbx16)	206.53	145.44	130.89	117.80	106.02	125.04	100.72	95.69	90.90	86.36	93.42	8-12
2Mbx36 SIMM 18 (1Mbx4)	233.67	161.60	145.44	130.89	117.80	138.93	111.91	106.32	101.00	95.95	103.80	4-8
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	223.80	160.28	144.25	129.83	116.84	137.80	111.00	105.45	100.18	95.17	102.95	6-12

(Continued)

Table 5 (Continued)
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)
256Kbx4 VRAM 70ns SOJ	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	8-12
128Kbx8 VRAM 70ns SOJ	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	8-12
256Kbx16 VRAM 70ns SOP	24.25	23.00	20.25	19.50	18.00	20.19	17.20	16.60	15.50	14.80	16.03	8-12

*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 1996)

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

Product	1996	1997	1998	1999	2000
1Mbx1 DRAM 70 80ns (DIP/SOJ)	3.44	3.45	3.42	3.38	3.35
256Kbx4 DRAM 60ns SOJ	3.47	3.62	3.59	3.55	3.51
4Mbx1 DRAM 70ns SOJ	7.26	5.43	4.88	4.40	3.96
1Mbx4 DRAM 60ns SOJ FPM	7.31	5.46	4.91	4.42	3.98
1Mbx4 DRAM 60ns SOJ EDO	7.35	5.49	4.94	4.45	4.00
512Kbx8 DRAM 70ns	7.57	5.66	5.09	4.58	4.13
256Kbx16 DRAM 70ns SOJ	8.60	6.42	5.78	5.20	4.68
4Mbx4 DRAM 70ns SOJ 300 mil	28.73	21.47	17.17	13.74	11.68
1Mbx16 DRAM 60ns TSOP 300 mil FPM	29.60	22.11	17.69	14.15	12.03
1Mbx16 DRAM 60ns TSOP 300 mil EDO	29.77	22.24	17.79	14.23	12.10
2Mbx8 DRAM 60ns TSOP 300mil	29.66	22.16	17.73	14.18	12.06
1Mbx9 SIMM 2 (1Mbx4) + 1 (1Mbx1)	18.68	14.87	13.70	12.65	11.70
4Mbx9 SIMM 2 (4Mbx4) + 1 (4Mbx1)	73.47	59.14	50.15	42.93	38.53
1Mbx36 SIMM 9 (1Mbx4)	68.14	50.91	45.82	41.24	37.11
1Mbx32 SIMM 8 (1Mbx4)	60.57	45.25	40.73	36.65	32.99
1Mbx32 SIMM 2 (1Mbx16)	61.33	45.82	36.65	29.32	24.93
2Mbx32 SIMM 16 (1Mbx4)	123.49	92.26	83.04	74.73	67.26
2Mbx32 SIMM 4 (1Mbx16)	125.04	93.42	74.73	59.79	50.82
2Mbx36 SIMM 18 (1Mbx4)	138.93	103.80	93.42	84.07	75.67
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	137.80	102.95	83.49	67.81	58.10
256Kbx4 VRAM 70ns SOJ	6.00	6.00	5.40	4.86	4.37
128Kbx8 VRAM 70ns SOJ	6.25	6.25	5.63	5.06	4.56
256Kbx16 VRAM 70ns SOP	20.19	16.03	14.42	12.98	11.68

*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 1996)

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)
16Kbx4 35ns	2.90	2.87	2.73	2.66	2.60	2.72	2.58	2.52	2.48	2.42	2.50	8-10
8Kbx8 25ns	2.75	2.35	2.35	2.35	2.35	2.35	2.25	2.25	2.25	2.25	2.25	8-10
8Kbx8 100 120ns	1.85	1.90	1.90	1.90	1.90	1.90	2.00	2.00	2.00	2.00	2.00	8-10
64Kbx4 10ns	10.00	9.00	9.00	8.00	8.00	8.50	7.00	7.00	6.00	6.00	6.50	12
64Kbx4 25ns	4.50	4.50	4.50	4.50	4.50	4.50	4.25	4.25	4.25	4.25	4.25	12
32Kbx8 12ns	6.10	5.10	5.05	4.85	4.65	4.91	4.25	4.00	3.50	3.25	3.75	12
32Kbx9 12ns Burst	13.00	12.00	10.50	9.25	8.75	10.13	8.10	7.00	5.90	5.20	6.55	12
32Kbx8 15ns, 5V	3.50	3.85	3.65	3.45	3.25	3.55	3.00	3.00	3.00	3.00	3.00	12
32Kbx8 15ns, 3.3V	4.00	3.75	3.50	3.25	3.00	3.38	3.00	3.00	3.00	3.00	3.00	12
32Kbx8 25ns	3.65	3.08	3.08	3.03	3.03	3.05	2.65	2.65	2.65	2.65	2.65	12
32Kbx8 70 100ns SOJ	3.40	3.35	3.25	3.15	3.05	3.20	2.68	2.63	2.53	2.53	2.59	8-10
64Kbx18 12ns Burst	35.00	33.00	31.50	29.50	27.30	30.33	25.70	24.10	23.20	22.40	23.85	12
256Kbx4 20ns	18.00	16.00	15.75	15.25	15.25	15.56	14.00	14.00	13.25	13.25	13.63	12
128Kbx8 15ns	21.50	20.20	19.50	18.50	18.50	19.18	17.25	17.25	16.50	16.00	16.75	12
128Kbx8 20ns	18.00	16.00	16.00	15.25	15.25	15.63	14.80	14.40	14.00	13.50	14.18	12
128Kbx8 25ns	16.50	16.20	16.20	15.50	15.50	15.85	15.00	14.60	14.30	13.80	14.43	12
128Kbx8 70 100ns SOJ	8.25	8.20	7.60	7.40	7.15	7.59	6.95	6.75	6.50	6.35	6.64	12
32Kbx32 15ns, 3.3V PQFP	24.00	14.67	12.00	11.17	11.00	12.21	10.75	10.00	9.88	9.75	10.09	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 (March 1996)

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
16Kbx4 35ns	2.72	2.50	2.50	2.60	2.70
8Kbx8 25ns	2.35	2.25	2.25	2.30	2.50
8Kbx8 100 120ns	1.90	2.00	2.20	2.40	2.60
64Kbx4 10ns	8.50	6.50	5.25	4.75	4.75
64Kbx4 25ns	4.50	4.25	4.00	4.00	4.00
32Kbx8 12ns	4.91	3.75	3.30	3.00	3.00
32Kbx9 12ns Burst	10.13	6.55	5.50	5.50	5.50
32Kbx8 15ns, 5V	3.55	3.00	3.00	3.00	3.00
32Kbx8 15ns, 3.3V	3.38	3.00	3.00	3.00	3.00
32Kbx8 25ns	3.05	2.65	2.50	2.50	2.50
32Kbx8 70 100ns SOJ	3.20	2.59	2.25	2.25	2.25
64Kbx18 12ns Burst	30.33	23.85	21.00	19.00	17.00
256Kbx4 20ns	15.56	13.63	11.25	8.33	6.55
128Kbx8 15ns	19.18	16.75	13.57	10.61	7.85
128Kbx8 20ns	15.63	14.18	13.65	11.24	8.42
128Kbx8 25ns	15.85	14.43	10.55	8.29	6.20
128Kbx8 70 100ns SOJ	7.59	6.64	5.12	5.00	5.00
32Kbx32 15ns, 3.3V PQFP	12.21	10.09	7.80	6.20	5.50

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

These prices are intended for use as price guidelines.

Source: Dataquest (March 1996)

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)
128Kbx8 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
64Kbx16 ROM	2.1	2.08	2.05	2.05	2.05	2.06	2.05	2.05	2.05	2.05	2.05	8-12
256Kbx8 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
512Kbx8 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
256Kbx16 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]256Kbx16 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 1996)

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
128Kbx8 ROM	1.90	1.70	1.60	1.60	1.60
64Kbx16 ROM	2.06	2.05	2.05	2.15	2.25
256Kbx8 ROM	2.48	2.40	2.40	2.45	2.50
512Kbx8 ROM	3.38	2.80	2.50	2.50	2.50
256Kbx16 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]256Kbx16 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 1996)

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)
32Kbx8 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
64Kbx8 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
128Kbx8 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
256Kbx8 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
128Kbx16 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
512Kbx8 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
256Kbx16 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 (March 1996)

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
32Kbx8 EPROM	1.99	2.19	1.90	2.00	2.00
64Kbx8 EPROM	2.18	2.30	2.40	2.50	2.50
128Kbx8 EPROM	2.81	2.60	2.75	2.95	2.95
256Kbx8 EPROM	4.81	4.75	4.30	4.25	4.20
128Kbx16 EPROM	6.80	6.70	4.55	4.46	4.40
512Kbx8 EPROM	8.20	7.68	6.35	6.35	6.35
256Kbx16 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 (March 1996)

Table 13
Estimated Flash Memory Price Trends—North American Bookings (12V; 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)
64Kbx8 PDIP/PLCC	3.95	3.95	3.90	3.80	3.70	3.84	3.60	3.50	3.40	3.30	3.45	4-8
64Kbx8 TSOP	4.20	4.20	4.20	4.10	4.00	4.13	3.90	3.70	3.50	3.30	3.60	4-8
128Kbx8, PDIP/PLCC	4.39	4.27	3.79	3.74	3.64	3.86	3.48	3.40	3.28	3.28	3.36	4-8
128Kbx8 TSOP 12V	5.05	4.70	4.50	4.30	4.10	4.40	4.05	3.97	3.90	3.85	3.94	4-8
128Kbx8 TSOP 5V	6.12	5.83	5.63	5.40	5.40	5.56	5.35	5.30	5.00	4.95	5.15	8
256Kbx8 TSOP 12V	10.15	9.85	9.31	9.05	8.72	9.23	8.40	7.90	7.60	7.20	7.78	8
256Kbx8 TSOP 5V	10.70	10.53	10.25	10.15	9.95	10.22	9.30	8.60	8.20	7.80	8.48	6-8
512Kbx8 PDIP/PLCC	13.05	12.50	12.25	11.80	11.15	11.93	10.90	10.15	9.40	8.50	9.74	8
512Kbx8 TSOP 12V	13.15	12.90	12.60	12.05	11.75	12.33	11.30	10.80	10.05	9.55	10.43	8
512Kbx8 TSOP 5V	15.90	15.50	14.55	13.60	12.71	14.09	11.65	11.00	10.55	9.95	10.79	8
1Mbx8 TSOP 12V	18.00	17.55	17.40	17.00	16.80	17.19	16.50	15.45	14.10	13.00	14.76	6-8
1Mbx8 TSOP 5V	23.10	21.90	20.05	18.90	17.90	19.69	16.50	15.45	14.10	13.00	14.76	6-8
2Mbx8 TSOP 12V	40.00	39.00	38.25	36.10	32.00	36.34	29.65	26.80	25.42	24.20	26.52	6-8
2Mbx8 TSOP 5V	45.00	41.25	39.50	38.00	35.50	38.56	32.50	30.00	27.75	25.25	28.88	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount.
These prices are intended for use as guidelines.
Source: Dataquest (March 1996)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
64Kbx8 PDIP/PLCC	3.84	3.45	3.00	2.50	2.50
64Kbx8 TSOP	4.13	3.60	3.00	2.50	2.50
128Kbx8 PDIP/PLCC	3.86	3.36	2.75	2.75	2.50
128Kbx8 TSOP, 12V	4.40	3.94	3.50	2.80	2.60
128Kbx8 TSOP, 5V	5.56	5.15	4.75	4.00	3.65
256Kbx8 TSOP, 12V	9.23	7.78	5.25	4.00	3.50
256Kbx8 TSOP, 5V	10.22	8.48	6.50	4.25	3.80
512Kbx8 PDIP/PLCC	11.93	9.74	6.50	5.00	3.75
512Kbx8 TSOP, 12V	12.33	10.43	7.20	5.00	3.75
512Kbx8 TSOP, 5V	14.09	10.79	8.50	6.25	5.25
1Mbx8 TSOP, 12V	17.19	14.76	12.00	9.00	6.50
1Mbx8 TSOP, 5V	19.69	14.76	12.00	9.00	6.50
2Mbx8 TSOP, 12V	36.34	26.52	17.00	12.00	9.00
2Mbx8 TSOP, 5V	38.56	28.88	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 guidelines.

Source: Dataquest (March 1996)

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)

	5K-9.99K Gates			10K-19.99K 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	40	40	38	2-3
0.6 /0.5 Micron	31	30	29	NA	NA	NA	NA
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 above prices by 30 percent to 40 percent.
Source: Dataquest (March 1996)

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 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)

	20K-29.99K Gates			30K-59.9K Gates			60K-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	52	52	52	59	59	59	80	80	80	2-7
0.8 Micron	50	50	50	57	57	57	75	75	75	2-3
0.6 /0.5 Micron	45	45	45	55	55	55	75	75	75	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	80	80	80	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 above prices by 30 percent to 40 percent.
Source: Dataquest (March 1996)

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)

	5K-9.99K Gates			10K-19.99K 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							Prototype:
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 (March 1996)

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)

	20K-29.99K Gates			30K-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	70	70	70	75	75	75	95	95	95	6-10
0.8 Micron	70	70	70	75	75	74	90	90	90	4-7
0.6 /0.5 Micron	70	70	70	85	84	77	90	90	90	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	95	95	95	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 1996)

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)	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (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 price.

These prices are intended as guidelines.

Source: Dataquest (March 1996)

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
	> = 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 price.

These prices are intended as guidelines.

Source: Dataquest (March 1996)

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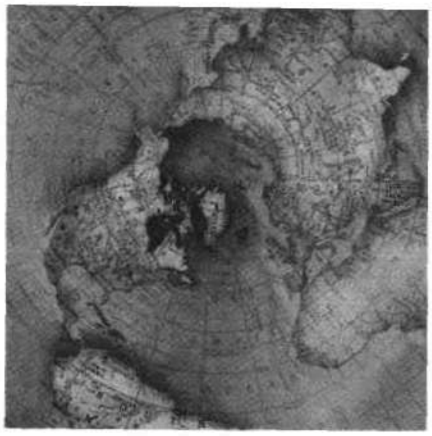

Dataquest

Final 1995 Worldwide Semiconductor Market Share

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SPSG-WW-MS-9602
Publication Date: April 29, 1996
Filing: Market Statistics

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Table of Contents

	Page
Introduction	1
Segmentation	1
Definitions	2
Product Definitions	2
Regional Definitions	4
Americas	4
Japan	4
Europe, Africa, and the Middle East	4
Asia/Pacific	4
Line Item Definitions	4
Market Share Methodology	4
Notes on Market Share	5
Notes to Market Share Tables	5
Exchange Rates	6
Section 1: Final 1995 Worldwide Market Share	8
Section 2: Final 1995 Worldwide Market Share Rankings	51

List of Tables

Table		Page
1	Exchange Rates	7
1-1	Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide	8
1-2	Each Company's Factory Revenue from Shipments of Total Semiconductors (Excluding Hybrid) to Worldwide	13
1-3	Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide	18
1-4	Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Excluding Hybrid) to Worldwide	23
1-5	Each Company's Factory Revenue from Shipments of Bipolar Digital Memory/Logic to Worldwide	28
1-6	Each Company's Factory Revenue from Shipments of Bipolar Digital Memory to Worldwide	29
1-7	Each Company's Factory Revenue from Shipments of Bipolar Digital Logic to Worldwide	30
1-8	Each Company's Factory Revenue from Shipments of MOS Digital Integrated Circuits to Worldwide	31
1-9	Each Company's Factory Revenue from Shipments of MOS Memory to Worldwide	35
1-10	Each Company's Factory Revenue from Shipments of MOS Microcomponents to Worldwide	37
1-11	Each Company's Factory Revenue from Shipments of MOS Logic to Worldwide	40
1-12	Each Company's Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide	43
1-13	Each Company's Factory Revenue from Shipments of Total Optical Semiconductors to Worldwide	45
1-14	Each Company's Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide	46
1-15	Each Company's Factory Revenue from Shipments of Hybrid Analog Integrated Circuits to Worldwide	49
2-1	Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide	51
2-2	Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Excluding Hybrid) to Worldwide	53
2-3	Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide	55
2-4	Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Excluding Hybrid) to Worldwide	57
2-5	Top 20 Companies' Factory Revenue from Shipments of Bipolar Digital Memory/Logic to Worldwide	59
2-6	Top Nine Companies' Factory Revenue from Shipments of Bipolar Digital Memory to Worldwide	60

Note: All tables show estimated data.

List of Tables (Continued)

Table		Page
2-7	Top 20 Companies' Factory Revenue from Shipments of Bipolar Digital Logic to Worldwide	61
2-8	Top 40 Companies' Factory Revenue from Shipments of MOS Digital Integrated Circuits to Worldwide	62
2-9	Top 40 Companies' Factory Revenue from Shipments of MOS Memory to Worldwide	64
2-10	Top 40 Companies' Factory Revenue from Shipments of MOS Microcomponents to Worldwide	66
2-11	Top 40 Companies' Factory Revenue from Shipments of MOS Logic to Worldwide	68
2-12	Top 40 Companies' Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide	70
2-13	Top 20 Companies' Factory Revenue from Shipments of Total Optical Semiconductors to Worldwide	72
2-14	Top 40 Companies' Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide	73
2-15	Top 10 Companies' Factory Revenue from Shipments of Hybrid Analog Integrated Circuits to Worldwide	75

Note: All tables show estimated data.

Final 1995 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:

- 1993-1995 market share estimates
- 1994-1995 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 titled "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 the Dataquest Perspectives.

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 optoelectronics 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 Monolithic Integrated Circuit (Including Hybrids)
  - Total Monolithic 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 Monolithic 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 Monolithic 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.

Regional Definitions

Americas

North America: Includes Canada, Mexico, and the United States (50 states)

South America

Central America

Japan

Japan is the only single-country region.

Europe, Africa, and the Middle East

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 Turkmenistan).

Asia/Pacific

Includes Hong Kong, Singapore, South Korea, Taiwan, Australia, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

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, dies, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.

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.

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 sources.

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. Appian Technology product lines were acquired by Cirrus Logic in 1994.

2. Dialog, Eurosil, Matra, Telefunken, and Siliconix are now known as Temic.

3. LG Semicon was formerly known as Goldstar.

4. IMP was formerly known as International Microelectronic Products.

5. Inmos revenue is included in SGS-Thomson revenue.

6. Linfinity was formerly known as Silicon General.

7. NCR was acquired by Hyundai in 1994 and is operated as Symbios Logic Inc.

8. Nippon Steel Semiconductor was formerly known as NMB Semiconductor.

9. Philips revenue includes Signetics revenue.

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

11. 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

12. In 1994, three quarters of Intel's PLD Divison'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.

13. Telcom was formerly known as Teledyne Semiconductor.

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

15. Part of IBM's 1994 and 1995 logic revenue has been reclassified and restated.

16. Rockwell's 1994 revenue has been restated.

17. National Semiconductor's 1994 revenue has been restated.

18. Comlinear revenue is included in National Semiconductor's revenue.

19. Silicon Storage Technology has been added to worldwide market share starting in 1995.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1 outlines these rates for 1993 through 1995.

Table 1
Exchange Rates

	1993	1994	1995
Japan (Yen/U.S.$)	111.20	101.81	93.90
France (Franc/U.S.$)	5.67	5.54	4.97
Germany (Deutsche Mark/U.S.$)	1.66	1.62	1.43
United Kingdom (U.S.$/Pound Sterling)	1.50	1.53	1.59

Source: Dataquest (April 1996)

Section 1: Final 1995 Worldwide Market Share

Table 1-1
Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	85,514	110,513	151,272	100.0	100.0	100.0
North American Companies	37,083	46,052	59,956	43.4	41.7	39.6
ACC Microelectronics	36	49	40	0	0	0
Actel	60	76	108	0.1	0.1	0.1
Adaptec	122	125	124	0.1	0.1	0.1
Advanced Micro Devices	1,660	2,134	2,330	1.9	1.9	1.5
Allegro MicroSystems	118	148	183	0.1	0.1	0.1
Alliance Semiconductor	41	90	220	0	0.1	0.1
Altera	140	199	402	0.2	0.2	0.3
Analog Devices	635	739	986	0.7	0.7	0.7
Applied Micro Circuits Corp.	48	48	48	0.1	0	0
AT&T	1,110	1,307	1,615	1.3	1.2	1.1
Atmel	225	375	590	0.3	0.3	0.4
Bipolar Integrated Technology	15	0	0	0	0	0
Brooktree	117	109	120	0.1	0.1	0.1
Burr-Brown	158	165	186	0.2	0.1	0.1
California Micro Devices	14	10	12	0	0	0
Catalyst	55	50	49	0.1	0	0
Cherry Semiconductor	55	77	87	0.1	0.1	0.1
Chips & Technologies	89	89	138	0.1	0.1	0.1
Cirrus Logic	451	781	1,002	0.5	0.7	0.7
Comlinear	16	16	-	0	0	0
Cypress Semiconductor	300	400	552	0.4	0.4	0.4
Cyrix	125	241	212	0.1	0.2	0.1
Dallas Semiconductor	112	154	228	0.1	0.1	0.2
Elantec	23	24	26	0	0	0
Electronic Designs	23	26	43	0	0	0
ETEQ Microsystems	19	6	7	0	0	0
Exar	158	169	146	0.2	0.2	0.1
General Instrument	239	262	414	0.3	0.2	0.3
Gennum	30	31	36	0	0	0
Gould AMI	101	136	72	0.1	0.1	0
Harris	605	665	681	0.7	0.6	0.5
Hewlett-Packard	469	714	648	0.5	0.6	0.4

(Continued)

Table 1-1 (Continued)
Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Honeywell	53	55	64	0.1	0	0
Hughes	40	40	36	0	0	0
IBM	2,510	2,532	3,522	2.9	2.3	2.3
IMI	21	20	35	0	0	0
IMP	37	49	55	0	0	0
Integrated Circuit Systems	41	81	96	0	0.1	0.1
Integrated Device Technology	303	385	617	0.4	0.3	0.4
Integrated Information Technology	40	35	44	0	0	0
Integrated Silicon Solutions Inc.	0	60	158	0	0.1	0.1
Intel	7,970	10,099	13,172	9.3	9.1	8.7
International CMOS Technology	0	12	17	0	0	0
International Rectifier	288	361	487	0.3	0.3	0.3
ITT	262	241	319	0.3	0.2	0.2
Kulite	24	20	24	0	0	0
Lattice	127	134	186	0.1	0.1	0.1
Level One Communications	0	-	78	0	0	0.1
Linear Technology	173	225	305	0.2	0.2	0.2
Linfinity	37	44	51	0	0	0
Logic Devices	12	14	18	0	0	0
LSI Logic	719	901	1,268	0.8	0.8	0.8
Maxim	115	169	190	0.1	0.2	0.1
Micrel	18	25	25	0	0	0
Micro Linear	45	41	54	0.1	0	0
Micro Power Systems	23	23	-	0	0	0
Microchip Technology	140	212	271	0.2	0.2	0.2
Micron Technology	925	1,492	2,601	1.1	1.4	1.7
Microsemi	97	100	118	0.1	0.1	0.1
Mitel	69	100	88	0.1	0.1	0.1
Motorola	5,957	7,238	8,732	7.0	6.5	5.8
Natel Engineering	12	0	0	0	0	0
National Semiconductor	2,060	2,127	2,408	2.4	1.9	1.6
Novasensor	16	13	15	0	0	0
Oak Technology	50	62	84	0.1	0.1	0.1
Optek	56	56	63	0.1	0.1	0
OPTi	86	130	167	0.1	0.1	0.1
Performance Semiconductor	41	20	28	0	0	0
Powerex	58	76	98	0.1	0.1	0.1

(Continued)

Table 1-1 (Continued)
Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Q Logic	21	45	60	0	0	0
Quality Semiconductor	22	22	46	0	0	0
Quality Technologies	47	49	60	0.1	0	0
QuickLogic	0	8	16	0	0	0
Ramtron	0	15	24	0	0	0
Raytheon	103	108	123	0.1	0.1	0.1
Rockwell	176	514	744	0.2	0.5	0.5
S3	113	130	315	0.1	0.1	0.2
Seeq Technology	29	22	27	0	0	0
Semtech	19	25	48	0	0	0
Sierra Semiconductor	96	120	141	0.1	0.1	0.1
Silicon Systems	265	298	368	0.3	0.3	0.2
Sipex	20	16	16	0	0	0
Silicon Storage Technology	0	-	35	0	0	0
Solitron	11	7	8	0	0	0
Standard Microsystems	47	100	150	0.1	0.1	0.1
Supertex	25	30	36	0	0	0
Symbios	275	354	395	0.3	0.3	0.3
Symphony Laboratories	66	12	15	0.1	0	0
Teccor Electronics	45	60	69	0.1	0.1	0
Tektronix	54	0	0	0.1	0	0
Telcom	0	18	17	0	0	0
Teledyne	26	0	0	0	0	0
Texas Instruments	4,079	5,548	7,831	4.8	5.0	5.2
Trident Microsystems	60	87	139	0.1	0.1	0.1
Tseng Labs	71	83	105	0.1	0.1	0.1
Unitrode	78	88	102	0.1	0.1	0.1
Universal	14	13	15	0	0	0
VLSI Technology	517	588	673	0.6	0.5	0.4
VTC	70	70	155	0.1	0.1	0.1
WaferScale Integration	25	21	36	0	0	0
Weitek	33	28	37	0	0	0
Western Digital	218	184	239	0.3	0.2	0.2
Xicor	105	100	114	0.1	0.1	0.1
Xilinx	231	321	520	0.3	0.3	0.3
Zilog	203	222	265	0.2	0.2	0.2
Other North American Companies	125	139	214	0.1	0.1	0.1

(Continued)

Table 1-1 (Continued)
Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Japanese Companies	34,573	44,778	60,612	40.4	40.5	40.1
Fuji Electric	366	446	566	0.4	0.4	0.4
Fujitsu	2,928	3,869	5,538	3.4	3.5	3.7
Hitachi	5,015	6,644	9,137	5.9	6.0	6.0
Matsushita	2,344	2,896	3,476	2.7	2.6	2.3
Mitsubishi	2,823	3,772	5,272	3.3	3.4	3.5
NEC	6,141	7,961	11,314	7.2	7.2	7.5
New JRC	186	218	237	0.2	0.2	0.2
Nippon Steel Semiconductor	148	160	549	0.2	0.1	0.4
Oki	1,187	1,471	2,029	1.4	1.3	1.3
Ricoh	143	182	213	0.2	0.2	0.1
Rohm	930	1,345	1,933	1.1	1.2	1.3
Sanken	533	608	733	0.6	0.6	0.5
Sanyo	1,843	2,321	2,714	2.2	2.1	1.8
Seiko Epson	252	273	314	0.3	0.2	0.2
Shindengen Electric	211	242	328	0.2	0.2	0.2
Sharp	1,760	2,188	2,592	2.1	2.0	1.7
Sony	1,398	1,876	2,338	1.6	1.7	1.5
Toko	81	91	113	0.1	0.1	0.1
Toshiba	5,727	7,556	10,077	6.7	6.8	6.7
Yamaha	317	382	444	0.4	0.3	0.3
Other Japanese Companies	240	277	694	0.3	0.3	0.5
European Companies	7,645	9,834	12,903	8.9	8.9	8.5
ABB-Hafo	34	40	38	0	0	0
ABB-Ixys	38	55	64	0	0	0
Austria Mikro Systeme	85	110	148	0.1	0.1	0.1
Elex	0	20	33	0	0	0
Elmos	0	15	19	0	0	0
EM Microelectronics Marin	50	65	78	0.1	0.1	0.1
Ericsson	72	113	120	0.1	0.1	0.1
Eupec	82	98	120	0.1	0.1	0.1
European Silicon Structures	36	40	59	0	0	0
Fagor	19	27	38	0	0	0
GEC Plessey	290	314	368	0.3	0.3	0.2
Micronas	14	20	43	0	0	0
Mietec	148	178	179	0.2	0.2	0.1
Philips	2,300	2,920	3,901	2.7	2.6	2.6

(Continued)

Table 1-1 (Continued)
Each Company's Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Semikron	94	112	126	0.1	0.1	0.1
SGS-Thomson	2,038	2,640	3,397	2.4	2.4	2.2
Siemens	1,509	2,090	3,062	1.8	1.9	2.0
TEMIC	625	719	774	0.7	0.7	0.5
TCS	65	78	100	0.1	0.1	0.1
Thesys	0	15	20	0	0	0
Westcode	35	41	54	0	0	0
Zetex	32	40	56	0	0	0
Other European Companies	79	84	106	0.1	0.1	0.1
Asia/Pacific Companies	6,213	9,849	17,802	7.3	8.9	11.8
Acer	50	70	80	0.1	0.1	0.1
Daewoo	31	38	48	0	0	0
Dongsung Semiconductor	2	0	0	0	0	0
Holtek	53	70	87	0.1	0.1	0.1
Hualon Microelectronics Corp.	83	89	107	0.1	0.1	0.1
Hyundai	853	1,521	4,132	1.0	1.4	2.7
Korean Electronics Company	177	225	288	0.2	0.2	0.2
LG Semicon	946	1,697	2,863	1.1	1.5	1.9
Macronix	144	221	271	0.2	0.2	0.2
Mosel Vitelic	223	259	502	0.3	0.2	0.3
Samsung	3,044	4,832	8,329	3.6	4.4	5.5
Silicon Integrated Systems	71	101	127	0.1	0.1	0.1
United Microelectronics Corp.	309	418	477	0.4	0.4	0.3
Winbond Electronics	184	308	491	0.2	0.3	0.3
Other Asia/Pacific Companies	43	0	0	0.1	0	0

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	84,051	108,848	149,336	100.0	100.0	100.0
North American Companies	36,713	45,627	59,489	43.7	41.9	39.8
ACC Microelectronics	36	49	40	0	0	0
Actel	60	76	108	0.1	0.1	0.1
Adaptec	122	125	124	0.1	0.1	0.1
Advanced Micro Devices	1,660	2,134	2,330	2.0	2.0	1.6
Allegro MicroSystems	118	148	171	0.1	0.1	0.1
Alliance Semiconductor	41	90	220	0	0.1	0.1
Altera	140	199	402	0.2	0.2	0.3
Analog Devices	595	687	927	0.7	0.6	0.6
Applied Micro Circuits Corp.	48	48	48	0.1	0	0
AT&T	1,110	1,307	1,615	1.3	1.2	1.1
Atmel	225	375	590	0.3	0.3	0.4
Bipolar Integrated Technology	15	0	0	0	0	0
Brooktree	117	109	120	0.1	0.1	0.1
Burr-Brown	88	105	126	0.1	0.1	0.1
California Micro Devices	14	10	12	0	0	0
Catalyst	55	50	49	0.1	0	0
Cherry Semiconductor	55	77	87	0.1	0.1	0.1
Chips & Technologies	89	89	138	0.1	0.1	0.1
Cirrus Logic	451	781	1,002	0.5	0.7	0.7
Comlinear	8	9	-	0	0	0
Cypress Semiconductor	300	400	552	0.4	0.4	0.4
Cyrix	125	241	212	0.1	0.2	0.1
Dallas Semiconductor	112	154	228	0.1	0.1	0.2
Elantec	21	21	23	0	0	0
Electronic Designs	23	26	43	0	0	0
ETEQ Microsystems	19	6	7	0	0	0
Exar	158	169	146	0.2	0.2	0.1
General Instrument	239	262	414	0.3	0.2	0.3
Gennum	30	29	34	0	0	0
Gould AMI	101	136	72	0.1	0.1	0
Harris	605	665	681	0.7	0.6	0.5
Hewlett-Packard	469	714	648	0.6	0.7	0.4
Honeywell	53	55	64	0.1	0.1	0
Hughes	40	40	36	0	0	0
IBM	2,510	2,532	3,522	3.0	2.3	2.4

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
IMI	21	20	35	0	0	0
IMP	37	49	55	0	0	0
Integrated Circuit Systems	41	81	96	0	0.1	0.1
Integrated Device Technology	303	385	617	0.4	0.4	0.4
Integrated Information Technology	40	35	44	0	0	0
Integrated Silicon Solutions Inc.	0	60	158	0	0.1	0.1
Intel	7,970	10,099	13,172	9.5	9.3	8.8
International CMOS Technology	0	12	17	0	0	0
International Rectifier	288	361	487	0.3	0.3	0.3
ITT	262	241	319	0.3	0.2	0.2
Kulite	24	20	24	0	0	0
Lattice	127	134	186	0.2	0.1	0.1
Level One Communications	0	-	78	0	0	0.1
Linear Technology	173	225	305	0.2	0.2	0.2
Linfinity	34	41	48	0	0	0
Logic Devices	12	14	18	0	0	0
LSI Logic	719	901	1,268	0.9	0.8	0.8
Maxim	111	165	186	0.1	0.2	0.1
Micrel	18	25	25	0	0	0
Micro Linear	45	41	54	0.1	0	0
Micro Power Systems	23	23	-	0	0	0
Microchip Technology	140	212	271	0.2	0.2	0.2
Micron Technology	925	1,492	2,601	1.1	1.4	1.7
Microsemi	97	100	118	0.1	0.1	0.1
Mitel	55	70	68	0.1	0.1	0
Motorola	5,786	7,012	8,452	6.9	6.4	5.7
Natel Engineering	7	0	0	0	0	0
National Semiconductor	2,046	2,120	2,400	2.4	1.9	1.6
Novasensor	16	13	15	0	0	0
Oak Technology	50	62	84	0.1	0.1	0.1
Optek	56	56	63	0.1	0.1	0
OPTi	86	130	167	0.1	0.1	0.1
Performance Semiconductor	41	20	28	0	0	0
Powerex	58	76	98	0.1	0.1	0.1
Q Logic	21	45	60	0	0	0
Quality Semiconductor	22	22	46	0	0	0
Quality Technologies	47	49	60	0.1	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
QuickLogic	0	8	16	0	0	0
Ramtron	0	15	24	0	0	0
Raytheon	103	108	123	0.1	0.1	0.1
Rockwell	176	514	744	0.2	0.5	0.5
S3	113	130	315	0.1	0.1	0.2
Seeq Technology	29	22	27	0	0	0
Semtech	19	25	48	0	0	0
Sierra Semiconductor	96	120	141	0.1	0.1	0.1
Silicon Systems	265	298	368	0.3	0.3	0.2
Sipex	3	2	2	0	0	0
Silicon Storage Technology	0	-	35	0	0	0
Solitron	11	5	6	0	0	0
Standard Microsystems	47	100	150	0.1	0.1	0.1
Supertex	25	30	36	0	0	0
Symbios	275	354	395	0.3	0.3	0.3
Symphony Laboratories	66	12	15	0.1	0	0
Teccor Electronics	45	60	69	0.1	0.1	0
Tektronix	46	0	0	0.1	0	0
Telcom	0	18	17	0	0	0
Teledyne	26	0	0	0	0	0
Texas Instruments	4,079	5,548	7,831	4.9	5.1	5.2
Trident Microsystems	60	87	139	0.1	0.1	0.1
Tseng Labs	71	83	105	0.1	0.1	0.1
Unitrode	64	73	102	0.1	0.1	0.1
Universal	14	13	15	0	0	0
VLSI Technology	517	588	673	0.6	0.5	0.5
VTC	70	70	155	0.1	0.1	0.1
WaferScale Integration	25	21	36	0	0	0
Weitek	33	28	37	0	0	0
Western Digital	218	184	239	0.3	0.2	0.2
Xicor	105	100	114	0.1	0.1	0.1
Xilinx	231	321	520	0.3	0.3	0.3
Zilog	203	222	265	0.2	0.2	0.2
Other North American Companies	125	139	214	0.1	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Japanese Companies	33,585	43,642	59,242	40.0	40.1	39.7
Fuji Electric	345	424	543	0.4	0.4	0.4
Fujitsu	2,866	3,753	5,389	3.4	3.4	3.6
Hitachi	4,913	6,508	9,000	5.8	6.0	6.0
Matsushita	2,344	2,896	3,476	2.8	2.7	2.3
Mitsubishi	2,717	3,663	5,074	3.2	3.4	3.4
NEC	6,043	7,863	11,184	7.2	7.2	7.5
New JRC	186	218	237	0.2	0.2	0.2
Nippon Steel Semiconductor	148	160	549	0.2	0.1	0.4
Oki	1,175	1,458	2,017	1.4	1.3	1.4
Ricoh	143	182	213	0.2	0.2	0.1
Rohm	862	1,273	1,855	1.0	1.2	1.2
Sanken	331	368	450	0.4	0.3	0.3
Sanyo	1,677	2,147	2,520	2.0	2.0	1.7
Seiko Epson	252	273	314	0.3	0.3	0.2
Shindengen Electric	162	194	300	0.2	0.2	0.2
Sharp	1,760	2,188	2,592	2.1	2.0	1.7
Sony	1,362	1,835	2,297	1.6	1.7	1.5
Toko	73	83	105	0.1	0.1	0.1
Toshiba	5,669	7,497	10,003	6.7	6.9	6.7
Yamaha	317	382	444	0.4	0.4	0.3
Other Japanese Companies	240	277	680	0.3	0.3	0.5
European Companies	7,540	9,730	12,803	9.0	8.9	8.6
ABB-Hafo	34	32	33	0	0	0
ABB-Ixys	38	55	64	0	0.1	0
Austria Mikro Systeme	85	110	148	0.1	0.1	0.1
Elex	0	20	33	0	0	0
Elmos	0	15	19	0	0	0
EM Microelectronics Marin	50	65	78	0.1	0.1	0.1
Ericsson	60	94	105	0.1	0.1	0.1
Eupec	82	98	120	0.1	0.1	0.1
European Silicon Structures	36	40	59	0	0	0
Fagor	19	27	38	0	0	0
GEC Plessey	269	308	365	0.3	0.3	0.2
Micronas	14	20	33	0	0	0
Mietec	148	178	179	0.2	0.2	0.1
Philips	2,245	2,866	3,855	2.7	2.6	2.6

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Semikron	94	112	126	0.1	0.1	0.1
SGS-Thomson	2,038	2,640	3,397	2.4	2.4	2.3
Siemens	1,509	2,090	3,062	1.8	1.9	2.1
TEMIC	623	719	774	0.7	0.7	0.5
TCS	65	78	100	0.1	0.1	0.1
Thesys	0	15	20	0	0	0
Westcode	35	41	54	0	0	0
Zetex	32	40	56	0	0	0
Other European Companies	64	67	85	0.1	0.1	0.1
Asia/Pacific Companies	6,213	9,849	17,802	7.4	9.0	11.9
Acer	50	70	80	0.1	0.1	0.1
Daewoo	31	38	48	0	0	0
Dongsung Semiconductor	2	0	0	0	0	0
Holtek	53	70	87	0.1	0.1	0.1
Hualon Microelectronics Corp.	83	89	107	0.1	0.1	0.1
Hyundai	853	1,521	4,132	1.0	1.4	2.8
Korean Electronics Company	177	225	288	0.2	0.2	0.2
LG Semicon	946	1,697	2,863	1.1	1.6	1.9
Macronix	144	221	271	0.2	0.2	0.2
Mosel Vitelic	223	259	502	0.3	0.2	0.3
Samsung	3,044	4,832	8,329	3.6	4.4	5.6
Silicon Integrated Systems	71	101	127	0.1	0.1	0.1
United Microelectronics Corp.	309	418	477	0.4	0.4	0.3
Winbond Electronics	184	308	491	0.2	0.3	0.3
Other Asia/Pacific Companies	43	0	0	0.1	0	0

Source: Dataquest (April 1996)

Table 1-3
Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	73,429	95,861	132,437	100.0	100.0	100.0
North American Companies	34,384	42,814	56,045	46.8	44.7	42.3
ACC Microelectronics	36	49	40	0	0.1	0
Actel	60	76	108	0.1	0.1	0.1
Adaptec	122	125	124	0.2	0.1	0.1
Advanced Micro Devices	1,660	2,134	2,330	2.3	2.2	1.8
Allegro MicroSystems	108	139	158	0.1	0.1	0.1
Alliance Semiconductor	41	90	220	0.1	0.1	0.2
Altera	140	199	402	0.2	0.2	0.3
Analog Devices	635	739	986	0.9	0.8	0.7
Applied Micro Circuits Corp.	48	48	48	0.1	0.1	0
AT&T	1,065	1,250	1,534	1.5	1.3	1.2
Atmel	225	375	590	0.3	0.4	0.4
Bipolar Integrated Technology	15	0	0	0	0	0
Brooktree	117	109	120	0.2	0.1	0.1
Burr-Brown	158	165	186	0.2	0.2	0.1
California Micro Devices	14	10	12	0	0	0
Catalyst	55	50	49	0.1	0.1	0
Cherry Semiconductor	55	77	87	0.1	0.1	0.1
Chips & Technologies	89	89	138	0.1	0.1	0.1
Cirrus Logic	451	781	1,002	0.6	0.8	0.8
Comlinear	16	16	-	0	0	0
Cypress Semiconductor	300	400	552	0.4	0.4	0.4
Cyrix	125	241	212	0.2	0.3	0.2
Dallas Semiconductor	112	154	228	0.2	0.2	0.2
Elantec	23	24	26	0	0	0
Electronic Designs	23	26	43	0	0	0
ETEQ Microsystems	19	6	7	0	0	0
Exar	158	169	146	0.2	0.2	0.1
Gennum	30	31	36	0	0	0
Gould AMI	101	136	72	0.1	0.1	0.1
Harris	467	478	454	0.6	0.5	0.3
Hewlett-Packard	230	255	343	0.3	0.3	0.3
Honeywell	26	23	27	0	0	0
Hughes	40	40	36	0.1	0	0
IBM	2,510	2,532	3,522	3.4	2.6	2.7
IMI	21	20	35	0	0	0

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
IMP	37	49	55	0.1	0.1	0
Integrated Circuit Systems	41	81	96	0.1	0.1	0.1
Integrated Device Technology	303	385	617	0.4	0.4	0.5
Integrated Information Technology	40	35	44	0.1	0	0
Integrated Silicon Solutions Inc.	0	60	158	0	0.1	0.1
Intel	7,970	10,099	13,172	10.9	10.5	9.9
International CMOS Technology	0	12	17	0	0	0
International Rectifier	3	8	17	0	0	0
ITT	155	127	126	0.2	0.1	0.1
Kulite	24	20	24	0	0	0
Lattice	127	134	186	0.2	0.1	0.1
Level One Communications	0	-	78	0	0	0.1
Linear Technology	173	225	305	0.2	0.2	0.2
Linfinity	37	44	51	0.1	0	0
Logic Devices	12	14	18	0	0	0
LSI Logic	719	901	1,268	1.0	0.9	1.0
Maxim	115	169	190	0.2	0.2	0.1
Micrel	18	25	25	0	0	0
Micro Linear	45	41	54	0.1	0	0
Micro Power Systems	23	23	-	0	0	0
Microchip Technology	140	212	271	0.2	0.2	0.2
Micron Technology	925	1,492	2,601	1.3	1.6	2.0
Mitel	69	100	88	0.1	0.1	0.1
Motorola	4,922	6,096	7,323	6.7	6.4	5.5
Natel Engineering	12	0	0	0	0	0
National Semiconductor	1,983	2,028	2,243	2.7	2.1	1.7
Novasensor	16	13	15	0	0	0
Oak Technology	50	62	84	0.1	0.1	0.1
Optek	0	7	8	0	0	0
OPTi	86	130	167	0.1	0.1	0.1
Performance Semiconductor	41	20	28	0.1	0	0
Q Logic	21	45	60	0	0	0
Quality Semiconductor	22	22	46	0	0	0
QuickLogic	0	8	16	0	0	0
Ramtron	0	15	24	0	0	0
Raytheon	95	100	110	0.1	0.1	0.1
Rockwell	176	514	744	0.2	0.5	0.6

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
S3	113	130	315	0.2	0.1	0.2
Seeq Technology	29	22	27	0	0	0
Semtech	2	5	19	0	0	0
Sierra Semiconductor	96	120	141	0.1	0.1	0.1
Silicon Systems	265	298	368	0.4	0.3	0.3
Sipex	20	16	16	0	0	0
Silicon Storage Technology	0	-	35	0	0	0
Solitron	0	2	2	0	0	0
Standard Microsystems	47	100	150	0.1	0.1	0.1
Supertex	15	19	20	0	0	0
Symbios	275	354	395	0.4	0.4	0.3
Symphony Laboratories	66	12	15	0.1	0	0
Tektronix	49	0	0	0.1	0	0
Telcom	0	18	17	0	0	0
Teledyne	26	0	0	0	0	0
Texas Instruments	4,000	5,471	7,772	5.4	5.7	5.9
Trident Microsystems	60	87	139	0.1	0.1	0.1
Tseng Labs	71	83	105	0.1	0.1	0.1
Unitrode	78	88	102	0.1	0.1	0.1
Universal	14	13	15	0	0	0
VLSI Technology	517	588	673	0.7	0.6	0.5
VTC	70	70	155	0.1	0.1	0.1
WaferScale Integration	25	21	36	0	0	0
Weitek	33	28	37	0	0	0
Western Digital	218	184	239	0.3	0.2	0.2
Xicor	105	100	114	0.1	0.1	0.1
Xilinx	231	321	520	0.3	0.3	0.4
Zilog	203	222	265	0.3	0.2	0.2
Other North American Companies	61	70	150	0.1	0.1	0.1
Japanese Companies	27,550	36,288	49,737	37.5	37.9	37.6
Fuji Electric	73	89	99	0.1	0.1	0.1
Fujitsu	2,648	3,542	5,087	3.6	3.7	3.8
Hitachi	4,286	5,757	8,163	5.8	6.0	6.2
Matsushita	1,536	1,968	2,350	2.1	2.1	1.8
Mitsubishi	2,413	3,172	4,644	3.3	3.3	3.5
NEC	5,444	7,159	10,281	7.4	7.5	7.8

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
New JRC	170	205	223	0.2	0.2	0.2
Nippon Steel Semiconductor	148	160	549	0.2	0.2	0.4
Oki	1,150	1,437	1,989	1.6	1.5	1.5
Ricoh	143	182	213	0.2	0.2	0.2
Rohm	438	643	876	0.6	0.7	0.7
Sanken	202	240	283	0.3	0.3	0.2
Sanyo	1,370	1,782	2,058	1.9	1.9	1.6
Seiko Epson	252	273	314	0.3	0.3	0.2
Shindengen Electric	49	48	28	0.1	0.1	0
Sharp	1,342	1,678	1,956	1.8	1.8	1.5
Sony	1,073	1,513	1,901	1.5	1.6	1.4
Toko	36	40	45	0	0	0
Toshiba	4,384	5,931	8,028	6.0	6.2	6.1
Yamaha	317	382	444	0.4	0.4	0.3
Other Japanese Companies	76	87	206	0.1	0.1	0.2
European Companies	5,614	7,278	9,417	7.6	7.6	7.1
ABB-Hafo	20	28	24	0	0	0
Austria Mikro Systeme	85	110	148	0.1	0.1	0.1
Elex	0	20	31	0	0	0
Elmos	0	15	19	0	0	0
EM Microelectronics Marin	50	65	78	0.1	0.1	0.1
Ericsson	72	83	84	0.1	0.1	0.1
European Silicon Structures	36	40	59	0	0	0
GEC Plessey	269	286	333	0.4	0.3	0.3
Micronas	14	20	43	0	0	0
Mietec	148	178	179	0.2	0.2	0.1
Philips	1,696	2,159	2,843	2.3	2.3	2.1
SGS-Thomson	1,654	2,207	2,806	2.3	2.3	2.1
Siemens	1,110	1,586	2,313	1.5	1.7	1.7
TEMIC	396	391	343	0.5	0.4	0.3
TCS	43	51	65	0.1	0.1	0
Thesys	0	15	20	0	0	0
Zetex	2	3	4	0	0	0
Other European Companies	19	21	25	0	0	0

(Continued)

Table 1-3 (Continued)
Each Company's Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Asia/Pacific Companies	5,881	9,481	17,238	8.0	9.9	13.0
Acer	50	70	80	0.1	0.1	0.1
Daewoo	31	38	48	0	0	0
Holtek	53	70	87	0.1	0.1	0.1
Hualon Microelectronics Corp.	83	89	107	0.1	0.1	0.1
Hyundai	853	1,521	4,132	1.2	1.6	3.1
Korean Electronics Company	37	47	45	0.1	0	0
LG Semicon	946	1,697	2,863	1.3	1.8	2.2
Macronix	144	221	271	0.2	0.2	0.2
Mosel Vitelic	223	259	502	0.3	0.3	0.4
Samsung	2,897	4,642	8,008	3.9	4.8	6.0
Silicon Integrated Systems	71	101	127	0.1	0.1	0.1
United Microelectronics Corp.	309	418	477	0.4	0.4	0.4
Winbond Electronics	184	308	491	0.3	0.3	0.4

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	71,966	94,196	130,502	100.0	100.0	100.0
North American Companies	34,014	42,389	55,578	47.3	45.0	42.6
ACC Microelectronics	36	49	40	0.1	0.1	0
Actel	60	76	108	0.1	0.1	0.1
Adaptec	122	125	124	0.2	0.1	0.1
Advanced Micro Devices	1,660	2,134	2,330	2.3	2.3	1.8
Allegro MicroSystems	108	139	146	0.2	0.1	0.1
Alliance Semiconductor	41	90	220	0.1	0.1	0.2
Altera	140	199	402	0.2	0.2	0.3
Analog Devices	595	687	927	0.8	0.7	0.7
Applied Micro Circuits Corp.	48	48	48	0.1	0.1	0
AT&T	1,065	1,250	1,534	1.5	1.3	1.2
Atmel	225	375	590	0.3	0.4	0.5
Bipolar Integrated Technology	15	0	0	0	0	0
Brooktree	117	109	120	0.2	0.1	0.1
Burr-Brown	88	105	126	0.1	0.1	0.1
California Micro Devices	14	10	12	0	0	0
Catalyst	55	50	49	0.1	0.1	0
Cherry Semiconductor	55	77	87	0.1	0.1	0.1
Chips & Technologies	89	89	138	0.1	0.1	0.1
Cirrus Logic	451	781	1,002	0.6	0.8	0.8
Comlinear	8	9	-	0	0	0
Cypress Semiconductor	300	400	552	0.4	0.4	0.4
Cyrix	125	241	212	0.2	0.3	0.2
Dallas Semiconductor	112	154	228	0.2	0.2	0.2
Elantec	21	21	23	0	0	0
Electronic Designs	23	26	43	0	0	0
ETEQ Microsystems	19	6	7	0	0	0
Exar	158	169	146	0.2	0.2	0.1
Gennum	30	29	34	0	0	0
Gould AMI	101	136	72	0.1	0.1	0.1
Harris	467	478	454	0.6	0.5	0.3
Hewlett-Packard	230	255	343	0.3	0.3	0.3
Honeywell	26	23	27	0	0	0
Hughes	40	40	36	0.1	0	0
IBM	2,510	2,532	3,522	3.5	2.7	2.7
IMI	21	20	35	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
IMP	37	49	55	0.1	0.1	0
Integrated Circuit Systems	41	81	96	0.1	0.1	0.1
Integrated Device Technology	303	385	617	0.4	0.4	0.5
Integrated Information Technology	40	35	44	0.1	0	0
Integrated Silicon Solutions Inc.	0	60	158	0	0.1	0.1
Intel	7,970	10,099	13,172	11.1	10.7	10.1
International CMOS Technology	0	12	17	0	0	0
International Rectifier	3	8	17	0	0	0
ITT	155	127	126	0.2	0.1	0.1
Kulite	24	20	24	0	0	0
Lattice	127	134	186	0.2	0.1	0.1
Level One Communications	0	-	78	0	0	0.1
Linear Technology	173	225	305	0.2	0.2	0.2
Linfinity	34	41	48	0	0	0
Logic Devices	12	14	18	0	0	0
LSI Logic	719	901	1,268	1.0	1.0	1.0
Maxim	111	165	186	0.2	0.2	0.1
Micrel	18	25	25	0	0	0
Micro Linear	45	41	54	0.1	0	0
Micro Power Systems	23	23	-	0	0	0
Microchip Technology	140	212	271	0.2	0.2	0.2
Micron Technology	925	1,492	2,601	1.3	1.6	2.0
Mitel	55	70	68	0.1	0.1	0.1
Motorola	4,751	5,870	7,043	6.6	6.2	5.4
Natel Engineering	7	0	0	0	0	0
National Semiconductor	1,969	2,021	2,235	2.7	2.1	1.7
Novasensor	16	13	15	0	0	0
Oak Technology	50	62	84	0.1	0.1	0.1
Optek	0	7	8	0	0	0
OPTi	86	130	167	0.1	0.1	0.1
Performance Semiconductor	41	20	28	0.1	0	0
Q Logic	21	45	60	0	0	0
Quality Semiconductor	22	22	46	0	0	0
QuickLogic	0	8	16	0	0	0
Ramtron	0	15	24	0	0	0
Raytheon	95	100	110	0.1	0.1	0.1
Rockwell	176	514	744	0.2	0.5	0.6

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
S3	113	130	315	0.2	0.1	0.2
Seeq Technology	29	22	27	0	0	0
Semtech	2	5	19	0	0	0
Sierra Semiconductor	96	120	141	0.1	0.1	0.1
Silicon Systems	265	298	368	0.4	0.3	0.3
Sipex	3	2	2	0	0	0
Silicon Storage Technology	0	-	35	0	0	0
Standard Microsystems	47	100	150	0.1	0.1	0.1
Supertex	15	19	20	0	0	0
Symbios	275	354	395	0.4	0.4	0.3
Symphony Laboratories	66	12	15	0.1	0	0
Tektronix	41	0	0	0.1	0	0
Telcom	0	18	17	0	0	0
Teledyne	26	0	0	0	0	0
Texas Instruments	4,000	5,471	7,772	5.6	5.8	6.0
Trident Microsystems	60	87	139	0.1	0.1	0.1
Tseng Labs	71	83	105	0.1	0.1	0.1
Unitrode	64	73	102	0.1	0.1	0.1
Universal	14	13	15	0	0	0
VLSI Technology	517	588	673	0.7	0.6	0.5
VTC	70	70	155	0.1	0.1	0.1
WaferScale Integration	25	21	36	0	0	0
Weitek	33	28	37	0	0	0
Western Digital	218	184	239	0.3	0.2	0.2
Xicor	105	100	114	0.1	0.1	0.1
Xilinx	231	321	520	0.3	0.3	0.4
Zilog	203	222	265	0.3	0.2	0.2
Other North American Companies	61	70	150	0.1	0.1	0.1
Japanese Companies	26,562	35,152	48,368	36.9	37.3	37.1
Fuji Electric	52	67	76	0.1	0.1	0.1
Fujitsu	2,586	3,426	4,938	3.6	3.6	3.8
Hitachi	4,184	5,621	8,026	5.8	6.0	6.1
Matsushita	1,536	1,968	2,350	2.1	2.1	1.8
Mitsubishi	2,307	3,063	4,446	3.2	3.3	3.4
NEC	5,346	7,061	10,151	7.4	7.5	7.8
New JRC	170	205	223	0.2	0.2	0.2
Nippon Steel Semiconductor	148	160	549	0.2	0.2	0.4

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Oki	1,138	1,424	1,977	1.6	1.5	1.5
Ricoh	143	182	213	0.2	0.2	0.2
Rohm	370	571	798	0.5	0.6	0.6
Sanyo	1,204	1,608	1,864	1.7	1.7	1.4
Seiko Epson	252	273	314	0.4	0.3	0.2
Sharp	1,342	1,678	1,956	1.9	1.8	1.5
Sony	1,037	1,472	1,861	1.4	1.6	1.4
Toko	28	32	36	0	0	0
Toshiba	4,326	5,872	7,954	6.0	6.2	6.1
Yamaha	317	382	444	0.4	0.4	0.3
Other Japanese Companies	76	87	192	0.1	0.1	0.1
European Companies	5,509	7,174	9,317	7.7	7.6	7.1
ABB-Hafo	20	20	19	0	0	0
Austria Mikro Systeme	85	110	148	0.1	0.1	0.1
Elex	0	20	31	0	0	0
Elmos	0	15	19	0	0	0
EM Microelectronics Marin	50	65	78	0.1	0.1	0.1
Ericsson	60	64	69	0.1	0.1	0.1
European Silicon Structures	36	40	59	0.1	0	0
GEC Plessey	248	280	330	0.3	0.3	0.3
Micronas	14	20	33	0	0	0
Mietec	148	178	179	0.2	0.2	0.1
Philips	1,641	2,105	2,797	2.3	2.2	2.1
SGS-Thomson	1,654	2,207	2,806	2.3	2.3	2.2
Siemens	1,110	1,586	2,313	1.5	1.7	1.8
TEMIC	394	391	343	0.5	0.4	0.3
TCS	43	51	65	0.1	0.1	0.1
Thesys	0	15	20	0	0	0
Zetex	2	3	4	0	0	0
Other European Companies	4	4	4	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Asia/Pacific Companies	5,881	9,481	17,238	8.2	10.1	13.2
Acer	50	70	80	0.1	0.1	0.1
Daewoo	31	38	48	0	0	0
Holtek	53	70	87	0.1	0.1	0.1
Hualon Microelectronics Corp.	83	89	107	0.1	0.1	0.1
Hyundai	853	1,521	4,132	1.2	1.6	3.2
Korean Electronics Company	37	47	45	0.1	0	0
LG Semicon	946	1,697	2,863	1.3	1.8	2.2
Macronix	144	221	271	0.2	0.2	0.2
Mosel Vitelic	223	259	502	0.3	0.3	0.4
Samsung	2,897	4,642	8,008	4.0	4.9	6.1
Silicon Integrated Systems	71	101	127	0.1	0.1	0.1
United Microelectronics Corp.	309	418	477	0.4	0.4	0.4
Winbond Electronics	184	308	491	0.3	0.3	0.4

Source: Dataquest (April 1996)

Table 1-5
Each Company's Factory Revenue from Shipments of Bipolar Digital Memory/Logic to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	3,079	2,912	2,496	100.0	100.0	100.0
North American Companies	1,650	1,473	1,337	53.6	50.6	53.6
Advanced Micro Devices	199	143	99	6.5	4.9	4.0
Applied Micro Circuits Corp.	26	20	18	0.8	0.7	0.7
AT&T	60	63	50	1.9	2.2	2.0
Atmel	1	-	-	0	0	0
Bipolar Integrated Technology	15	0	0	0.5	0	0
Chips & Technologies	3	-	-	0.1	0	0
Harris	13	6	4	0.4	0.2	0.2
Intel	1	-	-	0	0	0
Motorola	432	421	425	14.0	14.5	17.0
National Semiconductor	279	221	210	9.1	7.6	8.4
Raytheon	27	22	19	0.9	0.8	0.7
Texas Instruments	594	577	512	19.3	19.8	20.5
Japanese Companies	1,158	1,207	970	37.6	41.4	38.9
Fujitsu	371	395	204	12.0	13.6	8.2
Hitachi	391	465	442	12.7	16.0	17.7
Matsushita	26	29	28	0.8	1.0	1.1
Mitsubishi	63	23	36	2.0	0.8	1.4
NEC	201	194	109	6.5	6.7	4.4
Oki	31	33	35	1.0	1.1	1.4
Toshiba	75	68	116	2.4	2.3	4.6
European Companies	227	186	174	7.4	6.4	7.0
GEC Plessey	23	16	10	0.7	0.5	0.4
Philips	152	121	123	4.9	4.2	4.9
SGS-Thomson	7	12	6	0.2	0.4	0.3
Siemens	41	33	31	1.3	1.1	1.2
Other European Companies	4	4	4	0.1	0.1	0.2
Asia/Pacific Companies	44	46	14	1.4	1.6	0.6
LG Semicon	44	46	14	1.4	1.6	0.6

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	244	199	160	100.0	100.0	100.0
North American Companies	59	44	36	24.2	22.1	22.3
Advanced Micro Devices	39	28	27	16.0	14.1	16.8
Harris	4	-	-	1.6	0	0
Motorola	2	1	1	0.8	0.5	0.6
National Semiconductor	5	5	2	2.0	2.5	1.3
Raytheon	6	5	4	2.5	2.5	2.3
Texas Instruments	3	5	2	1.2	2.5	1.2
Japanese Companies	182	141	111	74.6	70.9	69.0
Fujitsu	81	32	21	33.2	16.1	12.9
Hitachi	85	93	81	34.8	46.7	50.4
NEC	16	16	9	6.6	8.0	5.7
European Companies	3	14	14	1.2	7.0	8.7
Philips	3	14	14	1.2	7.0	8.7

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	2,835	2,713	2,335	100.0	100.0	100.0
North American Companies	1,591	1,429	1,301	56.1	52.7	55.7
Advanced Micro Devices	160	115	72	5.6	4.2	3.1
Applied Micro Circuits Corp.	26	20	18	0.9	0.7	0.8
AT&T	60	63	50	2.1	2.3	2.1
Atmel	1	-	-	0	0	0
Bipolar Integrated Technology	15	0	0	0.5	0	0
Chips & Technologies	3	-	-	0.1	0	0
Harris	9	6	4	0.3	0.2	0.2
Intel	1	-	-	0	0	0
Motorola	430	420	424	15.2	15.5	18.2
National Semiconductor	274	216	208	9.7	8.0	8.9
Raytheon	21	17	15	0.7	0.6	0.6
Texas Instruments	591	572	510	20.8	21.1	21.9
Japanese Companies	976	1,066	860	34.4	39.3	36.8
Fujitsu	290	363	183	10.2	13.4	7.8
Hitachi	306	372	361	10.8	13.7	15.5
Matsushita	26	29	28	0.9	1.1	1.2
Mitsubishi	63	23	36	2.2	0.8	1.5
NEC	185	178	100	6.5	6.6	4.3
Oki	31	33	35	1.1	1.2	1.5
Toshiba	75	68	116	2.6	2.5	5.0
European Companies	224	172	160	7.9	6.3	6.9
GEC Plessey	23	16	10	0.8	0.6	0.4
Philips	149	107	109	5.3	3.9	4.7
SGS-Thomson	7	12	6	0.2	0.4	0.3
Siemens	41	33	31	1.4	1.2	1.3
Other European Companies	4	4	4	0.1	0.1	0.2
Asia/Pacific Companies	44	46	14	1.6	1.7	0.6
LG Semicon	44	46	14	1.6	1.7	0.6

Source: Dataquest (April 1996)

Table 1-8
Each Company's Factory Revenue from Shipments of MOS Digital Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	56,374	76,021	110,399	100.0	100.0	100.0
North American Companies	26,784	34,456	46,954	47.5	45.3	42.5
ACC Microelectronics	36	49	40	0.1	0.1	0
Actel	60	76	108	0.1	0.1	0.1
Adaptec	122	125	124	0.2	0.2	0.1
Advanced Micro Devices	1,307	1,804	2,059	2.3	2.4	1.9
Allegro MicroSystems	4	5	-	0	0	0
Alliance Semiconductor	41	90	220	0.1	0.1	0.2
Altera	140	199	402	0.2	0.3	0.4
Analog Devices	69	85	117	0.1	0.1	0.1
Applied Micro Circuits Corp.	22	21	26	0	0	0
AT&T	671	785	1,200	1.2	1.0	1.1
Atmel	223	363	574	0.4	0.5	0.5
California Micro Devices	6	5	6	0	0	0
Catalyst	54	49	49	0.1	0.1	0
Chips & Technologies	86	89	138	0.2	0.1	0.1
Cirrus Logic	371	681	886	0.7	0.9	0.8
Cypress Semiconductor	300	400	552	0.5	0.5	0.5
Cyrix	125	241	212	0.2	0.3	0.2
Dallas Semiconductor	104	154	228	0.2	0.2	0.2
Electronic Designs	23	26	43	0	0	0
ETEQ Microsystems	19	6	7	0	0	0
Exar	0	0	15	0	0	0
Gould AMI	63	105	72	0.1	0.1	0.1
Harris	204	188	191	0.4	0.2	0.2
Hewlett-Packard	230	255	343	0.4	0.3	0.3
Hughes	24	21	20	0	0	0
IBM	2,510	2,532	3,522	4.5	3.3	3.2
IMI	18	18	30	0	0	0
IMP	8	9	12	0	0	0
Integrated Circuit Systems	29	42	51	0.1	0.1	0
Integrated Device Technology	303	385	617	0.5	0.5	0.6
Integrated Information Technology	40	35	44	0.1	0	0
Integrated Silicon Solutions Inc.	0	60	158	0	0.1	0.1
Intel	7,957	10,079	13,162	14.1	13.3	11.9
International CMOS Technology	0	12	17	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
ITT	132	103	112	0.2	0.1	0.1
Lattice	127	134	186	0.2	0.2	0.2
Logic Devices	12	14	18	0	0	0
LSI Logic	719	901	1,268	1.3	1.2	1.1
Micrel	5	7	7	0	0	0
Micro Linear	0	6	-	0	0	0
Microchip Technology	140	212	271	0.2	0.3	0.2
Micron Technology	925	1,492	2,601	1.6	2.0	2.4
Motorola	3,612	4,525	5,595	6.4	6.0	5.1
National Semiconductor	902	893	992	1.6	1.2	0.9
Oak Technology	50	62	84	0.1	0.1	0.1
OPTi	86	130	167	0.2	0.2	0.2
Performance Semiconductor	41	20	28	0.1	0	0
Q Logic	21	45	60	0	0.1	0.1
Quality Semiconductor	22	22	46	0	0	0
QuickLogic	0	8	16	0	0	0
Ramtron	0	15	24	0	0	0
Rockwell	21	514	744	0	0.7	0.7
S3	113	130	315	0.2	0.2	0.3
Seeq Technology	20	22	27	0	0	0
Sierra Semiconductor	6	35	44	0	0	0
Silicon Storage Technology	0	-	35	0	0	0
Standard Microsystems	47	100	150	0.1	0.1	0.1
Supertex	5	6	7	0	0	0
Symbios	230	298	293	0.4	0.4	0.3
Symphony Laboratories	66	12	15	0.1	0	0
Texas Instruments	2,789	4,052	6,326	4.9	5.3	5.7
Trident Microsystems	60	87	139	0.1	0.1	0.1
Tseng Labs	71	83	105	0.1	0.1	0.1
Universal	9	7	8	0	0	0
VLSI Technology	515	588	673	0.9	0.8	0.6
WaferScale Integration	25	21	36	0	0	0
Weitek	33	28	37	0.1	0	0
Western Digital	218	184	239	0.4	0.2	0.2
Xicor	105	100	114	0.2	0.1	0.1
Xilinx	231	321	520	0.4	0.4	0.5
Zilog	203	222	265	0.4	0.3	0.2
Other North American Companies	54	63	142	0.1	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Japanese Companies	21,501	29,034	41,692	38.1	38.2	37.8
Fuji Electric	36	40	46	0.1	0.1	0
Fujitsu	2,093	2,876	4,418	3.7	3.8	4.0
Hitachi	3,513	4,799	7,229	6.2	6.3	6.5
Matsushita	1,037	1,328	1,681	1.8	1.7	1.5
Mitsubishi	1,867	2,584	3,956	3.3	3.4	3.6
NEC	4,768	6,361	9,402	8.5	8.4	8.5
New JRC	12	32	40	0	0	0
Nippon Steel Semiconductor	148	160	549	0.3	0.2	0.5
Oki	1,085	1,365	1,914	1.9	1.8	1.7
Ricoh	135	168	175	0.2	0.2	0.2
Rohm	112	210	376	0.2	0.3	0.3
Sanyo	571	797	971	1.0	1.0	0.9
Seiko Epson	241	260	298	0.4	0.3	0.3
Sharp	1,255	1,582	1,851	2.2	2.1	1.7
Sony	612	1,007	1,306	1.1	1.3	1.2
Toshiba	3,636	5,015	6,921	6.4	6.6	6.3
Yamaha	304	363	416	0.5	0.5	0.4
Other Japanese Companies	76	87	142	0.1	0.1	0.1
European Companies	2,595	3,499	4,930	4.6	4.6	4.5
Austria Mikro Systeme	36	46	68	0.1	0.1	0.1
Elex	0	20	23	0	0	0
Elmos	0	15	19	0	0	0
EM Microelectronics Marin	0	0	2	0	0	0
Ericsson	15	15	19	0	0	0
European Silicon Structures	36	40	48	0.1	0.1	0
GEC Plessey	111	129	164	0.2	0.2	0.1
Mietec	25	32	35	0	0	0
Philips	737	1,027	1,418	1.3	1.4	1.3
SGS-Thomson	789	998	1,318	1.4	1.3	1.2
Siemens	687	1,007	1,590	1.2	1.3	1.4
TEMIC	132	124	165	0.2	0.2	0.1
TCS	27	31	41	0	0	0
Thesys	0	15	20	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Asia/Pacific Companies	5,494	9,032	16,822	9.7	11.9	15.2
Acer	50	70	80	0.1	0.1	0.1
Daewoo	11	21	27	0	0	0
Holtek	38	70	87	0.1	0.1	0.1
Hualon Microelectronics Corp.	76	80	98	0.1	0.1	0.1
Hyundai	853	1,521	4,130	1.5	2.0	3.7
LG Semicon	862	1,606	2,807	1.5	2.1	2.5
Macronix	144	221	271	0.3	0.3	0.2
Mosel Vitelic	223	259	502	0.4	0.3	0.5
Samsung	2,731	4,409	7,775	4.8	5.8	7.0
Silicon Integrated Systems	71	101	127	0.1	0.1	0.1
United Microelectronics Corp.	309	418	477	0.5	0.5	0.4
Winbond Electronics	126	256	442	0.2	0.3	0.4

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	23,306	33,505	55,262	100.0	100.0	100.0
North American Companies	6,253	8,430	13,615	26.8	25.2	24.6
Advanced Micro Devices	427	442	717	1.8	1.3	1.3
Alliance Semiconductor	41	90	210	0.2	0.3	0.4
AT&T	10	3	3	0	0	0
Atmel	181	331	477	0.8	1.0	0.9
Catalyst	54	49	49	0.2	0.1	0.1
Cypress Semiconductor	235	285	424	1.0	0.9	0.8
Dallas Semiconductor	38	30	56	0.2	0.1	0.1
Electronic Designs	23	26	43	0.1	0.1	0.1
Gould AMI	23	44	-	0.1	0.1	0
Harris	19	12	18	0.1	0	0
IBM	1,133	1,520	2,100	4.9	4.5	3.8
IMP	2	1	-	0	0	0
Integrated Device Technology	189	252	444	0.8	0.8	0.8
Integrated Silicon Solutions Inc.	0	60	158	0	0.2	0.3
Intel	468	458	766	2.0	1.4	1.4
ITT	11	10	-	0	0	0
Logic Devices	4	2	5	0	0	0
Microchip Technology	64	82	102	0.3	0.2	0.2
Micron Technology	925	1,492	2,601	4.0	4.5	4.7
Motorola	762	948	1,213	3.3	2.8	2.2
National Semiconductor	172	179	188	0.7	0.5	0.3
Performance Semiconductor	8	5	7	0	0	0
Quality Semiconductor	12	7	14	0.1	0	0
Ramtron	0	15	24	0	0	0
Seeq Technology	16	5	6	0.1	0	0
Silicon Storage Technology	0	-	35	0	0	0.1
Symbios	2	-	-	0	0	0
Texas Instruments	1,275	1,931	3,756	5.5	5.8	6.8
WaferScale Integration	20	15	17	0.1	0	0
Xicor	105	100	114	0.5	0.3	0.2
Other North American Companies	34	36	69	0.1	0.1	0.1

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Japanese Companies	11,180	15,519	24,063	48.0	46.3	43.5
Fujitsu	1,135	1,692	2,589	4.9	5.0	4.7
Hitachi	2,369	3,232	5,132	10.2	9.6	9.3
Matsushita	305	396	492	1.3	1.2	0.9
Mitsubishi	1,206	1,652	2,547	5.2	4.9	4.6
NEC	2,173	3,096	5,352	9.3	9.2	9.7
Nippon Steel Semiconductor	148	160	549	0.6	0.5	1.0
Oki	486	697	1,228	2.1	2.1	2.2
Ricoh	21	19	6	0.1	0.1	0
Rohm	39	56	61	0.2	0.2	0.1
Sanyo	155	183	257	0.7	0.5	0.5
Seiko Epson	38	42	41	0.2	0.1	0.1
Sharp	697	867	1,030	3.0	2.6	1.9
Sony	287	387	490	1.2	1.2	0.9
Toshiba	2,101	3,018	4,264	9.0	9.0	7.7
Yamaha	1	1	1	0	0	0
Other Japanese Companies	19	21	23	0.1	0.1	0
European Companies	1,089	1,484	2,023	4.7	4.4	3.7
GEC Plessey	3	0	-	0	0	0
Philips	32	14	-	0.1	0	0
SGS-Thomson	467	589	646	2.0	1.8	1.2
Siemens	556	858	1,353	2.4	2.6	2.4
TEMIC	31	23	24	0.1	0.1	0
Asia/Pacific Companies	4,784	8,072	15,561	20.5	24.1	28.2
Daewoo	1	-	-	0	0	0
Hualon Microelectronics Corp.	36	46	54	0.2	0.1	0.1
Hyundai	851	1,515	4,116	3.7	4.5	7.4
LG Semicon	804	1,525	2,635	3.4	4.6	4.8
Macronix	129	200	236	0.6	0.6	0.4
Mosel Vitelic	223	259	502	1.0	0.8	0.9
Samsung	2,512	4,194	7,498	10.8	12.5	13.6
Silicon Integrated Systems	5	0	-	0	0	0
United Microelectronics Corp.	146	191	203	0.6	0.6	0.4
Winbond Electronics	77	142	317	0.3	0.4	0.6

Source: Dataquest (April 1996)

Table 1-10
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	19,947	26,408	34,513	100.0	100.0	100.0
North American Companies	14,395	18,843	24,205	72.2	71.4	70.1
ACC Microelectronics	36	49	40	0.2	0.2	0.1
Adaptec	122	125	124	0.6	0.5	0.4
Advanced Micro Devices	563	1,021	922	2.8	3.9	2.7
Alliance Semiconductor	0	-	10	0	0	0
Analog Devices	69	85	117	0.3	0.3	0.3
AT&T	246	305	510	1.2	1.2	1.5
Atmel	5	5	28	0	0	0.1
California Micro Devices	6	5	6	0	0	0
Chips & Technologies	86	89	138	0.4	0.3	0.4
Cirrus Logic	371	681	886	1.9	2.6	2.6
Cypress Semiconductor	8	40	48	0	0.2	0.1
Cyrix	125	241	212	0.6	0.9	0.6
Dallas Semiconductor	56	22	35	0.3	0.1	0.1
ETEQ Microsystems	19	0	-	0.1	0	0
Harris	47	52	66	0.2	0.2	0.2
Hughes	3	3	3	0	0	0
IBM	337	399	703	1.7	1.5	2.0
IMP	6	8	1	0	0	0
Integrated Device Technology	48	51	63	0.2	0.2	0.2
Integrated Information Technology	40	35	44	0.2	0.1	0.1
Intel	7,444	9,595	12,396	37.3	36.3	35.9
ITT	25	12	15	0.1	0	0
LSI Logic	77	78	107	0.4	0.3	0.3
Micro Linear	0	6	-	0	0	0
Microchip Technology	72	130	169	0.4	0.5	0.5
Motorola	2,065	2,363	2,996	10.4	8.9	8.7
National Semiconductor	477	452	541	2.4	1.7	1.6
Oak Technology	50	62	84	0.3	0.2	0.2
OPTi	86	130	167	0.4	0.5	0.5
Performance Semiconductor	18	15	21	0.1	0.1	0.1
Q Logic	21	45	60	0.1	0.2	0.2
Rockwell	17	509	738	0.1	1.9	2.1
S3	113	130	315	0.6	0.5	0.9
Seeq Technology	4	17	21	0	0.1	0.1

(Continued)

Table 1-10 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Sierra Semiconductor	0	35	44	0	0.1	0.1
Standard Microsystems	43	100	150	0.2	0.4	0.4
Supertex	2	1	1	0	0	0
Symbios	63	81	85	0.3	0.3	0.2
Symphony Laboratories	66	12	15	0.3	0	0
Texas Instruments	781	1,006	1,254	3.9	3.8	3.6
Trident Microsystems	60	87	139	0.3	0.3	0.4
Tseng Labs	71	83	105	0.4	0.3	0.3
VLSI Technology	173	216	194	0.9	0.8	0.6
WaferScale Integration	5	3	18	0	0	0.1
Weitek	33	28	37	0.2	0.1	0.1
Western Digital	218	184	239	1.1	0.7	0.7
Zilog	203	222	265	1.0	0.8	0.8
Other North American Companies	15	25	69	0.1	0.1	0.2
Japanese Companies	4,585	6,137	8,102	23.0	23.2	23.5
Fuji Electric	1	2	3	0	0	0
Fujitsu	282	390	651	1.4	1.5	1.9
Hitachi	718	998	1,441	3.6	3.8	4.2
Matsushita	286	460	557	1.4	1.7	1.6
Mitsubishi	532	698	982	2.7	2.6	2.8
NEC	1,341	1,678	2,063	6.7	6.4	6.0
New JRC	0	2	4	0	0	0
Oki	180	217	235	0.9	0.8	0.7
Ricoh	89	83	75	0.4	0.3	0.2
Rohm	23	50	71	0.1	0.2	0.2
Sanyo	145	161	186	0.7	0.6	0.5
Seiko Epson	17	21	28	0.1	0.1	0.1
Sharp	170	192	221	0.9	0.7	0.6
Sony	112	194	235	0.6	0.7	0.7
Toshiba	540	718	1,095	2.7	2.7	3.2
Yamaha	149	273	245	0.7	1.0	0.7
Other Japanese Companies	0	0	10	0	0	0
European Companies	640	851	1,432	3.2	3.2	4.1
Elex	0	15	23	0	0.1	0.1
EM Microelectronics Marin	0	0	2	0	0	0
GEC Plessey	7	11	10	0	0	0
Philips	305	403	662	1.5	1.5	1.9

(Continued)

Table 1-10 (Continued)
Each Company's Factory Revenue from Shipments of MOS Microcomponents to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
SGS-Thomson	162	227	437	0.8	0.9	1.3
Siemens	107	128	208	0.5	0.5	0.6
TEMIC	44	51	68	0.2	0.2	0.2
TCS	15	16	22	0.1	0.1	0.1
Asia/Pacific Companies	327	577	774	1.6	2.2	2.2
Acer	50	68	77	0.3	0.3	0.2
Daewoo	7	17	23	0	0.1	0.1
Holtek	18	20	34	0.1	0.1	0.1
Hualon Microelectronics Corp.	10	0	-	0.1	0	0
Hyundai	0	2	1	0	0	0
LG Semicon	12	29	56	0.1	0.1	0.2
Macronix	15	21	35	0.1	0.1	0.1
Samsung	46	44	87	0.2	0.2	0.3
Silicon Integrated Systems	26	101	127	0.1	0.4	0.4
United Microelectronics Corp.	113	227	274	0.6	0.9	0.8
Winbond Electronics	30	48	60	0.2	0.2	0.2

Source: Dataquest (April 1996)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	13,121	16,108	20,623	100.0	100.0	100.0
North American Companies	6,136	7,183	9,134	46.8	44.6	44.3
Actel	60	76	108	0.5	0.5	0.5
Advanced Micro Devices	317	341	420	2.4	2.1	2.0
Allegro MicroSystems	4	5	-	0	0	0
Altera	140	199	402	1.1	1.2	1.9
Applied Micro Circuits Corp.	22	21	26	0.2	0.1	0.1
AT&T	415	477	687	3.2	3.0	3.3
Atmel	37	27	69	0.3	0.2	0.3
Cypress Semiconductor	57	75	79	0.4	0.5	0.4
Dallas Semiconductor	10	102	137	0.1	0.6	0.7
ETEQ Microsystems	0	6	7	0	0	0
Exar	0	0	15	0	0	0.1
Gould AMI	40	61	72	0.3	0.4	0.3
Harris	138	124	108	1.1	0.8	0.5
Hewlett-Packard	230	255	343	1.8	1.6	1.7
Hughes	21	18	17	0.2	0.1	0.1
IBM	1,040	613	719	7.9	3.8	3.5
IMI	18	18	30	0.1	0.1	0.1
IMP	0	0	11	0	0	0.1
Integrated Circuit Systems	29	42	51	0.2	0.3	0.2
Integrated Device Technology	66	82	110	0.5	0.5	0.5
Intel	45	26	-	0.3	0.2	0
International CMOS Technology	0	12	17	0	0.1	0.1
ITT	96	81	96	0.7	0.5	0.5
Lattice	127	134	186	1.0	0.8	0.9
Logic Devices	8	12	13	0.1	0.1	0.1
LSI Logic	642	823	1,161	4.9	5.1	5.6
Micrel	5	7	7	0	0	0
Microchip Technology	4	-	-	0	0	0
Motorola	785	1,214	1,386	6.0	7.5	6.7
National Semiconductor	253	262	263	1.9	1.6	1.3
Performance Semiconductor	15	0	-	0.1	0	0
Quality Semiconductor	10	15	32	0.1	0.1	0.2
QuickLogic	0	8	16	0	0	0.1
Rockwell	4	5	6	0	0	0

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Sierra Semiconductor	6	0	-	0	0	0
Standard Microsystems	4	-	-	0	0	0
Supertex	3	5	6	0	0	0
Symbios	165	217	208	1.3	1.3	1.0
Texas Instruments	733	1,115	1,317	5.6	6.9	6.4
Universal	9	7	8	0.1	0	0
VLSI Technology	342	372	479	2.6	2.3	2.3
WaferScale Integration	0	3	1	0	0	0
Xilinx	231	321	520	1.8	2.0	2.5
Other North American Companies	5	2	4	0	0	0
Japanese Companies	5,736	7,378	9,527	43.7	45.8	46.2
Fuji Electric	35	38	43	0.3	0.2	0.2
Fujitsu	676	794	1,179	5.2	4.9	5.7
Hitachi	426	569	655	3.2	3.5	3.2
Matsushita	446	472	632	3.4	2.9	3.1
Mitsubishi	129	234	427	1.0	1.5	2.1
NEC	1,254	1,587	1,987	9.6	9.9	9.6
New JRC	12	30	36	0.1	0.2	0.2
Oki	419	451	451	3.2	2.8	2.2
Ricoh	25	66	94	0.2	0.4	0.5
Rohm	50	104	244	0.4	0.6	1.2
Sanyo	271	453	528	2.1	2.8	2.6
Seiko Epson	186	197	229	1.4	1.2	1.1
Sharp	388	523	600	3.0	3.2	2.9
Sony	213	426	581	1.6	2.6	2.8
Toshiba	995	1,279	1,562	7.6	7.9	7.6
Yamaha	154	89	170	1.2	0.6	0.8
Other Japanese Companies	57	66	109	0.4	0.4	0.5
European Companies	866	1,164	1,475	6.6	7.2	7.2
Austria Mikro Systeme	36	46	68	0.3	0.3	0.3
Elex	0	5	-	0	0	0
Elmos	0	15	19	0	0.1	0.1
Ericsson	15	15	19	0.1	0.1	0.1
European Silicon Structures	36	40	48	0.3	0.2	0.2
GEC Plessey	101	118	154	0.8	0.7	0.7
Mietec	25	32	35	0.2	0.2	0.2
Philips	400	610	756	3.0	3.8	3.7

(Continued)

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

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
SGS-Thomson	160	182	235	1.2	1.1	1.1
Siemens	24	21	29	0.2	0.1	0.1
TEMIC	57	50	73	0.4	0.3	0.4
TCS	12	15	19	0.1	0.1	0.1
Thesys	0	15	20	0	0.1	0.1
Asia/Pacific Companies	383	383	487	2.9	2.4	2.4
Acer	0	2	3	0	0	0
Daewoo	3	4	4	0	0	0
Holtek	20	50	53	0.2	0.3	0.3
Hualon Microelectronics Corp.	30	34	44	0.2	0.2	0.2
Hyundai	2	4	13	0	0	0.1
LG Semicon	46	52	116	0.4	0.3	0.6
Samsung	173	171	190	1.3	1.1	0.9
Silicon Integrated Systems	40	0	-	0.3	0	0
United Microelectronics Corp.	50	0	-	0.4	0	0
Winbond Electronics	19	66	65	0.1	0.4	0.3

Source: Dataquest (April 1996)

Table 1-12
Each Company's Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	9,083	10,763	14,023	100.0	100.0	100.0
North American Companies	2,180	2,539	3,364	24.0	23.6	24.0
Allegro MicroSystems	10	9	25	0.1	0.1	0.2
AT&T	4	6	-	0	0.1	0
General Instrument	239	262	414	2.6	2.4	3.0
Harris	138	187	227	1.5	1.7	1.6
Hewlett-Packard	49	99	146	0.5	0.9	1.0
International Rectifier	285	353	470	3.1	3.3	3.4
ITT	107	114	192	1.2	1.1	1.4
Microsemi	97	100	118	1.1	0.9	0.8
Motorola	994	1,097	1,359	10.9	10.2	9.7
National Semiconductor	77	99	164	0.8	0.9	1.2
Optek	2	1	1	0	0	0
Powerex	58	76	98	0.6	0.7	0.7
Raytheon	8	8	13	0.1	0.1	0.1
Semtech	17	20	29	0.2	0.2	0.2
Solitron	11	5	6	0.1	0	0
Supertex	10	11	16	0.1	0.1	0.1
Teccor Electronics	45	60	69	0.5	0.6	0.5
Texas Instruments	29	32	16	0.3	0.3	0.1
Japanese Companies	4,861	5,692	7,140	53.5	52.9	50.9
Fuji Electric	293	357	467	3.2	3.3	3.3
Fujitsu	157	192	283	1.7	1.8	2.0
Hitachi	662	798	890	7.3	7.4	6.3
Matsushita	450	511	631	5.0	4.7	4.5
Mitsubishi	380	424	478	4.2	3.9	3.4
NEC	579	652	832	6.4	6.1	5.9
New JRC	3	2	2	0	0	0
Oki	9	10	12	0.1	0.1	0.1
Rohm	380	524	771	4.2	4.9	5.5
Sanken	299	334	398	3.3	3.1	2.8
Sanyo	336	389	487	3.7	3.6	3.5
Shindengen Electric	162	194	300	1.8	1.8	2.1
Sony	89	50	53	1.0	0.5	0.4
Toko	45	51	68	0.5	0.5	0.5
Toshiba	1,017	1,204	1,428	11.2	11.2	10.2
Other Japanese Companies	0	0	40	0	0	0.3

(Continued)

Table 1-12 (Continued)
Each Company's Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
European Companies	1,767	2,178	2,981	19.5	20.2	21.3
ABB-Hafo	6	0	-	0.1	0	0
ABB-Ixys	38	55	64	0.4	0.5	0.5
Elex	0	0	1	0	0	0
Ericsson	0	15	20	0	0.1	0.1
Eupec	82	98	120	0.9	0.9	0.9
Fagor	19	27	38	0.2	0.3	0.3
GEC Plessey	21	28	35	0.2	0.3	0.2
Philips	604	761	1,058	6.6	7.1	7.5
Semikron	94	112	126	1.0	1.0	0.9
SGS-Thomson	384	433	591	4.2	4.0	4.2
Siemens	229	284	435	2.5	2.6	3.1
TEMIC	175	235	321	1.9	2.2	2.3
TCS	1	1	1	0	0	0
Westcode	35	41	54	0.4	0.4	0.4
Zetex	29	36	51	0.3	0.3	0.4
Other European Companies	50	52	66	0.6	0.5	0.5
Asia/Pacific Companies	275	354	538	3.0	3.3	3.8
Dongsung Semiconductor	2	0	0	0	0	0
Korean Electronics Company	130	167	221	1.4	1.6	1.6
Samsung	143	187	317	1.6	1.7	2.3

Source: Dataquest (April 1996)

Table 1-13
Each Company's Factory Revenue from Shipments of Total Optical Semiconductors to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	3,002	3,889	4,811	100.0	100.0	100.0
North American Companies	519	699	547	17.3	18.0	11.4
AT&T	41	51	81	1.4	1.3	1.7
Hewlett-Packard	190	360	159	6.3	9.3	3.3
Honeywell	27	32	37	0.9	0.8	0.8
Motorola	41	45	50	1.4	1.2	1.0
Optek	54	48	53	1.8	1.2	1.1
Quality Technologies	47	49	60	1.6	1.3	1.2
Tektronix	5	0	0	0.2	0	0
Texas Instruments	50	45	43	1.7	1.2	0.9
Other North American Companies	64	69	64	2.1	1.8	1.3
Japanese Companies	2,162	2,798	3,734	72.0	71.9	77.6
Fujitsu	123	135	168	4.1	3.5	3.5
Hitachi	67	89	85	2.2	2.3	1.8
Matsushita	358	417	495	11.9	10.7	10.3
Mitsubishi	30	176	151	1.0	4.5	3.1
NEC	118	150	200	3.9	3.9	4.2
New JRC	13	11	12	0.4	0.3	0.2
Oki	28	24	28	0.9	0.6	0.6
Rohm	112	178	286	3.7	4.6	5.9
Sanken	32	34	52	1.1	0.9	1.1
Sanyo	137	150	169	4.6	3.9	3.5
Sharp	418	510	636	13.9	13.1	13.2
Sony	236	313	383	7.9	8.0	8.0
Toshiba	326	421	622	10.9	10.8	12.9
Other Japanese Companies	164	190	448	5.5	4.9	9.3
European Companies	264	378	504	8.8	9.7	10.5
ABB-Hafo	8	12	14	0.3	0.3	0.3
Ericsson	0	15	16	0	0.4	0.3
Siemens	170	220	314	5.7	5.7	6.5
TEMIC	54	93	110	1.8	2.4	2.3
TCS	21	26	34	0.7	0.7	0.7
Zetex	1	1	1	0	0	0
Other European Companies	10	11	15	0.3	0.3	0.3
Asia/Pacific Companies	57	14	26	1.9	0.4	0.5
Korean Electronics Company	10	11	22	0.3	0.3	0.5
Samsung	4	3	4	0.1	0.1	0.1
Other Asia/Pacific Companies	43	0	0	1.4	0	0

Source: Dataquest (April 1996)

Table 1-14
Each Company's Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	12,513	15,263	17,607	100.0	100.0	100.0
North American Companies	5,580	6,460	7,287	44.6	42.3	41.4
Advanced Micro Devices	154	187	172	1.2	1.2	1.0
Allegro MicroSystems	104	134	146	0.8	0.9	0.8
Analog Devices	526	602	810	4.2	3.9	4.6
Applied Micro Circuits Corp.	0	7	5	0	0	0
AT&T	334	402	284	2.7	2.6	1.6
Atmel	1	12	16	0	0.1	0.1
Brooktree	117	109	120	0.9	0.7	0.7
Burr-Brown	88	105	126	0.7	0.7	0.7
California Micro Devices	8	5	6	0.1	0	0
Catalyst	1	1	-	0	0	0
Cherry Semiconductor	55	77	87	0.4	0.5	0.5
Cirrus Logic	80	100	117	0.6	0.7	0.7
Comlinear	8	9	-	0.1	0.1	0
Dallas Semiconductor	8	-	-	0.1	0	0
Elantec	21	21	23	0.2	0.1	0.1
Exar	158	169	131	1.3	1.1	0.7
Gennum	30	29	34	0.2	0.2	0.2
Gould AMI	38	31	-	0.3	0.2	0
Harris	250	284	259	2.0	1.9	1.5
Honeywell	26	23	27	0.2	0.2	0.2
Hughes	16	19	16	0.1	0.1	0.1
IMI	3	2	5	0	0	0
IMP	29	40	42	0.2	0.3	0.2
Integrated Circuit Systems	12	39	45	0.1	0.3	0.3
Intel	12	20	9	0.1	0.1	0.1
International Rectifier	3	8	17	0	0.1	0.1
ITT	23	24	15	0.2	0.2	0.1
Kulite	24	20	24	0.2	0.1	0.1
Level One Communications	0	-	78	0	0	0.4
Linear Technology	173	225	305	1.4	1.5	1.7
Linfinity	34	41	48	0.3	0.3	0.3
Maxim	111	165	186	0.9	1.1	1.1
Micrel	13	18	19	0.1	0.1	0.1
Micro Linear	45	35	54	0.4	0.2	0.3
Micro Power Systems	23	23	-	0.2	0.2	0

(Continued)

Table 1-14 (Continued)
Each Company's Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Mitel	55	70	68	0.4	0.5	0.4
Motorola	707	924	1,024	5.7	6.1	5.8
Natel Engineering	7	0	0	0.1	0	0
National Semiconductor	788	907	1,033	6.3	5.9	5.9
Novasensor	16	13	15	0.1	0.1	0.1
Optek	0	7	8	0	0	0
Raytheon	68	78	92	0.5	0.5	0.5
Rockwell	155	-	-	1.2	0	0
Seeq Technology	9	0	0	0.1	0	0
Semtech	2	5	19	0	0	0.1
Sierra Semiconductor	90	85	97	0.7	0.6	0.6
Silicon Systems	265	298	368	2.1	2.0	2.1
Sipex	3	2	2	0	0	0
Supertex	10	13	13	0.1	0.1	0.1
Symbios	45	56	102	0.4	0.4	0.6
Tektronix	41	0	0	0.3	0	0
Telcom	0	18	17	0	0.1	0.1
Teledyne	26	0	0	0.2	0	0
Texas Instruments	617	842	933	4.9	5.5	5.3
Unitrode	64	73	102	0.5	0.5	0.6
Universal	5	6	7	0	0	0
VLSI Technology	2	-	-	0	0	0
VTC	70	70	155	0.6	0.5	0.9
Other North American Companies	7	7	8	0.1	0	0
Japanese Companies	3,903	4,911	5,706	31.2	32.2	32.4
Fuji Electric	16	27	30	0.1	0.2	0.2
Fujitsu	122	155	316	1.0	1.0	1.8
Hitachi	280	357	355	2.2	2.3	2.0
Matsushita	473	611	640	3.8	4.0	3.6
Mitsubishi	377	456	454	3.0	3.0	2.6
NEC	377	506	641	3.0	3.3	3.6
New JRC	158	173	183	1.3	1.1	1.0
Oki	22	26	28	0.2	0.2	0.2
Ricoh	8	14	38	0.1	0.1	0.2
Rohm	258	361	422	2.1	2.4	2.4
Sanyo	633	811	893	5.1	5.3	5.1
Seiko Epson	11	13	16	0.1	0.1	0.1

(Continued)

Table 1-14 (Continued)
Each Company's Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Sharp	87	96	105	0.7	0.6	0.6
Sony	425	465	555	3.4	3.0	3.2
Toko	28	32	36	0.2	0.2	0.2
Toshiba	615	789	917	4.9	5.2	5.2
Yamaha	13	19	27	0.1	0.1	0.2
Other Japanese Companies	0	0	50	0	0	0.3
European Companies	2,687	3,489	4,213	21.5	22.9	23.9
ABB-Hafo	20	20	19	0.2	0.1	0.1
Austria Mikro Systeme	49	64	80	0.4	0.4	0.5
Elex	0	0	8	0	0	0
EM Microelectronics Marin	50	65	76	0.4	0.4	0.4
Ericsson	45	49	50	0.4	0.3	0.3
European Silicon Structures	0	0	11	0	0	0.1
GEC Plessey	114	135	156	0.9	0.9	0.9
Micronas	14	20	33	0.1	0.1	0.2
Mietec	123	146	144	1.0	1.0	0.8
Philips	752	957	1,256	6.0	6.3	7.1
SGS-Thomson	858	1,197	1,482	6.9	7.8	8.4
Siemens	382	546	692	3.1	3.6	3.9
TEMIC	262	267	178	2.1	1.7	1.0
TCS	16	20	24	0.1	0.1	0.1
Zetex	2	3	4	0	0	0
Asia/Pacific Companies	343	403	401	2.7	2.6	2.3
Daewoo	20	17	21	0.2	0.1	0.1
Holtek	15	-	-	0.1	0	0
Hualon Microelectronics Corp.	7	9	9	0.1	0.1	0.1
Hyundai	0	0	2	0	0	0
Korean Electronics Company	37	47	45	0.3	0.3	0.3
LG Semicon	40	45	42	0.3	0.3	0.2
Samsung	166	233	233	1.3	1.5	1.3
Winbond Electronics	58	52	49	0.5	0.3	0.3

Source: Dataquest (April 1996)

Table 1-15
Each Company's Factory Revenue from Shipments of Hybrid Analog Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
Total Market	1,463	1,665	1,935	100.0	100.0	100.0
North American Companies	370	425	466	25.3	25.5	24.1
Allegro MicroSystems	0	-	12	0	0	0.6
Analog Devices	40	52	58	2.7	3.1	3.0
Burr-Brown	70	60	60	4.8	3.6	3.1
Comlinear	8	7	-	0.5	0.4	0
Elantec	2	3	3	0.1	0.2	0.2
Gennum	0	2	2	0	0.1	0.1
Linfinity	3	3	3	0.2	0.2	0.2
Maxim	4	4	4	0.3	0.2	0.2
Mitel	14	30	20	1.0	1.8	1.0
Motorola	171	226	280	11.7	13.6	14.5
Natel Engineering	5	0	0	0.3	0	0
National Semiconductor	14	7	8	1.0	0.4	0.4
Sipex	17	14	14	1.2	0.8	0.7
Solitron	0	2	2	0	0.1	0.1
Tektronix	8	0	0	0.5	0	0
Unitrode	14	15	-	1.0	0.9	0
Japanese Companies	988	1,136	1,369	67.5	68.2	70.7
Fuji Electric	21	22	23	1.4	1.3	1.2
Fujitsu	62	116	149	4.2	7.0	7.7
Hitachi	102	136	137	7.0	8.2	7.1
Mitsubishi	106	109	198	7.2	6.5	10.2
NEC	98	98	130	6.7	5.9	6.7
Oki	12	13	13	0.8	0.8	0.7
Rohm	68	72	78	4.6	4.3	4.0
Sanken	202	240	283	13.8	14.4	14.6
Sanyo	166	174	193	11.3	10.5	10.0
Shindengen Electric	49	48	28	3.3	2.9	1.4
Sony	36	41	41	2.5	2.5	2.1
Toko	8	8	9	0.5	0.5	0.4
Toshiba	58	59	74	4.0	3.5	3.8
Other Japanese Companies	0	0	14	0	0	0.7

(Continued)

Table 1-15 (Continued)
Each Company's Factory Revenue from Shipments of Hybrid Analog Integrated Circuits to Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1993	1994	1995	1993	1994	1995
European Companies	105	104	100	7.2	6.2	5.2
ABB-Hafo	0	8	5	0	0.5	0.3
Ericsson	12	19	15	0.8	1.1	0.8
GEC Plessey	21	6	3	1.4	0.4	0.2
Micronas	0	0	10	0	0	0.5
Philips	55	54	46	3.8	3.2	2.4
TEMIC	2	-	-	0.1	0	0
Other European Companies	15	17	21	1.0	1.0	1.1

Source: Dataquest (April 1996)

Section 2: Final 1995 Worldwide Market Share Rankings

Table 2-1
Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	10,099	13,172	30	8.7
2	2	NEC	7,961	11,314	42	7.5
3	3	Toshiba	7,556	10,077	33	6.7
4	5	Hitachi	6,644	9,137	38	6.0
5	4	Motorola	7,238	8,732	21	5.8
6	7	Samsung	4,832	8,329	72	5.5
7	6	Texas Instruments	5,548	7,831	41	5.2
8	8	Fujitsu	3,869	5,538	43	3.7
9	9	Mitsubishi	3,772	5,272	40	3.5
10	21	Hyundai	1,521	4,132	172	2.7
11	10	Philips	2,920	3,901	34	2.6
12	13	IBM	2,532	3,522	39	2.3
13	11	Matsushita	2,896	3,476	20	2.3
14	12	SGS-Thomson	2,640	3,397	29	2.2
15	18	Siemens	2,090	3,062	47	2.0
16	20	LG Semicon	1,697	2,863	69	1.9
17	14	Sanyo	2,321	2,714	17	1.8
18	22	Micron Technology	1,492	2,601	74	1.7
19	15	Sharp	2,188	2,592	18	1.7
20	17	National Semiconductor	2,127	2,408	13	1.6
21	19	Sony	1,876	2,338	25	1.5
22	16	Advanced Micro Devices	2,134	2,330	9	1.5
23	23	Oki	1,471	2,029	38	1.3
24	24	Rohm	1,345	1,933	44	1.3
25	25	AT&T	1,307	1,615	24	1.1
26	26	LSI Logic	901	1,268	41	0.8
27	27	Cirrus Logic	781	1,002	28	0.7
28	28	Analog Devices	739	986	33	0.7
29	29	TEMIC	719	774	8	0.5
30	34	Rockwell	514	744	45	0.5
31	32	Sanken	608	733	20	0.5
32	31	Harris	665	681	2	0.5
33	33	VLSI Technology	588	673	15	0.4
34	30	Hewlett-Packard	714	648	-9	0.4

(Continued)

Table 2-1 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
35	38	Integrated Device Technology	385	617	60	0.4
36	40	Atmel	375	590	57	0.4
37	35	Fuji Electric	446	566	27	0.4
38	37	Cypress Semiconductor	400	552	38	0.4
39	66	Nippon Steel Semiconductor	160	549	243	0.4
40	43	Xilinx	321	520	62	0.3
		All Others	12,121	16,053	32	10.6
		North American Companies	46,052	59,956	30	39.6
		Japanese Companies	44,778	60,612	35	40.1
		European Companies	9,834	12,903	31	8.5
		Asia/Pacific Companies	9,849	17,802	81	11.8
		Total Market	110,513	151,272	37	100.0

Source: Dataquest (April 1996)

Table 2-2
Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Excluding Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	10,099	13,172	30	8.8
2	2	NEC	7,863	11,184	42	7.5
3	3	Toshiba	7,497	10,003	33	6.7
4	5	Hitachi	6,508	9,000	38	6.0
5	4	Motorola	7,012	8,452	21	5.7
6	7	Samsung	4,832	8,329	72	5.6
7	6	Texas Instruments	5,548	7,831	41	5.2
8	8	Fujitsu	3,753	5,389	44	3.6
9	9	Mitsubishi	3,663	5,074	39	3.4
10	21	Hyundai	1,521	4,132	172	2.8
11	11	Philips	2,866	3,855	35	2.6
12	13	IBM	2,532	3,522	39	2.4
13	10	Matsushita	2,896	3,476	20	2.3
14	12	SGS-Thomson	2,640	3,397	29	2.3
15	18	Siemens	2,090	3,062	47	2.1
16	20	LG Semicon	1,697	2,863	69	1.9
17	22	Micron Technology	1,492	2,601	74	1.7
18	14	Sharp	2,188	2,592	18	1.7
19	15	Sanyo	2,147	2,520	17	1.7
20	17	National Semiconductor	2,120	2,400	13	1.6
21	16	Advanced Micro Devices	2,134	2,330	9	1.6
22	19	Sony	1,835	2,297	25	1.5
23	23	Oki	1,458	2,017	38	1.4
24	25	Rohm	1,273	1,855	46	1.2
25	24	AT&T	1,307	1,615	24	1.1
26	26	LSI Logic	901	1,268	41	0.8
27	27	Cirrus Logic	781	1,002	28	0.7
28	30	Analog Devices	687	927	35	0.6
29	28	TEMIC	719	774	8	0.5
30	33	Rockwell	514	744	45	0.5
31	31	Harris	665	681	2	0.5
32	32	VLSI Technology	588	673	15	0.5
33	29	Hewlett-Packard	714	648	-9	0.4
34	37	Integrated Device Technology	385	617	60	0.4
35	39	Atmel	375	590	57	0.4
36	36	Cypress Semiconductor	400	552	38	0.4
37	65	Nippon Steel Semiconductor	160	549	243	0.4

(Continued)

Table 2-2 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Total Semiconductors (Excluding Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	34	Fuji Electric	424	543	28	0.4
39	43	Xilinx	321	520	62	0.3
40	49	Mosel Vitelic	259	502	94	0.3
		All Others	11,984	15,777	32	10.6
		North American Companies	45,627	59,489	30	39.8
		Japanese Companies	43,642	59,242	36	39.7
		European Companies	9,730	12,803	32	8.6
		Asia/Pacific Companies	9,849	17,802	81	11.9
		Total Market	108,848	149,336	37	100.0

Source: Dataquest (April 1996)

Table 2-3
Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	10,099	13,172	30	9.9
2	2	NEC	7,159	10,281	44	7.8
3	5	Hitachi	5,757	8,163	42	6.2
4	4	Toshiba	5,931	8,028	35	6.1
5	7	Samsung	4,642	8,008	73	6.0
6	6	Texas Instruments	5,471	7,772	42	5.9
7	3	Motorola	6,096	7,323	20	5.5
8	8	Fujitsu	3,542	5,087	44	3.8
9	9	Mitsubishi	3,172	4,644	46	3.5
10	20	Hyundai	1,521	4,132	172	3.1
11	10	IBM	2,532	3,522	39	2.7
12	17	LG Semicon	1,697	2,863	69	2.2
13	12	Philips	2,159	2,843	32	2.1
14	11	SGS-Thomson	2,207	2,806	27	2.1
15	22	Micron Technology	1,492	2,601	74	2.0
16	15	Matsushita	1,968	2,350	19	1.8
17	13	Advanced Micro Devices	2,134	2,330	9	1.8
18	19	Siemens	1,586	2,313	46	1.7
19	14	National Semiconductor	2,028	2,243	11	1.7
20	16	Sanyo	1,782	2,058	15	1.6
21	23	Oki	1,437	1,989	38	1.5
22	18	Sharp	1,678	1,956	17	1.5
23	21	Sony	1,513	1,901	26	1.4
24	24	AT&T	1,250	1,534	23	1.2
25	25	LSI Logic	901	1,268	41	1.0
26	26	Cirrus Logic	781	1,002	28	0.8
27	27	Analog Devices	739	986	33	0.7
28	28	Rohm	643	876	36	0.7
29	30	Rockwell	514	744	45	0.6
30	29	VLSI Technology	588	673	15	0.5
31	35	Integrated Device Technology	385	617	60	0.5
32	37	Atmel	375	590	57	0.4
33	33	Cypress Semiconductor	400	552	38	0.4
34	60	Nippon Steel Semiconductor	160	549	243	0.4
35	39	Xilinx	321	520	62	0.4
36	44	Mosel Vitelic	259	502	94	0.4
37	40	Winbond Electronics	308	491	60	0.4

(Continued)

Table 2-3 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Including Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	32	United Microelectronics Corp.	418	477	14	0.4
39	31	Harris	478	454	-5	0.3
40	36	Yamaha	382	444	16	0.3
		All Others	9,356	11,772	26	8.9
		North American Companies	42,814	56,045	31	42.3
		Japanese Companies	36,288	49,737	37	37.6
		European Companies	7,278	9,417	29	7.1
		Asia/Pacific Companies	9,481	17,238	82	13.0
		Total Market	95,861	132,437	38	100.0

Source: Dataquest (April 1996)

Table 2-4
Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Excluding Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	10,099	13,172	30	10.1
2	2	NEC	7,061	10,151	44	7.8
3	5	Hitachi	5,621	8,026	43	6.1
4	7	Samsung	4,642	8,008	73	6.1
5	3	Toshiba	5,872	7,954	35	6.1
6	6	Texas Instruments	5,471	7,772	42	6.0
7	4	Motorola	5,870	7,043	20	5.4
8	8	Fujitsu	3,426	4,938	44	3.8
9	9	Mitsubishi	3,063	4,446	45	3.4
10	20	Hyundai	1,521	4,132	172	3.2
11	10	IBM	2,532	3,522	39	2.7
12	16	LG Semicon	1,697	2,863	69	2.2
13	11	SGS-Thomson	2,207	2,806	27	2.2
14	13	Philips	2,105	2,797	33	2.1
15	21	Micron Technology	1,492	2,601	74	2.0
16	15	Matsushita	1,968	2,350	19	1.8
17	12	Advanced Micro Devices	2,134	2,330	9	1.8
18	19	Siemens	1,586	2,313	46	1.8
19	14	National Semiconductor	2,021	2,235	11	1.7
20	23	Oki	1,424	1,977	39	1.5
21	17	Sharp	1,678	1,956	17	1.5
22	18	Sanyo	1,608	1,864	16	1.4
23	22	Sony	1,472	1,861	26	1.4
24	24	AT&T	1,250	1,534	23	1.2
25	25	LSI Logic	901	1,268	41	1.0
26	26	Cirrus Logic	781	1,002	28	0.8
27	27	Analog Devices	687	927	35	0.7
28	29	Rohm	571	798	40	0.6
29	30	Rockwell	514	744	45	0.6
30	28	VLSI Technology	588	673	15	0.5
31	35	Integrated Device Technology	385	617	60	0.5
32	37	Atmel	375	590	57	0.5
33	33	Cypress Semiconductor	400	552	38	0.4
34	58	Nippon Steel Semiconductor	160	549	243	0.4
35	39	Xilinx	321	520	62	0.4
36	44	Mosel Vitelic	259	502	94	0.4
37	40	Winbond Electronics	308	491	60	0.4

(Continued)

Table 2-4 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Total Integrated Circuits (Excluding Hybrid) to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	32	United Microelectronics Corp.	418	477	14	0.4
39	31	Harris	478	454	-5	0.3
40	36	Yamaha	382	444	16	0.3
		All Others	8,848	11,242	27	8.6
		North American Companies	42,389	55,578	31	42.6
		Japanese Companies	35,152	48,368	38	37.1
		European Companies	7,174	9,317	30	7.1
		Asia/Pacific Companies	9,481	17,238	82	13.2
		Total Market	94,196	130,502	39	100.0

Source: Dataquest (April 1996)

Table 2-5
Top 20 Companies' Factory Revenue from Shipments of Bipolar Digital Memory/Logic to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Texas Instruments	577	512	-11	20.5
2	2	Hitachi	465	442	-5	17.7
3	3	Motorola	421	425	1	17.0
4	5	National Semiconductor	221	210	-5	8.4
5	4	Fujitsu	395	204	-48	8.2
6	8	Philips	121	123	2	4.9
7	9	Toshiba	68	116	71	4.6
8	6	NEC	194	109	-44	4.4
9	7	Advanced Micro Devices	143	99	-31	4.0
10	10	AT&T	63	50	-21	2.0
11	15	Mitsubishi	23	36	57	1.4
12	13	Oki	33	35	7	1.4
13	12	Siemens	33	31	-6	1.2
14	14	Matsushita	29	28	-2	1.1
15	16	Raytheon	22	19	-15	0.7
16	17	Applied Micro Circuits Corp.	20	18	-10	0.7
17	11	LG Semicon	46	14	-70	0.6
18	18	GEC Plessey	16	10	-38	0.4
19	19	SGS-Thomson	12	6	-47	0.3
20	20	Harris	6	4	-33	0.2
		All Others	4	4	0	0.2
		North American Companies	1,473	1,337	-9	53.6
		Japanese Companies	1,207	970	-20	38.9
		European Companies	186	174	-6	7.0
		Asia/Pacific Companies	46	14	-70	0.6
		Total Market	2,912	2,496	-14	100.0

Source: Dataquest (April 1996)

Table 2-6
Top Nine Companies' Factory Revenue from Shipments of Bipolar Digital Memory to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Hitachi	93	81	-13	50.4
2	3	Advanced Micro Devices	28	27	-4	16.8
3	2	Fujitsu	32	21	-35	12.9
4	5	Philips	14	14	0	8.7
5	4	NEC	16	9	-43	5.7
6	8	Raytheon	5	4	-28	2.3
7	7	National Semiconductor	5	2	-58	1.3
8	6	Texas Instruments	5	2	-60	1.2
9	9	Motorola	1	1	0	0.6
		All Others	0	0	NA	0
		North American Companies	44	36	-19	22.3
		Japanese Companies	141	111	-22	69.0
		European Companies	14	14	0	8.7
		Asia/Pacific Companies	0	0	NA	0
		Total Market	199	160	-19	100.0

NA = Not available
Source: Dataquest (April 1996)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Texas Instruments	572	510	-11	21.9
2	2	Motorola	420	424	1	18.2
3	3	Hitachi	372	361	-3	15.5
4	5	National Semiconductor	216	208	-4	8.9
5	4	Fujitsu	363	183	-50	7.8
6	9	Toshiba	68	116	71	5.0
7	8	Philips	107	109	2	4.7
8	6	NEC	178	100	-44	4.3
9	7	Advanced Micro Devices	115	72	-38	3.1
10	10	AT&T	63	50	-21	2.1
11	15	Mitsubishi	23	36	57	1.5
12	12	Oki	33	35	7	1.5
13	13	Siemens	33	31	-6	1.3
14	14	Matsushita	29	28	-2	1.2
15	16	Applied Micro Circuits Corp.	20	18	-10	0.8
16	17	Raytheon	17	15	-11	0.6
17	11	LG Semicon	46	14	-70	0.6
18	18	GEC Plessey	16	10	-38	0.4
19	19	SGS-Thomson	12	6	-47	0.3
20	20	Harris	6	4	-33	0.2
		All Others	4	4	0	0.2
		North American Companies	1,429	1,301	-9	55.7
		Japanese Companies	1,066	860	-19	36.8
		European Companies	172	160	-7	6.9
		Asia/Pacific Companies	46	14	-70	0.6
		Total Market	2,713	2,335	-14	100.0

Source: Dataquest (April 1996)

Table 2-8
Top 40 Companies' Factory Revenue from Shipments of MOS Digital Integrated Circuits to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	10,079	13,162	31	11.9
2	2	NEC	6,361	9,402	48	8.5
3	6	Samsung	4,409	7,775	76	7.0
4	4	Hitachi	4,799	7,229	51	6.5
5	3	Toshiba	5,015	6,921	38	6.3
6	7	Texas Instruments	4,052	6,326	56	5.7
7	5	Motorola	4,525	5,595	24	5.1
8	8	Fujitsu	2,876	4,418	54	4.0
9	14	Hyundai	1,521	4,130	172	3.7
10	9	Mitsubishi	2,584	3,956	53	3.6
11	10	IBM	2,532	3,522	39	3.2
12	12	LG Semicon	1,606	2,807	75	2.5
13	15	Micron Technology	1,492	2,601	74	2.4
14	11	Advanced Micro Devices	1,804	2,059	14	1.9
15	16	Oki	1,365	1,914	40	1.7
16	13	Sharp	1,582	1,851	17	1.7
17	17	Matsushita	1,328	1,681	27	1.5
18	19	Siemens	1,007	1,590	58	1.4
19	18	Philips	1,027	1,418	38	1.3
20	21	SGS-Thomson	998	1,318	32	1.2
21	20	Sony	1,007	1,306	30	1.2
22	22	LSI Logic	901	1,268	41	1.1
23	25	AT&T	785	1,200	53	1.1
24	23	National Semiconductor	893	992	11	0.9
25	24	Sanyo	797	971	22	0.9
26	26	Cirrus Logic	681	886	30	0.8
27	28	Rockwell	514	744	45	0.7
28	27	VLSI Technology	588	673	15	0.6
29	31	Integrated Device Technology	385	617	60	0.6
30	32	Atmel	363	574	58	0.5
31	30	Cypress Semiconductor	400	552	38	0.5
32	49	Nippon Steel Semiconductor	160	549	243	0.5
33	34	Xilinx	321	520	62	0.5
34	37	Mosel Vitelic	259	502	94	0.5
35	29	United Microelectronics Corp.	418	477	14	0.4
36	38	Winbond Electronics	256	442	73	0.4
37	33	Yamaha	363	416	15	0.4

(Continued)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	45	Altera	199	402	102	0.4
39	44	Rohm	210	376	79	0.3
40	39	Hewlett-Packard	255	343	34	0.3
		All Others	5,304	6,913	30	6.3
		North American Companies	34,456	46,954	36	42.5
		Japanese Companies	29,034	41,692	44	37.8
		European Companies	3,499	4,930	41	4.5
		Asia/Pacific Companies	9,032	16,822	86	15.2
		Total Market	76,021	110,399	45	100.0

Source: Dataquest (April 1996)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Samsung	4,194	7,498	79	13.6
2	3	NEC	3,096	5,352	73	9.7
3	2	Hitachi	3,232	5,132	59	9.3
4	4	Toshiba	3,018	4,264	41	7.7
5	10	Hyundai	1,515	4,116	172	7.4
6	5	Texas Instruments	1,931	3,756	95	6.8
7	8	LG Semicon	1,525	2,635	73	4.8
8	11	Micron Technology	1,492	2,601	74	4.7
9	6	Fujitsu	1,692	2,589	53	4.7
10	7	Mitsubishi	1,652	2,547	54	4.6
11	9	IBM	1,520	2,100	38	3.8
12	14	Siemens	858	1,353	58	2.4
13	15	Oki	697	1,228	76	2.2
14	12	Motorola	948	1,213	28	2.2
15	13	Sharp	867	1,030	19	1.9
16	17	Intel	458	766	67	1.4
17	18	Advanced Micro Devices	442	717	62	1.3
18	16	SGS-Thomson	589	646	10	1.2
19	29	Nippon Steel Semiconductor	160	549	243	1.0
20	23	Mosel Vitelic	259	502	94	0.9
21	19	Matsushita	396	492	24	0.9
22	20	Sony	387	490	27	0.9
23	21	Atmel	331	477	44	0.9
24	24	Integrated Device Technology	252	444	76	0.8
25	22	Cypress Semiconductor	285	424	49	0.8
26	30	Winbond Electronics	142	317	123	0.6
27	27	Sanyo	183	257	41	0.5
28	25	Macronix	200	236	18	0.4
29	32	Alliance Semiconductor	90	210	133	0.4
30	26	United Microelectronics Corp.	191	203	6	0.4
31	28	National Semiconductor	179	188	5	0.3
32	34	Integrated Silicon Solutions Inc.	60	158	164	0.3
33	31	Xicor	100	114	14	0.2
34	33	Microchip Technology	82	102	24	0.2
35	35	Rohm	56	61	8	0.1
36	41	Dallas Semiconductor	30	56	87	0.1
37	40	Paradigm	36	55	53	0.1

(Continued)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	37	Hualon Microelectronics Corp.	46	54	18	0.1
39	36	Catalyst	49	49	0	0.1
40	42	Electronic Designs	26	43	65	0.1
		All Others	239	237	-1	0.4
		North American Companies	8,430	13,615	62	24.6
		Japanese Companies	15,519	24,063	55	43.5
		European Companies	1,484	2,023	36	3.7
		Asia/Pacific Companies	8,072	15,561	93	28.2
		Total Market	33,505	55,262	65	100.0

Source: Dataquest (April 1996)

Table 2-10
Top 40 Companies' Factory Revenue from Shipments of MOS Microcomponents to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Intel	9,595	12,396	29	35.9
2	2	Motorola	2,363	2,996	27	8.7
3	3	NEC	1,678	2,063	23	6.0
4	6	Hitachi	998	1,441	44	4.2
5	5	Texas Instruments	1,006	1,254	25	3.6
6	7	Toshiba	718	1,095	52	3.2
7	8	Mitsubishi	698	982	41	2.8
8	4	Advanced Micro Devices	1,021	922	-10	2.7
9	9	Cirrus Logic	681	886	30	2.6
10	10	Rockwell	509	738	45	2.1
11	14	IBM	399	703	76	2.0
12	13	Philips	403	662	64	1.9
13	15	Fujitsu	390	651	67	1.9
14	11	Matsushita	460	557	21	1.6
15	12	National Semiconductor	452	541	20	1.6
16	16	AT&T	305	510	67	1.5
17	19	SGS-Thomson	227	437	92	1.3
18	29	S3	130	315	142	0.9
19	20	United Microelectronics Corp.	227	274	21	0.8
20	21	Zilog	222	265	19	0.8
21	17	Yamaha	273	245	-10	0.7
22	26	Western Digital	184	239	30	0.7
23	22	Oki	217	235	8	0.7
24	24	Sony	194	235	21	0.7
25	25	Sharp	192	221	15	0.6
26	18	Cyrix	241	212	-12	0.6
27	31	Siemens	128	208	63	0.6
28	23	VLSI Technology	216	194	-10	0.6
29	27	Sanyo	161	186	16	0.5
30	28	Microchip Technology	130	169	30	0.5
31	30	OPTi	130	167	28	0.5
32	34	Standard Microsystems	100	150	50	0.4
33	36	Trident Microsystems	87	139	60	0.4
34	35	Chips & Technologies	89	138	55	0.4
35	33	Silicon Integrated Systems	101	127	26	0.4
36	32	Adaptec	125	124	-1	0.4
37	37	Analog Devices	85	117	37	0.3

(Continued)

Table 2-10 (Continued)
Top 40 Companies' Factory Revenue from Shipments of MOS Microcomponents to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	41	LSI Logic	78	107	37	0.3
39	39	Tseng Labs	83	105	26	0.3
40	51	Samsung	44	87	98	0.3
		All Others	1,068	1,421	33	4.1
		North American Companies	18,843	24,205	28	70.1
		Japanese Companies	6,137	8,102	32	23.5
		European Companies	851	1,432	68	4.1
		Asia/Pacific Companies	577	774	34	2.2
		Total Market	26,408	34,513	31	100.0

Source: Dataquest (April 1996)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	NEC	1,587	1,987	25	9.6
2	2	Toshiba	1,279	1,562	22	7.6
3	3	Motorola	1,214	1,386	14	6.7
4	4	Texas Instruments	1,115	1,317	18	6.4
5	6	Fujitsu	794	1,179	48	5.7
6	5	LSI Logic	823	1,161	41	5.6
7	8	Philips	610	756	24	3.7
8	7	IBM	613	719	17	3.5
9	11	AT&T	477	687	44	3.3
10	9	Hitachi	569	655	15	3.2
11	12	Matsushita	472	632	34	3.1
12	10	Sharp	523	600	15	2.9
13	15	Sony	426	581	36	2.8
14	13	Sanyo	453	528	17	2.6
15	18	Xilinx	321	520	62	2.5
16	16	VLSI Technology	372	479	29	2.3
17	14	Oki	451	451	0	2.2
18	21	Mitsubishi	234	427	82	2.1
19	17	Advanced Micro Devices	341	420	23	2.0
20	23	Altera	199	402	102	1.9
21	20	Hewlett-Packard	255	343	34	1.7
22	19	National Semiconductor	262	263	0	1.3
23	30	Rohm	104	244	135	1.2
24	25	SGS-Thomson	182	235	29	1.1
25	24	Seiko Epson	197	229	16	1.1
26	22	Symbios	217	208	-4	1.0
27	26	Samsung	171	190	11	0.9
28	27	Lattice	134	186	39	0.9
29	32	Yamaha	89	170	91	0.8
30	29	GEC Plessey	118	154	31	0.7
31	31	Dallas Semiconductor	102	137	34	0.7
32	40	LG Semicon	52	116	123	0.6
33	33	Integrated Device Technology	82	110	34	0.5
34	35	Actel	76	108	42	0.5
35	28	Harris	124	108	-13	0.5
36	34	ITT	81	96	19	0.5
37	37	Ricoh	66	94	43	0.5

(Continued)

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

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	36	Cypress Semiconductor	75	79	6	0.4
39	41	TEMIC	50	73	46	0.4
40	39	Gould AMI	61	72	18	0.3
		All Others	737	960	30	4.7
		North American Companies	7,183	9,134	27	44.3
		Japanese Companies	7,378	9,527	29	46.2
		European Companies	1,164	1,475	27	7.2
		Asia/Pacific Companies	383	487	27	2.4
		Total Market	16,108	20,623	28	100.0

Source: Dataquest (April 1996)

Table 2-12
Top 40 Companies' Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Toshiba	1,204	1,428	19	10.2
2	2	Motorola	1,097	1,359	24	9.7
3	4	Philips	761	1,058	39	7.5
4	3	Hitachi	798	890	11	6.3
5	5	NEC	652	832	28	5.9
6	6	Rohm	524	771	47	5.5
7	7	Matsushita	511	631	24	4.5
8	8	SGS-Thomson	433	591	36	4.2
9	10	Sanyo	389	487	25	3.5
10	9	Mitsubishi	424	478	13	3.4
11	12	International Rectifier	353	470	33	3.4
12	11	Fuji Electric	357	467	31	3.3
13	14	Siemens	284	435	53	3.1
14	15	General Instrument	262	414	58	3.0
15	13	Sanken	334	398	19	2.8
16	16	TEMIC	235	321	37	2.3
17	20	Samsung	187	317	70	2.3
18	17	Shindengen Electric	194	300	55	2.1
19	18	Fujitsu	192	283	47	2.0
20	19	Harris	187	227	21	1.6
21	21	Korean Electronics Company	167	221	32	1.6
22	22	ITT	114	192	69	1.4
23	25	National Semiconductor	99	164	66	1.2
24	26	Hewlett-Packard	99	146	47	1.0
25	23	Semikron	112	126	13	0.9
26	27	Eupec	98	120	22	0.9
27	24	Microsemi	100	118	18	0.8
28	28	Powerex	76	98	28	0.7
29	29	Teccor Electronics	60	69	16	0.5
30	31	Toko	51	68	34	0.5
31	30	ABB-Ixys	55	64	16	0.5
32	33	Westcode	41	54	32	0.4
33	32	Sony	50	53	6	0.4
34	34	Zetex	36	51	42	0.4
35	37	Fagor	27	38	41	0.3
36	36	GEC Plessey	28	35	25	0.2
37	38	Semtech	20	29	45	0.2

(Continued)

Table 2-12 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Total Discrete Semiconductors to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	42	Allegro MicroSystems	9	25	178	0.2
39	39	Ericsson	15	20	33	0.1
40	35	Texas Instruments	32	16	-49	0.1
		All Others	96	158	64	1.1
		North American Companies	2,539	3,364	32	24.0
		Japanese Companies	5,692	7,140	25	50.9
		European Companies	2,178	2,981	37	21.3
		Asia/Pacific Companies	354	538	52	3.8
		Total Market	10,763	14,023	30	100.0

Source: Dataquest (April 1996)

Table 2-13
Top 20 Companies' Factory Revenue from Shipments of Total Optical Semiconductors to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Sharp	510	636	25	13.2
2	2	Toshiba	421	622	48	12.9
3	3	Matsushita	417	495	19	10.3
4	5	Sony	313	383	22	8.0
5	6	Siemens	220	314	43	6.5
6	7	Rohm	178	286	61	5.9
7	9	NEC	150	200	34	4.2
8	10	Sanyo	150	169	12	3.5
9	11	Fujitsu	135	168	25	3.5
10	4	Hewlett-Packard	360	159	-56	3.3
11	8	Mitsubishi	176	151	-14	3.1
12	12	TEMIC	93	110	18	2.3
13	13	Hitachi	89	85	-5	1.8
14	14	AT&T	51	81	59	1.7
15	15	Quality Technologies	49	60	22	1.2
16	16	Optek	48	53	11	1.1
17	19	Sanken	34	52	53	1.1
18	18	Motorola	45	50	11	1.0
19	17	Texas Instruments	45	43	-4	0.9
20	20	Honeywell	32	37	15	0.8
		All Others	373	658	76	13.7
		North American Companies	699	547	-22	11.4
		Japanese Companies	2,798	3,734	33	77.6
		European Companies	378	504	33	10.5
		Asia/Pacific Companies	14	26	86	0.5
		Total Market	3,889	4,811	24	100.0

Source: Dataquest (April 1996)

Table 2-14
Top 40 Companies' Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	SGS-Thomson	1,197	1,482	24	8.4
2	2	Philips	957	1,256	31	7.1
3	4	National Semiconductor	907	1,033	14	5.9
4	3	Motorola	924	1,024	11	5.8
5	5	Texas Instruments	842	933	11	5.3
6	7	Toshiba	789	917	16	5.2
7	6	Sanyo	811	893	10	5.1
8	9	Analog Devices	602	810	35	4.6
9	10	Siemens	546	692	27	3.9
10	11	NEC	506	641	27	3.6
11	8	Matsushita	611	640	5	3.6
12	12	Sony	465	555	19	3.2
13	13	Mitsubishi	456	454	0	2.6
14	15	Rohm	361	422	17	2.4
15	17	Silicon Systems	298	368	23	2.1
16	16	Hitachi	357	355	-1	2.0
17	26	Fujitsu	155	316	104	1.8
18	21	Linear Technology	225	305	35	1.7
19	14	AT&T	402	284	-29	1.6
20	18	Harris	284	259	-9	1.5
21	20	Samsung	233	233	0	1.3
22	25	Maxim	165	186	13	1.1
23	23	New JRC	173	183	6	1.0
24	19	TEMIC	267	178	-33	1.0
25	22	Advanced Micro Devices	187	172	-8	1.0
26	28	GEC Plessey	135	156	15	0.9
27	38	VTC	70	155	122	0.9
28	29	Allegro MicroSystems	134	146	9	0.8
29	27	Mietec	146	144	-1	0.8
30	24	Exar	169	131	-22	0.7
31	31	Burr-Brown	105	126	20	0.7
32	30	Brooktree	109	120	10	0.7
33	32	Cirrus Logic	100	117	17	0.7
34	33	Sharp	96	105	9	0.6
35	42	Symbios	56	102	83	0.6
36	37	Unitrode	73	102	40	0.6
37	34	Sierra Semiconductor	85	97	14	0.6

(Continued)

Table 2-14 (Continued)
Top 40 Companies' Factory Revenue from Shipments of Analog-Monolithic Integrated Circuits to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
38	35	Raytheon	78	92	18	0.5
39	36	Cherry Semiconductor	77	87	14	0.5
40	41	Austria Mikro Systeme	64	80	25	0.5
		All Others	1,046	1,257	20	7.1
		North American Companies	6,460	7,287	13	41.4
		Japanese Companies	4,911	5,706	16	32.4
		European Companies	3,489	4,213	21	23.9
		Asia/Pacific Companies	403	401	0	2.3
		Total Market	15,263	17,607	15	100.0

Source: Dataquest (April 1996)

Table 2-15
Top 10 Companies' Factory Revenue from Shipments of Hybrid Analog Integrated Circuits to Worldwide (Millions of U.S. Dollars)

1995 Rank	1994 Rank		1994 Revenue	1995 Revenue	Percent Change	1995 Market Share (%)
1	1	Sanken	240	283	18	14.6
2	2	Motorola	226	280	24	14.5
3	6	Mitsubishi	109	198	82	10.2
4	3	Sanyo	174	193	11	10.0
5	5	Fujitsu	116	149	28	7.7
6	4	Hitachi	136	137	1	7.1
7	7	NEC	98	130	33	6.7
8	8	Rohm	72	78	8	4.0
9	10	Toshiba	59	74	25	3.8
10	9	Burr-Brown	60	60	0	3.1
		All Others	375	353	-6	18.2
		North American Companies	425	466	10	24.1
		Japanese Companies	1,136	1,369	21	70.7
		European Companies	104	100	-4	5.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	1,665	1,935	16	100.0

NA = Not available
Source: Dataquest (April 1996)

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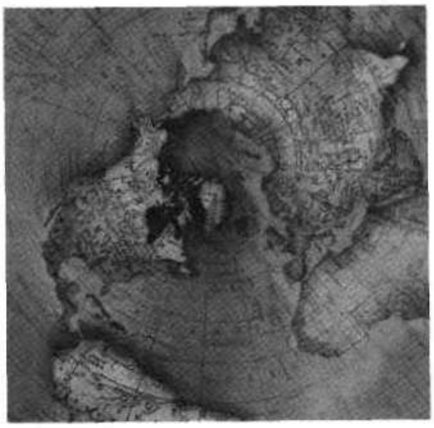

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North American Semiconductor Price Outlook: Second Quarter 1996

Market Statistics

Program: Semiconductor Supply and Pricing Worldwide
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North American Semiconductor Price Outlook: Second Quarter 1996

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Table of Contents

Page

North American Semiconductor Price Outlook:

Second Quarter 1996 1

Methodology and Sources 1

Price Variations 1

List of Tables

Table		Page
1	Estimated Standard Logic Price Trends—North American Bookings	2
2	Estimated Long-Range Standard Logic Price Trends—North American Bookings	4
3	Estimated Microprocessor Price Trends—North American Bookings	5
4	Estimated Long-Range Microprocessor Price Trends—North American Bookings	7
5	Estimated DRAM Price Trends—North American Bookings	8
6	Estimated Long-Range DRAM Price Trends—North American Bookings	10
7	Estimated Static RAM Price Trends—North American Bookings	11
8	Estimated Long-Range Static RAM Price Trends—North American Bookings	12
9	Estimated ROM Price Trends—North American Bookings	13
10	Estimated Long-Range ROM Price Trends—North American Bookings	14
11	Estimated EPROM Price Trends—North American Bookings	15
12	Estimated Long-Range EPROM Price Trends—North American Bookings	16
13	Estimated Flash Memory Price Trends—North American Bookings	17
14	Estimated Long-Range Flash Memory Price Trends—North American Bookings	18
15	Estimated Gate Array Pricing (5K to 19.99K Gates)—North American Production Bookings	19
16	Estimated Gate Array Pricing (20K to 100K Gates)—North American Production Bookings	20
17	Estimated CBIC Pricing (5K to 19.99K Gates)—North American Production Bookings	21
18	Estimated CBIC Pricing (20K to 100K Gates)—North American Production Bookings	22
19	Estimated CMOS PLD Price per Unit—North American Bookings	23
20	Estimated Long-Range CMOS PLD Price per Unit—North American Bookings	24

Note: All tables show estimated data.

North American Semiconductor Price Outlook: Second 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 Supply and Pricing Worldwide (SPSG) program 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 SPSG clients that use the SPSG online service, the prices presented here correlate with the quarterly and long-range price tables dated September 1995 in the SPSG 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 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 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 (March 1996)

Table 2
Estimated Long-Range Standard Logic Price Trends—North American Bookings (Volume: 100,000 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 (March 1996)

(Continued)

Table 3
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 per Year; Dollars)
(Package: 8-Bit/16-Bit Devices—PDIPP; 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	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4-6
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	4-6
68EC020-16 PQFP	9.50	8.75	8.75	8.75	8.75	8.75	8.00	8.00	8.00	8.00	8.00	4-6
68EC020-25 PQFP	10.00	9.00	9.00	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00	4-6
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	4-6
68040-25	140.00	105.00	90.00	80.00	70.00	86.25	60.00	60.00	60.00	60.00	60.00	4-6
68LC040-25 CQFP 184	65.00	55.00	48.00	40.00	35.00	44.50	29.00	29.00	29.00	29.00	29.00	4-6
386SL-25 PQFP	40.00	29.00	29.00	29.00	29.00	29.00	25.00	25.00	25.00	25.00	25.00	4-6
AM386-40 PQFP[1]	22.00	20.00	20.00	20.00	20.00	20.00	18.00	18.00	18.00	18.00	18.00	4-6
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	4-6
80486DX-33 PQFP	65.00	55.00	45.00	35.00	30.00	41.25	25.00	25.00	25.00	25.00	25.00	4-6
80486DX-50	95.00	80.00	65.00	50.00	40.00	58.75	35.00	35.00	35.00	35.00	35.00	4-6
80486DX2-50 PQFP	49.00	41.00	32.00	25.00	20.00	29.50	20.00	20.00	20.00	20.00	20.00	4-6
80486DX2-66	65.00	55.00	45.00	35.00	30.00	41.25	25.00	25.00	25.00	25.00	25.00	4-6
80486DX4-75	100.00	90.00	80.00	70.00	60.00	75.00	55.00	55.00	55.00	55.00	55.00	4-6
Pentium-66	134.00	100.00	90.00	90.00	90.00	92.50	70.00	70.00	70.00	70.00	70.00	4-8
Pentium-75	150.00	100.00	90.00	90.00	90.00	92.50	70.00	70.00	70.00	70.00	70.00	4-8
Pentium-90	225.00	182.00	138.00	105.00	105.00	132.50	90.00	90.00	90.00	90.00	90.00	4-8
Pentium-100	281.00	199.00	150.00	125.00	125.00	149.75	115.00	115.00	115.00	115.00	115.00	4-8
PowerPC 601-66	111.00	105.00	90.00	90.00	90.00	93.75	70.00	70.00	70.00	70.00	70.00	4-8
PowerPC 601-80	159.00	125.00	105.00	95.00	90.00	103.75	90.00	90.00	90.00	90.00	90.00	4-8
PowerPC 601-100	273.00	235.00	195.00	150.00	120.00	175.00	120.00	120.00	120.00	120.00	120.00	4-8
Power PC 603-80	108.00	105.00	95.00	85.00	77.00	90.50	60.00	60.00	60.00	60.00	60.00	4-8
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	4-6

(Continued)

Table 3 (Continued)
Estimated Microprocessor Price Trends—North American Bookings
(Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 per Year; Dollars)
(Package: 8-Bit/16-Bit Devices—PDIPP; 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]	40.00	39.00	39.00	39.00	39.00	39.00	35.00	35.00	35.00	35.00	35.00	4-6
R4000SC-50	375.00	360.00	345.00	330.00	320.00	338.75	300.00	225.00	170.00	125.00	205.00	4-8
R4400SC-75	515.00	475.00	450.00	420.00	395.00	435.00	370.00	350.00	320.00	295.00	333.75	4-8
SPARC-25[2]	45.00	42.00	42.00	42.00	42.00	42.00	35.00	35.00	35.00	35.00	35.00	4-6
80960CA-25	55.00	50.00	50.00	45.00	45.00	47.50	40.00	40.00	40.00	40.00	40.00	4-6

[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 1996)

Table 4
Estimated Long-Range Microprocessor Price Trends—North American Bookings (Volume: 8-Bit, 16-Bit, and 32-Bit—25,000 Year; Dollars) (Package: 8-Bit/16-Bit Devices—PDIPP; 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	9.00	8.00	7.00	NA	NA
68EC030-25 PQFP	21.00	19.00	17.00	NA	NA
68040-25	86.25	60.00	50.00	NA	NA
68LC040-25 CQFP 184	44.50	29.00	NA	NA	NA
386SL-25 PQFP	29.00	25.00	NA	NA	NA
AM386-40 PQFP[1]	20.00	18.00	NA	NA	NA
80486SX-25 PQFP	26.25	20.00	NA	NA	NA
80486DX-33 PQFP	41.25	25.00	NA	NA	NA
80486DX-50	58.75	35.00	NA	NA	NA
80486DX2-50 PQFP	29.50	20.00	NA	NA	NA
80486DX2-66	41.25	25.00	NA	NA	NA
80486DX4-75	75.00	55.00	50.00	NA	NA
Pentium-66	92.50	70.00	60.00	NA	NA
Pentium-75	92.50	70.00	60.00	NA	NA
Pentium-90	132.50	90.00	70.00	NA	NA
Pentium-100	149.75	115.00	100.00	70.00	50.00
PowerPC-601-66	93.75	70.00	50.00	NA	NA
PowerPC-601-80	103.75	90.00	85.00	75.00	NA
PowerPC-601-100	175.00	120.00	99.00	85.00	75.00
Power PC 603-80	90.50	60.00	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	338.75	205.00	155.00	120.00	99.00
R4400SC-75	435.00	333.75	295.00	235.00	192.00
SPARC-25[2]	42.00	35.00	NA	NA	NA
80960CA-25	47.50	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 guidelines.
Source: Dataquest (March 1996)

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)	3.77	3.44	3.44	3.44	3.44	3.44	3.45	3.45	3.45	3.45	3.45	4-8
256Kbx4 DRAM 60ns SOJ	3.80	3.43	3.45	3.49	3.50	3.47	3.60	3.61	3.63	3.65	3.62	4-8
4Mbx1 DRAM 70ns SOJ	12.33	8.45	7.61	6.84	6.16	7.26	5.85	5.56	5.28	5.02	5.43	4-8
1Mbx4 DRAM 60ns SOJ FPM	12.26	8.50	7.65	6.89	6.20	7.31	5.89	5.59	5.31	5.05	5.46	4-8
1Mbx4 DRAM 60ns SOJ EDO	12.13	8.55	7.70	6.93	6.23	7.35	5.92	5.63	5.34	5.08	5.49	4-8
512Kbx8 DRAM 70ns	15.10	8.81	7.93	7.14	6.42	7.57	6.10	5.80	5.51	5.23	5.66	10-12
256Kbx16 DRAM 70ns SOJ	14.69	10.00	9.00	8.10	7.29	8.60	6.93	6.58	6.25	5.94	6.42	4-8
4Mbx4 DRAM 70ns SOJ 300 mil	46.50	33.42	30.08	27.07	24.36	28.73	23.15	21.99	20.89	19.84	21.47	8-12
1Mbx16 DRAM 60ns TSOP 300 mil FPM	53.20	34.43	30.98	27.88	25.10	29.60	23.84	22.65	21.52	20.44	22.11	6-12
1Mbx16 DRAM 60ns TSOP 300 mil EDO	53.50	34.63	31.16	28.05	25.24	29.77	23.98	22.78	21.64	20.56	22.24	8-12
2Mbx8 DRAM 60ns TSOP 300mil	51.08	34.50	31.05	27.95	25.15	29.66	23.89	22.70	21.56	20.49	22.16	8-12
1Mbx9 SIMM 2 (1Mbx4) + 1 (1Mbx1)	32.55	21.15	19.39	17.81	16.38	18.68	15.75	15.14	14.56	14.01	14.87	4-8
4Mbx9 SIMM 2 (4Mbx4) + 1 (4Mbx1)	116.00	82.96	76.17	70.13	64.61	73.47	62.51	60.18	57.97	55.92	59.14	8-12
1Mbx36 SIMM 9 (1Mbx4)	118.74	79.26	71.33	64.20	57.78	68.14	54.89	52.15	49.54	47.06	50.91	6-12
1Mbx32 SIMM 8 (1Mbx4)	107.50	70.45	63.41	57.07	51.36	60.57	48.79	46.35	44.03	41.83	45.25	4-8
1Mbx32 SIMM 2 (1Mbx16)	114.00	71.33	64.20	57.78	52.00	61.33	49.40	46.93	44.58	42.36	45.82	6-12
2Mbx32 SIMM 16 (1Mbx4)	214.00	143.64	129.28	116.35	104.71	123.49	99.48	94.50	89.78	85.29	92.26	8-12
2Mbx32 SIMM 4 (1Mbx16)	206.53	145.44	130.89	117.80	106.02	125.04	100.72	95.69	90.90	86.36	93.42	8-12
2Mbx36 SIMM 18 (1Mbx4)	233.67	161.60	145.44	130.89	117.80	138.93	111.91	106.32	101.00	95.95	103.80	4-8
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	223.80	160.28	144.25	129.83	116.84	137.80	111.00	105.45	100.18	95.17	102.95	6-12

(Continued)

Table 5 (Continued)
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)
256Kbx4 VRAM 70ns SOJ	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	8-12
128Kbx8 VRAM 70ns SOJ	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	8-12
256Kbx16 VRAM 70ns SOP	24.25	23.00	20.25	19.50	18.00	20.19	17.20	16.60	15.50	14.80	16.03	8-12

*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 1996)

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

Product	1996	1997	1998	1999	2000
1Mbx1 DRAM 70 80ns (DIP/SOJ)	3.44	3.45	3.42	3.38	3.35
256Kbx4 DRAM 60ns SOJ	3.47	3.62	3.59	3.55	3.51
4Mbx1 DRAM 70ns SOJ	7.26	5.43	4.88	4.40	3.96
1Mbx4 DRAM 60ns SOJ FPM	7.31	5.46	4.91	4.42	3.98
1Mbx4 DRAM 60ns SOJ EDO	7.35	5.49	4.94	4.45	4.00
512Kbx8 DRAM 70ns	7.57	5.66	5.09	4.58	4.13
256Kbx16 DRAM 70ns SOJ	8.60	6.42	5.78	5.20	4.68
4Mbx4 DRAM 70ns SOJ 300 mil	28.73	21.47	17.17	13.74	11.68
1Mbx16 DRAM 60ns TSOP 300 mil FPM	29.60	22.11	17.69	14.15	12.03
1Mbx16 DRAM 60ns TSOP 300 mil EDO	29.77	22.24	17.79	14.23	12.10
2Mbx8 DRAM 60ns TSOP 300mil	29.66	22.16	17.73	14.18	12.06
1Mbx9 SIMM 2 (1Mbx4) + 1 (1Mbx1)	18.68	14.87	13.70	12.65	11.70
4Mbx9 SIMM 2 (4Mbx4) + 1 (4Mbx1)	73.47	59.14	50.15	42.93	38.53
1Mbx36 SIMM 9 (1Mbx4)	68.14	50.91	45.82	41.24	37.11
1Mbx32 SIMM 8 (1Mbx4)	60.57	45.25	40.73	36.65	32.99
1Mbx32 SIMM 2 (1Mbx16)	61.33	45.82	36.65	29.32	24.93
2Mbx32 SIMM 16 (1Mbx4)	123.49	92.26	83.04	74.73	67.26
2Mbx32 SIMM 4 (1Mbx16)	125.04	93.42	74.73	59.79	50.82
2Mbx36 SIMM 18 (1Mbx4)	138.93	103.80	93.42	84.07	75.67
2Mbx36 SIMM 4 (1Mbx16) + 2 (1Mbx4)	137.80	102.95	83.49	67.81	58.10
256Kbx4 VRAM 70ns SOJ	6.00	6.00	5.40	4.86	4.37
128Kbx8 VRAM 70ns SOJ	6.25	6.25	5.63	5.06	4.56
256Kbx16 VRAM 70ns SOP	20.19	16.03	14.42	12.98	11.68

*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 1996)

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)
16Kbx4 35ns	2.90	2.87	2.73	2.66	2.60	2.72	2.58	2.52	2.48	2.42	2.50	8-10
8Kbx8 25ns	2.75	2.35	2.35	2.35	2.35	2.35	2.25	2.25	2.25	2.25	2.25	8-10
8Kbx8 100 120ns	1.85	1.90	1.90	1.90	1.90	1.90	2.00	2.00	2.00	2.00	2.00	8-10
64Kbx4 10ns	10.00	9.00	9.00	8.00	8.00	8.50	7.00	7.00	6.00	6.00	6.50	12
64Kbx4 25ns	4.50	4.50	4.50	4.50	4.50	4.50	4.25	4.25	4.25	4.25	4.25	12
32Kbx8 12ns	6.10	5.10	5.05	4.85	4.65	4.91	4.25	4.00	3.50	3.25	3.75	12
32Kbx9 12ns Burst	13.00	12.00	10.50	9.25	8.75	10.13	8.10	7.00	5.90	5.20	6.55	12
32Kbx8 15ns, 5V	3.50	3.85	3.65	3.45	3.25	3.55	3.00	3.00	3.00	3.00	3.00	12
32Kbx8 15ns, 3.3V	4.00	3.75	3.50	3.25	3.00	3.38	3.00	3.00	3.00	3.00	3.00	12
32Kbx8 25ns	3.65	3.08	3.08	3.03	3.03	3.05	2.65	2.65	2.65	2.65	2.65	12
32Kbx8 70 100ns SOJ	3.40	3.35	3.25	3.15	3.05	3.20	2.68	2.63	2.53	2.53	2.59	8-10
64Kbx18 12ns Burst	35.00	33.00	31.50	29.50	27.30	30.33	25.70	24.10	23.20	22.40	23.85	12
256Kbx4 20ns	18.00	16.00	15.75	15.25	15.25	15.56	14.00	14.00	13.25	13.25	13.63	12
128Kbx8 15ns	21.50	20.20	19.50	18.50	18.50	19.18	17.25	17.25	16.50	16.00	16.75	12
128Kbx8 20ns	18.00	16.00	16.00	15.25	15.25	15.63	14.80	14.40	14.00	13.50	14.18	12
128Kbx8 25ns	16.50	16.20	16.20	15.50	15.50	15.85	15.00	14.60	14.30	13.80	14.43	12
128Kbx8 70 100ns SOJ	8.25	8.20	7.60	7.40	7.15	7.59	6.95	6.75	6.50	6.35	6.64	12
32Kbx32 15ns, 3.3V PQFP	24.00	14.67	12.00	11.17	11.00	12.21	10.75	10.00	9.88	9.75	10.09	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 (March 1996)

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
16Kbx4 35ns	2.72	2.50	2.50	2.60	2.70
8Kbx8 25ns	2.35	2.25	2.25	2.30	2.50
8Kbx8 100 120ns	1.90	2.00	2.20	2.40	2.60
64Kbx4 10ns	8.50	6.50	5.25	4.75	4.75
64Kbx4 25ns	4.50	4.25	4.00	4.00	4.00
32Kbx8 12ns	4.91	3.75	3.30	3.00	3.00
32Kbx9 12ns Burst	10.13	6.55	5.50	5.50	5.50
32Kbx8 15ns, 5V	3.55	3.00	3.00	3.00	3.00
32Kbx8 15ns, 3.3V	3.38	3.00	3.00	3.00	3.00
32Kbx8 25ns	3.05	2.65	2.50	2.50	2.50
32Kbx8 70 100ns SOJ	3.20	2.59	2.25	2.25	2.25
64Kbx18 12ns Burst	30.33	23.85	21.00	19.00	17.00
256Kbx4 20ns	15.56	13.63	11.25	8.33	6.55
128Kbx8 15ns	19.18	16.75	13.57	10.61	7.85
128Kbx8 20ns	15.63	14.18	13.65	11.24	8.42
128Kbx8 25ns	15.85	14.43	10.55	8.29	6.20
128Kbx8 70 100ns SOJ	7.59	6.64	5.12	5.00	5.00
32Kbx32 15ns, 3.3V PQFP	12.21	10.09	7.80	6.20	5.50

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount.
These prices are intended for use as price guidelines.
Source: Dataquest (March 1996)

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)
128Kbx8 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
64Kbx16 ROM	2.1	2.08	2.05	2.05	2.05	2.06	2.05	2.05	2.05	2.05	2.05	8-12
256Kbx8 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
512Kbx8 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
256Kbx16 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]256Kbx16 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 1996)

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
128Kbx8 ROM	1.90	1.70	1.60	1.60	1.60
64Kbx16 ROM	2.06	2.05	2.05	2.15	2.25
256Kbx8 ROM	2.48	2.40	2.40	2.45	2.50
512Kbx8 ROM	3.38	2.80	2.50	2.50	2.50
256Kbx16 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]256Kbx16 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 1996)

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)
32Kbx8 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
64Kbx8 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
128Kbx8 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
256Kbx8 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
128Kbx16 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
512Kbx8 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
256Kbx16 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 (March 1996)

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
32Kbx8 EPROM	1.99	2.19	1.90	2.00	2.00
64Kbx8 EPROM	2.18	2.30	2.40	2.50	2.50
128Kbx8 EPROM	2.81	2.60	2.75	2.95	2.95
256Kbx8 EPROM	4.81	4.75	4.30	4.25	4.20
128Kbx16 EPROM	6.80	6.70	4.55	4.46	4.40
512Kbx8 EPROM	8.20	7.68	6.35	6.35	6.35
256Kbx16 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 (March 1996)

Table 13
Estimated Flash Memory Price Trends—North American Bookings (12V; 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)
64Kbx8 PDIP/PLCC	3.95	3.95	3.90	3.80	3.70	3.84	3.60	3.50	3.40	3.30	3.45	4-8
64Kbx8 TSOP	4.20	4.20	4.20	4.10	4.00	4.13	3.90	3.70	3.50	3.30	3.60	4-8
128Kbx8, PDIP/PLCC	4.39	4.27	3.79	3.74	3.64	3.86	3.48	3.40	3.28	3.28	3.36	4-8
128Kbx8 TSOP 12V	5.05	4.70	4.50	4.30	4.10	4.40	4.05	3.97	3.90	3.85	3.94	4-8
128Kbx8 TSOP 5V	6.12	5.83	5.63	5.40	5.40	5.56	5.35	5.30	5.00	4.95	5.15	8
256Kbx8 TSOP 12V	10.15	9.85	9.31	9.05	8.72	9.23	8.40	7.90	7.60	7.20	7.78	8
256Kbx8 TSOP 5V	10.70	10.53	10.25	10.15	9.95	10.22	9.30	8.60	8.20	7.80	8.48	6-8
512Kbx8 PDIP/PLCC	13.05	12.50	12.25	11.80	11.15	11.93	10.90	10.15	9.40	8.50	9.74	8
512Kbx8 TSOP 12V	13.15	12.90	12.60	12.05	11.75	12.33	11.30	10.80	10.05	9.55	10.43	8
512Kbx8 TSOP 5V	15.90	15.50	14.55	13.60	12.71	14.09	11.65	11.00	10.55	9.95	10.79	8
1Mbx8 TSOP 12V	18.00	17.55	17.40	17.00	16.80	17.19	16.50	15.45	14.10	13.00	14.76	6-8
1Mbx8 TSOP 5V	23.10	21.90	20.05	18.90	17.90	19.69	16.50	15.45	14.10	13.00	14.76	6-8
2Mbx8 TSOP 12V	40.00	39.00	38.25	36.10	32.00	36.34	29.65	26.80	25.42	24.20	26.52	6-8
2Mbx8 TSOP 5V	45.00	41.25	39.50	38.00	35.50	38.56	32.50	30.00	27.75	25.25	28.88	6-8

Note: Actual negotiated market prices may vary from these prices because of manufacturer-specific factors such as quality, service, and volume discount.
These prices are intended for use as guidelines.
Source: Dataquest (March 1996)

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

Product	1996 Year	1997 Year	1998 Year	1999 Year	2000 Year
64Kbx8 PDIP/PLCC	3.84	3.45	3.00	2.50	2.50
64Kbx8 TSOP	4.13	3.60	3.00	2.50	2.50
128Kbx8 PDIP/PLCC	3.86	3.36	2.75	2.75	2.50
128Kbx8 TSOP, 12V	4.40	3.94	3.50	2.80	2.60
128Kbx8 TSOP, 5V	5.56	5.15	4.75	4.00	3.65
256Kbx8 TSOP, 12V	9.23	7.78	5.25	4.00	3.50
256Kbx8 TSOP, 5V	10.22	8.48	6.50	4.25	3.80
512Kbx8 PDIP/PLCC	11.93	9.74	6.50	5.00	3.75
512Kbx8 TSOP, 12V	12.33	10.43	7.20	5.00	3.75
512Kbx8 TSOP, 5V	14.09	10.79	8.50	6.25	5.25
1Mbx8 TSOP, 12V	17.19	14.76	12.00	9.00	6.50
1Mbx8 TSOP, 5V	19.69	14.76	12.00	9.00	6.50
2Mbx8 TSOP, 12V	36.34	26.52	17.00	12.00	9.00
2Mbx8 TSOP, 5V	38.56	28.88	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 guidelines.
Source: Dataquest (March 1996)

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)

	5K-9.99K Gates			10K-19.99K 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	40	40	38	2-3
0.6 /0.5 Micron	31	30	29	NA	NA	NA	NA
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 above prices by 30 percent to 40 percent.
Source: Dataquest (March 1996)

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 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)

	20K-29.99K Gates			30K-59.9K Gates			60K-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	52	52	52	59	59	59	80	80	80	2-7
0.8 Micron	50	50	50	57	57	57	75	75	75	2-3
0.6 /0.5 Micron	45	45	45	55	55	55	75	75	75	4-7
0.3 Micron	NA	NA	NA	NA	NA	NA	80	80	80	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 above prices by 30 percent to 40 percent.
Source: Dataquest (March 1996)

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)

	5K-9.99K Gates			10K-19.99K 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							Prototype:
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 (March 1996)

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)

	20K-29.99K Gates			30K-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	70	70	70	75	75	75	95	95	95	6-10
0.8 Micron	70	70	70	75	75	74	90	90	90	4-7
0.6 /0.5 Micron	70	70	70	85	84	77	90	90	90	5-7
0.3 Micron	NA	NA	NA	NA	NA	NA	95	95	95	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 1996)

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)	1995 Q4	1996 Q1	Q2	Q3	Q4	1996 Year	1997 Q1	Q2	Q3	Q4	1997 Year	Lead Time (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 price.

These prices are intended as guidelines.

Source: Dataquest (March 1996)

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
	> = 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 price.

These prices are intended as guidelines.

Source: Dataquest (March 1996)

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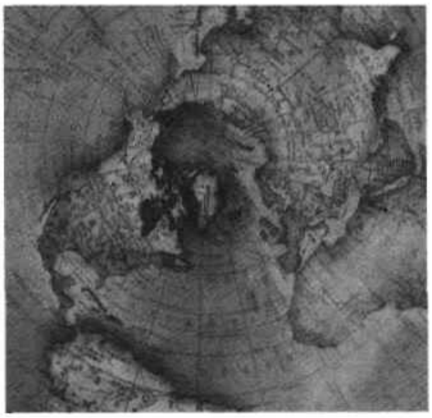

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IC Assembly Update 1996, Report 1: Commercial Aspects

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Table of Contents

Page

1. Executive Summary 1
   Definitions—The Three Groups 1
   Objective of Survey 1
   Management Summary 1
   Content 2
2. Survey Respondents' Demographics 3
   Methodology 3
   Respondents' Demographics 3
   IC Assembly Spending 5
3. Basics—IC Assembler Locations, Strategic Suppliers, and Price Negotiations 7
   Geographical Location of IC Assemblers 7
   Strategic IC Assembler Suppliers 8
   Price Negotiations 9
4. Forecasting and Lead Times: The Tie-Ins 13
   Do You or Do You Not Forecast? 13
   Lead Time Findings 15
   Forecasting and Lead Time Tie-Ins 16
5. Quality Audits 17
   Overall Findings 17
   Frequency of Quality Audits 17
      Merchant Market Sellers: How Often Customers Conduct Quality Audits 17
      Merchant Users: How Often They Conduct Quality Audits 18
      Captive Assemblers and Users: How Often They Conduct Quality Audits 18
   Will the Nos Do It in the Future? 19
6. Component Sourcing and Prototype Suppliers 21
   Component Sourcing Practices 21
      Component Sourcing Practices of Merchant Market Sellers 21
      Component Sourcing Practices of Merchant Market Users 22
      Component Sourcing Practices of the Captive Group 22
   Prototype IC Assemblers 23
   Is Proximity a Factor? 24
7. How Important Are the Issues, and How Satisfied Are the Respondents? 27
   Importance Levels on Key Components: Overall Findings 27
   Quality Takes Priority Hands Down 27
   Top Eight Importance Criteria 28
      Merchant Market Sellers 28
      Merchant Market Users 29
      Captive Assemblers and Users 30
   Importance Analysis 30

Table of Contents (Continued)

Page

Importance versus Satisfaction 31
Merchant Market Sellers 31
Merchant Market Users 32
Captive Assemblers and Users 33
Importance versus Satisfaction Comparisons 33
8. Conclusions and Analysis 37

List of Figures

Figure		Page
2-1	Company Revenue Size Range among Survey Respondents	4
2-2	Number of Employees per Company	4
2-3	The Three Groups Surveyed	5
2-4	Spending on IC Assembly	6
3-1	Geographical Location of Assembly Houses	8
3-2	Number of Strategic Suppliers	9
3-3	Regularity of Price Negotiations	10
3-4	Frequency of Price Negotiations	11
4-1	Respondents Forecasting Long Term to Book Up Capacity	13
4-2	Length of Forecast	14
4-3	Average Lead Time for IC Assembly	15
5-1	Merchant Market Sellers—How Often Customers Conduct Quality Audits	18
5-2	Merchant Market Buyers—How Often They Conduct Quality Audits of Their IC Assemblers	19
5-3	Captive Assemblers and Users: How Often They Conduct Quality Audits	20
6-1	Component Sourcing Practices of Merchant Market Sellers	21
6-2	Component Sourcing Practices of Merchant Market Users	22
6-3	Component Sourcing Practices of Captive Assemblers and Users	23
6-4	Use of Different Prototype IC Assemblers	24
6-5	Importance of Proximity of the Prototype Vendor	25
7-1	Mean Score for Importance Ranking on Key Purchasing Criteria	28
7-2	Importance versus Satisfaction Ratings for the Merchant Market Sellers	32
7-3	Importance versus Satisfaction Ratings for the Merchant Market Users	33
7-4	Importance versus Satisfaction Ratings for Captive Assemblers and Users	34

List of Tables

Table		Page
1-1	Satisfaction Levels for Merchant Suppliers and Buyers	2
4-1	Plans of Those Who Do Not Now Forecast	15
4-2	Forecasting and Lead Time Tie-Ins	16
5-1	Percentage of Respondents Who Conduct Quality Audits	17
5-2	Plans of Those Who Do Not Currently Conduct Quality Audits	20
7-1	Top Eight Importance Criteria for Merchant Market Assemblers	29
7-2	Top Eight Importance Criteria for Merchant Market Users	29
7-3	Top Eight Importance Criteria for Captive Assemblers and Users	30
7-4	Difference between Importance and Satisfaction for the Merchant Market Groups	35

Chapter 1
Executive Summary

Definitions—The Three Groups

Dataquest identified three distinct categories within the realm of IC assemblers. These three groups were:

- Merchant market IC assemblers: This group is the traditional IC assembly supplier. For the purpose of this survey, this group is known as the merchant market seller group.
- Merchant market buyers: This group buys and uses IC assemblies made externally by the merchant market sellers. Throughout this survey, this category of external buyers will be referred to as the merchant market users group.
- Captive assemblers and users: This group covers companies that made and used IC assemblies. The IC assembly can be made and used within the same location/facility or by two divisions. This group does not source IC assemblies externally, nor does it sell IC assemblies externally.

This aim of this report was to get 50 percent of the responses from the merchant market and 50 percent from the captive market.

Objective of Survey

For this Focus Report, Dataquest surveyed users and suppliers of IC assembling. The survey covers commercial issue trends, importance and satisfaction ratings, and packaging technology and printed circuit board (PCB) trends. For ease of use, the survey has been split into two separate reports. Report 1 deals with commercial issues and trends. Report 2 focuses more on packaging and PCB trends.

Management Summary

Dataquest has just completed a study on the IC assembly market, surveying both merchant and captive suppliers and buyers in North America. The respondents surveyed were responsible for combined IC spending of over $1.6 billion on IC assembly.

This report covers commercial aspects within this segment, with a particular focus on the respondents' views on the importance of certain characteristics and relative satisfaction. The merchant buyers and the captive group both rated what was important to them, while the merchant IC assemblers (suppliers) ranked what they thought was most important for their customers. The key finding is that quality is king. Quality was No. 1 for all three groups—yet it was also the criteria with which most merchant buyers surveyed were most dissatisfied. Test and assembly featured in the top three of importance for all groups.

Much discussion surrounds the importance of actual assembly cost (read price). The merchant IC assemblers ranked it second, while the merchant buyers listed it fourth and the captive group sixth. Clearly, the buyer and captive groups in this sample concern themselves with the total cost of ownership rather than pure buying price. This reflects the relative sophistication of the responding companies.

Table 1-1 shows four of the importance versus satisfaction criteria for the merchant buyers of IC assemblies surveyed. Merchant buyers rated their suppliers, while suppliers speculated on how satisfied their customers are with their actual performance. With effective communication, the expectation is that the satisfaction levels should be similar. However, this is not the case. Clearly, the suppliers in their self-critique rank their performance higher than their customers do.

Table 1-1
Satisfaction Levels for Merchant Suppliers and Buyers (Percent)

Criteria	Merchant Suppliers	Merchant Buyers
Quality	73.8	57.5
Test and Assembly	69.7	55.2
Lead Time	65.5	56.1
Cost	66.7	53.9

Source: Dataquest (October 1996)

Other areas covered in detail are quality audits, forecasting, lead time, prototype IC vendors, component sourcing trends, price negotiation, and strategic suppliers.

Chapter Content

This report is broken into eight parts. Chapters 1 and 2 highlight the scope of the report, demographics and methodology used, and groups identified and summarizes the overall findings. Chapter 3 deals with the geographical locations of IC assemblers of all groups, with price negotiation trends within the merchant market only, and with strategic suppliers for merchant users. Chapter 4 covers the findings on lead time and forecasting trends, and Chapter 5 deals with quality audits. The topics of prototype vendors and component sourcing trends are dealt with in Chapter 6. Chapter 7 deals with the whole area of importance and satisfaction of each surveyed group on selected criteria. The report concludes with an analysis of the findings, in Chapter 8.

Chapter 2
Survey Respondents' Demographics

Methodology

The survey questionnaire was developed by Dataquest's Semiconductor Supply and Pricing Worldwide program, and it comprised a total of 115 questions. Trained interviewers at Dataquest's field interviewing facility in San Jose, California, conducted the survey in October 1996 by telephone. The sample list was obtained from CorpTech. Using the CorpTech database, Dataquest targeted the manufacturers of the following types of electronic devices for inclusion in this survey: voice and data communications, data processing or computers, office electronics, consumer electronics, industrial electronics, medical devices, transportation or aerospace equipment, and military/defense electronics. To qualify, the respondent company had to do at least one of the following activities: assemble boards for use by companies that manufactured electronic devices, manufacture electronic devices using boards obtained primarily from external assemblers, or manufacture electronic devices using boards obtained primarily from internal or in-house assemblers. The respondent had to be knowledgeable about the board assembly practices within this company.

A total of over 1,200 calls was made, of which 100 were completed—a hit rate of 8.3 percent.

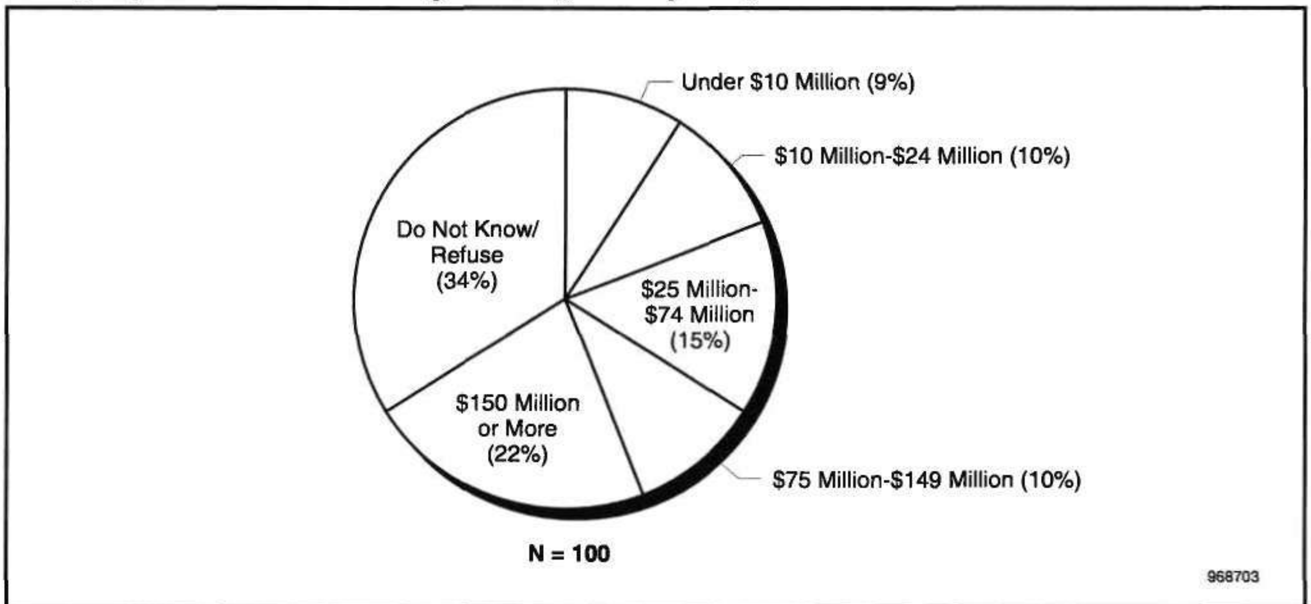
Once Dataquest's field interviewing staff had completed its work, the information was passed to the Semiconductor Supply and Pricing Worldwide program, where the analysis of the data was conducted.

Respondents' Demographics

Figure 2-1 shows company revenue of the respondents for 1996. There is quite a range of revenue among the survey participants. Nineteen percent of respondents had a revenue forecast for 1996 of less than $25 million, while one-quarter of respondents had a revenue forecast between $25 million and $74 million. Twenty-two percent of respondents had forecast revenue above $75 million. One point, though, is that 34 percent of respondents either refused to release or did not know their companies' revenue.

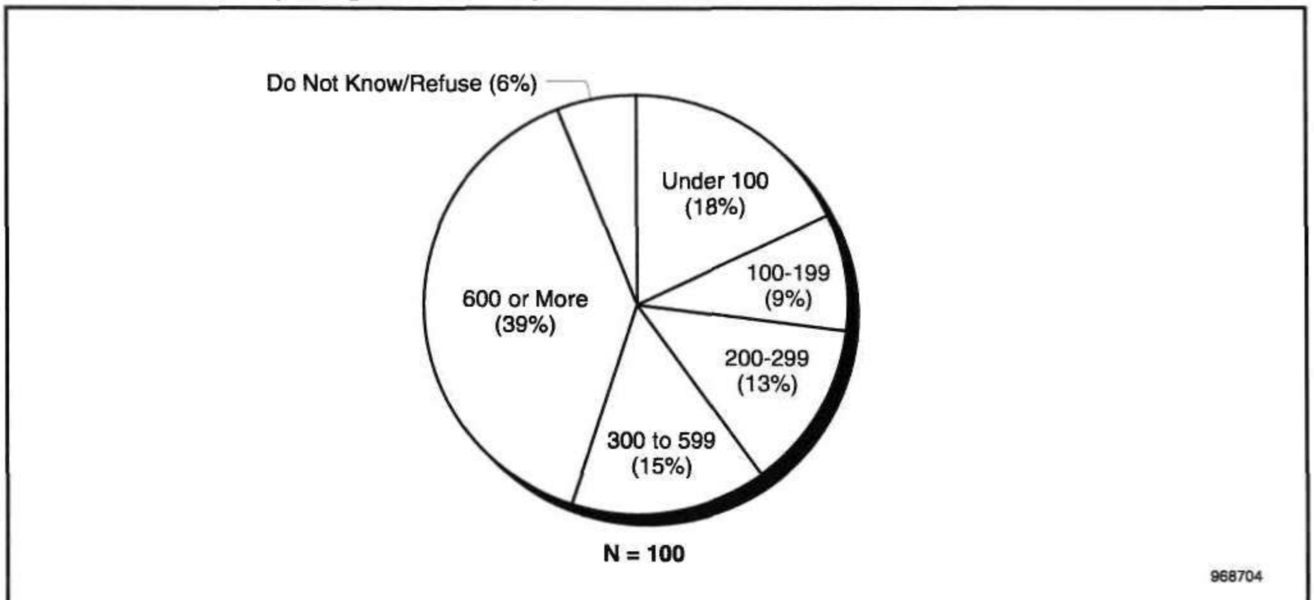
The group was fairly mixed in company size. Half of the respondents were from companies with fewer than 500 people and half from larger organizations. Figure 2-2 shows the overall split of respondents by number of employees at the time of the survey. The merchant assemblers surveyed were, on average, smaller in size than the other two groups—68 percent were companies with fewer than 400 employees. Well over 50 percent of the external buyers and 67 percent of the captive group had more than 400 employees.

Figure 2-1
Company Revenue Size Range among Survey Respondents



Source: Dataquest (October 1996)

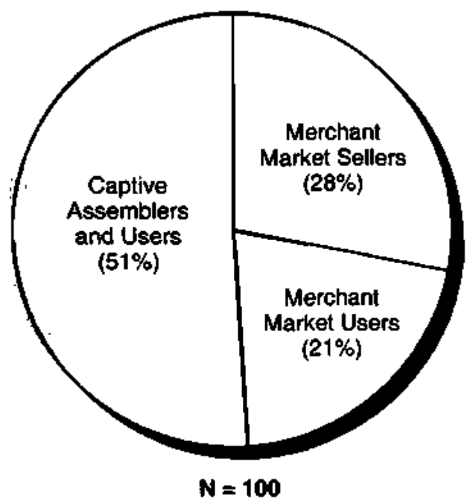
Figure 2-2
Number of Employees per Company



Source: Dataquest (October 1996)

We came very close to the original aim of the report, which was to have 50 percent of the respondents from the merchant market and 50 percent from the captive market. Figure 2-3 shows the actual split by market type: 49 percent of respondents were from the merchant community—split between IC assemblers and buyers/users and 51 percent were from the captive community—companies that make IC assemblies for their own consumption.

Figure 2-3
The Three Groups Surveyed

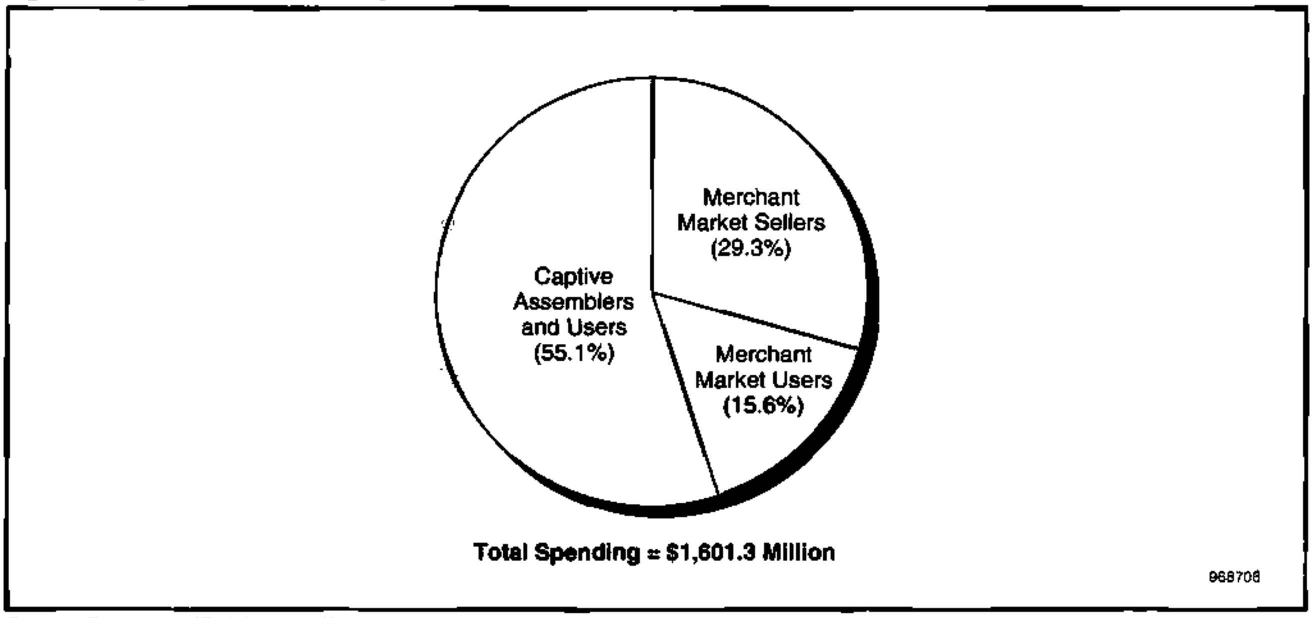


Source: Dataquest (October 1996)

IC Assembly Spending

Figure 2-4 shows spending on IC assembly by the respondents for 1996. As shown, the respondents who participated in the survey have combined IC assembly spending in excess of $1.6 billion. The figure shows the respondents split into three groups. The captive group represented 51 percent, merchant sellers, 28 percent, and merchant users, 21 percent. Thus, not surprisingly, the captive group was the largest IC assembly spender of the three groups—this group accounted for 55.1 percent of the total survey spending. Next in size was the merchant sellers, at 29.3 percent of the total spending. The merchant buyers made up the rest.

Figure 2-4
Spending on IC Assembly



Source: Dataquest (October 1996)

Chapter 3

Basics—IC Assembler Locations, Strategic Suppliers, and Price Negotiations

First, for all three categories, IC assembly locations were determined. This was to see where our respondents did business. Next, information on price negotiations and strategic suppliers was elicited. However, these questions were confined to the merchant market users (that is, buyers) only, for obvious reasons.

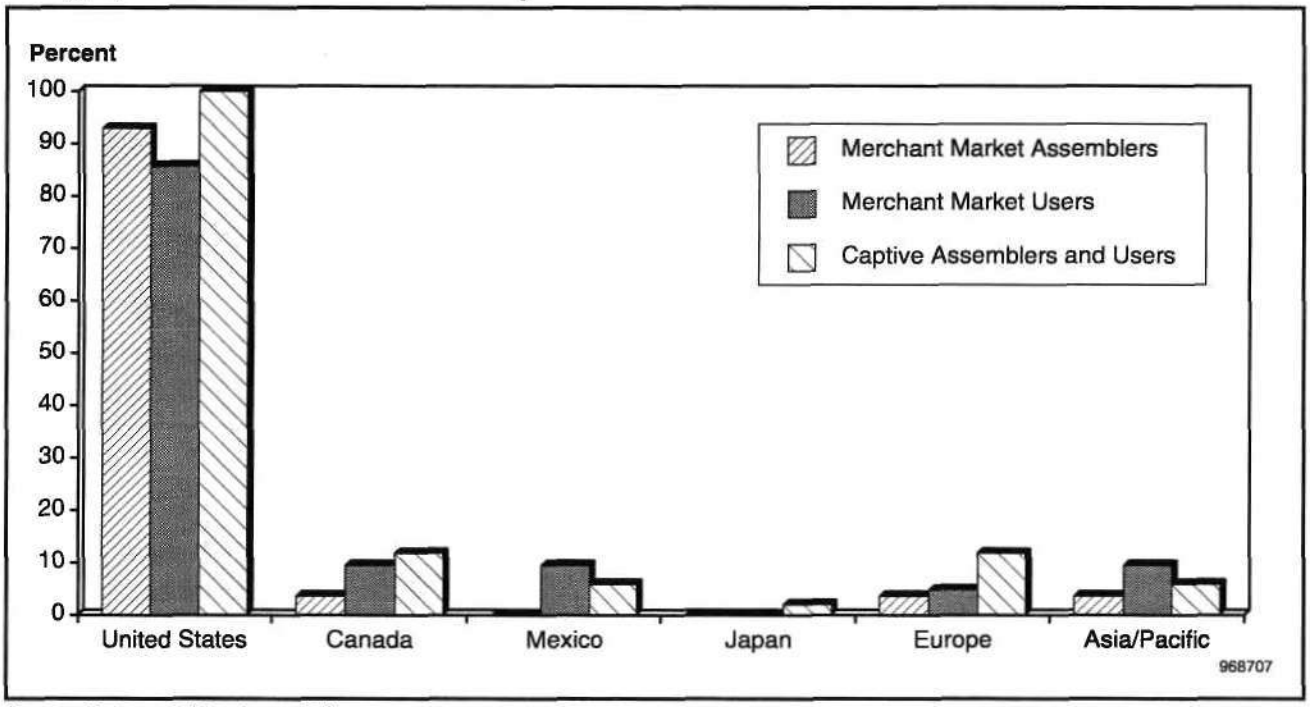
Geographical Location of IC Assemblers

Figure 3-1 shows the geographical split of assembly locations. For the merchant market assemblers, it indicates where their assembly houses are located. For the merchant market users, it shows where their IC assemblers are located geographically. The captive segment shows where their own companies or sister companies assemble.

For the merchant market assemblers, 92.9 percent had assembly facilities in the United States. Other countries or regions used were Canada, Mexico, and Asia/Pacific. In the Asia/Pacific region, one assembler had operations in both Korea and the Philippines. With the merchant market users group, again the United States was where the majority of their IC assembly suppliers were located—85.7 percent. A higher percentage, however, had IC assemblers located outside the United States. Canada, Mexico, and the Asia/Pacific region all scored a 9.5 percent affirmative response. Europe's percentage of affirmative responses was 4.8. In the Asia/Pacific region, the countries used were China and Singapore. The captive assemblers and users all had assembly operations in the United States. After the United States came Canada and Europe, both scoring 11.8 percent, with Mexico and Asia/Pacific receiving 5.9 percent and Japan 2 percent.

As all survey participants are located in the United States, it is not surprising that the majority of respondents have business in the United States. Canada's appearance as the second most popular location also is not surprising. The language is common, the labor force is skilled, and it is a country that uses many assemblers. Europe and Mexico are other popular locations, which, given the business sectors our respondents are involved in, is normal. Mexico offers cheaper labor costs than either the United States or Canada and enjoys favorable business relations with the United States. It is becoming a more popular location for overseas investors also. Europe features in all three categories. These affirmative replies came from the largest (by revenue) respondents with a presence in markets outside the United States. What is interesting is the spread of countries seen in the Asia/Pacific region—Korea, the Philippines, China, and Singapore.

Figure 3-1
Geographical Location of Assembly Houses



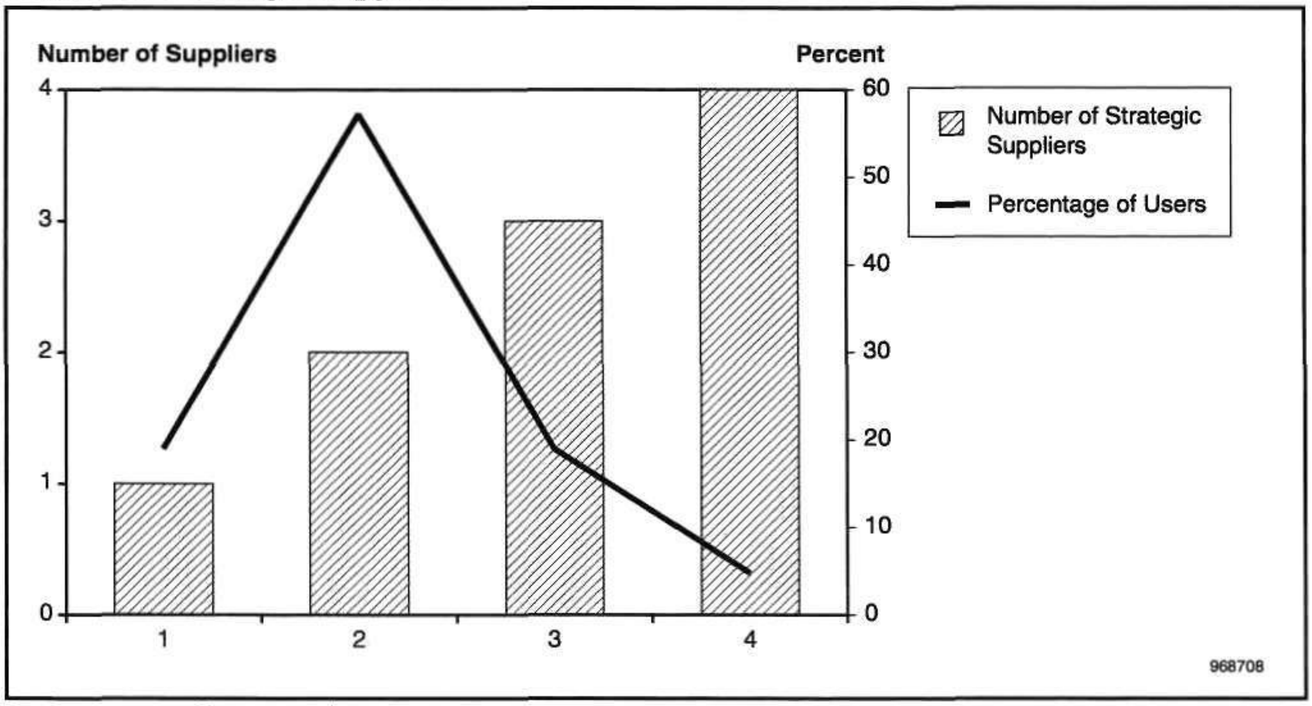
Source: Dataquest (October 1996)

Strategic IC Assembler Suppliers

The merchant market users group was next asked about strategic IC assembly suppliers. Every member of the group had defined strategic suppliers for IC assembly. Figure 3-2 shows the percentage split of respondents on the number of strategic suppliers each had: 57.2 percent of respondents had two strategic IC assemblers; 19 percent had one or three strategic IC assemblers; and only 4.8 percent claimed four strategic IC assemblers.

It is not surprising that two is the most popular choice for strategic IC assemblers among the users. Most buyers feel that a second-source supplier is vital as a contingency plan—the old proverb of putting all one's eggs in one basket is a risk buyers are loath to take. Two suppliers on the go minimize the element of risk. Also, given the degree of trust and closeness of the relationship between assembler and buyers, the majority of buyers would find it difficult to build and maintain such a partnership approach with three or more vendors at a given time.

Figure 3-2
Number of Strategic Suppliers



Source: Dataquest (October 1996)

Price Negotiations

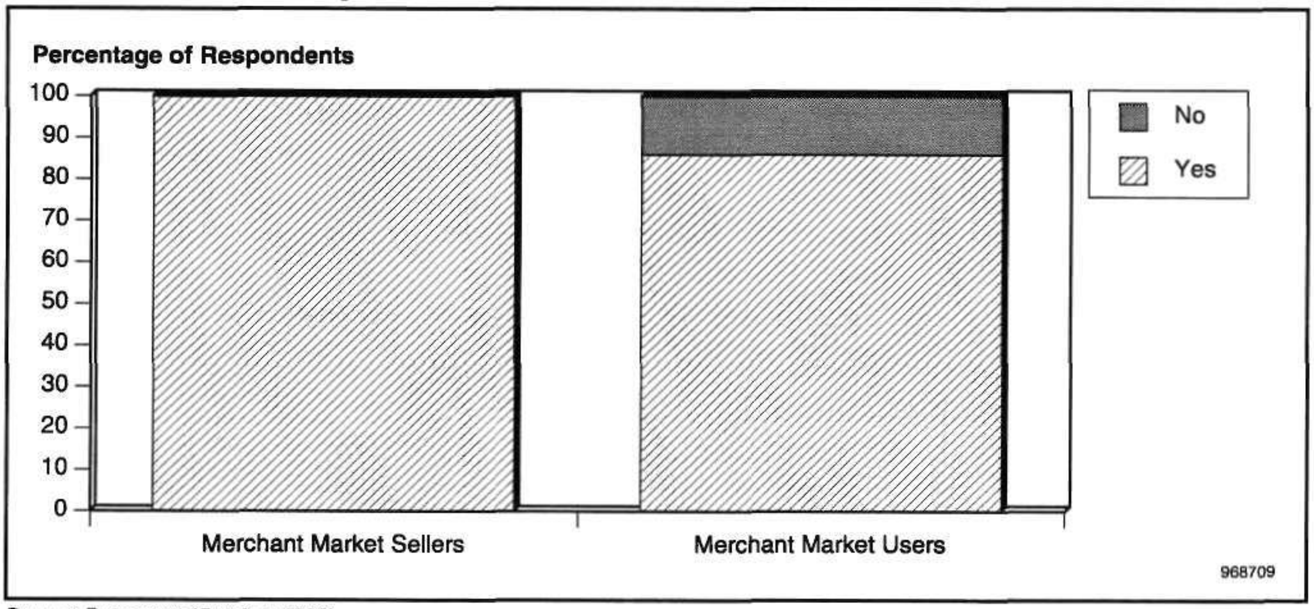
Price negotiation is an important part of doing business. For the purposes of this survey, this set of questions was asked of the merchant market players only.

The respondents were asked if they conduct regular price negotiations. Figure 3-3 shows the response. Not surprisingly, 100 percent of the assembler community regularly negotiates price with customers, no doubt at the customer's insistence! However, although the majority of the user community does conduct regular price negotiations with IC assemblers, 14.3 percent does not.

Of those who do conduct regular price negotiations, the frequency of the negotiations was established. As seen in Figure 3-4, the range of frequency is large. The method of negotiation is tied either to the calendar year or to the project.

Of the suppliers (merchant market assemblers), over 46 percent negotiate price per project. This compares with 27.8 percent of the buyers (merchant market buyers). Of the buyers, 22.2 percent negotiate price quarterly (that is, four times a year). Only 14.3 percent of suppliers do. Twice a year negotiations are conducted by about 11 percent of buyers but by 3.6 percent of suppliers. Over 21 percent of suppliers conduct annual price negotiations, with only 5.6 percent of buyers adopting this method.

Figure 3-3
Regularity of Price Negotiations

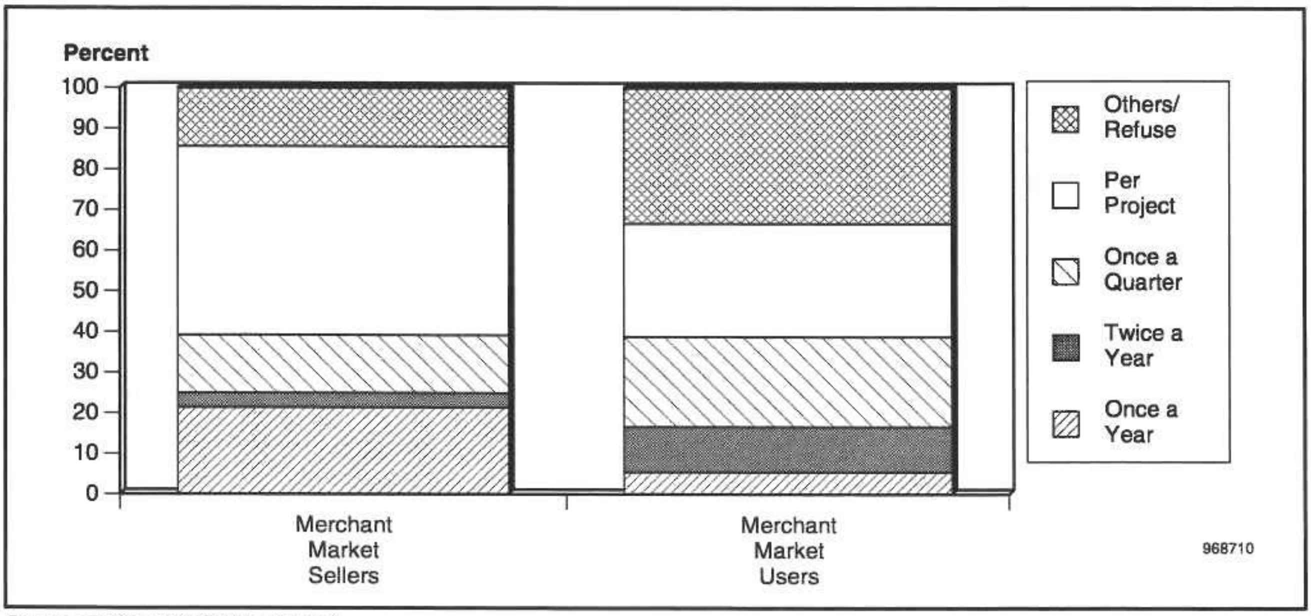


Source: Dataquest (October 1996)

Dataquest also asked if price negotiation frequency would change next year. The majority of buyers and suppliers said that it would remain the same—66.7 percent and 64.3 percent, respectively.

The variation in negotiation methods is not unusual between the buyer and supplier communities surveyed. What is unusual is that some buyers still do not conduct such a fundamental business practice regularly with their suppliers. Price negotiation is a major factor in managing a buyer's total cost of ownership and should be conducted regularly. The frequency of negotiation is tied to company culture and standard buying practices. However, I would recommend that pricing be reviewed with suppliers once a quarter. Often the per-project method is linked to a bid or set of work for which the IC assembly is being used. Although this is effective, it can be quite short term. Price negotiations should also leverage the total volume of all projects in a period. Individual pricing can then be set on a per-project basis, to be reviewed in line with other work. Savings made on the IC assembly front can be used to improve profitability or decrease the price of the bid. Regular price review sessions can also be used as a forum for discussion on forecast, lead time, inventory holding, and quality issues.

Figure 3-4
Frequency of Price Negotiations



Source: Dataquest (October 1996)

Chapter 4

Forecasting and Lead Times: The Tie-Ins

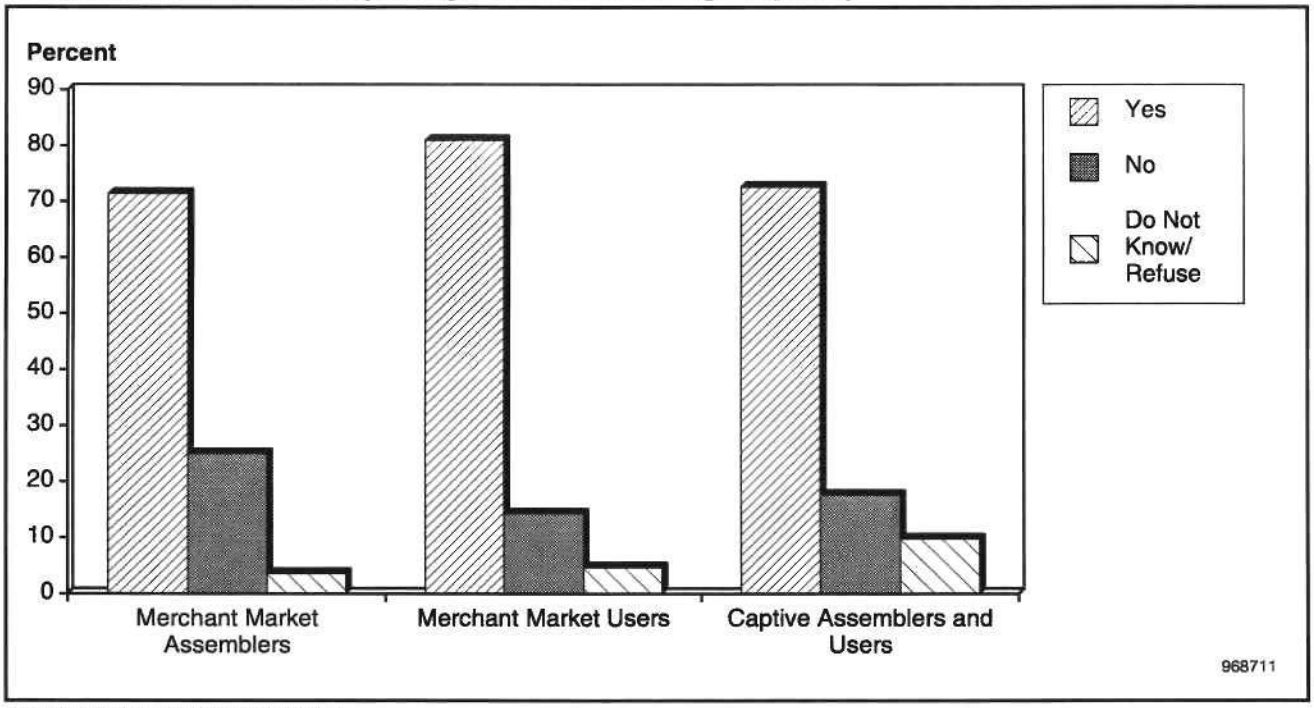
Dataquest wished to survey the forecasting practices of the respondents. This section was answered by the three groups—the two merchant markets and the captives. Dataquest sought to determine what percentage of respondents give a forecast of future demand to their suppliers and how far out most such forecasts went. The plans of those that do not forecast were also of interest to Dataquest. Next, average lead times were determined to see if any trend was apparent.

Do You or Do You Not Forecast?

Dataquest asked the respondents whether they forecast long term in order to secure assembly capacity. Over 70 percent of respondents in each group forecasts. Captive assemblers and users and merchant users forecast with their IC assemblers, while merchant sellers demand and get forecasts from their customers. Figure 4-1 illustrates the responses.

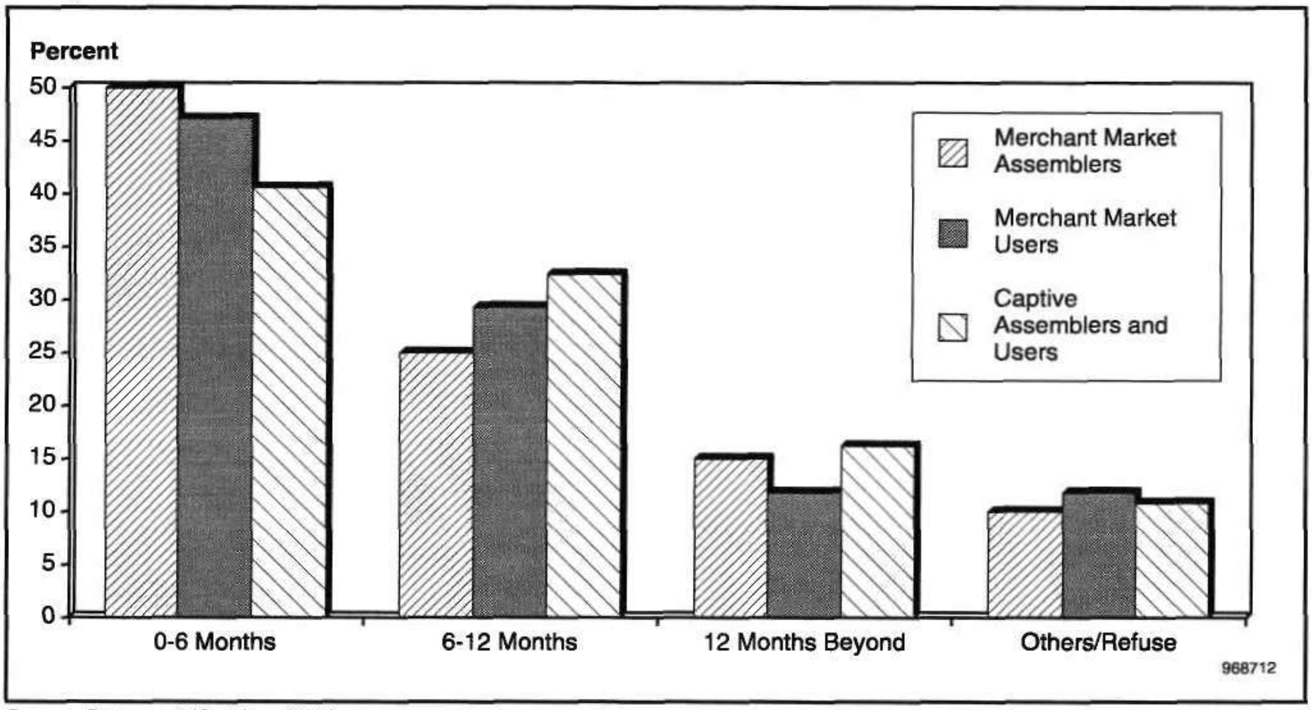
Of those respondents who forecast, Dataquest proceeded to determine the length of forecast. Figure 4-2 shows the range of replies. A zero-to-six-month forecast was the most popular response from all three groups. This was followed by a six-to-12-month forecast range, again by all three groups. The 12-month-and-beyond forecast segment was the least popular in all three groups. This is a reflection on current market conditions. However, if capacity became more constrained, then forecast lengths would also increase to secure allocation.

Figure 4-1
Respondents Forecasting Long Term to Book Up Capacity



Source: Dataquest (October 1996)

Figure 4-2
Length of Forecast



Source: Dataquest (October 1996)

The people who currently do not forecast were asked if they planned to do so by the end of 1997. Table 4-1 illustrates the responses. The majority of those surveyed answered no—they do not plan to forecast by the end of 1997. This was true of all three groups, with stronger or weaker negative replies given.

Forecasting is an important commercial aspect and one that the majority of survey participants do. It indicated that the buyers are aware of what their future demand will be and can plan ahead accordingly. By passing the information on to their IC assemblers, they can ensure that capacity can be provisionally reserved for their needs. This generally reduces their actual lead times for assembly turnaround. An added benefit is in price negotiations. Knowledge of future volumes and business projections is an important lever in price negotiation. An interesting statistic among the merchant users is that the three respondents who do not negotiate price regularly are the same three who do not forecast. Within the captive group, forecasting of future requirement is seen as unnecessary by nearly 18 percent. This subset may hold the view that, as the work is done internally, there is no reason to bother with forecasting—a rather old-fashioned view that does not make for good business practice. With the majority of nonforecasters having no plans to change in the near future, problems may occur should the market become constrained. Their medium-term goal should definitely be to establish a forecasting methodology and to implement it as a priority.

Table 4-1
Plans of Those Who Do Not Now Forecast

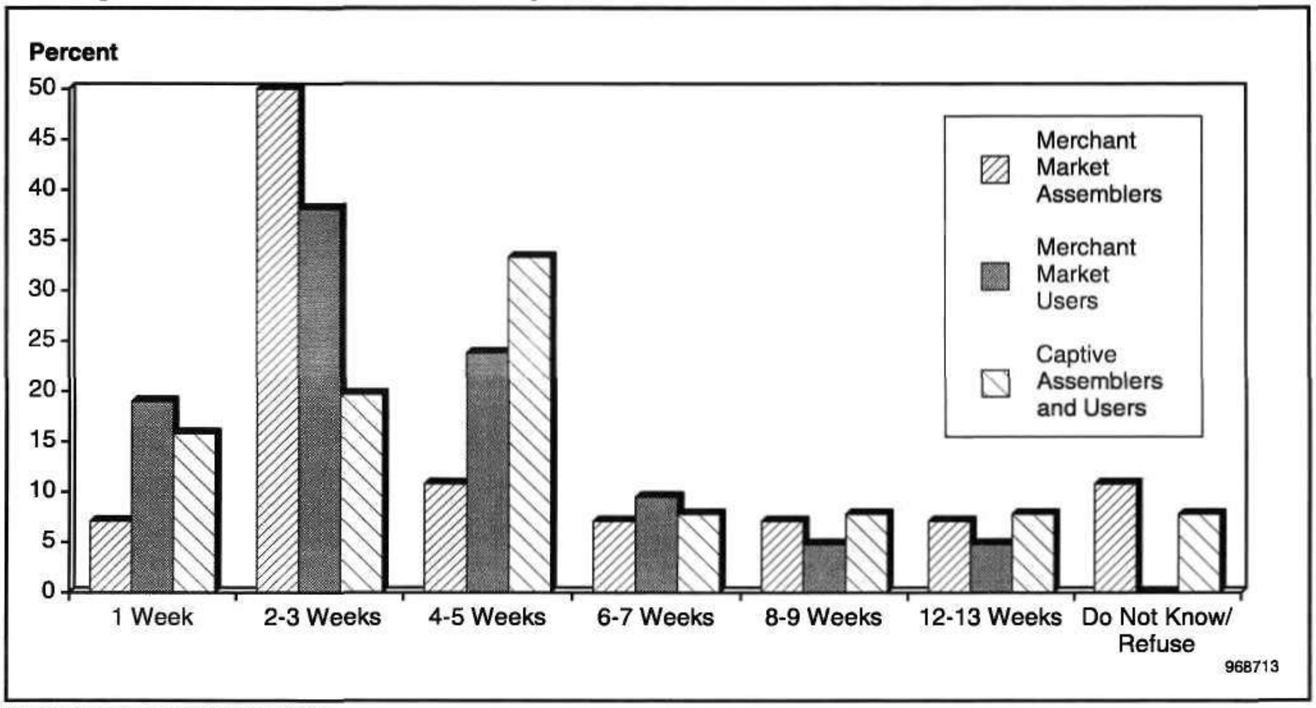
	Merchant Market Assemblers	Merchant Market Users	Captive Assemblers and Users
Do Not Plan to Forecast by the End of 1997	71.4	66.7	44.5
Plan to Forecast by the End of 1997	28.6	0	33.3
Do Not Know/Refuse	0	33.3	22.2

Source: Dataquest (October 1996)

Lead Time Findings

Figure 4-3 shows the average lead time for IC assembly work, as determined by our three groups. The vast majority of respondents worked with average lead times of less than five weeks—nearly 68 percent of merchant market sellers, about 81 percent of merchant market users, and 69 percent of captive assemblers and suppliers. In the merchant market arena, two to three weeks was the average lead time reported by most respondents—38.1 percent of users and 50 percent of sellers. However, for the captive area, the most common lead time was four to five weeks—33.3 percent.

Figure 4-3
Average Lead Time for IC Assembly



Source: Dataquest (October 1996)

Forecasting and Lead Time Tie-Ins

It was seen from Figure 4-3 that the majority of respondents from all groups enjoyed lead times of less than five weeks—these are impressively low lead times and are a reflection of current market conditions. This also ties in with the high rate of forecasting done by the three groups. Forecasting long term helps reduce order lead times. Table 4-2 compares forecasting rates with lead times of under five weeks for each group.

Table 4-2
Forecasting and Lead Time Tie-Ins (Percent)

	Merchant Market Sellers	Merchant Market Users	Captive Assemblers and Users
Percentage Who Forecast	71.4	81.0	72.6
Percentage with Lead Times of 0-5 Weeks	67.9	80.9	68.8
Percentage Who Do Not Forecast or Do Not Know/Refuse	28.6	19.0	27.4
Percentage with Lead Times over 5 Weeks or Do Not Know/Refuse	32.1	19.1	31.2

Source: Dataquest (October 1996)

The percentage rates of those who forecast and those who enjoy lead times of less than five weeks are approximately the same. This holds for all three groups surveyed.

Those who take the time to understand their future business requirements and volumes and pass this information on to their suppliers gain real benefits in terms of lower lead times. This should be an example of how closely both track each other and how forecasting can be used to leverage lead time reductions.

Chapter 5
Quality Audits

This category was designed to examine the importance of quality for IC assemblers. Quality audits are a means of assessing the working practices of the assembler and of determining the fallout rate or defect rate of the finished product.

Overall Findings

Table 5-1 shows the percentage of respondents who conduct quality audits at their IC assemblers. For IC assemblers, it measures how often, on average, quality audits are conducted by their customers.

Table 5-1
Percentage of Respondents Who Conduct Quality Audits

	Merchant Market Seller	Merchant Market Users	Captive Assemblers and Users
Conduct Quality Audits	82.1	95.2	80.4
Do Not Conduct Quality Audits	14.3	4.8	17.6
Do Not Know or Refuse	3.6	0	2.0

Source: Dataquest (October 1996)

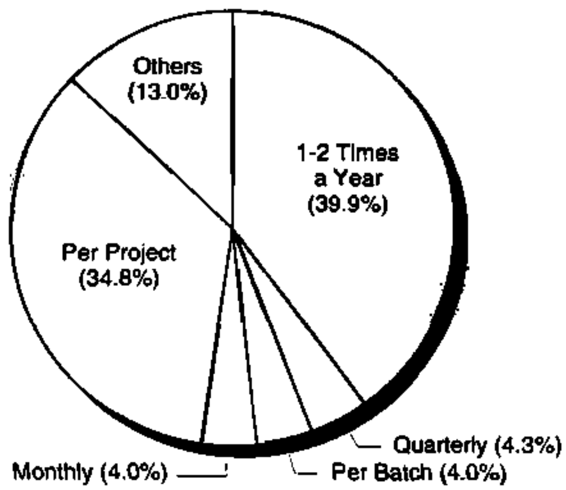
Across the board, well over 80 percent of respondents regularly conduct quality audits. Not surprisingly, the merchant market buyers (users) are the strongest in affirmative responses—over 95 percent surveyed regularly conduct quality audits at their IC assemblers.

Frequency of Quality Audits

Merchant Market Sellers: How Often Customers Conduct Quality Audits

The frequency at which the merchant sellers' customers conduct quality audits is shown in Figure 5-1. Among the merchant sellers/IC assemblers, customers on average conduct quality audits once or twice a year (about 40 percent) or on a per-project basis (about 35 percent). Quarterly quality audits are conducted only by 4.3 percent of their customers. Only 4 percent of customers conduct audits every month and 4 percent audit per batch; 13 percent of IC assemblers gave other frequencies. This means that their customers conduct random quality audits at no set interval—their customers swoop down on the assemblers' locations without warning and check out working practices and finished goods, rather like a Special Forces raid. The fact that 40 percent, on average, of customers do one or two quality audits a year means that the customers/buyers are relatively satisfied with the level of quality in the suppliers' factories. Also, the fact that 35 percent of customers, on average, conduct a quality audit on a per-project basis would again indicate a high confidence level in the overall quality of the suppliers.

Figure 5-1
Merchant Market Sellers—How Often Customers Conduct Quality Audits



Source: Dataquest (October 1996)

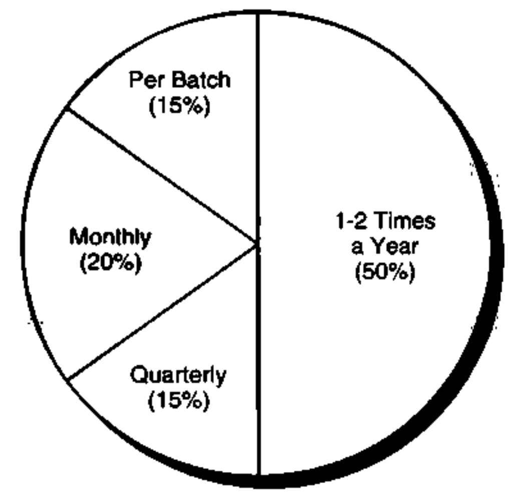
Merchant Users: How Often They Conduct Quality Audits

Figure 5-2 shows how often the merchant users/buyers conduct quality audits at their suppliers. Among the merchant market buyer community, the favored quality audit frequency rate was once or twice a year. On average, 50 percent of respondents conduct quality audits at this frequency rate at their IC assembly supplier. The second most popular frequency rate was monthly—20 percent. Tying for third were quarterly audits and per-batch audits—each received 15 percent. It is somewhat surprising that 20 percent of respondents conduct audits as often as once a month at their IC assemblers. It does, however, illustrate that there are issues with quality that are being closely monitored. It would also indicate that these companies would have dedicated quality audit individuals whose responsibility it is to ensure that regular audits occur. That per-batch quality audits are conducted by 15 percent of the respondents again is surprisingly high. This means that for every finished batch of IC assemblies at their suppliers, the buying company conducts a quality audit. Again, this would indicate a dedicated quality audit department. It may also mean that once the assemblies reach the buying company, they may not be inspected and that their quality is essential to minimize costly scrapping of defective finished products in which they are used.

Captive Assemblers and Users: How Often They Conduct Quality Audits

For the captive group, the frequency of quality audits is shown in Figure 5-3. Here the three most popular choices for frequency of quality audits are once or twice a year (26.8 percent), per project (26.8 percent), and quarterly (24.5 percent).

Figure 5-2
Merchant Market Buyers—How Often They Conduct Quality Audits of Their IC Assemblers



Source: Dataquest (October 1996)

These three categories would indicate how organized quality audits are internally, how important they are to business, and how satisfied the auditors are with what is found. The organized nature of the audits is indicated by the scheduled approach and by the regularity with which audits are conducted. The importance to overall business is seen by the fact that the buyers' internal divisions conduct the quality audit at their internal assembler—they do not rely on the word of or audit conducted by a sister division. Their overall satisfaction can be noted in that the frequency has not gone up to once a month or per batch, as was seen in the merchant market buyers. Thus, there is a good deal of trust between the internal buying and manufacturing divisions.

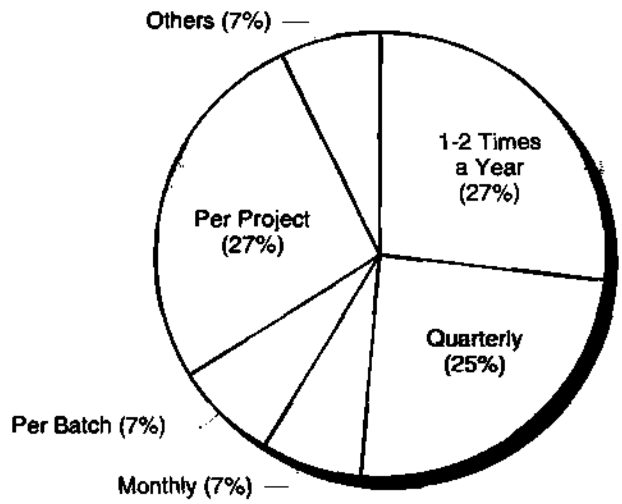
The other categories were like a list of "also rans"—monthly audits, 7.3 percent, per batch, 7.3 percent, and others (random), 7.3 percent.

Will the Nos Do It in the Future?

Of those who do not currently conduct quality audits, the majority have no plans to start them in the future. From Table 5-1 it could be seen that only a minority of those surveyed do not carry out regular quality audits: merchant market sellers, 14.3 percent, merchant market users, 4.3 percent, and captive assemblers and users, 17.6 percent.

The highest rate of negative responses came from the captive respondents. Perhaps they feel that the business always goes to the same group because they are internal, so why bother checking quality. Or is it that they fear the political fallout that comes from rocking the boat or challenging manufacturing, which is often the king within a company? Either way, they need to wake up. This is a free market, not a dictatorship. Just because an internal

Figure 5-3
Captive Assemblers and Users: How Often They Conduct Quality Audits



Source: Dataquest (October 1996)

division always got the business does not mean that it will always get it in the future or that it will exist a few years down the road. There are many ex-divisions of large companies that attest to this trend. The same degree of professionalism and supplier management should be employed for external *and* internal vendors.

Table 5-2 illustrates the plans of these negative respondents. The vast majority have no plans to implement quality audits in the future. Either their suppliers walk on water from a quality point of view or ignorance is bliss. Either way, the buyer and the supplier are both losing out, as quantifying quality through regular audits is essential to professional business practices. Mistakes made throughout the process are passed straight on to external customers if not picked up. The market is tough and unforgiving—if you have bad name for quality, there are many other companies with a good name only too eager to pick up your business. We will see in Chapter 7's importance versus satisfaction section how important test and assembly and quality are to all three groups.

Table 5-2
Plans of Those Who Do Not Currently Conduct Quality Audits (Percent)

	Merchant Market Sellers	Merchant Market Users	Captive Assemblers and Users
Plan to Conduct Quality Audits	25.0	0	0
Do Not Plan to Conduct Quality Audits	50.0	100.0	88.9
Do Not Know or Refuse	25.0	0	11.1

Source: Dataquest (October 1996)

Chapter 6
Component Sourcing and Prototype Suppliers

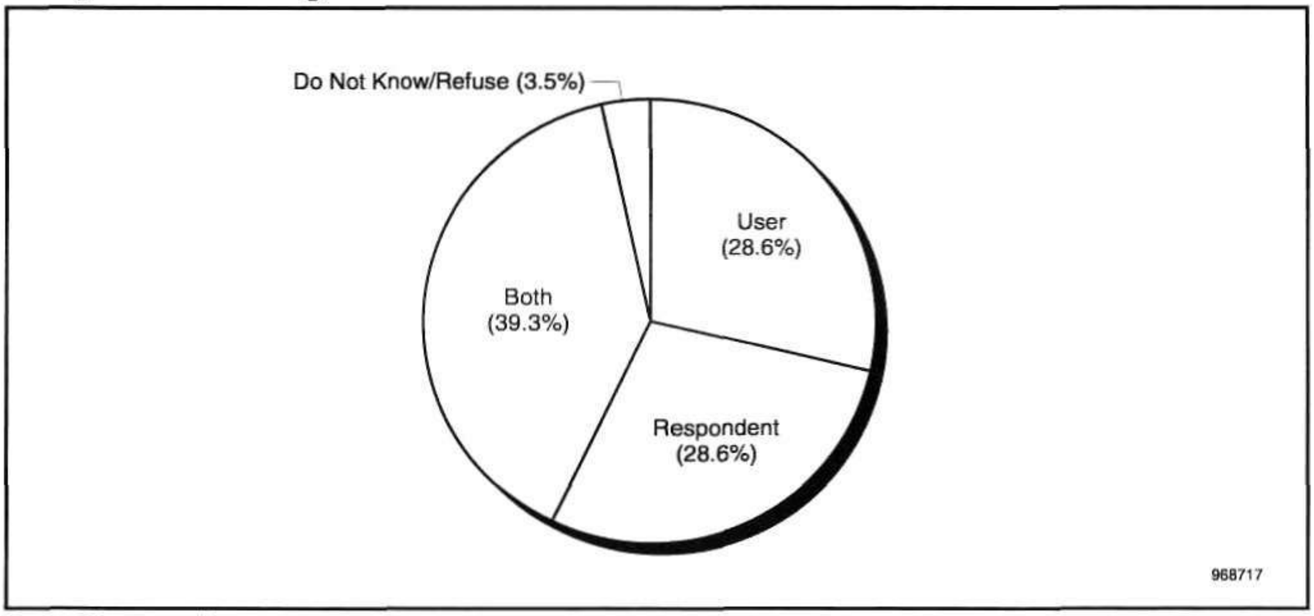
Component sourcing decisions are commonly faced by suppliers and buyers alike, both in the merchant and captive arena. Should the IC assembler buy the components? Can a buyer trust some other group, either internal or external, to serve its needs? Is it a time-saving benefit, or are the inventory obsolescence risks too high? Who sources our respondents' components? This is what Dataquest sought to establish.

Component Sourcing Practices

Component Sourcing Practices of Merchant Market Sellers

The results for component sourcing for the merchant market sellers group are shown in Figure 6-1. This group shows the practices of their customers—the merchant buyers. Most respondents in the merchant sellers group jointly sourced components—that is, the sellers and their customers, the buyers, both shared procurement responsibilities. The split between the respondent (who here is the supplier/IC assembler) and the customer (in this case, the buyer) was determined, by and large, by component type.

Figure 6-1
Component Sourcing Practices of Merchant Market Sellers

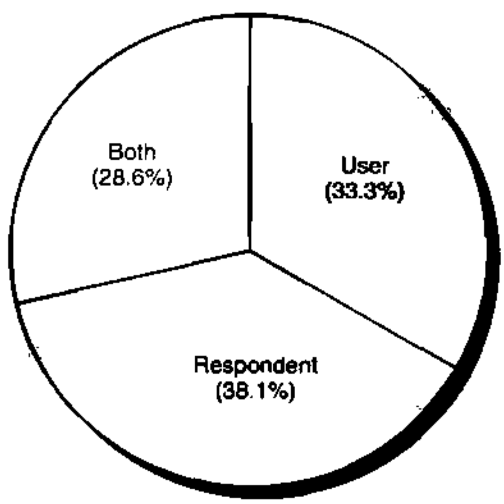


Source: Dataquest (October 1996)

Component Sourcing Practices of Merchant Market Users

The majority of this group sources all the components themselves. This is not surprising when one considers that this is purely a buyers group. However, over 33 percent of buyers give full component sourcing responsibility to their IC assembler suppliers (see Figure 6-2). This indicates the degree of trust between the buyer and supplier. It also may show that the buyer finds it a better use of time to pass the responsibility on to an assembler. Also, the assembler may obtain better component pricing if it buys on behalf of many of its customers and leverages the total volumes. However, for this component sourcing to be successful for the buying community, due care must be taken of obsolescence risk and inventory holdings.

Figure 6-2
Component Sourcing Practices of Merchant Market Users

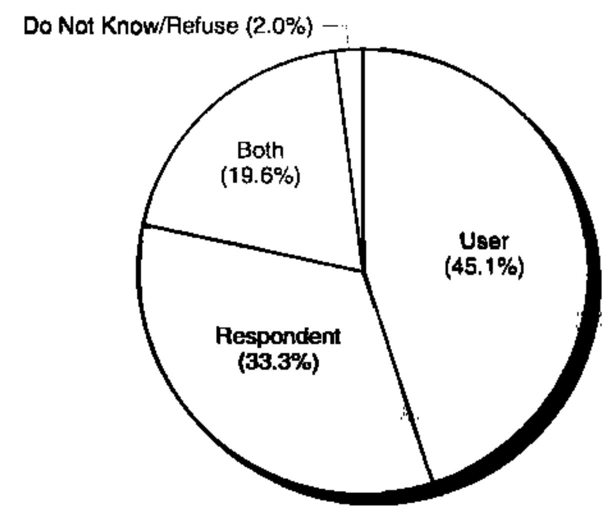


Source: Dataquest (October 1996)

Component Sourcing Practices of the Captive Group

The practices of the captive group are summarized in Figure 6-3. Here, over 45 percent passed on total component sourcing responsibility to their internal IC assembler. This is an extremely high percentage. It indicates that this group feels that, as the work is carried out by their own company, common interests are shared. Thus, their assemblers can be fully trusted to obtain the best pricing on the components and manage inventory holding, among others functions. In these groups, the component purchasing department may well be located at the assembler site or in that division. Thus, it is not a matter of choice, but more of business necessity. About 33 percent of captive assemblers and users source 100 percent of the components themselves. These respondents may have a central purchasing location, with the assembler division solely responsible for assembly work. Nearly 19 percent of the captive sector jointly sources the components—this is lower than both groups in the merchant market arena. Thus, it would appear that, in the captive organizations, component purchasing sits either entirely in the assembler site or entirely centrally.

Figure 6-3
Component Sourcing Practices of Captive Assemblers and Users



Source: Dataquest (October 1996)

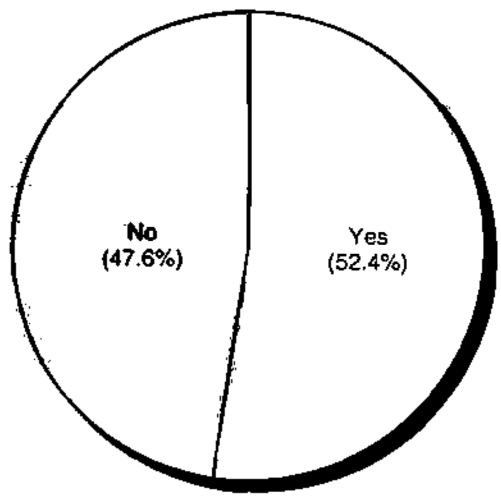
Prototype IC Assemblers

There is a lot of talk and speculation as to whether this is an actual business segment. Are buyers really willing to use an extra supplier or suppliers for small-volume prototype work, or do they stick with their regular suppliers? Can an assembler make a living from concentrating on prototype work only? Dataquest surveyed all three groups to see if prototype IC assemblers are used that are different from the regular suppliers.

Merchant market sellers say their customers do not use different location—over 64 percent of respondents answered no. However, over 20 percent did say yes. Similarly, the captive assemblers and users generally do not use specific prototype IC assemblers—over 72 percent said no when asked if they have different prototype IC assemblers. However, over 27 percent of the captive players surveyed do use different IC assemblers for prototype manufacturing. Of the merchant market buyers, it was close to 50/50, but the majority do in fact use different prototype suppliers for IC assembly. About 52 percent responded yes, with about 48 percent saying no (see Figure 6-4).

Thus, prototype IC assemblers do play an important role in the merchant market. As it is the buyer's decision where this work is sent, clearly the majority do favor a specialized prototype assembler. The buyer respondents who do not use a prototype assembler no doubt have a relationship with their existing assemblers who handle prototype batches in a certain, special way.

Figure 6-4
Use of Different Prototype IC Assemblers



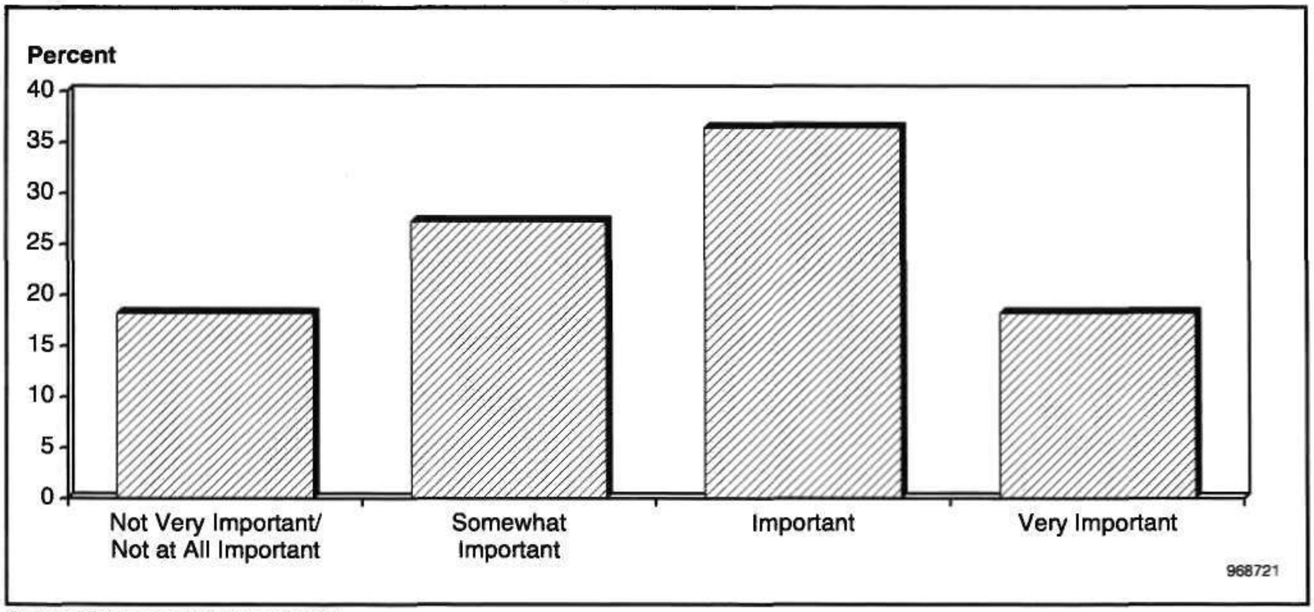
Source: Dataquest (October 1996)

Is Proximity a Factor?

Next, those who did use different prototype IC assemblers were asked if the supplier's proximity was an important consideration. As the largest sample of separate prototype users came from the merchant market users/ buyers group, this is the sample that was analyzed.

Figure 6-5 shows the survey results. Over 80 percent of respondents said proximity was somewhat to very important. Only less than 20 percent said it was not important. The single highest response rate was against the "very important" choice. This would indicate that local suppliers are used for low-volume prototype IC assembly work. Generally, speed is the biggest factor. A local assembler can quickly turn around the prototype, and proximity reduces time lost while the goods are being transported. Logistics are also improved and transportation costs cut down. Prototype IC assemblers tend to be smaller and offer greater turnaround time flexibility—for prototype batch runs, cost is not as important. Also, the level of trust tends to be higher, as designers and component engineers from the buyer's company have worked with the prototype vendor, and each knows the other's strengths and limitations. However, for volume production levels, the business is transferred to a more cost-effective IC assembler. The proximity becomes less important—cost kicks in, and with good forecasting, the distance from the buyer's location is immaterial.

Figure 6-5
Importance of Proximity of the Prototype Vendor



Source: Dataquest (October 1996)

Chapter 7
How Important Are the Issues, and How Satisfied Are the Respondents?

Importance Levels on Key Components: Overall Findings

The merchant market buyers/users rated their IC assemblers. The captive survey respondents rated their internal suppliers of IC assemblers. The merchant market sellers, namely the IC assemblers, were asked to give their perception of the most important issues for their customers. Respondents were asked to rate a list of criteria from 0 to 6, with 6 being the most important.

Figure 7-1 lists the mean score for the 12 key criteria for each of the three groups. The overall highest and lowest mean rankings are quality for the captive assemblers and users, which scored a 4.915, and duty for the merchant market sellers, which scored a 1.571.

Quality Takes Priority Hands Down

Quality was the single most important issue facing each group, across the board. Also, test and assembly was seen as a key issue across the board, scoring second, third, and fourth place, respectively for the merchant users, the captive group, and the merchant sellers. Lead time was another criterion in the top three for all groups. It was second on the captive group's list and third for both the merchant sellers and the merchant users.

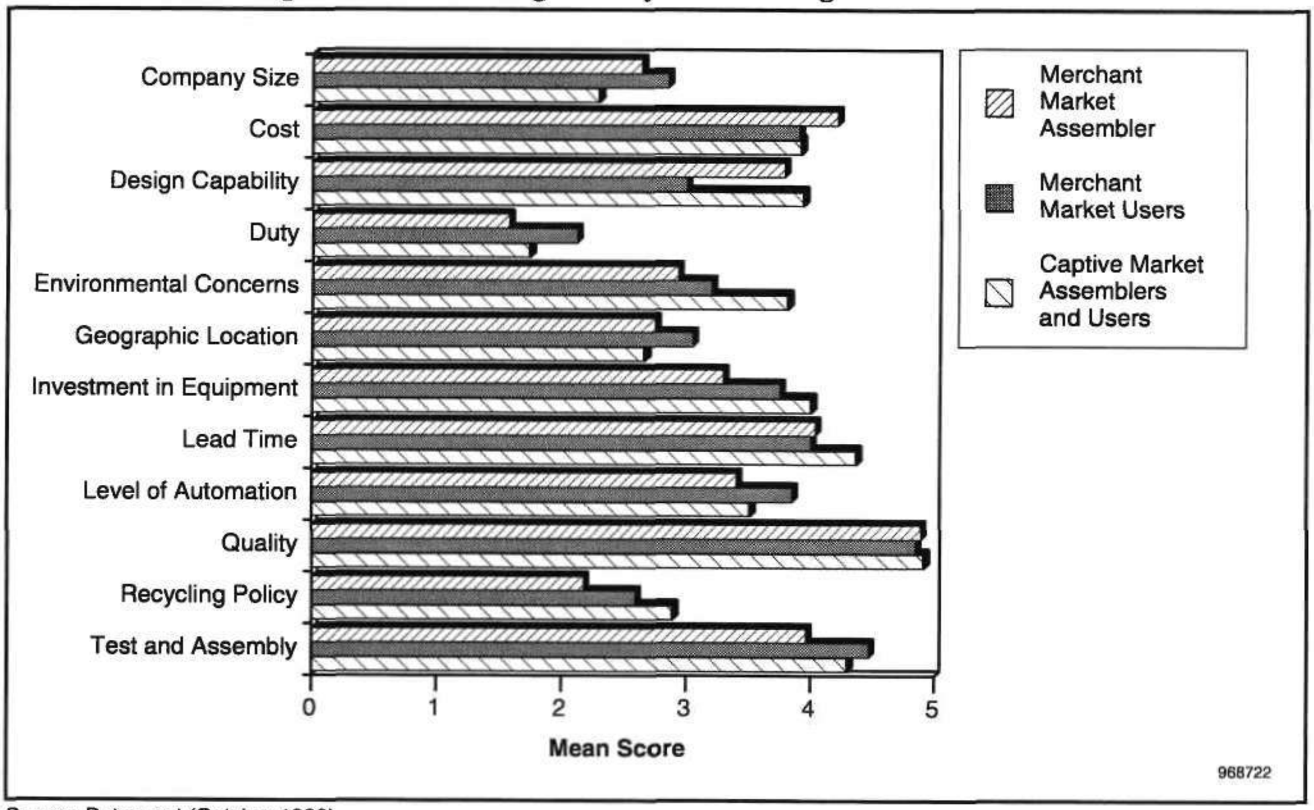
Cost was seen as important by all group but to varying degrees. While the merchant sellers ranked it as second most important, the merchant users had it as fourth most important, with the captive group ranking it sixth most important. Cost remains the most tangible of benchmarks, however. Design capability was fifth on the list for merchant sellers and captive assemblers and users but was only eighth on the list for merchant users.

Investment in equipment was seen as relatively important to all groups. It ranked fourth, sixth, and seventh, respectively, for the captive group, the merchant users, and the merchant sellers. Level of automation ranked very close to investment in equipment. This was No. 5 for merchant users, No. 6 for merchant sellers, and No. 8 for captive assemblers and users.

Another moderately important concern was geographic location—it was eighth, ninth, and tenth, respectively, for merchant users, merchant sellers, and the captive community.

Environmental concerns were moderately important on every group's list, a reflection of the growing green movement! It was seventh on the merchant users' and the captives' lists and featured No. 8 on the merchant sellers' list. Recycling policy, by contrast, was quite low on every group's list. Does this mean that while our respondents are concerned about the environment, they have not translated that into a recycling policy yet? Recycling policy was eleventh on the merchant users' and sellers' lists—second from bottom—and was ninth on the captive group's list.

Figure 7-1
Mean Score for Importance Ranking on Key Purchasing Criteria



Source: Dataquest (October 1996)

Size does not matter much to our respondents—company size was viewed by all respondents as quite unimportant. The merchant sellers and users both ranked it at No. 10 overall, with captive assemblers and users ranking it No. 11 overall. Duty was uniformly the least important criterion; it was twelfth on every group's list.

Top Eight Importance Criteria

Merchant Market Sellers

The results of the merchant market assemblers group is seen in Table 7-1. This group's rankings can be classed into three groups—those that scored in the fours, in the threes, and in the twos (albeit virtually in the threes). The first group contains quality, cost, and lead time. Quality was the most important criterion among the merchant sellers group, getting a mean score of 4.893. Cost came in at No. 2, with a 4.214 mean score, followed by lead time, with a mean score of 4.036. The second group is the largest of the three and comprises test and assembly, design capability, level of automation, and investment in equipment. Test and assembly ranked fourth, scoring 3.964—a four, when rounded. Design capability ranked 3.786. Level of automation scored a mean 3.407, with investment in equipment gaining 3.296. The final group has a single element—environmental concerns, which scored 2.929—a three, when rounded.

Table 7-1
Top Eight Importance Criteria for Merchant Market Assemblers

Ranking	Criteria	Mean Score	Percentage
1	Quality	4.896	81.6
2	Cost	4.214	70.2
3	Lead time	4.036	67.3
4	Test and assembly	3.964	66.1
5	Design capability	3.786	63.1
6	Level of automation	3.407	56.8
7	Investment in equipment	3.296	55.0
8	Environmental concerns	2.929	48.8

Note: The mean score is on a scale of six. The percentage column is based on the *mean score.*
Source: Dataquest (October 1996)

Merchant Market Users

Table 7-2 shows the top eight importance criteria for the merchant market users group, by mean score value. The merchant market users again ranked quality the most important of all the criteria. It had a mean score of 4.850. Test and assembly was second, with a mean score of 4.474, followed by lead time (with 4.000) and cost (with 3.900). Level of automation received a mean score of 3.85, ranking it No. 5 overall. Investment in equipment was ranked No. 6 and scored 3.750, while investment in environmental concerns scored 3.200 and was No. 7. Design capability and geographic location tied for eighth place with scores of 3.000.

Table 7-2
Top Eight Importance Criteria for Merchant Market Users

Ranking	Criteria	Mean Score	Percentage
1	Quality	4.850	80.8
2	Test and assembly	4.474	74.6
3	Lead time	4.000	66.7
4	Cost	3.900	65.0
5	Level of automation	3.850	64.2
6	Investment in equipment	3.750	62.5
7	Environmental concerns	3.200	53.3
8	Design capability	3.000	50.0
8	Geographic location	3.000	50.0

Source: Dataquest (October 1996)

Captive Assemblers and Users

Table 7-3 shows the top eight importance criteria for the captive group surveyed. Once again, quality was the most important concern, with a mean score of 4.915—the highest score of all criteria in all groups. Lead time was in second position (4.370), with test and assembly (4.298) in third position. The fourth slot was filled by investment in equipment (4.000), the fifth by design capability (3.936), and the sixth by cost (3.915). Environmental concerns and level of automation were in No. 7 and No. 8 position, scoring 3.809 and 3.511, respectively.

Table 7-3
Top Eight Importance Criteria for Captive Assemblers and Users

Ranking	Criteria	Mean Score	Percentage
1	Quality	4.915	81.2
2	Lead time	4.370	72.8
3	Test and assembly	4.298	71.6
4	Investment in equipment	4.000	66.7
5	Design capability	3.936	65.6
6	Cost	3.915	65.3
7	Environmental concerns	3.809	63.5
8	Level of automation	3.511	58.5

Source: Dataquest (October 1996)

Importance Analysis

The merchant sellers group was asked how they perceived their customers' rating of the criteria. Although on target with quality and close with lead time (the merchant users and the captive group ranked these No. 3 and No. 2, respectively), they underestimated the importance of test and assembly and overestimated the importance of cost. The sellers had cost ranked No. 2 but test and assembly down in fifth position. This was almost the reverse of how both of the other groups ranked these criteria. On all other criteria, however, the merchant sellers proved that they do know their customers well—their ranking closely matched what the merchant users and the captive group thought.

As for the merchant market users group, the buyers here clearly rank quality and test and assembly at their IC assemblers highest. These are key ways of reducing the total cost of ownership. Lead time scored higher than cost—the buyers know that if lead times are long or if a supplier is unable to offer accurate lead times, then goods will not be delivered on time, which adds to the real cost of doing business. Cost actually ranked No. 4. The sophisticated buyers know that, while important, it is only one factor playing into total cost of ownership. Level of automation and investment in equipment both scored high, but company size ranked low. Thus, businesses with a good degree of automation and capital equipment plans are more valued, regardless of size or number of employees. Similarly, design capability ranked in the top eight—a supplier with value-add is all important. Environmental concerns and geographic location also feature in the top eight.

The top three importance criteria for the captive assemblers and buyers were the same as for the merchant users group—test and assembly and lead time merely swapped position for the captive group. Again, these issues are critical to effective business practices. What is interesting about this group is that actual cost ranked only sixth. It was outranked by investment in equipment and design capability. This group clearly valued the add-on aspect of assemblers. It also reflected the fact that, for internal business dealings, while cost is undoubtedly important, it is not critical. The relationship is close and solid, and business goals are the same, so that the actual cost is low on the priority list. What is interesting, however, is that while investment in equipment was in fourth position for the captive group, level of automation only ranked No. 8. Clearly, the group is comfortable with a high degree of manual assembly work, provided it is of the highest quality, of course. Last, environmental concerns ranked No. 7.

One point worth emphasizing is that the top eight importance criteria were the same for each group. It was merely the rank order that changed among the groups. The merchant users did have one extra—geographic location—that tied at eighth position.

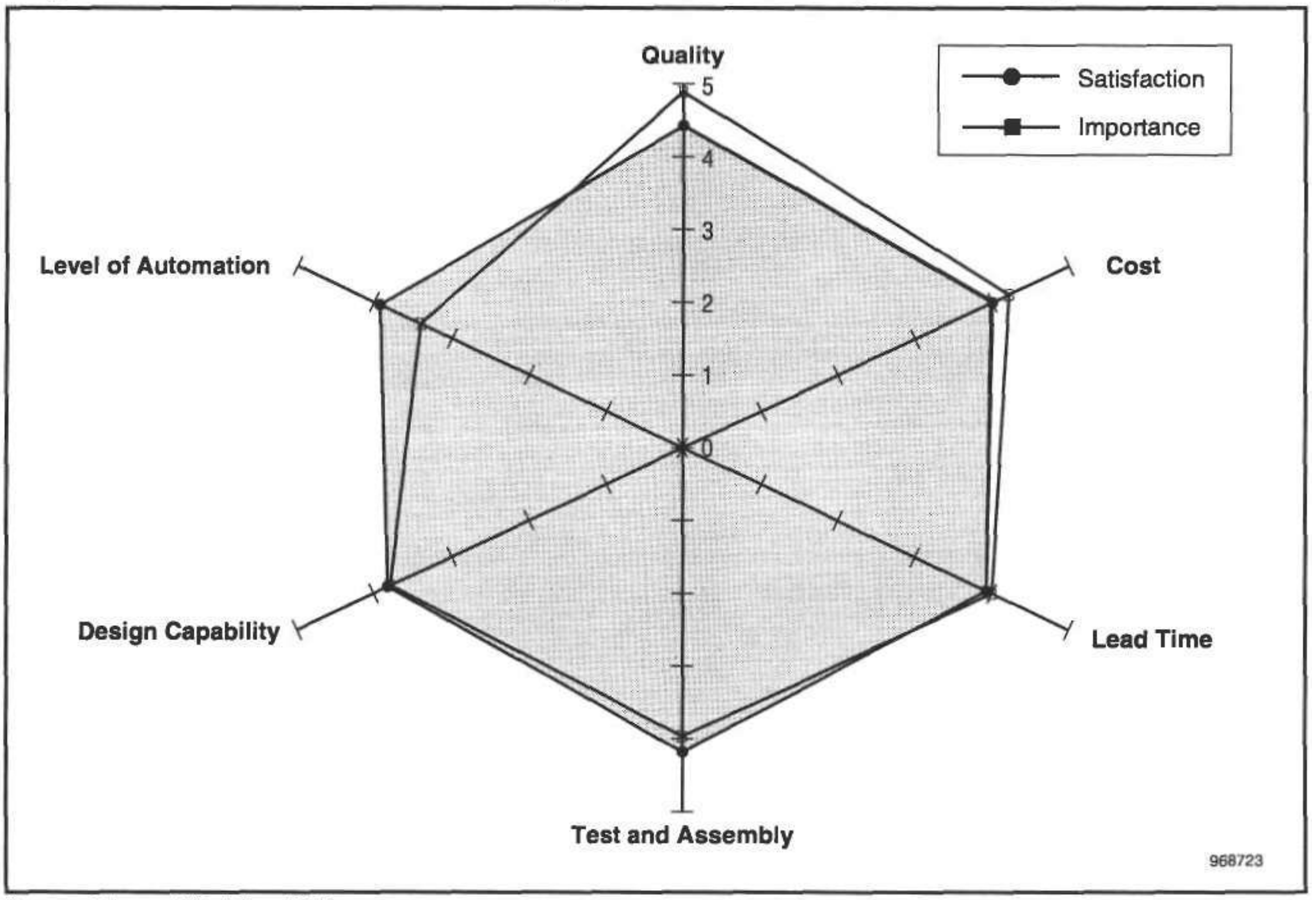
Importance versus Satisfaction

The three groups have given clear signals of what issues are most important to them. While they all are of one voice in the selection of the top eight criteria, the mean score for each varied considerably, as did its overall ranking. This section examines the satisfaction level of all three groups against six defined criteria. The merchant users rated their IC assembly suppliers on satisfaction level, while the captive group rated their internal suppliers of IC assemblies. However, once again, the merchant sellers measured how satisfied they perceived their customers to be against each criteria—in other words, they are rating themselves. The mean score obtained from each criterion is graphed against the equivalent score for importance level. There are three separate figures, one for each of the three groups.

Merchant Market Sellers

The merchant seller group's response is very interesting because it is a self-critique. This group is speculating on how satisfied their customers are with their actual performance against each criterion. Not surprisingly, given the results seen in Figure 7-2, they feel that their customers are very satisfied with them! On three of the six criteria, the sellers actually rated satisfaction level higher than importance level—for test and assembly, design capability, and level of automation. Also, they scored themselves wholly in the high threes to fours for satisfaction—their mean lowest score was 3.821 for design capability, while their mean highest score was quality, with 4.429. Impressive confidence levels abound in the merchant supplier community, by all accounts.

Figure 7-2
Importance versus Satisfaction Ratings for the Merchant Market Sellers

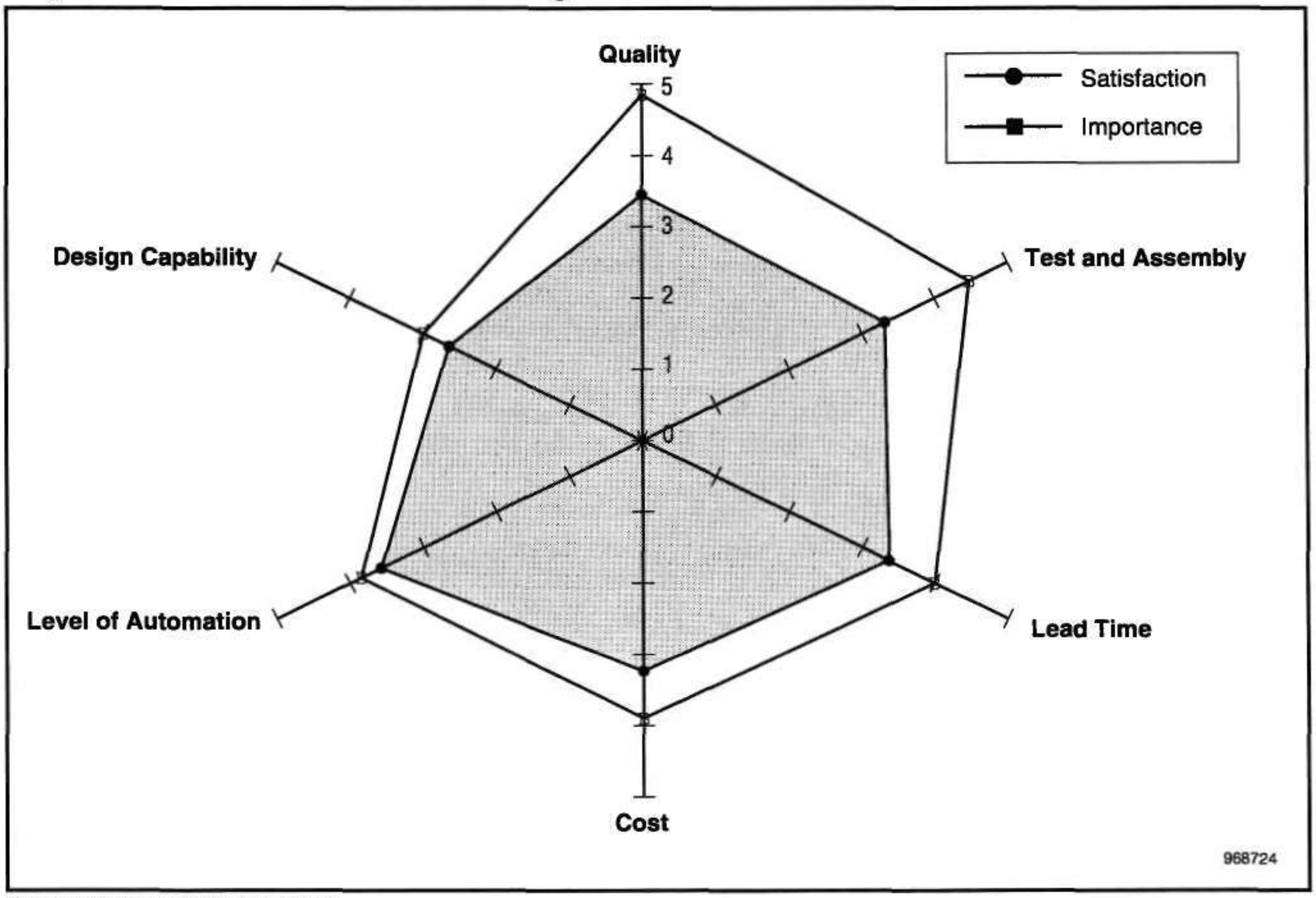


Source: Dataquest (October 1996)

Merchant Market Users

This group of buyers ranked their suppliers of IC assemblies, all external, against the same six set of criteria. Figure 7-3 plots their mean satisfaction score against their mean importance score for each of the six criteria. Clearly, they believe their suppliers have room for improvement. Quality was especially targeted. The buyers gave it a mean importance score of 4.850. However, the buyers rated 3.450 in satisfaction level against quality—a difference of 29 percent for this most important category. This pattern of low satisfaction levels continues throughout the set of criteria. Test and assembly satisfaction level is 26 percent below importance, while lead time is 16 percent below. One interesting observation is that the lowest satisfaction level that the suppliers gave themselves is higher than the highest satisfaction score given by their customers. These results certainly give the impression that suppliers still have considerable room for improvement in the minds of their customers.

Figure 7-3
Importance versus Satisfaction Ratings for the Merchant Market Users



Source: Dataquest (October 1996)

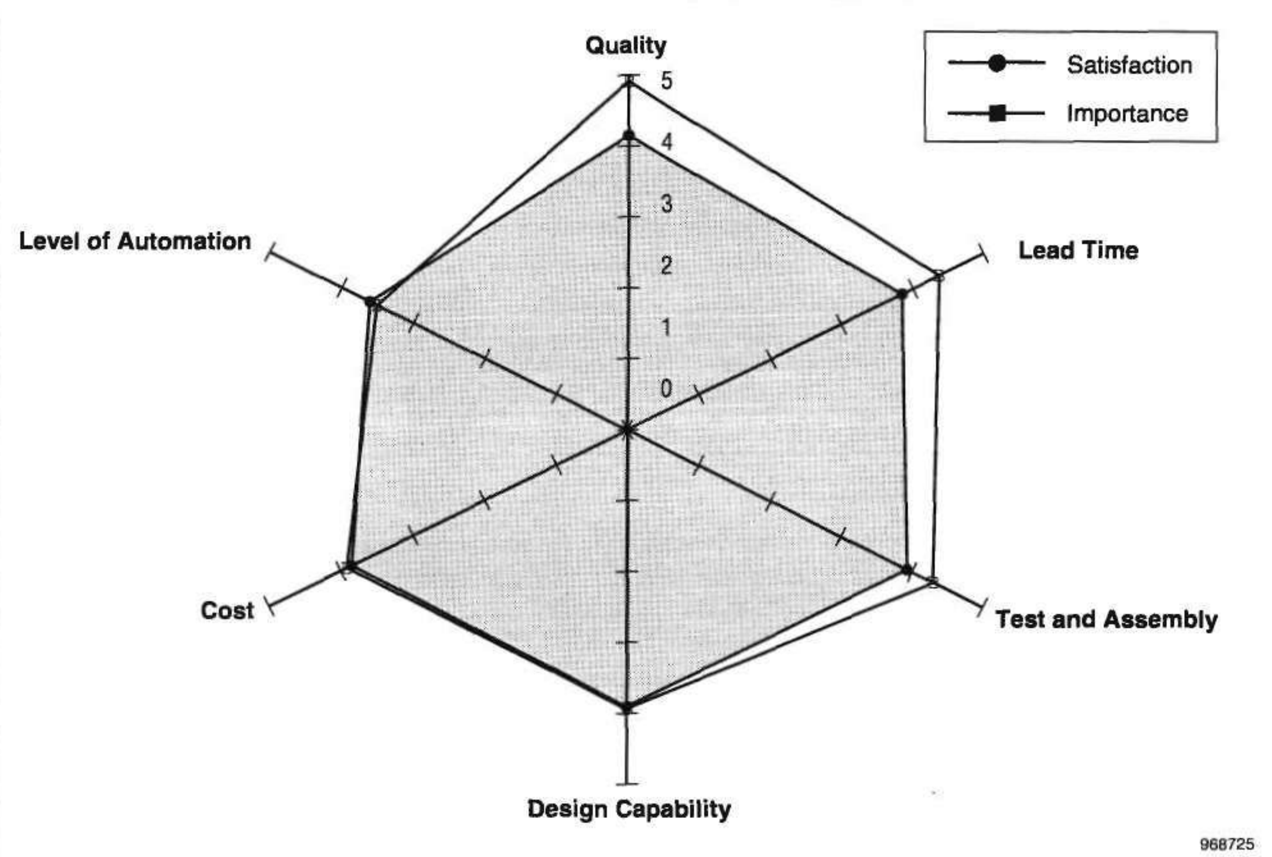
Captive Assemblers and Users

The captive group had the task of rating how satisfied they are with their internal suppliers. And it's a lot more difficult to be objective when the person you're rating sits in the cubicle next door or down the corridor. The lines between supplier and customer do tend to blur. Figure 7-4 plots the results—mean satisfaction score versus importance score. Satisfaction level mean scores were lower than importance mean scores on five out of six criteria. The exception was level of automation, which scored slightly higher. For quality, the satisfaction level was 16 percent below the importance level, based on mean scores. The equivalent difference was 12 percent for lead time and 8.5 percent for test and assembly.

Importance versus Satisfaction Comparisons

The buyers group (merchant market users) were the most critical and least satisfied. They consistently scored satisfaction below importance, with considerable deltas. The suppliers group (merchant market sellers) were very satisfied with their own performance and demonstrated a certain degree of complacency. They know what is important to their customers, but they fail to judge their satisfaction level. As these two merchant market groups rely on each other, why are the wires so crossed?

Figure 7-4
Importance versus Satisfaction Ratings for Captive Assemblers and Users



Source: Dataquest (October 1996)

Table 7-4 shows the perception difference for both merchant groups by percentage. The percent is the delta between satisfaction and importance, divided by importance. If the result is positive, it means that the group members, on average, rank their satisfaction with the criterion higher than they rank its importance. If the result is zero, it means that the mean score for the group was equal—satisfaction and importance scored the same. If the result is negative, however, it means that the mean satisfaction score is less than the mean importance score. Ideally, the satisfaction score should be at least equal to the importance score. The buyers give all negatives—in some cases, the difference is as high as 29 percent negative. There is definite room for improvement among the sellers to improve the buyers' satisfaction levels, based on the buyers' own results. However, the sellers' results paint a much rosier picture.

Perhaps it indicates that while the buyers are good at communicating what is important for the business relationship to work, they do not give enough honest feedback on how the suppliers are performing. Perhaps buyers need to consider some form of vendor assessment and sit down with the suppliers to share results and come up with improvement plans. Good relationships develop from honest dialog and grow over time. The supplier/buyer relationship here is no different. By focusing on certain key areas (for example, quality and test and assembly), the two groups can set realistic measures and goals toward which to work. Earlier, we saw

Table 7-4
Difference between Importance and Satisfaction for the Merchant Market Groups (Percent)

	Merchant Market Sellers: The Suppliers	Merchant Market Users: The Buyers
Quality	-9.5	-29.0
Test and Assembly	+5.0	-26.0
Lead Time	-2.0	-16.0
Cost	-5.0	-17.0
Level of Automation	+15.0	-7.0
Design Capability	+1.0	-12.0

Note: A negative score indicates less satisfaction, positive indicates more satisfaction, and zero indicates satisfaction/importance parity.
Source: Dataquest (October 1996)

that all buyers surveyed have strategic suppliers of IC assemblies. The lessons learned in building those close relationships can be applied to other errant vendors.

The supplier has real incentive to perform. Business is competitive, and the buyer's orders are vital for profitability and expansion. If, however, the buyer cannot get the required level of service, then it may be worth considering alternative suppliers. Although this is problematic and time consuming short term, it pays dividends long term. It should, however, be used only if the current relationship cannot be sufficiently improved.

Chapter 8
Conclusions and Analysis

A clear link was seen between forecasting and lead time in this survey. Over 70 percent of respondents forecast—typically up to six months ahead. Not surprisingly, average lead times were low—most enjoyed lead times below five weeks, with two to three weeks being typical in the merchant area. The fact that so many respondents issue forecasts shows that their organizations are aware of their future business and can convert this into data that can be shared with suppliers—either internal or external. Forecasting is also a useful tool for price negotiation, as total volumes can be leveraged to ensure the best price is obtained.

Quality is the king of the IC assembly importance list and, not surprisingly, quality audits have become more commonplace over the past decade. A higher percentage of Dataquest's respondents conduct regular quality audits with suppliers than forecast. Now well over 80 percent of Dataquest's survey respondents conduct regular quality audits with suppliers or have quality audits performed on them by customers. Most respondents said that the audit process tends to be conducted in a regular manner, indicating that most organizations have dedicated staff members who assess suppliers. This is excellent news and shows how close buyers and sellers work together to get the best product for all concerned.

Price negotiations are a regular business practice in the merchant community—buyers and sellers are familiar with regular price sessions. However, while assemblers use per-project negotiations, most buyers negotiate at set frequencies. Also, component sourcing is an activity that tends to be shared between both camps. All merchant buyers had strategic IC assembler suppliers, most having two. Further, merchant buyers clearly see prototype IC assemblers as a separate business, with over half using them.

There are very close working relations between merchant market suppliers and buyers of IC assemblies. Both groups conduct regular price, forecast, and lead time updates and have agreements on component sourcing responsibilities. Both groups have similar views on what is important for business—indicating that time has been spent focusing on these areas. However, there is room for improvement and more candid dialog when it comes to satisfaction levels on a number of areas. The suppliers' perception of the situation was a lot more positive than the buyers'. Although a difference in perception is to be expected, the degree of difference was of greatest concern in areas like quality, test and assembly, cost, design capability, level of automation, and lead time.

The captive group has a two-edged sword—while buyers and sellers share common high-level business concerns, there may be room for complacency from the seller's side because the business is captive. Forecasting is a regular part of business, and 33.3 percent have lead times of four to five weeks. For component sourcing, nearly half of respondents pass that responsibility on to their internal assembly house—quite different from the merchant model, where sharing was more common. This indicates that purchasing is more specialized and centralized in divisions within the captive community.

The importance and satisfaction questions of Chapter 7 highlight some further differences. Although the captive group had the same top eight (out of 12) importance criteria, ranking for some was quite different. Cost, for example was sixth on the list for the captive community, whereas the merchant sellers had it second and the merchant buyers fourth. Does this mean that price is less negotiable in the captive group, or is it that this group is concentrating more on reducing other factors to keep total cost of ownership down? Also, as the captive group shares common business goals and objectives, and in some cases assembly production and consumption occur at the same location, satisfaction levels should be the highest, as process information can be the most open. However, this is not the case. The captive buyers expressed dissatisfaction with their internal assemblers. Satisfaction with quality was rated 16 percent below importance; lead time was 12 percent below. Although it is harder to be objective in ranking internal suppliers, this still indicates room for improvement and better dialog.

On the whole, the respondents surveyed showed sophistication—their focus was on the total cost of ownership, not just on buying price. Quality audits, forecasting, and short lead times are regular parts of business practice for them, and issues such as component procuring have been thought through. However, the one area of weakness remains the variation in satisfaction levels between the groups.

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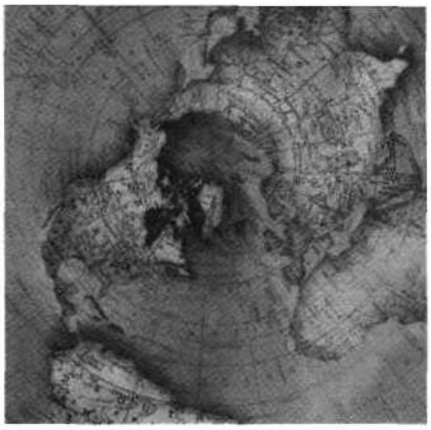

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Contract Manufacturing 1996 Update

Focus Report

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Product Code: SPSG-WW-FR-9602
Publication Date: April 22, 1996
Filing: Reports

Contract Manufacturing 1996 Update

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Table of Contents

Page

1. Executive Summary ... 1
   - Definition ... 1
   - Coverage ... 1
   - Report Highlights ... 2
   - Organization ... 2
2. Introduction ... 3
   - Objectives of This Report ... 3
   - Dataquest Analysis and Recommendations: Methodology Overview ... 3
     - Demographic Profile ... 4
3. Contract Manufacturing Trends ... 7
   - Market Size and Forecast ... 7
   - The Top Five ... 8
4. Contract Manufacturer Perceptions ... 9
   - Contract Manufacturing Issues ... 9
   - Strengths and Areas for Improvement ... 10
   - Growing and Shrinking Markets in Contract Manufacturing ... 11
   - Consignment versus Turnkey Contract Manufacturing ... 12
5. Contract Manufacturing Customer Perceptions ... 15
   - Reasons to Use an Electronics Contract Manufacturer ... 15
   - Disadvantages of Using an Electronics Contract Manufacturer ... 15
   - Contract Manufacturing Customer Satisfaction Levels ... 16
   - Importance Ranking ... 17
     - Competitive Pricing ... 17
     - Manufacturing Expertise and Ease of Work Relations ... 18
     - Inventory Control ... 19
     - Access to New Technology ... 19
   - The Status of Competition in Contract Manufacturing ... 19
   - Overall Satisfaction Levels of Contract Manufacturer Customers 19
6. Contract Manufacturing Benchmark Criteria ... 23
   - Cycle Time Differences ... 23
   - Incremental Costs of Contract Manufacturing ... 24
     - Component Costs ... 24
     - Contract Manufacturing/Procurement Costs ... 25
     - Obsolescence Costs and Costs of Receiving from a Contract Manufacturer ... 25
     - Inventory Costs ... 25
     - Shipping and Handling Costs ... 25
7. Dataquest Analysis ... 27
   - An Increasing Force ... 27
   - Shrinking Product Life Cycles ... 27
   - Capital Equipment Expense ... 27
   - Increased Pressure from Global Competition ... 27
   - Where Contract Manufacturing Makes Sense ... 28
     - Strategic Outsourcing ... 28
     - Improved Performance ... 28
     - Regional Competition ... 28

Appendix A—North American Contract Manufacturers ... 31

List of Figures

Figure		Page
2-1	Contract Manufacturers' Revenue, 1994-1996	4
2-2	Contract Manufacturers' Production Capability	5
2-3	Contract Manufacturers' Electronic Data Interface Use	5
2-4	Contract Manufacturing Customer Respondents	6
2-5	Contract Manufacturing Customers' Forecast Purchases	6
3-1	Forecast Market Growth Rates for Contract Manufacturing, Semiconductors, and Electronics, 1994-1999	7
4-1	Strengths Cited by Contract Manufacturers	10
4-2	Areas Needing Improvement Cited by Contract Manufacturers	11
4-3	Contract Manufacturing Trends: Growing and Shrinking Markets	12
4-4	Consignment versus Turnkey Manufacturing	13
5-1	Areas Needing Attention by Contract Manufacturers	16
5-2	Contract Manufacturing User Issues and Satisfaction Levels	18
5-3	Composition of Competition with Pure Contract Manufacturers, 1993 and 1996	20
5-4	Type of Contract Manufacturing Supplier Preferred by Users, 1993 and 1996	21
6-1	Contract Manufacturing Cycle Times Reported by Suppliers and Users	23
6-2	Incremental Contract Manufacturing Costs	24

List of Tables

Table		Page
3-1	The Top Five U.S. Contract Manufacturers, 1995	8
4-1	Contract Manufacturers' Top Issues	9
5-1	Reasons to Choose Contract Manufacturing over In-House Manufacturing	15
5-2	Contract Manufacturer Performance Criteria, Historical Ranking	17

Chapter 1
Executive Summary

Electronics contract manufacturing continues to become more mainstream with every passing year. The global marketplace is forcing companies to squeeze costs out of every operational expense. This Semiconductor Supply and Pricing Worldwide Focus Report, *Contract Manufacturing Update 1996*, highlights the current status of electronics contract manufacturing and compares it with Dataquest's initial report on this topic, published in 1993. In addition to polling the top contract manufacturing customers in North America, Dataquest also surveyed the top North American contract manufacturers to gain a fuller view of this expanding market. This report also examines the advantages and disadvantages of outsourcing and pinpoints areas that electronics contract manufacturers themselves, as well as their customers, see as needing improvement.

Definition

Dataquest defines an electronics contract manufacturer as a company or division of a company that provides electronics manufacturing or design capabilities to the market. Typical contract manufactured work includes printed circuit board assembly, subsystem assembly, or complete system manufacture. The combined component purchasing power of an electronics contract manufacturer often is more powerful than the separate users it supports. The contract manufacturing customer often benefits from this economy of scale in procuring semiconductors, thus lowering materials costs.

Coverage

Although contract manufacturing has many virtues, it also has room for improvement to meet customer requirements fully. This report, based on a survey of the largest worldwide contract manufacturers and many of the largest North American contract manufacturing customers, provides a critique of the current status (strengths and shortcomings) of this fast-growing industry. This report covers the following areas:

- Contract manufacturing market size and forecast
- Top North American contract manufacturers
- Hot issues of contract manufacturers and their customers
- Strengths and improvement areas of contract manufacturers (self-critique)
- Growth and no growth markets for contract manufacturing
- Consignment versus turnkey trends
- The pros and cons of contract manufacturing
- The satisfaction level of contract manufacturing customers
- Contract manufacturing competition review
- Benchmark criteria
  - Cycle time comparisons
  - Incremental costs of contract manufacturing

Report Highlights

Contract manufacturing is a strong force in the electronics industry because of the following three market trends that have converged during the past 15 years:

- The shorter life cycles of all systems
- The more expensive capital equipment needed to make advanced systems
- The global competition that continues to force cost cutting at all levels

Smaller and cheaper cost per function systems will continue to push down the cost per bit, cost per mips, and cost per byte. This inherent trend of the electronics industry will force companies to improve operations. One result of these improvements is shorter product life cycles.

Shrinking product life cycles correlate with increased capital equipment costs. As systems become increasingly complex, the tolerances and levels of precision needed for manufacturing these systems become more expensive. The natural tendency of the market to consolidate assets (survival of the fittest) is preventing many smaller companies from competing effectively, not for lack of viable products but for lack of funds to build state-of-the-art manufacturing plants.

The "worldwide market" also includes worldwide competition. Worldwide competition continues to force the industry to higher levels of efficiency and, as a result, will keep pressure on cost control at all levels of organizations, regardless of the regional business transaction.

Organization

Chapters 1 and 2 highlight the main points, objectives, methodology, and demographics used in this report. Chapter 3 discusses current contract manufacturing trends in relation to market size, forecasts, and top contract manufacturers. Chapters 4 and 5 look at the market from the perspectives of top contract manufacturers and contract manufacturing customers, respectively. These two chapters examine the pros and cons of doing business with contract manufacturers and discuss areas of improvement needed. The contract manufacturers also note which markets they expect to grow or to shrink. Chapter 5 also includes a customer satisfaction gap analysis that highlights where contract manufacturers can get the most bang from their performance improvement dollar. Chapter 6 analyzes two critical contract manufacturing benchmark criteria—cycle times and incremental cost of manufacture. The report concludes with an analysis of the strategic role of contract manufacturing and some of the pitfalls to avoid when the question arises of whether to make or to buy.

Chapter 2
Introduction

Objectives of This Report

Much continues to be written on the trend of using contract manufacturing (CM) by all segments of the economy. This Focus Report is an update to the first Dataquest report on electronic system contract manufacturing done in 1993 and also includes the perceptions of the marketplace from top North American contract manufacturers. This report reviews how well contract manufacturers are meeting customer needs and what contract manufacturers see as their strengths and growth opportunities. It also provides some benchmarks of contract manufacturing performance for both contract manufacturers and current (or potential) customers of this growing industry. The objectives of this report are as follows:

- To highlight the status of electronic system contract manufacturing in North America
- To analyze the trends that will shape the future of this industry
- To review the strengths of contract manufacturers and areas needing improvement
- To review the pros and cons of using contract manufacturers and to measure the level of customer satisfaction
- To analyze two key CM benchmarks—cycle times and cost of manufacture

The report concludes with recommendations for improvement and analysis of how to approach the decision of whether to use a contract manufacturer. The report comprises seven sections, as follows:

- Executive summary
- Introduction
- Contract manufacturing trends
- Contract manufacturer perceptions
- Contract manufacturing customer perceptions
- Contract manufacturing benchmark criteria
- Dataquest analysis

Dataquest Analysis and Recommendations: Methodology Overview

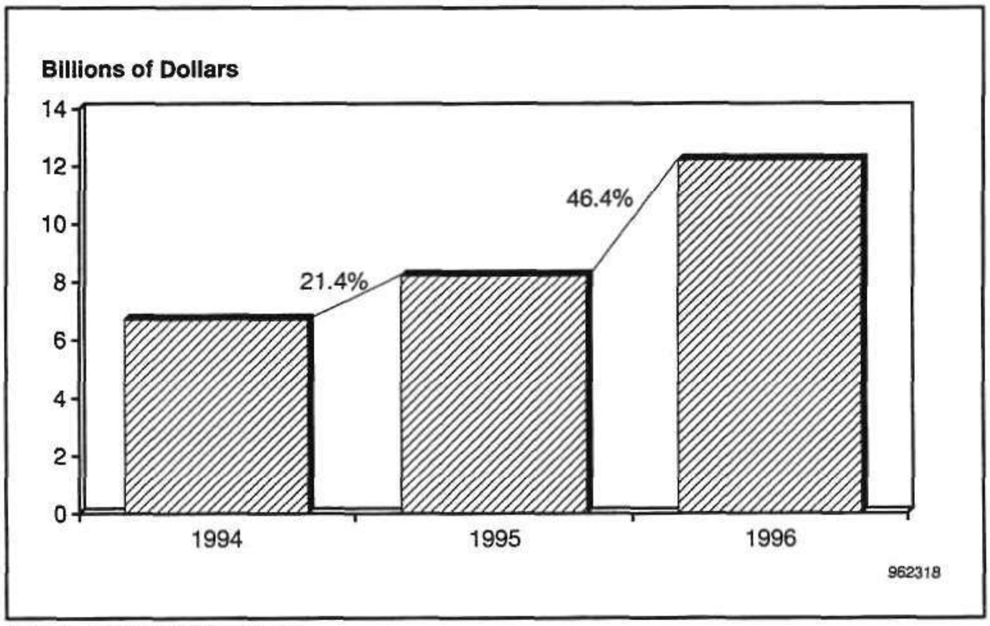
Between February 20 and March 15, 1996, Dataquest conducted telephone surveys and gathered responses from 49 key North American CM customers and 24 top North American electronics contract manufacturers. Trained interviewers conducted all surveys using a computer-aided telephone interviewing system. CM user responses were drawn from electronics company personnel in charge of purchasing semiconductors. The list of users was compiled from internal lists from prior studies of companies that were CM users or that purchased over $5 million in semiconductors annually. The list of top contract manufacturers was based on our last CM listing, continually updated over the past three years.

Demographic Profile

Contract Manufacturers

As seen in Figure 2-1, the contract manufacturers responding had 1995 revenue of over $8.2 billion and expect to exceed $12.0 billion this year. This represents 109 plants and 517 production lines, of which 382 are capable of surface mount technology (see Figure 2-2). Figure 2-3 shows that although over 80 percent of respondents use electronic data interface (EDI), on average, over 35 percent (responses ranged from 1 percent to 95 percent) of all business is done using this method.

Figure 2-1
Contract Manufacturers' Revenue, 1994-1996

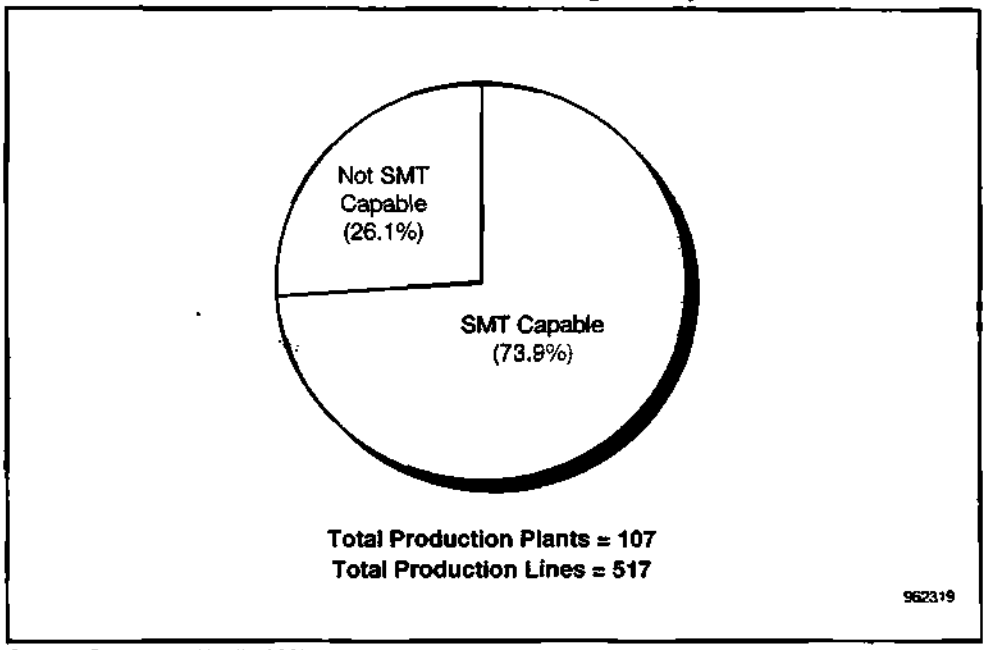


Source: Dataquest (April 1996)

CM Customers

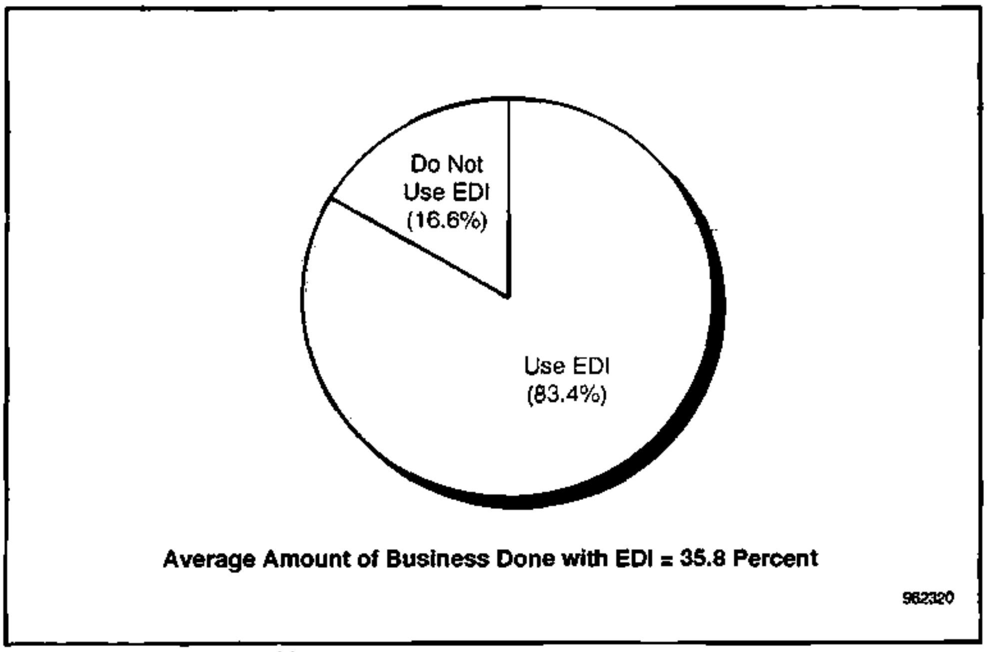
The 40 CM user respondents represented just under 10 percent of the worldwide electronics market by revenue in 1995 (see Figure 2-4). All the user survey respondents used some form of contract manufacturing. It is interesting to note (see Figure 2-5) that some respondents (35.3 percent) still refuse to declare or do not know what they will be spending in 1997. Under one-third plan on spending over $3 million each, and just over one-fourth expect to spend less than $1 million with contract manufacturers.

Figure 2-2
Contract Manufacturers' Production Capability



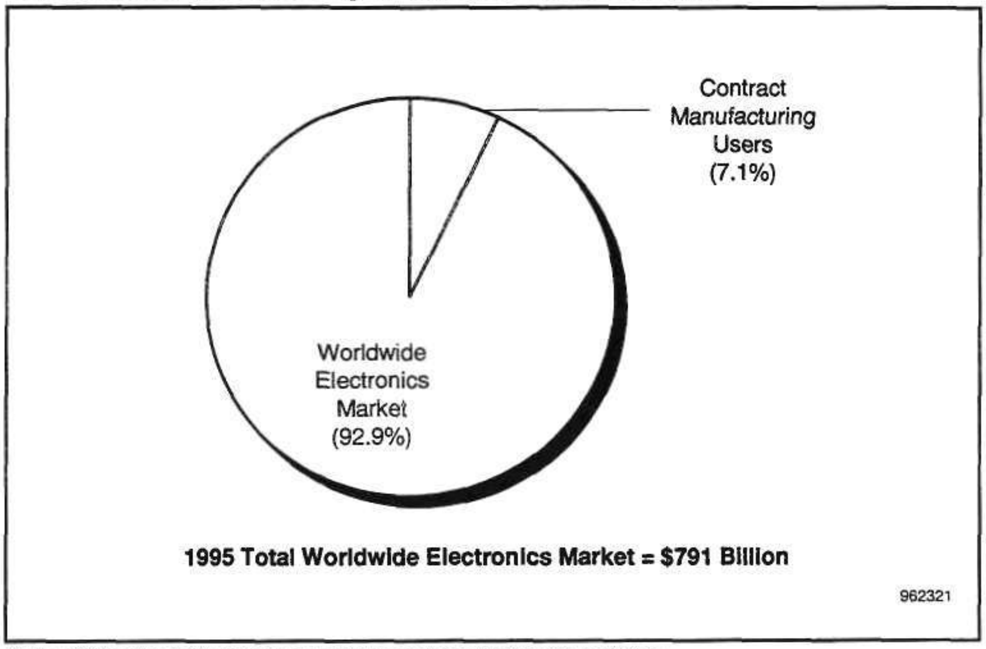
Source: Dataquest (April 1996)

Figure 2-3
Contract Manufacturers' Electronic Data Interface Use



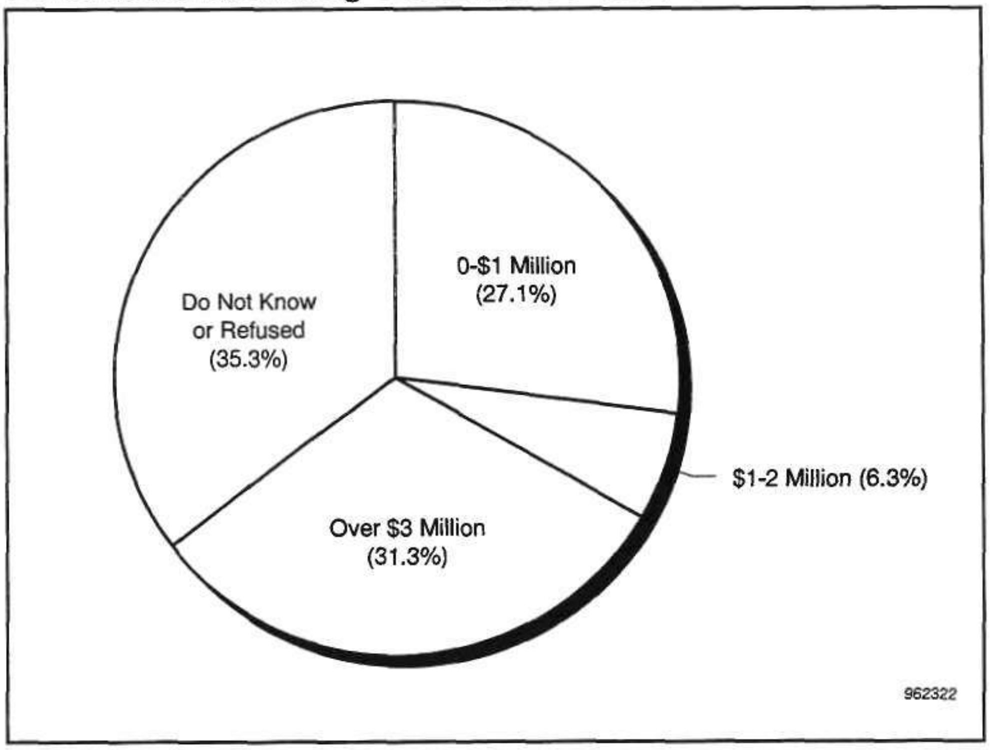
Source: Dataquest (April 1996)

Figure 2-4
Contract Manufacturing Customer Respondents



Note: 100 percent of survey respondents use contract manufacturing.
Source: Dataquest (April 1996)

Figure 2-5
Contract Manufacturing Customers' Forecast Purchases



Source: Dataquest (April 1996)

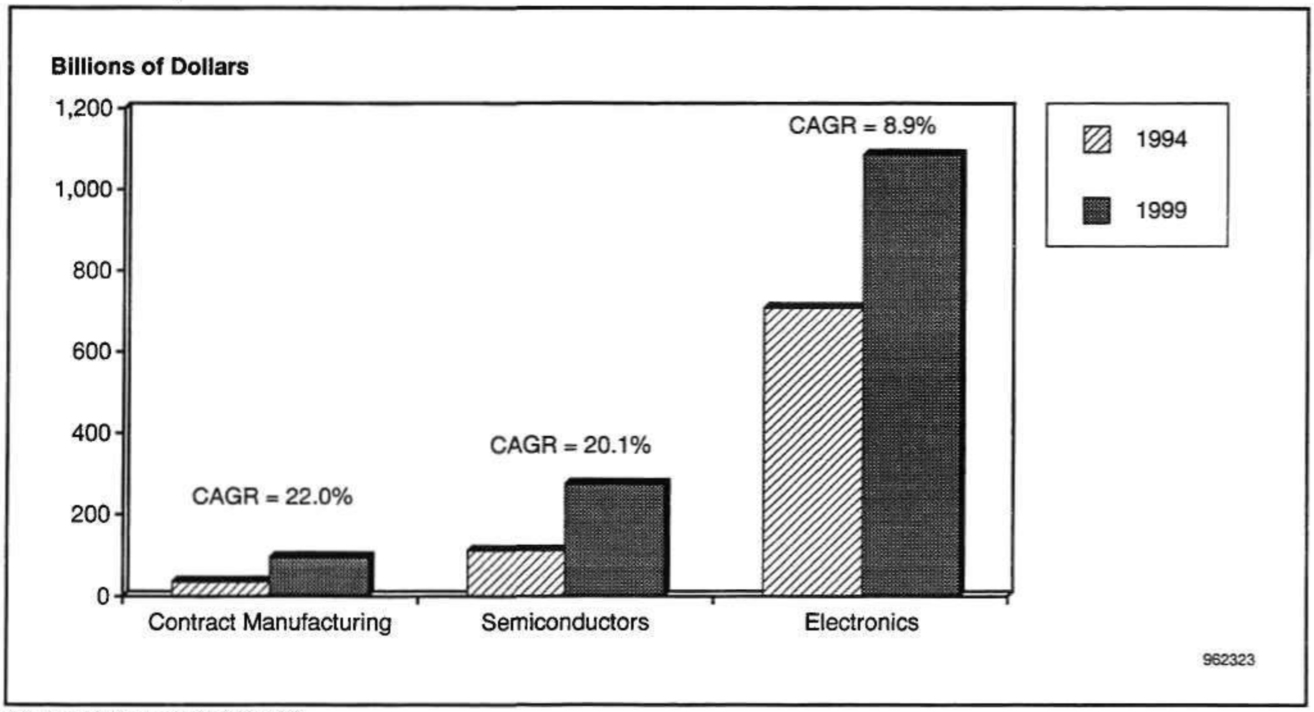
Chapter 3
Contract Manufacturing Trends

This chapter discusses the overall size of the contract manufacturing market, the top five U.S. electronics contract manufacturers, and the forces shaping this market.

Market Size and Forecast

Figure 3-1 shows that the compound annual growth rate (CAGR) of CM demand exceeds that of both electronics and semiconductors as OEM companies continue to struggle with worldwide competition and cost control issues. Contract manufacturing now makes up 5.3 percent of the electronics market. Dataquest expects it to grow to $95 billion by 1999. As noted in the previous report, the increased use of CM requires close review of issues such as proprietary design protection, time to market schedules, allocation priority, and technology access that the OEM customer no longer controls directly. How a company most effectively assimilates contract manufacturing into its overall operation (if at all) remains critical to its long-term future. The best strategic use of CM involves long-term planning rather than short-term, stopgap, cost-cutting goals.

Figure 3-1
Forecast Market Growth Rates for Contract Manufacturing, Semiconductors, and Electronics, 1994-1999



Source: Dataquest (April 1996)

The Top Five

Table 3-1 shows the top five of the more than 90 contract manufacturers in North America. The top five account for 33 percent of the North American market. These large companies control 15 percent of the world CM market. The main profit generators for the contract manufacturing industry are full capacity utilization (run rate) and economies of scale (size). As the top contract manufacturers increase in size and purchasing power, these two goals become increasingly attainable. The past two years have shown this trend, with the top two contract manufacturers, SCI Systems and Solectron, acquiring large amounts of additional manufacturing capacity primarily from their OEM customers.

Table 3-1
The Top Five U.S. Contract Manufacturers, 1995
(Millions of Dollars)

Rank	Company	Sales
1	SCI Systems	2,674
2	Solectron Corporation	2,100
3	AVEX Electronics Inc.	773
4	Jabil Circuit Company	529
5	Bull Electronics	300
	Top Five Total	6,376
	Rest of Survey Sample	1,837
	Total Sample	8,213
	Total North American Market	19,276
	Total Worldwide Market	42,700

Source: Technology Forecasters, Dataquest (April 1996)

Chapter 4
Contract Manufacturer Perceptions

This chapter reviews how contract manufacturers responding to Dataquest's survey see themselves and what areas of electronics they believe provide good opportunities for growth. We examine the top issues now facing contract manufacturers in the market. We then look at what contract manufacturers believe to be their strengths and review areas needing improvement. The next two areas are related: the contract manufacturers' perspective on the growth and no-growth markets of the next two years.

Contract Manufacturing Issues

Table 4-1 highlights what the contract manufacturer respondents believe to be the top issues facing them in the upcoming year. This question allowed for an open-ended response, and the table below reflects this format. Issues such as cycle times, competition, quality, materials management, and managing growth are grouped under manufacturing expertise. Many of the issues deal with gaining or maintaining manufacturing prowess, either through improvements in scheduling and quality or managing growth. The issues of obsolescence and on-time delivery involve inventory control directly. The No. 1 issue, on-time delivery, shows that contract manufacturers must be aware of their own and their customers' inventory levels. Pricing and costs contribute to the pricing category. The fact that pricing is the third-ranked category highlights how sensitive contract manufacturers are to their customers' concerns about cost control. Flexibility, ability to work with customers, ranked fourth of all issues contract manufacturers face this year.

Table 4-1
Contract Manufacturers' Top Issues

Rank Order	Issue
1	On-time delivery
2	Quality
3	Pricing
4	Flexibility
5	Managing growth
6	Competition
7	Cycle times
8	Costs
9	Obsolescence
10	International expansion
11	Materials management

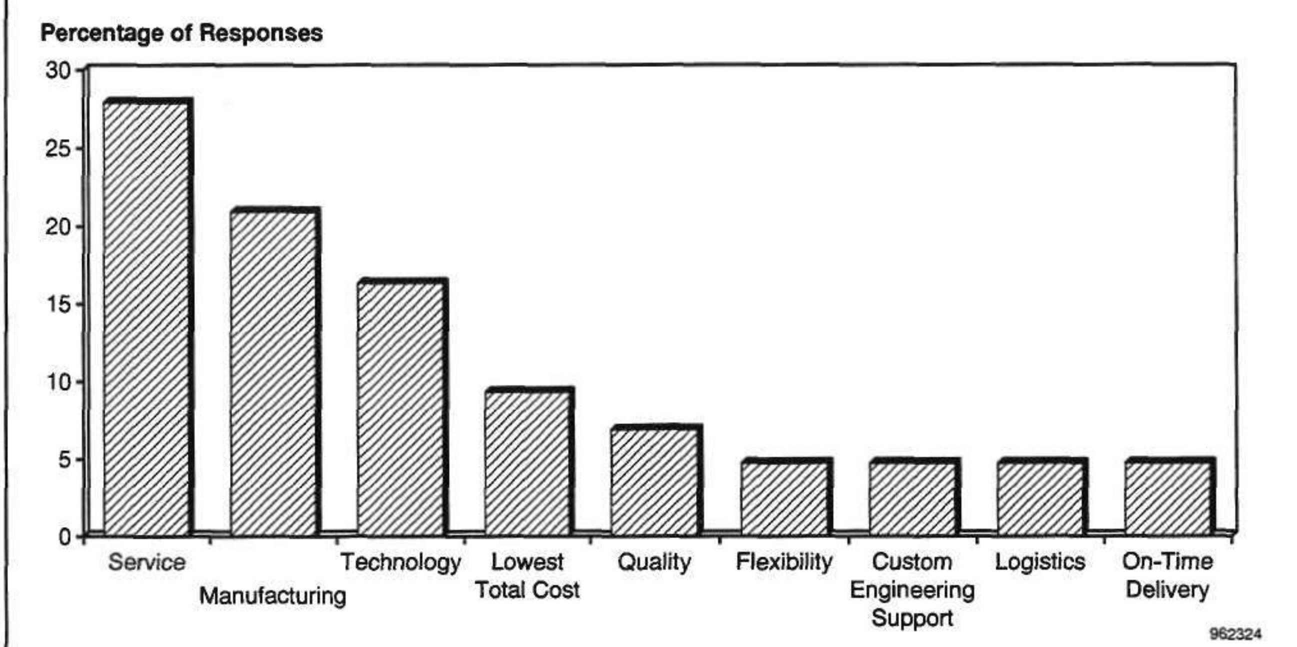
Source: Dataquest (April 1996)

Strengths and Areas for Improvement

Contract manufacturers see themselves primarily as very strong at serving customers, closely followed by skillful at manufacturing, and then as providers of technology (see Figure 4-1). After these top three areas, a variety of strengths were listed: offering the lowest total cost, quality, flexibility, and custom engineering support. Meeting customers' needs with service supported by solid manufacturing and technology, contract manufacturers can continue to grow by providing the lowest-cost solutions to many customer needs.

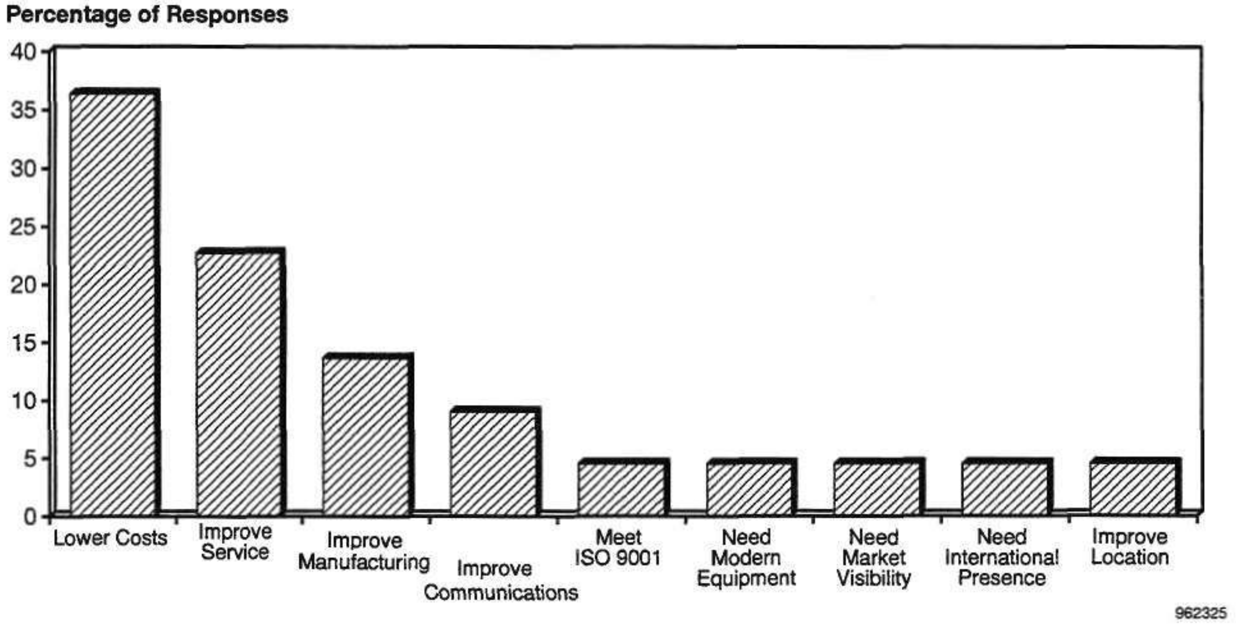
Although most of the survey respondents noted strengths in manufacturing, Figure 4-2 shows that contract manufacturers realize that improvement is needed in lowering overall costs and improving service levels, manufacturing, and communication. A variety of other issues were noted as needing attention, ranging from ISO 9001 compliance to improved international presence. Acknowledging the need to lower costs further and improve service and communication levels indicates that these responding contract manufacturers are listening to their customers. The next step is to act on these areas.

Figure 4-1
Strengths Cited by Contract Manufacturers



Source: Dataquest (April 1996)

Figure 4-2
Areas Needing Improvement Cited by Contract Manufacturers



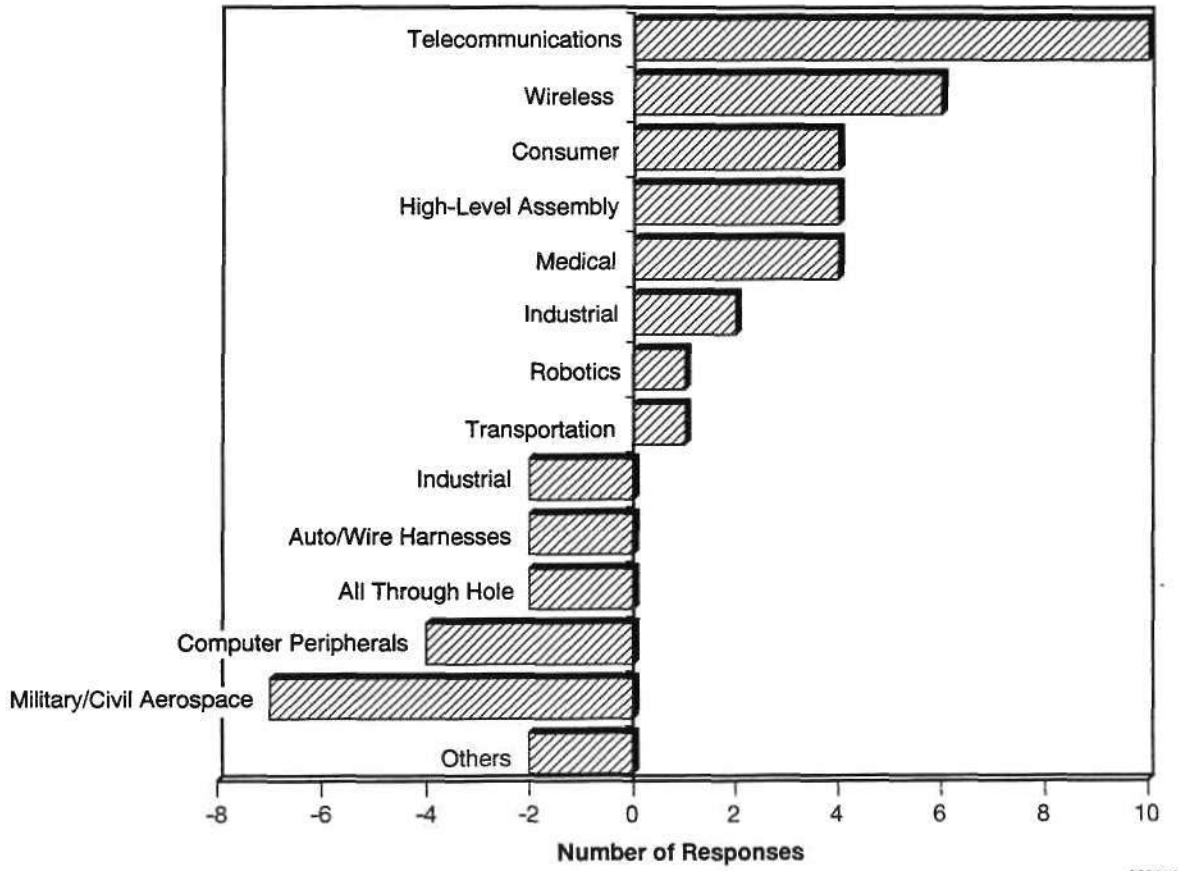
Source: Dataquest (April 1996)

Growing and Shrinking Markets in Contract Manufacturing

The growth of contract manufacturing in large part is a function of the types of customers it serves. Dataquest polled respondents on what they saw as the upcoming growth and no-growth areas for their businesses (see Figure 4-3). In many areas, contract manufacturing mirrors the electronics industry, yet there are differences. Telecommunications and wireless are two of the fastest-growing markets, and the majority of respondents also see these applications as fast-growing CM opportunities. Although there is growth potential in the medical and high-level assembly businesses, most analysts would consider growth potential higher for computers and consumer applications. contract manufacturers may see more opportunity in the medical arena because of their lack of presence to date in that market, which would allow for fast growth; computer and consumer markets are already relatively well served by contract manufacturers.

On the other side of the spectrum are the markets contract manufacturers see as not growing, markets that will not be targeted for new business. Overall, the results were not unexpected, but there were surprises. In general, the military/civil aerospace market will not grow, in line with government budget cuts. Most interesting was the No. 2 area considered to offer slow growth or no growth—computers and peripherals. Possibly the volatility of this market and the already high use of CM by computer and peripherals companies earned this market segment its dubious rank. The rest of the markets cited as shrinking are not surprising, except that the industrial segment made both the growth and no-growth area. The extreme variety of the industrial market would account for this apparent contradiction.

Figure 4-3
Contract Manufacturing Trends: Growing and Shrinking Markets

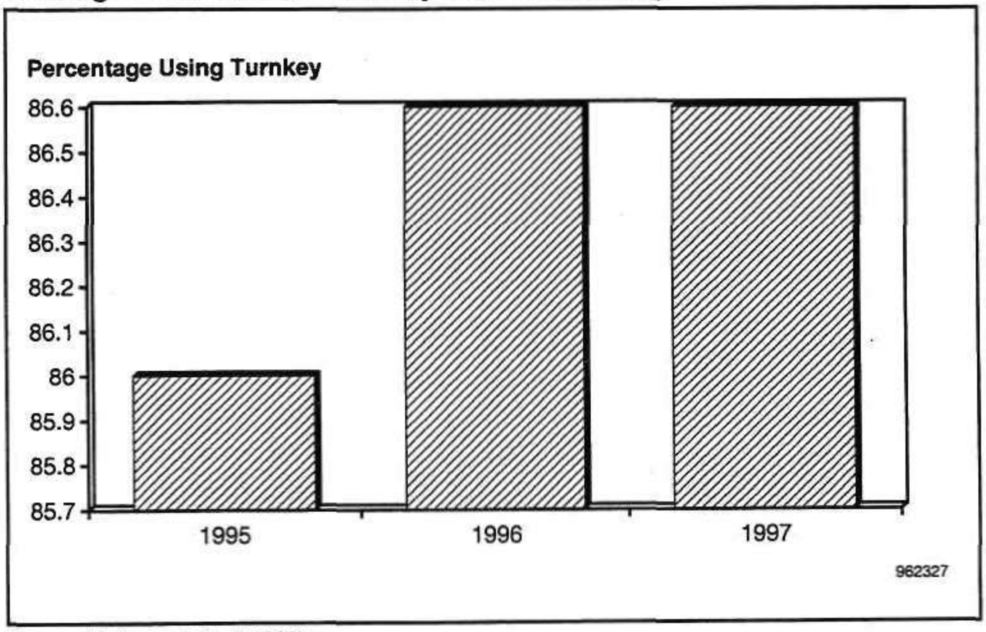


Source: Dataquest (April 1996)

Consignment versus Turnkey Contract Manufacturing

Our 1993 survey asked CM customers what percentage of their outsourcing was on a consignment or turnkey basis. (With consignment contract manufacturing, the customer procures the semiconductors for the CM; in a turnkey arrangement, the CM provides all manufacturing and procurement.) At that time, slightly less than half of the respondents (49.6 percent) used turnkey contract manufacturing. Figure 4-4 shows that the vast majority of CM customers now use turnkey contracts, and we expect this to remain relatively constant through 1997. The increase in this form of contracting reflects the ability of users to leverage the CM supplier's economies of scale for price reductions while reducing the overhead costs associated with logistics and procurement.

Figure 4-4
Consignment versus Turnkey Manufacturing



Source: Dataquest (April 1996)

Chapter 5
Contract Manufacturing Customer Perceptions

This chapter examines the criteria on which Dataquest's survey respondents rate contract manufacturers and what they dislike about contract manufacturers. We look first at the reasons companies use contract manufacturers from a pragmatic standpoint. We then analyze satisfaction with the top five CM attributes. After a look at the positives associated with contract manufacturing, the problems respondents have with the industry are examined and key parameters that require improvement are defined.

Reasons to Use an Electronics Contract Manufacturer

Much has been written about why an electronics company would opt to use a contract manufacturer. Table 5-1 highlights how issues have changed since Dataquest's last report on this issue. Although there has been a slight shuffle of the rankings, the overall criteria for choosing a contract manufacturer have not changed appreciably. This is because the issues facing electronics companies (that is, shrinking product life cycles, increasingly expensive capital equipment, and increased need for cost containment) remain the driving forces of the industry. Dataquest expects that, given these three issues, contract manufacturing growth will continue to outpace the electronics industry in the upcoming years.

Disadvantages of Using an Electronics Contract Manufacturer

As noted previously, lowering total costs (including materials, overhead, and communications, among others) is a high priority for the respondents we surveyed. It is true that the level of service provided by contract manufacturers now satisfies most users, but areas capable of improvement remain. Dataquest's survey asked current CM users to identify any disadvantages of using CM and to define some key benchmarks.

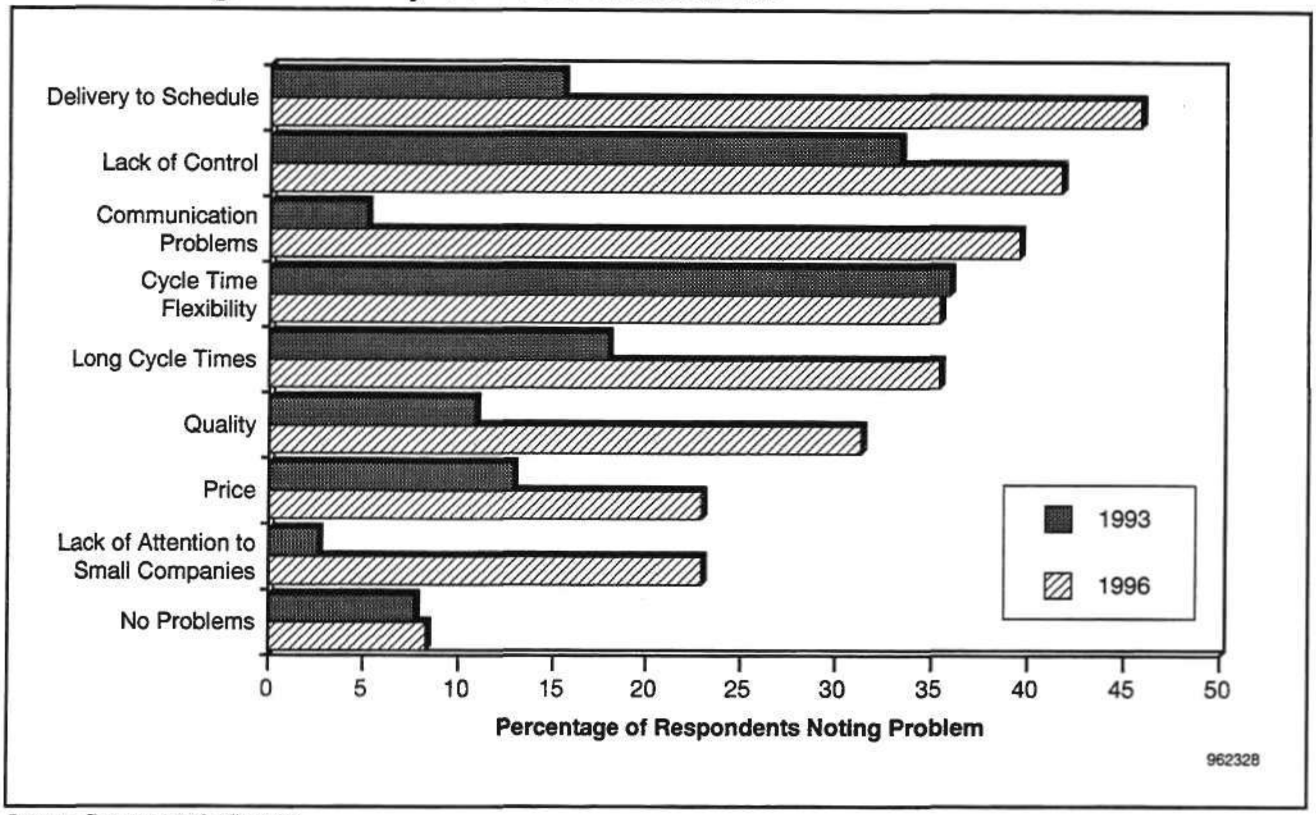
Figure 5-1 shows that the top three areas of concern cited by the current survey are delivery on schedule, lack of control, and communications. Issues of cycle time ranked fourth and fifth, followed by quality, price, and lack of attention (service). It is probably heartening to contract manufacturers that over 8 percent of those responding to this open-ended question independently noted that they had no problems in dealing with contract manufacturers. This compares negatively with our 1993 survey—the problems then centered on cycle time flexibility and lack of control. Cycle time issues remained relatively constant since our last report, but issues of delivery commitments, control, and communications need further focus.

Table 5-1
Reasons to Choose Contract Manufacturing over In-House Manufacturing

1996	1993
1. Lower total cost of manufacturing	1. Lower total cost of materials
2. Manufacturing expertise	2. Lower total handling costs
3. Easy to work with (service, flexibility)	3. Good service
4. Inventory control	4. Manufacturing expertise
5. Access to new technology	5. Additional manufacturing capacity

Source: Dataquest (April 1996)

Figure 5-1
Areas Needing Attention by Contract Manufacturers



Source: Dataquest (April 1996)

Improved communications between both contract manufacturers and CM customers by means of regular production status updates (either quarterly, monthly, or weekly) would go a long way toward preventing missed deliveries (either early or late) and the lack of control that CM users currently perceive. Tied in with loss of control is cycle time inflexibility by contract manufacturers and length of cycle times. Although economies of scale and low costs are predicated on manufacturing process standards, allowing customers the leeway in changing delivery or volume, for a fee, may satisfy customers better and increase revenue.

Contract Manufacturing Customer Satisfaction Levels

The five attributes shown in Table 5-2 (in rank order for 1996) were first identified in our 1993 report as key contract manufacturing performance attributes. We used them in this report as they are still the guidelines from which contract manufacturers are judged. The "easy to work with" category encompasses communications, flexibility, and similarity of business style. Table 5-2 shows how customer priorities have changed since our first survey.

Table 5-2
Contract Manufacturer Performance Criteria, Historical Ranking

1996	1993
1. Price competitiveness	1. Manufacturing expertise
2. Manufacturing expertise	2. Easy to work with
3. Easy to work with	3. Price competitiveness
4. Inventory control	4. Inventory control
5. Access to new technology	5. Access to new technology

Source: Dataquest (April 1996)

Importance Ranking

Dataquest's 1993 contract manufacturing Focus Report introduced a new way of both ranking issues and identifying levels of user satisfaction for this industry. Figure 5-2 ranks the variables clockwise, beginning at the top (issues of highest importance). Along each axis is a mean importance rating and a mean satisfaction rating for that criterion. The center of the polar diagram is equal to zero (the lowest score) and the end value is equal to 6, the maximum importance or satisfaction rating possible. The gaps between level of importance and level of satisfaction clearly identify where contract manufacturers can focus on the customers' list of priorities.

The satisfaction gap analysis diagram illustrates how the current contract manufacturing survey respondents rank these five attributes in importance. All respondents reported high levels of satisfaction (0 being low and 6 high)—all satisfaction attributes were higher than 4.5. However, customers' level of satisfaction with some attributes still offers room for improvement.

The figure shows that respondents to the survey were not completely satisfied with the level of contract manufacturing support in four out of five areas. In order, they are as follows:

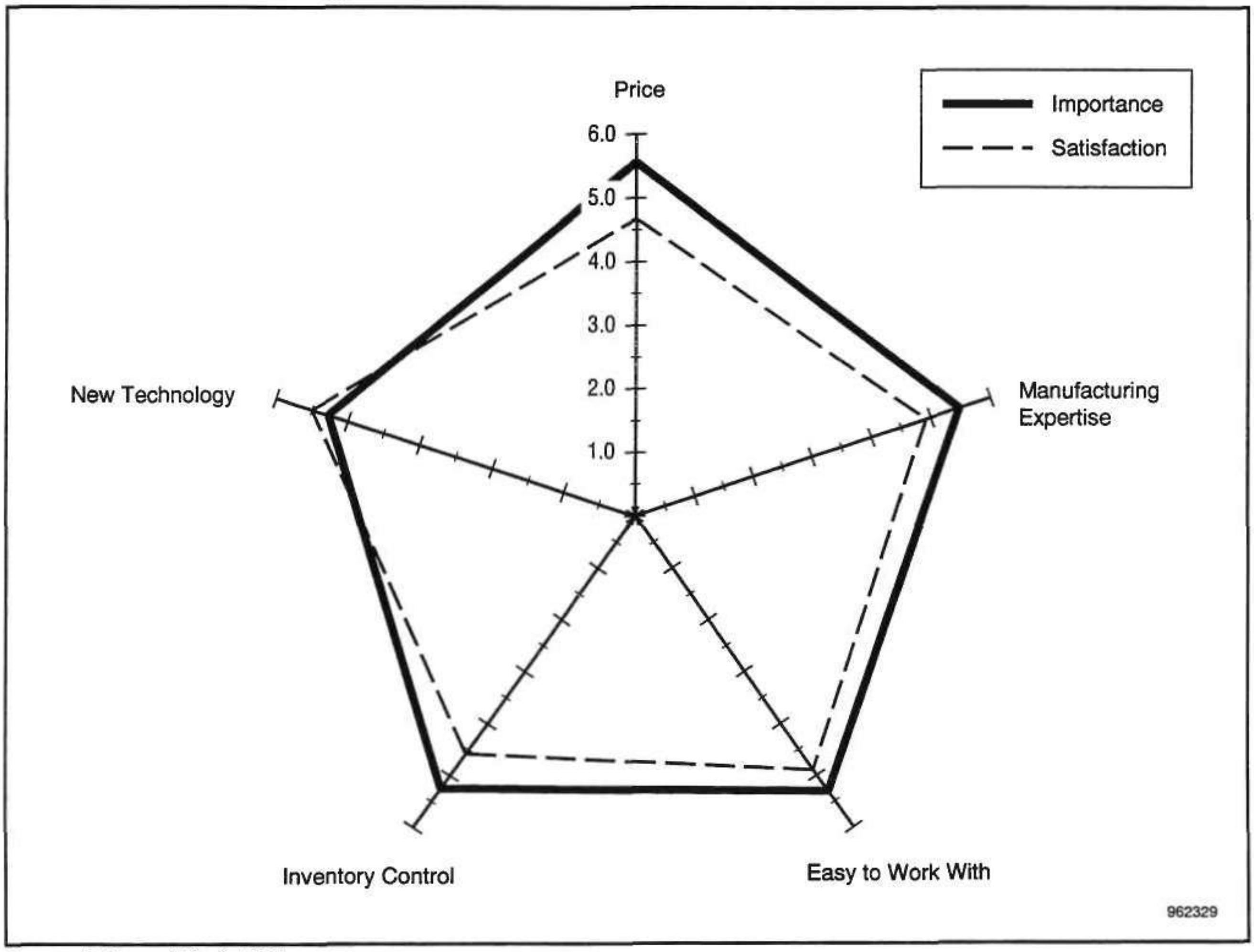
- Price competitiveness
- Manufacturing expertise
- Easy to work with
- Inventory control

Electronics contract manufacturers that want to meet user requirements better should focus on these four attributes in the order listed. Less emphasis on access to new technology is allowable because the level of satisfaction for this attribute exceeds its importance for respondents.

Competitive Pricing

The top-ranked attribute had the largest spread between importance and satisfaction level. One of the largest factors in total contract manufacturing cost is components (as shown in the second figure in Chapter 6). With the recent shift in availability and the resulting lower prices for components, this top-ranked attribute requires prompt attention. Many CM customers use their contractors to compete effectively with much larger companies, using the purchasing power of their contract manufacturer to even the playing field for the component price variable. It was a common practice

Figure 5-2
Contract Manufacturing User Issues and Satisfaction Levels



Source: Dataquest (April 1996)

in the past for semiconductor suppliers to stipulate that only end users (and not contract manufacturers) could procure semiconductors from them directly. This practice, while still seen, primarily affects semiconductors that are in limited supply, sole-sourced, or require direct purchaser warranty coverage—areas where increased competition would benefit the user.

Manufacturing Expertise and Ease of Work Relations

One of the main reasons that companies choose a contract manufacturer is to lower overall costs. Key in this determination is the level of manufacturing expertise offered to the market. It is important for contract manufacturers to have the latest assembly equipment to remain competitive. Nearly as important as manufacturing prowess is the area of work relations, where problems get resolved or are avoided entirely. How quickly and well a contract manufacturer and customer understand each other's business style helps greatly in smoothing the communication critical in any contract manufacturing relationship. Contract manufacturing users need responsive suppliers because the perception of loss of control has increased, not decreased, over the past three years.

Inventory Control

Inventory control, although ranked fourth, still needs some work from contract manufacturers in order to meet customer needs. Inventory control involves the balancing act of maintaining safety stocks sufficient for shipment flexibility and keeping inventory levels low to minimize internal costs. It appears that internal CM cost control is taking precedence over customer satisfaction. Because this is not the issue of highest priority, it is not likely to be quickly or fully resolved.

Access to New Technology

The lowest-ranked issue, access to new technology, shows a satisfaction level that exceeds the level of importance. This means that customers are getting access to more technology than they are expecting, a nice place to be as a customer but possibly expensive for the CM if sustained. Maintaining this level or a slightly lower level of satisfaction with new technology could lower costs.

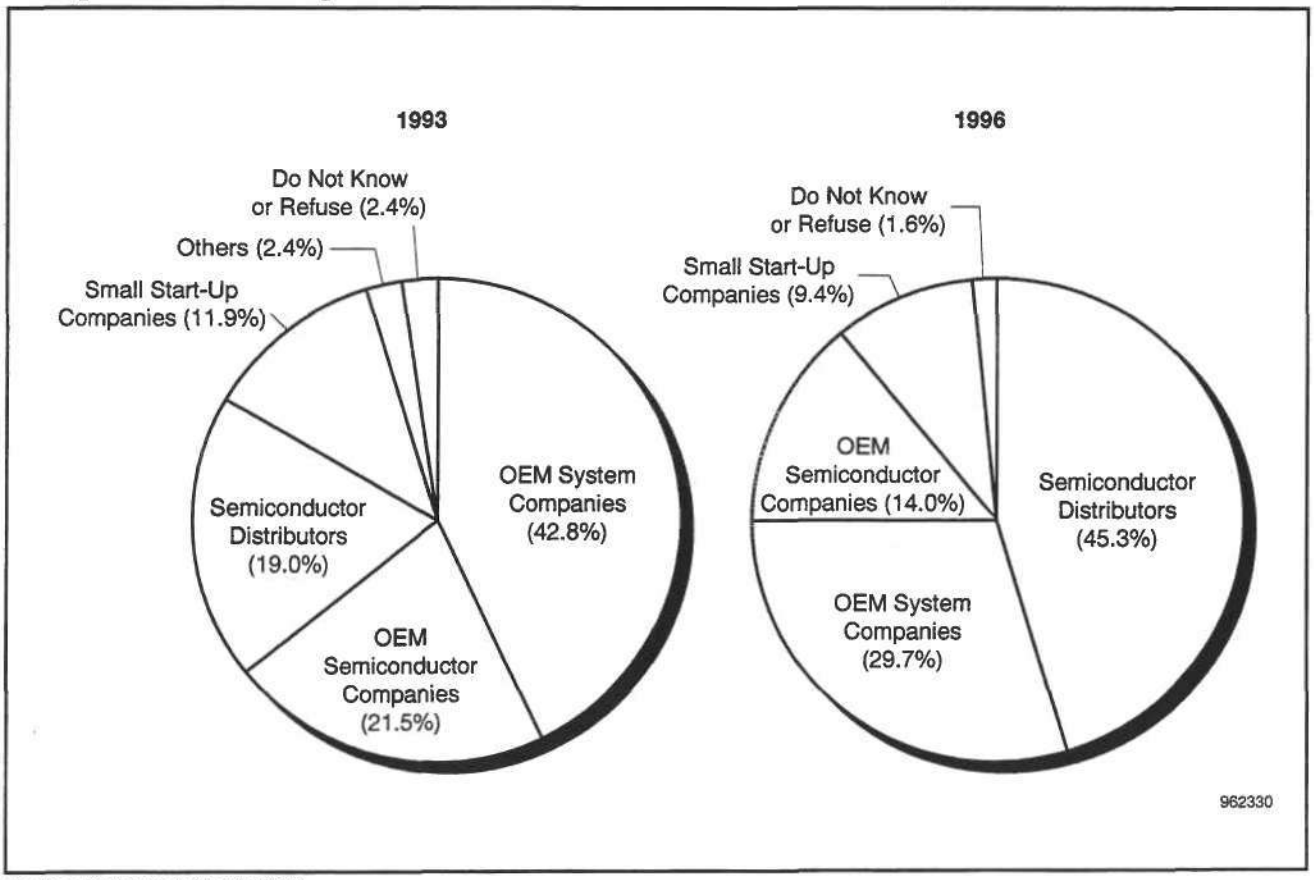
The Status of Competition in Contract Manufacturing

Dataquest noted a trend in 1993 in which large system companies, selected semiconductor manufacturers, and semiconductor distributors (among others) were expanding operations into the traditional contract manufacturing market. The effects of downsizing and the shift to providing customers with additional value were forcing many nontraditional providers into this arena. We asked user respondents then and in the current survey whether they had noticed new companies offering contract manufacturing capabilities. We then asked respondents what type of company was offering contract manufacturing compared with pure contract manufacturers. The level of CM hype may have decreased, and Figure 5-3 shows that the type of company offering contract manufacturing has shifted from system OEMs and semiconductor manufacturers (totaling 64.3 percent in 1993) to distributors and system OEMs (75 percent in 1996). The higher visibility of distributors in this survey answers a question asked then about where would the traditional semiconductor distributor would fit in an increasingly stratified market. The reduction in system OEM presence is likely a function of realizing that this business is not comparable to internal manufacturing for a captive customer. Many system companies did not anticipate the combination of low profits, manufacturing flexibility requirements, and good customer service needs required for contract manufacturing. As a result, these operations either left the market or were acquired by large contract manufacturers.

Overall Satisfaction Levels of Contract Manufacturer Customers

The contract manufacturing business is an inherently low profit-margin operation. Most companies in this industry target operating income of 4 percent to 5 percent. In Dataquest's previous and current surveys, user respondents were asked what type of contract manufacturer met their overall needs best. Figure 5-4 shows that system OEM companies offering contract manufacturing services have risen dramatically in customer satisfaction, largely at the expense of pure contract manufacturers. Semiconductor companies offering contract manufacturing capabilities also slipped in overall customer satisfaction, while smaller, niche contractors appear to be meeting application-specific customer needs.

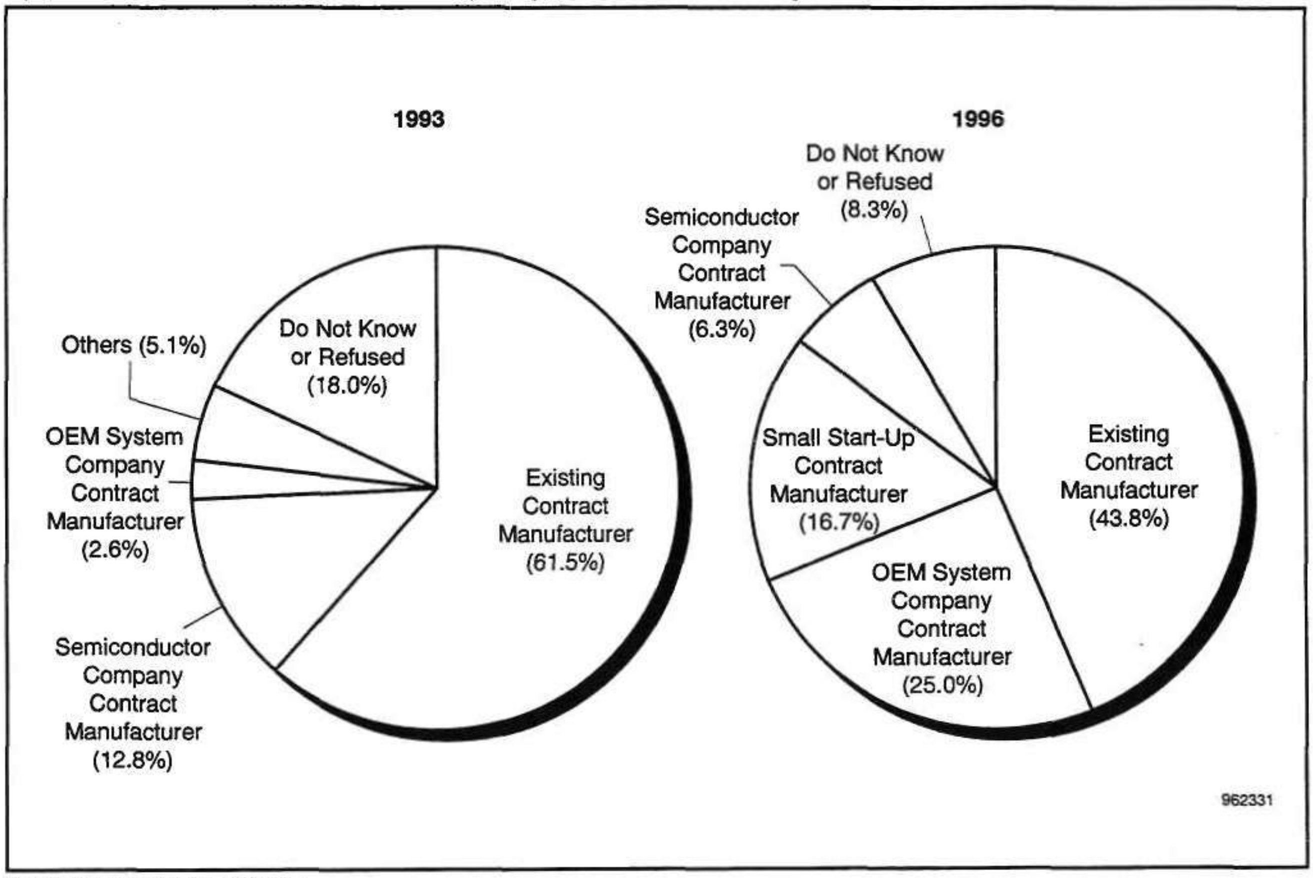
Figure 5-3
Composition of Competition with Pure Contract Manufacturers, 1993 and 1996



Source: Dataquest (April 1996)

Although there may be fewer system OEM companies offering contract manufacturing, those that remain in the market are being relatively well received. Contract manufacturers need to be aware of which companies are increasing levels of customer satisfaction in order to maintain or increase their own levels of customer satisfaction.

Figure 5-4
Type of Contract Manufacturing Supplier Preferred by Users, 1993 and 1996



Source: Dataquest (April 1996)

Chapter 6
Contract Manufacturing Benchmark Criteria

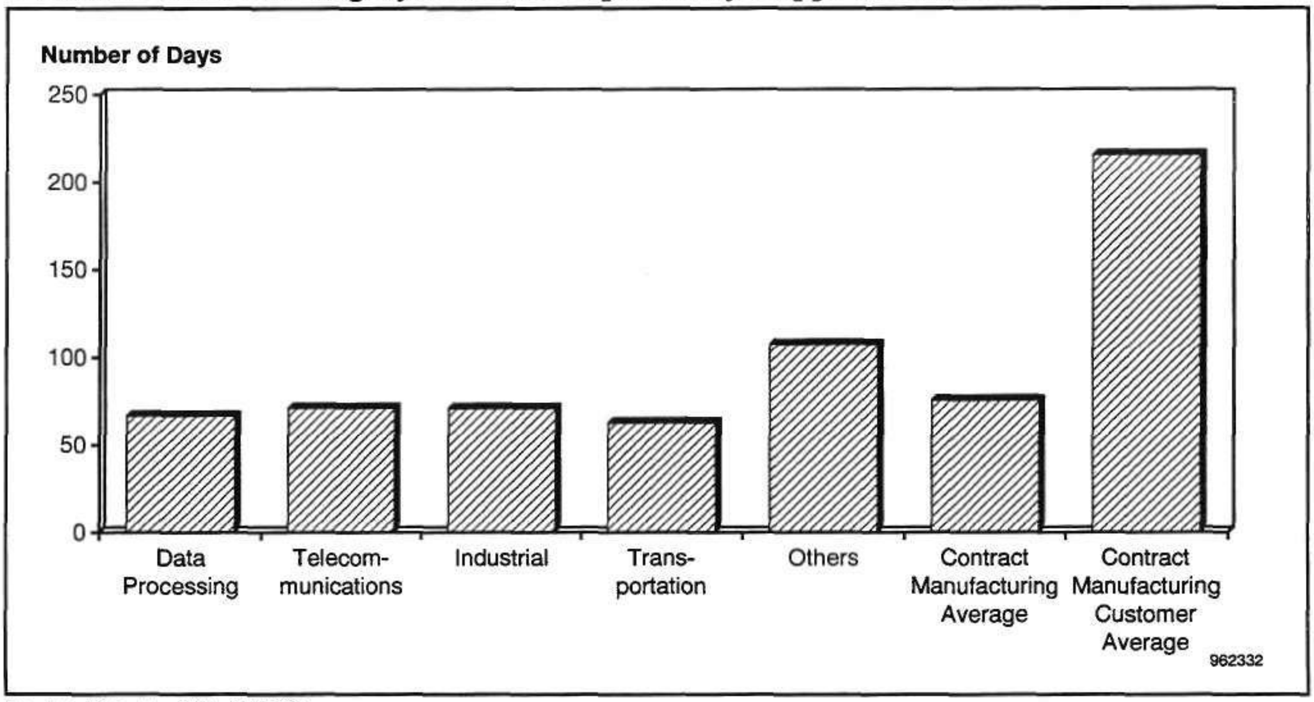
This chapter discusses two key contract manufacturing benchmarks, manufacturing cycle times and the incremental cost of manufacture. Both contract manufacturer and customer responses are examined to highlight the differences and similarities in perception in this symbiotic relationship.

Cycle Time Differences

Dataquest asked both CM users and contract manufacturers what their average cycle times were (we define cycle time as time from design release to production, ending when the finished product is shipped). Responses from contract manufacturers by market application, the average CM supplier response, and the average CM customer response are shown in Figure 6-1.

What is clearly noticeable is the wide difference between the weighted average CM supplier cycle time (75 days) and the weighted average CM user cycle time (215 days). The difference, over three months in average cycle times, highlights a key need for improved communication—in this case, about what cycle times mean. Although Dataquest interviewers supplied respondents with a clear definition of cycle time, the varied responses from users highlight the need to be more explicit in defining terms. When contract manufacturers were asked about their on-time delivery percentage (actual delivery date versus customer requirement), the average was 87.1 percent. When users were asked if contract manufacturers are meeting cycle time requirements, only 75 percent answered yes.

Figure 6-1
Contract Manufacturing Cycle Times Reported by Suppliers and Users



Source: Dataquest (April 1996)

If the average cycle time of users is above the highest cycle time noted by contract manufacturers (215 days versus 180 days), there is an obvious need to clarify terms. Otherwise, it is very unlikely that customers will ever be fully satisfied with cycle times.

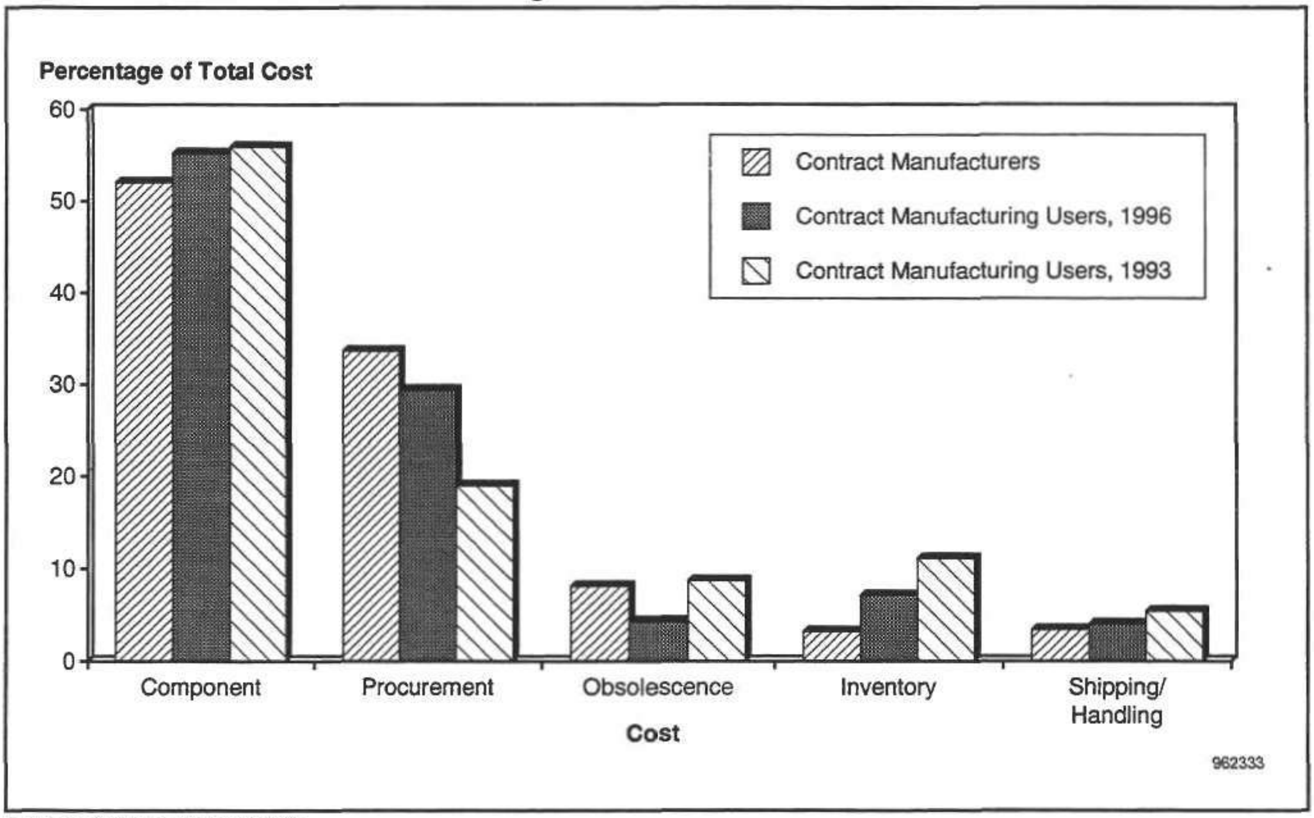
Incremental Costs of Contract Manufacturing

The incremental costs of contract manufacturing often need to be compared with internal manufacturing and logistical costs to justify the decision to outsource products or processes to a contract manufacturer. Figure 6-2 shows the cost increments reported by both contract manufacturers and CM customers in Dataquest's latest survey, as well as cost increments reported by customers in the 1993 survey.

Component Costs

Both respondent groups report that component costs account for over 50 percent of the total cost of contract manufacture. From a historical perspective, contract manufacturing customers have displayed remarkable consistency in the component cost percentages reported in 1993 and 1996, the change being less than 1 percent (55.9 percent in 1993 and 55.2 percent in 1996). This accounts for the high rank of price as a user issue and its importance as an area noted by contract manufacturers as needing attention. Because more than half of the contract manufacturing dollar is spent

Figure 6-2
Incremental Contract Manufacturing Costs



Source: Dataquest (April 1996)

on components, it is imperative that the user obtain the best possible material pricing—either through the CM supplier or independently—because contract manufacturing savings can evaporate with uncontrolled prices. Using a contract manufacturer still requires that the user company be aware of semiconductor pricing dynamics.

Contract Manufacturing/Procurement Costs

Estimates of actual manufacturing and procurement costs ranged between 29 percent of total costs from CM customers and 34 percent of total costs from the contract manufacturers—only a 5 percent spread. This minor difference in estimates emphasizes that both customers and suppliers are aware of the overhead cost of outsourcing and that the variable cost of material then becomes even more critical. Responses in the 1996 survey show a marked increase in estimates of these costs, from 19 percent in 1993 to 29.4 percent in 1996. This may reflect the shift toward turnkey contract manufacturing (which involves more costs) that is now the predominant CM practice.

Obsolescence Costs and Costs of Receiving from a Contract Manufacturer

The cost of carrying obsolete material for a CM supplier and the corresponding cost of receiving old material from a CM supplier were estimated at under 9 percent by contract manufacturers and under 5 percent by CM customers. This highlights the efforts made by contractors to meet customer requirements and maintain aged inventory flexibility. Comparing the 1996 survey's user response of 4.7 percent of CM receiving costs versus the 1993 survey's 8.7 percent estimate hints that contract manufacturers may be picking up some of these incremental costs.

Inventory Costs

Holding inventories to a bare minimum has become religion over the past five years. The low average percentages of inventory costs estimated by both CM users and contract manufacturers confirm that Dataquest's sample has gotten this religion. As confirmation of this trend, the current CM user inventory cost estimate of 7.1 percent (although still higher than the 3.2 percent CM supplier estimate) is 4 percent lower than the 11.1 percent reported by CM users in 1993. Dataquest expects inventory costs to remain below 5 percent as improvements in just-in-time and other logistical processes become more widespread.

Shipping and Handling Costs

Traditionally low, the shipping and handling cost estimates from both user and supplier respondents came in at or below 4 percent of the total cost of contract manufacture. This cost segment benefits from improved competition and deregulation, which lower this cost component. In 1993, the CM user sample estimated shipping and handling costs to be over 5 percent, the 1996 respondents report an average of 4 percent. At some point, this reduction rate of close to 0.5 percent per year will slow. Attaining and maintaining shipping and handling costs of under 4 percent will obviously help keep overall costs down.

Chapter 7
Dataquest Analysis

An Increasing Force

Contract manufacturing is becoming a permanent fixture of the modern manufacturing process. The three main forces that continue to push companies toward some form of contract manufacturing are the following:

- Increasingly short life cycles of all electronic systems
- Increasingly expensive capital equipment needed to manufacture the newer systems
- Increased global competition that continues to force cost cutting at all levels

Shrinking Product Life Cycles

The expansion of the electronics industry (fueled by increased functionality at lower cost) continues at a healthy pace. Shorter life cycles require a shorter time to earn a rate of return that covers overhead, cost of materials, and the other necessities of modern manufacturing. These three functions alone are reasons enough for some companies to opt for contract manufacturing.

Capital Equipment Expense

In conjunction with shorter product life cycles, the trend toward increasing capital equipment costs continues to benefit and hinder product innovation. Because of increased system complexity requiring higher levels of integration, the tolerances and precision of manufacturing machinery must also improve. Improvement is not cheap. Fabrication costs of semiconductors are a good example of this trend. In 1988, a state-of-the-art DRAM fab cost about $200,000; in 1996 a state-of-the-art fab will cost over $1 billion. Although other industries may not show such dramatic rises in capital costs, increasingly precise, automated equipment is necessary in order to compete. This new equipment generally costs more than upgrading machinery.

Increased Pressure from Global Competition

Global competition over the past three years has increasingly forced cost cutting involving personnel and unproductive plants. Worldwide markets imply a global level of competition, with differences in wage rates, government trade policies, and other regional economic issues. This competition increases industry efficiency, which keeps pressure on cost control at all levels of organizations, regardless of the business location. Of the components making up the cost of sale—raw materials, equipment, labor, marketing, and administration—the first three have the most direct long-term impact on the financial health of an organization. Although labor, marketing, and administrative costs all involve wage or head count levels that are adjustable, cost cutting at these levels has, in many cases, reached a marginal rate of return for most companies. This leaves the other two areas of cost of sale: raw materials and capital equipment. Costs associated with materials and modes of production depend on capital expenditure that generally is depreciated over three to five years. If families of products made on this machinery have life cycles shorter than this because of global competition, the loss of potential revenue cannot offset the capital costs. This accounts for the trend of OEM system companies offering contract manufacturing services to offset capital costs.

Where Contract Manufacturing Makes Sense

Strategic Outsourcing

The three situations described (shrinking product life cycles, higher equipment costs, and global competition) are based on the assumption that companies own all their production capacity and may not have access to worldwide regional manufacturing sites. Contract manufacturing will continue to provide companies a viable means to produce products as long as the OEM keeps its critical market value proprietary. If a company cannot "do what it does best, but outsources it all," it fails to bring value to the market as a manufacturer. Inevitably, that company faces the risk of fading from the market as a manufacturing entity.

Improved Performance

Contract manufacturing is being used by companies responding to all three of these situations, with varying levels of success, depending on the product being produced. Although this report highlights the fact that respondents facing shorter product life cycles desire lower costs and increased flexibility from their contract manufacturers, the current level of support satisfies the majority of them. Improved cycle times also can provide a competitive edge in the current market. Because of their manufacturing knowledge, contract manufacturers often suggest and implement manufacturing improvements for their customers that add further value to the end product.

Regional Competition

Different regions of the world have different methods of managing domestic and international trade. Companies around the world continue to adjust to regional market requirements. The flexibility and lower capital outlay afforded contract manufacturing customers makes CM an attractive option where a portion of production is commoditized and can be more economically produced off-site. Increased nontraditional competition (that is, competition from OEM companies with excess capacity, semiconductor suppliers, and semiconductor distributors) continues to put pressure on pure contract manufacturers. Improved levels of service and communication, areas that survey respondents cited as needing improvement, should result from this competition.

A company's operating procedures and output require frank assessment to determine if contract manufacturing is a viable option. The result must then be gauged against industry benchmarks. Those areas not up to industry standards (and not critical to the strategic survival of the company) are good candidates for outsourcing to contract manufacturing.

This study has highlighted what current contract manufacturing users need and where top contract manufacturers perceive the market is going. Although most of the market dynamics point to the use of some sort of contract manufacturing in the future, individual companies still need to determine the pros and cons of what, if any, procedure or process can be outsourced successfully.

Appendix A
North American Contract Manufacturers

Company	Phone Number	SMT Capability
Accurate Electronics Corporation Northridgeville, Ohio	(216) 366-6330	Yes
Aerospace Industries Inc. Cuyahoga Falls, Ohio	(330) 928-5002	No
Altek Company Torrington, Connecticut	(203) 482-7626	Yes
Altron Inc. Anoka, Minnesota	(612) 427-7735	Yes
AVEX Electronics Inc. Huntsville, Alabama	(205) 722-6301	Yes
AVG/LMC Carol Stream, Illinois	(708) 668-3900	Yes
Benchmark Electronics Inc. Angleton, Texas	(409) 849-6550	Yes
Beta Industries Inc. Dayton, Ohio	(800) 571-9979	Yes
Celestica Inc. North York, Ontario, Canada	(416) 448-5800	Yes
Cerberus Pyrotronics Cedar Knolls, New Jersey	(201) 267-1300	Yes
Colt Technology Corporation Lee's Summit, Missouri	(816) 525-2658	Yes
Comptronix Corporation Gentersville, Alabama	(205) 582-1800	Yes
Contract Manufacturing Co. (CMC) Corinth, Michigan	(601) 287-3771	Yes
DARE Electronics Troy, Ohio	(800) 366-3273	Yes
Data Signal Inc. Albany, Georgia	(912) 883-4703	No
Diagnostic Instrument Corporation Ayer, Massachusetts	(508) 772-4572	Yes
Dovatron East Division (formerly Dover Electronics) Binghamton, New York	(607) 773-2290	Yes

Company	Phone Number	SMT Capability
Dovatron West Division (formerly Dover Electronics) Longmont, Colorado	(303) 772-5933	Yes
Flashpoint Technology Irvine, California	(714) 261-2308	Yes
E.C.M. Inc. Harbor City, California	(310) 530-3456	Yes
Elamex El Paso, Texas	(915) 774-8369	Yes
Electronic Engineering Research Chatsworth, California	(818) 709-1195	No
Electronics Systems Inc. Sioux Falls, South Dakota	(605) 338-6868	Yes
EMD Associates Winona, Minnesota	(507) 452-8932	Yes
Entra Corporation Indianapolis, Indiana	(317) 849-8270	Yes
EOG Inc. Hunt Valley, Maryland	(410) 785-3000	Yes
Express Manufacturing Inc. Santa Ana, California	(714) 556-1878	Yes
Flextronix International San Jose, California	(408) 428-1300	Yes
Force Inc. Christiansburg, Virginia	(540) 382-0462	Yes
General Technology Corporation Albuquerque, New Mexico	(505) 345-5591	Yes
Griffin Limited Baltimore, Maryland	(410) 298-1710	Yes
Group Technologies Tampa, Florida	(813) 972-6000	Yes
GSS/Array Technology Inc. San Jose, California	(408) 229-6100	Yes
Halcyon Microelectronics Inc. Irwindale, California	(818) 814-4688	Yes
Hibbing Electronics Corporation Hibbing, Minnesota	(218) 263-8971	Yes
IEC Electronics Corporation Newark, New York	(315) 331-7742	Yes

Company	Phone Number	SMT Capability
IM/D Corporation Manchester, New Hampshire	(603) 669-5224	Yes
Jabil Circuit Company Inc. St. Petersburg, Florida	(813) 577-9749	Yes
Kimball Electronics Jasper, Indiana	(812) 634-4000	Yes
Kimchuk Inc. Danbury, Connecticut	(203) 790-7800	Yes
Liberty Contract Services Garden Grove, California	(714) 373-9944	Yes
Libra Industries/Electronics Division Mentor, Ohio	(216) 974-7770	Yes
Ma Labs San Jose, California	(408) 954-8188	Yes
Manu-Tec Inc. Addison, Illinois	(708) 543-3022	Yes
MEP Controls Bordentown, New Jersey	(609) 298-7303	No
Micro Industries Westerville, Ohio	(614) 548-7878	Yes
Micron Custom Manufacturing Services Boise, Idaho	(208) 368-2600	Yes
Milwaukee Elect. Corporation Milwaukee, WI	(414) 228-5500	Yes
MiNT Corporation Tucson, Arizona	(602) 741-6468	Yes
Mitech Electronics Corporation Otsego, Michigan	(616) 694-9471	Yes
National Telephone & Electronics Inc. Miami, Florida	(305) 592-0551	Yes
New Brunswick Industries El Cajon, California	(619) 441-3790	Yes
Philips Industrial Elect. Auburn, Indiana	(219) 925-8774	Yes
Pine Instrument Co. Grove City, Pennsylvania	(412) 458-6391	No
Plexus Corporation Neenah, Wisconsin	(414) 722-3451	Yes

Company	Phone Number	SMT Capability
Praegitzer Industries Dallas, Oregon	(503) 623-9273	No
Precision Graphics Inc. Raritan, New Jersey	(908) 707-8880	Yes
Quay Corporation Eatontown, New Jersey	(908) 542-7340	Yes
R&M Electronics Inc. Gibsonia, Pennsylvania	(412) 443-8222	Yes
Radio Television Products Corporation Douglas, Arizona	602) 364-4430	No
RAMP Industries Inc. Binghamton, New York	(607) 729-5256	No
SCI Systems Inc. Huntsville, Alabama	(205) 882-4800	Yes
Senior Systems Technology Inc. Chatsworth, California	(800) 800-0778	Yes
Specialty Industries San Jose, California	(408) 944-9500	Yes
Solectron Corporation Milpitas, California	(408) 957-8500	Yes
Sparton Electronics Brooksville, Florida	(904) 799-6520	Yes
Superior Manufacturing Co. Santa Ana, California	(714) 540-4605	Yes
Syntec Corporation Pflugerville, Texas	(512) 251-3484	Yes
Teledyne Lewisburg Lewisburg, Tennessee	(615) 359-4531	Yes
Test Group Inc. San Diego, California	(619) 452-4160	No
Turtle Mountain Corporation St. Paul, Minnesota	(612) 481-1427	Yes
Unisys/Paramax St. Paul, Minnesota	(612) 687-1490	Yes
Varian Tempe Electronics Center Tempe, Arizona	(602) 968-6790	Yes
VerTek International Inc. San Diego, California	(619) 661-6868	Yes

Company	Phone Number	SMT Capability
Western Reserve Electronics Twinsburg, Ohio	(216) 425-4951	No
XCEL Digitran Ontario, California	(810) 301-1582	No
Xetel Corporation Austin, Texas	(512) 834-2266	Yes
Zercom Corporation Merifield, Minnesota	(218) 765-3151	Yes

Source: Dataquest (April 1996)

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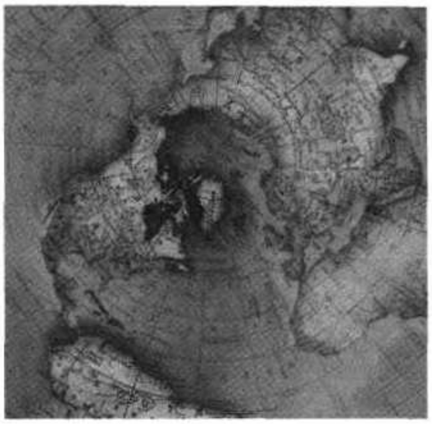

Dataquest

Focus Study: 1996 Semiconductor Industry Capital Spending Overview

Focus Report

Program: Semiconductor Supply and Pricing Worldwide
Product Code: SPSG-WW-FR-9601
Publication Date: March 4, 1996
Filing: Reports

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Table of Contents

Page

1. Capital Spending Overview 1
   - Overview 1
   - Year-End 1995: Backlog Heaven ... Needed for 1997 1
   - What Are the Trends? 2
   - Dataquest Perspective 4
2. Semiconductor Capital Spending Forecast 7
   - Highlights 7
   - Capital Spending Tables 8
   - And the Spending Binge Continues... 8
   - When Will the Spending Boom End? 11
   - The North American Market Continues to Exhibit Strategic Strength 12
   - Japan: DRAM Capacity Additions Drive Spending, but a Strong Yen Subdues 13
   - Europe Sustains Presence as a Growth Market 13
   - Asia/Pacific Is Madly Investing in Two Distinct Ways 14
   - Who's Investing Where? 16
   - Dataquest Perspective 17

List of Tables

Table		Page
2-1	Semiconductor Capital Spending—Top 20 Spenders, Comparison of 1994 and Projected 1995 Worldwide Capital Spending	9
2-2	Worldwide Capital Spending by Region — Historical, Includes Merchant and Captive Semiconductor Companies	10
2-3	Worldwide Capital Spending by Region — Forecast, 1994-2000, Includes Merchant and Captive Semiconductor Companies	10
2-4	Regional Investment Patterns of Semiconductor Manufacturers in 1994	16
2-5	Regional Investment Patterns of Semiconductor Manufacturers in 1995	17

Chapter 1

Capital Spending Overview

Overview

Capital spending patterns of semiconductor suppliers (or potential suppliers) are a good gauge of how a company responds to market competition and what its future plans are. Semiconductor users utilize this information to compare their strategic plans with their supply base in order to make adjustments to long-term arrangements if divergent spending levels occur.

Analysis done by Dataquest's Semiconductor Equipment, Materials, and Manufacturing service highlights the major trends of semiconductor company capital spending, along with a capital spending forecast. Capital spending on semiconductor equipment relates directly to semiconductor unit supply. 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 high level of capital spending is not offset by a similar increase in unit demand, the potential for an oversupplied market exists. Early knowledge of the situation can benefit users during price or delivery negotiations.

Year-End 1995: Backlog Heaven ... Needed for 1997

The year 1995 was one of those that the industry almost wishes will not be repeated for a while, because the infrastructure of supply is being strained. Backlogs in the equipment industry exploded in 1995, with reports that stepper lead times are over one year. Companies are having trouble filling all their open positions, and silicon supplies are extremely tight. Yet the engines of demand for semiconductors—PCs and communications/networking equipment—continue. A monthly leading indicator we have been developing went crazy in April and has not rested since.

A couple of trends do concern us, however. The number of planned fabs announced in the forecast horizon has increased dramatically from about 85 one year ago (counting 1994 and after) to over 130 (counting 1995 and after). The density of new fabs, about 35 per year, has not changed much, but the announcement horizon has lengthened. A year ago new fabs were announced to come on line in 18 to 21 months. Today, with the huge backlogs in equipment companies, announcements are made for fabs 24 to 30 months ahead. Funding to place an order for a stepper is generally done *before* ground is broken on a new fab, just to get in line. There are already about 25 fabs announced to come on line in 1998—a visibility that is uncharacteristic.

Are these fabs real? We believe so, because in order to achieve a $330 billion semiconductor market by 2000, the industry needs to maintain a run rate of 30 to 35 fabs per year. Our concern is that the 1996 and 1997 run rates are slightly ahead of this figure, and some of the 1997 and 1998 fabs may be delayed by six to 12 months, softening the quality of backlogs for 1997.

Although we think the recent talk on DRAM pricing has been overblown, we do believe we are past the "pinch point" in the supply/demand imbalance, and availability of DRAM is beginning to improve. We are now viewing 1996 as a year for a slight oversupply of DRAM (based on silicon area capacity), so capital investment in 1997 is likely to cool in this area.

Does this spell doom for 1997? No, the foundry industry supply will get tighter in 1996, leading to increased spending for logic-oriented capacity over DRAM starting late in 1996 and continuing into 1997. The foundry market will not see relief in capacity until the middle of 1998, by our silicon area-based capacity analysis.

What Are the Trends?

On the heels of booming growth in 1994, global semiconductor capital spending grew another 72 percent during 1995 to $38 billion. Anticipated continued tight capacity and a strong semiconductor market in 1995 mean continued growth into 1996, now forecast at about 30 percent.

North America is showing consistent strength, with a 69 percent growth in 1995. Worldwide demand for desktop connectivity products and telecommunications equipment continues to fuel the investment strategies in U.S.-manufactured semiconductor products, heavily weighted toward logic and ASIC capacity. North American capital spending is expected to remain strong in 1996 and to moderate in 1997 as these investments are absorbed, but we expect the North American region to grow at faster-than-market rates as foreign multinationals and foundry companies invest in capacity in the United States.

Japanese companies are continuing to invest in semiconductor capacity to preserve their market share position in memories, although the strength of the yen during the middle of the year temporarily put a lid on spending enthusiasm. Japan as a region kept pace with the world in investment in 1994 but lagged the market in 1995 as Japanese companies invested more outside Japan. Healthy, but subdued, growth of 47 percent in spending within Japan occurred during 1995—about 34 percent on a yen basis. Lagging investment patterns in Japan are expected to continue throughout the decade. Japanese companies, however, grew spending during 1995 at about 61 percent worldwide, for a total of $12.2 billion, second only to North American companies' spending of $13.6 billion and well ahead of Asian companies' $9.1 billion.

Dataquest has been bullish on the prospects in Europe, and remained so in 1995, although the region came in slightly under expected spending. European companies are a large part of this expansion, aided by strong domestic economies, and major projects by the multinational manufacturers are also contributing. We still see Europe as a significant growth region for spending through the decade.

Following very strong capital investment growth of 77 percent in 1994, the Asia/Pacific-Rest of World (ROW) region grew an astronomical 104 percent in 1995, as Korean DRAM expansion accelerated (further), foundry expansion in Taiwan, Singapore, and others continued to grow, and new DRAM players entered the scene in Taiwan. These new projects started in 1995 will continue to consume capital funds in 1996. We are expecting about 31 percent growth in 1996. Asia/Pacific-ROW will continue to be one of the fastest-growing regions through this decade.

Dataquest believes that the relatively large capacity expansion of 1993 to 1995 (three-year growth of 265 percent) has now exceeded the three-year growth recorded in the 1987-to-1989 expansion. It should be noted, however, that the two periods are different in two key respects. First, the current period is experiencing accelerated long-term growth for the underlying semiconductor industry, driven by a productivity-related PC boom. The PC boom is expected to continue, so we are not overly alarmed about the magnitude of this cycle. Second, the manufacturing infrastructure is more efficient today, and there is a diminishing return in productivity and yield improvements. This has led to a higher natural capital investment ratio required today than in the 1987-to-1989 period, closer to 22 percent of revenue, on average, being a standard (versus 18 percent in the late 1980s).

However, we also believe that, in 1996, spending will decelerate, starting in the second half of the year, causing a relatively flat spending pattern through 1997 and 1998. Although we continue to believe that the cyclical nature of investment in semiconductor capacity will diminish, the PC boom must continue to drive the underlying semiconductor growth strongly enough to dampen the memory component of the cycle. After a flat two-year period, investments should pick up again in 1999.

Wafer fab equipment spending grew 66 percent in 1995 and is expected to grow 36 percent worldwide in 1996, driven by massive spending in the Asia/Pacific region and strong investments in the United States. DRAM-sensitive Japanese investment and an expanding European production base complete the strong picture for 1996. Segment growth in 1994 and 1995 is being led by DRAM or capital spending-sensitive equipment, with steppers, implant, wafer inspection, and factory automation exhibiting significantly stronger-than-market growth. New technology segments, such as chemical mechanical polishing (CMP), high-voltage implant, and rapid thermal processing (RTP) were the fastest-growing segments. We expect no major segment declines in 1996, as capacity additions are broad-based and worldwide. Record backlog levels going into 1996 will be a buffer against a market decline in 1997, but we do expect softness from the DRAM companies to become evident by the end of 1996.

After strong expansion years from 1993 through 1996, equipment purchases in 1997 should decline markedly, followed by a slight decline in 1998. Investment in DRAM capacity will be curtailed as producers elect to convert their 4Mb DRAM capacity to 16Mb, which adds bit capacity through the instant increase in bits per square inch. Also, many Japanese DRAM facilities now running 150mm wafers will convert to 200mm wafers, further delaying the need for new equipment. DRAM-sensitive equipment technologies or capital-intensive segments such as steppers, implantation, diffusion, and polysilicon etch will be affected more than logic-sensitive technologies such as sputtering, epitaxial reactors, CMP, RTP, nontube chemical vapor deposition (CVD), or metal etch. The next expansion should begin by 1999, driven by 0.35-micron to 0.4-micron capacity expansion.

We have factored in an infrastructure investment in equipment for late 1997 through 1999, which will affect the forecast size of the markets positively. This additional investment will be for initial equipment to fill a couple of 300mm fabs for running silicon by 1999. However, we believe that a significant 300mm equipment market will wait until well after 2000.

Yield enhancement is the trend of the time. Any system technology that can be priced relatively low and that has a direct impact on yield will gain immediate acceptance in volume. Areas emerging today as particularly important are in cleaning technology, photostabilizers, and process control metrology.

The silicon wafer market, driven by a stronger long-term picture for semiconductors in general, will grow faster over the next six years than in the recent past. As the industry moves to a 200mm baseline, the outlook for silicon wafer manufacturers becomes brighter. The current sellers' market in silicon, which we expect to last for several years, will enable the industry to become healthy—a necessity for the semiconductor industry. Silicon manufacturers have answered the call for 200mm capacity, and the semiconductor market has again responded with a cry for more. We believe that the ramp plans of silicon manufacturers in 200mm have been strategically and smartly measured because the memory of the overcapacity of 1985 is still fresh. Although there will be activity with 300mm wafers, this is expected to be focused on R&D and of low volume until after the turn of the decade.

Dataquest Perspective

Our forecast for capital spending and wafer fab equipment sales during the next six years assumes that the explosive growth of 1995 will carry over into 1996. These sales are being driven by the PC market, with telecommunications and networking spurring demand for semiconductor chips across a broad spectrum—and with continued tight capacity is convincing companies to expand. Our outlook for the future includes moderated growth in equipment spending in 1997 and a slight decline in 1998 before a resumption of double-digit growth in 1999.

The semiconductor industry is a global manufacturing business. Production of semiconductors is constantly shifting among regions as new capital flows toward areas of relatively lower capital cost and higher consumption growth. Where the PC goes, so go semiconductors. This is true from the perspective of the business forecast as well as the production line. Europe and Asia/Pacific, with very large capital spending upticks over the last several years, will continue to gain share in world production over the next few years.

The shifts and currents in semiconductor production trends mean that equipment and material suppliers will absolutely need a global presence, in every sense of the word, to remain competitive in the market. Product supply and support can no longer concentrate on local trends, because all major semiconductor companies have made it clear that they are investing worldwide. Silicon plants are now being strategically placed, such as Shinetsu Handotai's (SEH's) Malaysia plant and its recently announced joint venture in Taiwan, Komatsu's joint venture with Formosa Plastics in Taiwan, and MEMC Electronic Materials' joint ventures in both Korea (Posco-Hüls) and Taiwan (Taisil).

Taiwan is clearly the new major production growth area. We would expect Malaysia and Thailand to be the next major growth countries in three to five years. Evidence of this includes recent joint-venture fab announcements by Texas Instruments and others.

Further, the concept of contract manufacturing in semiconductors is clearly here to stay. Equipment and material suppliers could find themselves selling their technical products to an international team from several companies, including the manufacturer and the designer. However, the emergence of the dedicated foundry company, taking ownership of the process and manufacturing flow, will tend to centralize this activity. Dataquest has started a research program in Semiconductor Contract Manufacturing, with a major report expected to be released in March. This report will explore the key trends in contract manufacturing and foundries, including technology trends and supply/demand balance through the decade.

Chapter 2
Semiconductor Capital Spending Forecast

This chapter 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.

Chapter Highlights

This chapter will discuss the following highlights:

- On the heels of booming growth in 1994, global semiconductor capital spending grew another 72 percent during 1995 to $38 billion. Anticipated continued tight capacity and a strong semiconductor market in 1995 mean continued growth into 1996, now forecast at about 30 percent.
- North America is showing consistent strength, with a 69 percent growth in 1995. Worldwide demand for desktop connectivity products and telecommunications equipment continues to fuel the investment strategies in U.S.-manufactured semiconductor products, heavily weighted toward logic and ASIC capacity. North American capital spending is expected to remain strong in 1996 and to moderate in 1997 as these investments are absorbed, but we expect the North American region to grow at faster-than-market rates as foreign multinationals and foundry companies invest in capacity in the United States.
- Japanese companies are continuing to invest in semiconductor capacity to preserve their market share position in memories, although the strength of the yen during the middle of the year temporarily put a lid on spending enthusiasm. Japan as a region kept pace with the world in investment in 1994 but lagged the market in 1995 as Japanese companies invested more outside Japan. Healthy, but subdued, growth of 47 percent in spending within Japan occurred during 1995—about 34 percent on a yen basis. Lagging investment patterns in Japan are expected to continue throughout the decade.
- Japanese companies, however, grew spending during 1995 at about 61 percent worldwide, for a total of $12.2 billion, second only to North American companies' spending of $13.6 billion and well ahead of Asian companies' $9.1 billion.
- Dataquest has been bullish on the prospects in Europe, and remained so in 1995, although the region came in slightly under expected spending. European companies are a large part of this expansion, aided by strong domestic economies, and major projects by the multinational manufacturers are also contributing. We still see Europe as a significant growth region for spending through the decade.
- Following very strong capital investment growth of 77 percent in 1994, the Asia/Pacific-ROW region grew an astronomical 104 percent in 1995, as Korean DRAM expansion accelerated (further), foundry expansion in Taiwan, Singapore, and others continued to grow, and new DRAM

players entered the scene in Taiwan (Powerchip Semiconductor, Vanguard, and Nan Ya Technology). These new projects started in 1995 will continue to consume capital funds in 1996. We are expecting about 31 percent growth in 1996. Asia/Pacific-ROW will continue to be one of the fastest-growing regions through this decade.

- In 1995, we stated that Asia/Pacific would actually exceed North American spending in this decade. During 1995, Asia/Pacific did surpass Japan, becoming the second-largest region for capital investment. However, we believe a renewed interest in setting up capacity in the United States, particularly by Asian companies, coupled with the low cost of capital will keep North American spending slightly ahead of Asia/Pacific spending through this decade. Eventually, as more countries join the semiconductor manufacturing "club" (such as Malaysia and Thailand), Asia/Pacific will become the top region in investment.

Capital Spending Tables

A list of the projected top 20 semiconductor capital spending companies in 1995 is presented in Table 2-1. Capital spending details by region are provided in two tables in this chapter: Table 2-2 shows historical semiconductor capital spending by region for 1987 through 1994, and Table 2-3 shows the capital spending forecast by region for 1994 through 2000.

And the Spending Binge Continues ...

After a three-year rest, the growth cycle began again in a big way in 1993. After a 23 percent growth in semiconductor capital spending in 1993, acceleration growth of 54 percent followed in 1994, and growth now peaks with a 72 percent increase worldwide during 1995, based on our most recent capital spending survey.

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 and advanced ASICs. The capacity shortage has given rise to sharp acceleration in capital spending in all areas, with the strongest growth occurring in DRAM expansion in Asia/Pacific and Japan.

The big three Korean companies increased spending an unbelievable 124 percent to a combined total of $5.6 billion in 1995. A mostly new crowd of Taiwanese companies is now entering the DRAM manufacturing business, spending over $1 billion collectively in 1995. Japanese suppliers of memory are increasing investment, as well, for a collective increase of nearly 61 percent, to $12.2 billion, a larger dollar increase than the Korean companies. Intel and Motorola still head the list for 1995 as microprocessor and microcontroller demand continues to be strong. Equipping new and acquired facilities (in the case of Motorola) will continue to drive spending for these companies. The big three Korean companies, with their increase in DRAM capacity spending, now occupy the No. 3, No. 5, and No. 9 spots, and fully 13 companies are now part of the $1 billion spending club, with five near or over $2 billion. NEC, Fujitsu, Hitachi, Toshiba, and IBM Microelectronics all make this top 10, as the memory capacity keeps rolling in. In fact, the top spenders from No. 3 through No. 15 are all heavily

Table 2-1
Semiconductor Capital Spending—Top 20 Spenders, Comparison of 1994 and Projected 1995 Worldwide Capital Spending (Millions of U.S. Dollars)

1995 Rank	1994 Rank	Company	Projected 1995	1994	Change (%)
1	1	Intel	3,538.0	2,419.0	46.3
2	2	Motorola	2,375.0	1,640.0	44.8
3	9	LG Semicon	2,125.0	800.0	165.6
4	3	NEC	2,028.7	1,117.3	81.6
5	5	Samsung	1,975.0	1,000.0	97.5
6	6	Hitachi	1,719.7	969.9	77.3
7	4	Fujitsu	1,606.8	1,072.6	49.8
8	7	Toshiba	1,558.5	933.1	67.0
9	11	Hyundai	1,500.0	700.0	114.3
10	14	IBM Microelectronics	1,200.0	525.0	128.6
11	12	Mitsubishi	1,128.5	675.3	67.1
12	8	Texas Instruments	1,100.0	825.0	33.3
13	16	Siemens AG	1,060.0	410.0	158.5
14	18	Micron Technology	960.0	387.0	148.1
15	15	Matsushita	854.5	513.2	66.5
16	10	SGS-Thomson	850.0	780.0	9.0
17	19	Philips	750.0	385.0	94.8
18	13	Advanced Micro Devices	745.0	625.0	19.2
19	20	Sanyo	672.6	356.1	88.9
20	23	National Semiconductor	597.0	325.0	83.7
		Total Top 20 Companies	28,344.3	16,458.5	72.2
		Total Worldwide Capital Spending	37,993.8	22,036.5	72.4
		Top 20 Companies Percentage of Total	74.6	74.7	

Source: Dataquest (December 1995)

Table 2-2
Worldwide Capital Spending by Region — Historical, Includes Merchant and Captive Semiconductor Companies (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991	1992	1993	1994	CAGR (%) 1989-1994
North America	2,622	3,349	3,794	4,217	3,895	4,135	4,943	7,182	13.6
Growth (%)	25.9	27.7	13.3	11.1	-7.6	6.2	19.5	45.3	
Japan	2,458	4,495	5,360	5,596	5,702	3,958	4,413	6,654	4.4
Growth (%)	33.2	82.9	19.2	4.4	1.9	-30.6	11.5	50.8	
Japan (Billions of Yen)	356	584	740	806	768	500	491	677	-1.8
Growth (%)	15.4	64.0	26.7	8.9	-4.7	-34.9	-1.9	38.0	
Europe	885	960	1,186	1,560	1,248	1,188	1,729	2,481	15.9
Growth (%)	15.7	8.5	23.5	31.5	-20.0	-4.8	45.5	43.5	
Asia/Pacific-ROW	540	1,033	1,865	1,542	2,300	2,318	3,238	5,720	25.1
Growth (%)	23.6	91.3	80.5	-17.3	49.2	0.8	39.7	76.7	
Worldwide	6,505	9,837	12,205	12,915	13,145	11,599	14,323	22,037	12.5
Growth (%)	26.8	51.2	24.1	5.8	1.8	-11.8	23.5	53.9	

Source: Dataquest (December 1995)

Table 2-3
Worldwide Capital Spending by Region — Forecast, 1994-2000, Includes Merchant and Captive Semiconductor Companies (Millions of U.S. Dollars)

	1994	1995	1996	1997	1998	1999	2000	CAGR (%) 1994-2000
North America	7,182	12,169	16,579	18,021	17,954	20,645	25,722	23.7
Growth (%)	45.3	69.4	36.2	8.7	-0.4	15.0	24.6	
Japan	6,654	9,777	12,102	11,766	11,320	12,542	15,986	15.7
Growth (%)	50.8	46.9	23.8	-2.8	-3.8	10.8	27.5	
Japan (Billions of Yen)	677	910	1,192	1,159	1,115	1,236	1,575	15.1
Growth (%)	38.0	34.3	31.1	-2.8	-3.8	10.8	27.5	
Europe	2,481	4,384	5,293	5,521	5,240	5,968	7,402	20.0
Growth (%)	43.5	76.7	20.7	4.3	-5.1	13.9	24.0	
Asia/Pacific-ROW	5,720	11,665	15,308	15,458	14,927	15,623	20,361	23.6
Growth (%)	76.7	103.9	31.2	1.0	-3.4	4.7	30.3	
Worldwide	22,037	37,994	49,281	50,765	49,441	54,778	69,472	21.1
Growth (%)	53.9	72.4	29.7	3.0	-2.6	10.8	26.8	

Source: Dataquest (December 1995)

concentrated in DRAM spending. With the general health of the industry, smaller semiconductor companies in all regions are participating in the capital spending boom in 1995, keeping the concentration of capital spending by the top 20 flat at 75 percent.

Taiwan Semiconductor Manufacturing Co. (TSMC) is on the cusp of debuting on the top 20 list for 1995 with an estimated $585 million spent on capacity. Foundry capacity expansion has now evolved into a major trend. In fact, foundry spending in Asia/Pacific will more than double in 1995 to an estimated $1.8 billion. This industry has been transformed into a dedicated, bona fide business and is no longer a specialized way to use excess capacity.

When Will the Spending Boom End?

Our longer-term forecast projects that significant growth in capital spending will spill into 1996 from sheer momentum, with a moderated growth of 30 percent, concentrated toward filling new fabs with equipment. Thirty new 200mm fabs are planned to come on line in 1996, as well as nine 150mm and smaller fabs, for a total of 39. This compares with a total of 30 for 1995 (18 of which are 200mm). Dataquest believes that, as the end of 1996 approaches, capital spending will begin to decelerate as the capacity additions of 1994 through 1996 are ramped. From what we can see, there is plenty of equipment that could be brought to bear on 16Mb DRAM capacity by the end of 1996 and to be on line to answer demand through 1997.

Overall semiconductor product demand is expected to remain strong through 1996, with long-term sustained growth through 2000 at a compound annual growth rate (CAGR) of 20.1 percent. We expect that microcomponent capacity will continue to ramp through 1997 before pausing in 1998, with the next major investment cycle picking up in 1999. Our model does not currently include significantly more 16Mb DRAM capacity expansion (over capacity being put in place in 1995 and 1996) until 1999. In the two "pause" years of 1997 and 1998, we believe DRAM manufacturers will concentrate on converting capacity from 4Mb toward 16Mb, which increases bits per square inch processed, and then concentrate on shrinks to squeeze out value per square inch before a capital cycle starts again. Further, in Japan, we expect that many 4Mb/16Mb fabs now running 150mm wafers will convert to 200mm wafers, further gaining efficiency and productivity from the capital investment made.

Through 2000, we project a five-year worldwide capital spending CAGR of 21.1 percent, slightly ahead of semiconductor consumption growth. We believe that capital spending may be influenced positively in 1997 and 1998 with facility construction and purchase of equipment for the world's first 300mm wafer fab. We have included this infrastructure investment in our model.

Over a year ago, we introduced a model that quantifies the over- and underinvestment picture for wafer fab equipment and semiconductor capacity. Although activity of the last several years has created and sustained a net underinvestment, not fully corrected to overinvestment in 1994, we expect about a 35 percent overinvestment by the end of 1996.

The North American Market Continues to Exhibit Strategic Strength

Capital spending in North America grew at an accelerated 69 percent in 1995, 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 1998, with acceleration resuming in 1999, resulting in a CAGR of 23.7 percent for 1994 through 2000. This is among the fastest-growing regions for investment, driven by recent low cost of capital and the need for foreign multinational and foundry manufacturers to be closer to their customers.

This relatively strong growth in capital spending has been driven by growth in PCs, telecommunications, and networking. These products have seen increasing use as tools to increase productivity in 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. U.S. companies dominate many of these market segments. These segments combined are expected to maintain fairly stable growth rates over the next few years, with PC growth slowing (but still maintaining a CAGR of 17 percent) and networking and telecommunications expanding. The near-term market for PCs has reaccelerated from Intel's new, aggressive Pentium pricing strategy, which has hastened the conversion to the Pentium.

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 the highly integrated complex logic and signal processing chips that will be the core engines of future systems.

Although the strategic strength of the core logic products makes for a healthy and flourishing semiconductor production environment, it also means less volatility in capital spending. In the boom years of 1994 and 1995, the North American region grew at somewhat lower-than-market rates. This will enable the North American capital spending to grow at faster-than-market rates in slower years like 1997 and 1998. We believe companies will invest strategically in capacity to preserve competitive advantage, and cutbacks are more likely to occur in the smaller companies rather than the first-tier manufacturers.

Capital investments in North America for 1995 came from equipping new fabs by both the majors and smaller companies. The major projects include Intel's Fab 11.2 in New Mexico and expected orders for Fab 12 in Arizona, Advanced Micro Devices' (AMD) Fab 25 in Austin, Texas, Motorola's MOS-13 in Texas and the continued ramp of MOS-12 in Arizona, Cypress' Fab 4 in Minnesota, SGS-Thomson's new Arizona facility, IBM's expansion in Burlington, Vermont (yes, IBM is back), and purchases for Texas Instruments' DMOS-5 fab in Dallas, Texas. Smaller companies are also spurring growth this year, with Integrated Device Technology, VLSI Technology, Zilog, Atmel, International Rectifier, American Microsystems Inc. (AMI), and National Semiconductor all bringing on new capacity. In 1996, equipment installation into these fabs will continue, plus 10 new fabs under construction, such as those of Sony and VLSI Technology in San Antonio, Texas, TwinStar in Texas, and Motorola's MOS-21 in Arizona. Samsung has stated its intention of investing $1 billion to build a fab in the United States. We have factored this and other foreign company fabs, such as TSMC's joint venture foundry and Toshiba's fab with IBM, into our 1997 to 1998 forecast.

Japan: DRAM Capacity Additions Drive Spending, but a Strong Yen Subdues

Japan's 47 percent increase in capital spending in 1995 is only a 34 percent increase on a yen basis, and Japanese companies look to invest outside Japan to optimize buying power. We are forecasting a subdued 24 percent growth in capital spending for 1996, factoring in a slight decline in 1997 as 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 world memory capacity presented an opportunity to increase profits from semiconductors. Investments by Japanese companies grew by nearly 61 percent in 1995, with an increased amount going overseas. However, as long as the Japanese economy is under pressure, Japanese companies will feel a "patriotic" dedication to invest in Japan, and we see no company spending more than 35 percent of committed investment outside Japan. With the strength of the yen, multinationals are reducing their investment proportion inside Japan as well.

Although new facilities by Japanese companies will come on line outside Japan throughout the rest of this decade, DRAM investments inside Japan are really the only driving force today. Beyond 1995, investment increases in Japan will need to come from growing the domestic economy. Dataquest believes an economic recovery in Japan started in 1994, but with slow acceleration. The degree at which companies will invest will be affected by the strength of this recovery. We are forecasting a below-average CAGR of 15.7 percent in Japan for 1994 through 2000.

One bright spot is that a PC boom could emerge in Japan over the next year or two, spawned by the networking infrastructure that is currently being built. This would breathe new life in the Japanese semiconductor market, and our forecast would brighten a bit. We do not think that even a PC boom, however, would create a forecast better than several percentage points below the world average. The fundamentals of Japanese production capacity are still too heavily concentrated in DRAMs, with no clear future direction emerging yet, which keeps us from being more optimistic about capital activities in Japan.

Europe Sustains Presence as a Growth Market

After a higher-than-expected growth bubble of 46 percent in 1993, European spending "moderated" to a slower-than-market growth in 1994 as multinationals (such as Intel) substantially completed the majority of their expansions in 1993. The growth of 43 percent in 1994 is nonetheless extremely healthy, fueled primarily by European companies themselves—the ever-present SGS-Thomson, Philips expanding in Nijmegen, Netherlands, and Ericsson equipping its expansion.

Europe continues to attract the capital in 1995, growing an impressive 76 percent. Large multinationals are still present, with Motorola upgrading the Scotland fab bought from Digital, the new IBM-Philips venture in Germany, Analog Devices expanding in Ireland, Texas Instruments expanding again in Italy, and the IBM-Siemens fab in France continuing to ramp 16Mb DRAMs. The key expansion is Siemens' new fab in Dresden, Germany, the key driver pulling Siemens into the top 10 in capital spending worldwide. The continued commitment of NEC and other Japanese companies to Europe has been the most recent boost to investment momentum, focused on land and facilities in 1995, bringing the growth in capital spending significantly above the growth in wafer fab equipment. We are looking for continued growth in 1996 of 21 percent as production continues to ramp from these investments and eight new fabs, most notably by GEC-Plessey, NEC, and Temic.

Europe is to be viewed as a strategic location for production to take better advantage of European and 16Mb DRAM growth in the future, driven by the PC production boom (see Chapter 6), while avoiding import tariffs. Samsung has announced a fab to come on line in Europe during 1998, but is still undecided about the exact location.

With a stronger multinational presence starting again in 1995 as economies pick up and with recent trends for PC production and foundry providers (such as Newport WaferFab and Tower Semiconductor), we now expect Europe to be an average investment region in the long term, with a six-year CAGR of 20 percent.

Asia/Pacific Is 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 77 percent in 1994. And those who thought this market could not accelerate from that level should think again—for 1995 is the year in which the Asia/Pacific region became the second-largest expansion region in the world, surpassing Japan in terms of dollars spent (that is, spending within the region, not by companies based in Asia). The region saw 104 percent growth in 1995, and we expect moderated growth of about 31 percent in 1996 as several new fab projects continue to be built and equipped and the number of new projects grows. Longer term, we expect Asia/Pacific's growth in capital spending to be among the most aggressive of any region. Dataquest forecasts a CAGR of 23.6 percent for 1994 through 2000.

Spending in 1995 is focused primarily in two areas: DRAMs and foundry capacity. The Korean conglomerates plan to continue their relentless DRAM capacity expansion in 1995. Hyundai is installing equipment for its new E-3 project, the third phase of a 200mm wafer, 16Mb DRAM fab started in 1992. LG Semicon (formerly Goldstar) is expanding its equivalent C2 line, in accordance with its agreement with Hitachi for the 16Mb DRAM ramps. LG Semicon is also bringing online the G-FAB for non-DRAM memory products. Samsung is continuing to spend, ramping Line 6, also a 200mm, 16Mb DRAM facility.

The real story in 1995 is the new Taiwan players. Vanguard International will be bringing on its new DRAM fab later this year, and Powerchip and Nan Ya have broken ground on DRAM fabs coming online in 1996. All of these are targeted at 16Mb DRAM running 200mm wafers. Current players such as TI/Acer and Mosel-Vitelic are also increasing their spending with new projects.

Taiwan chip companies TSMC, Macronix, Winbond, and United Microelectronics Corporation (UMC), along with Chartered Semiconductor in Singapore, have undertaken major projects in expanding foundry capacity, and a new foundry player has emerged in Thailand—SubMicron Technology. SubMicron has received funding of $1.6 billion for two separate fab lines, the first to come on line in 1996. Funding has also been allocated to establish a technology park in or near Bangkok, similar to Hsinchu in Taiwan. We have seen the start of this Bangkok park become reality as a new joint venture that includes Texas Instruments has just announced commitments for a new fab there. The combined spending of these companies for foundry (which excludes spending associated with their own products in the case of UMC, Macronix, and Winbond) increased from about $900 million in 1994 to about $1.8 billion in 1995, continuing at significantly higher levels into 1996 and 1997. The driving reason is the changing face of contract manufacturing in semiconductors. Gone are the days where excess fab capacity could support the foundry business of fabless companies (as well as integrated device manufacturers, or IDMs—companies with fabs).

Dataquest estimates that only about 32 percent of the contracted manufacturing of semiconductors originates from fabless companies. The remainder is from IDMs that wish to place lower manufacturing-value-added products away from their own facilities in order to maximize resources and cost, to reduce investment risks using foundries as an extension of their own capacity, or to use the more advanced technology of some foundries as a growth strategy. The last few years have seen the dedicated foundry flourish, mostly in Asia/Pacific. It is still believed that the largest concentration of foundry capacity in the world, however, is in Japan, with companies like 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 investment 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 for production equipment. Many joint ventures have been announced in the last several months, and we expect this trend to continue throughout 1996.

The foundry industry is now a strategic industry rather than simply a tactical one. With this transformation nearly complete, we are starting to see dedicated investment to build new foundry capacity.

In addition to the established semiconductor-producing countries, huge long-term opportunities exist in developing countries like China and the Unified States (formerly the Soviet Union). Ultimate demand for semiconductor products in those countries could approach demand in super-consumer countries like the United States and Japan. China, in particular, generates a gross domestic product comparable to that of Japan, if evaluated on the basis of purchasing power parity. 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 advanced 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 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 maintaining its status as a most favored nation with the United States. It will likely take a few years to sort out these issues. Dataquest assumes that semiconductor investment in China could begin to expand in 1997 (NEC is leading the investment charge today), accelerating into the later half of the decade.

Dataquest believes that the next countries to experience huge front-end semiconductor production growth will be Malaysia and Thailand. The latter's plans for a new science park we have already mentioned, and a new fab has been announced in Malaysia (Sarawak), financed by a group of investors, to start production in 1997.

Who's Investing Where?

Dataquest's recent capital spending survey shows how money is being spent. Table 2-4 summarizes how companies based in different regions are spending their money abroad for 1994, and Table 2-5 summarizes this for 1995. About 78 percent of money spent goes into the domestic economy worldwide, a ratio that held steady for 1994 and 1995.

Table 2-4
Regional Investment Patterns of Semiconductor Manufacturers in 1994 (Millions of U.S. Dollars)

	Worldwide	North America	Japan	Europe	Asia/ Pacific-ROW	Percentage of World Spending
North American Companies	8,628.3	6,223.7	566.3	957.4	880.9	39.2
Japanese Companies	7,587.4	545.7	6,087.5	311.5	643.7	34.4
European Companies	1,866.0	277.6	0.4	1,182.7	405.3	8.5
Asia/Pacific-ROW Companies	3,954.7	135.0	0	30.0	3,789.7	17.9
All Companies	22,036.5	7,182.0	6,654.3	2,481.5	5,719.6	100.0
Growth from 1993 (%)	53.8	45.3	50.8	43.5	76.6	

Source: Dataquest (January 1996)

Table 2-5
Regional Investment Patterns of Semiconductor Manufacturers in 1995
(Millions of U.S. Dollars)

	Worldwide	North America	Japan	Europe	Asia/ Pacific-ROW	Percentage of World Spending
North American Companies	13,616.6	9,963.6	588.4	1,525.0	1,539.6	35.8
Japanese Companies	12,194.2	1,390.7	9,187.8	835.3	780.4	32.1
European Companies	3,112.0	466.9	0.6	1,984.1	660.4	8.2
Asia/Pacific-ROW Companies	9,071.0	347.5	0	39.5	8,684.0	23.9
All Companies	37,993.8	12,168.7	9,776.8	4,383.8	11,664.5	100.0
Growth from 1993 (%)	72.4	69.4	46.9	76.7	103.9	

Source: Dataquest (January 1996)

Asia/Pacific companies have historically invested domestically, but diversification began in 1994 and continued in 1995. About 96 percent of Asia/Pacific companies' spending was domestic in 1994, and this proportion held steady in 1995. We would expect this ratio to decrease significantly over the next two or three years. Europeans have been the most aggressive capital exporters, historically, making only 63 percent of their investments within Europe. This figure has grown slightly to 64 percent in 1995 and should expand in 1996 as the domestic economies have resurged.

Japanese companies are very close to the worldwide average, with about 80 percent domestic investment in 1994, dropping to 75 percent in 1995. North American companies are also domestic spenders, with about 72 and 73 percent of investment staying at home for 1994 and 1995, respectively.

The North America and Japan regions are net investors, while the Europe and Asia/Pacific regions are net beneficiaries of that investment. This parallels the status of these regions as 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 this is one of the key elements necessary for a semiconductor company to be competitive on a global basis.

Dataquest Perspective

Capital spending in 1994 exploded and accelerated in 1995. The major reason for this is the surprisingly persistent growth in unit PC shipments, with the aggressiveness of Intel's Pentium pricing strategy. Major DRAM expansion accelerated in the second half of 1993 and will continue throughout 1996. From what we can see now, there is plenty of equipment that could be brought to bear on 16Mb DRAM capacity by the end of 1996 and brought on line to answer demand through 1997. A marked downturn in the DRAM investment cycle will be triggered by the 1Mbx16 configuration of the 16Mb DRAM, achieving yield in the area of 60 percent to 65 percent, which is expected to occur sometime in 1996.

Desktop connectivity products, telecommunications, and the PC market will lead to stable growth in microcomponents and logic devices, giving strategic strength to the North America region. Japanese companies will concentrate on ramping memories in order to hold their market share against Korean and Taiwanese companies. A struggling economy will keep capital investment muted once the DRAM ramp is satisfied. Globalization strategies will benefit both European and Asia/Pacific investment, with Asia/Pacific being the fastest-growing region over the next five years.

Dataquest believes that the relatively strong capacity expansion phase of 1993 to 1995 (with three-year growth of 265 percent) has now exceeded the three-year growth recorded in the 1987 to 1989 expansion. It should be noted, however, that these periods are different in two key respects. The current accelerated long-term growth for the underlying semiconductor industry is driven by a productivity-related PC boom. This PC boom is expected to continue, so we are not overly alarmed about the magnitude of this cycle. The momentum of investments will make 1996 a year of healthy growth in capital spending. Second, the manufacturing infrastructure is more efficient today, and there is a diminishing return in productivity and yield improvements. This has led to a higher natural capital investment ratio being required today than in 1987 to 1989.

However, we also believe that spending will decelerate starting in the second half of 1996, causing a somewhat flat spending pattern through 1997 and 1998. Although we continue to believe that the cyclical nature of investment in semiconductor capacity will diminish, the PC boom must continue to drive the underlying semiconductor growth strongly enough to dampen the memory component of the cycle. After a flat two-year period, investments should pick up again in 1999.

Strategic semiconductor procurement organizations analyze the total makeup of their supply base, starting with research and development expenditure, followed by capital spending plans, and then on to quality, delivery, and, ultimately, pricing. 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 supplier capital spending plans and ratio analysis of spending compared with sales, as well as with total expenses, give a good picture of where a supplier plans to go. A like analysis of R&D spending versus sales and total expenses is also helpful as an early indicator of potential problems. Often overlooked, capital spending is an important part of a total cost analysis. Regular reviews will prevent unpleasant surprises that may disrupt supply lines or cause supplier dislocations.

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